PUBLIC DOCUMENT . . . . No. 31.

THIRTY-NINTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1902.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 1, 1902.

To His Excellency W. MURRAY CRANE.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the thirty-ninth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

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CALENDAR FOR 1902–1903.

Jan. 2, 1902, Thursday, fall semester resumed, at 8 A.M.
February 5, Wednesday, fall semester ends.
February 6, Thursday, spring semester begins, at 8 A.M.
March 29, Saturday, to April 2, Wednesday, } spring recess.
April 2, Wednesday, spring semester resumed, at 8 A.M.
June 14, Saturday, Grinnell prize examination of the senior class in agriculture.
June 15, Sunday, { Baccalaureate sermon. Address before the College Young Men's Christian Association.
June 16, Monday, { Burnham prize speaking. Flint prize oratorical contest. Class-day exercises.
June 17, Tuesday, { Meeting of the alumni. Reception by the president and trustees.
June 18, Wednesday, commencement exercises.
June 19–20, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Sedgwick Institute, Great Barrington; and at Horticultural Hall, Worcester.
September 16–17, Tuesday and Wednesday, examinations for admission at 9 A.M., Botanic Museum.
September 18, Thursday, fall semester begins, at 8 A.M.
December 24, Wednesday, to Jan. 7, 1903, Wednesday, } winter recess.
January 7, Wednesday, fall semester resumed, at 8 A.M.
February 4, Wednesday, fall semester ends.
February 5, Thursday, spring semester begins, at 8 A.M.
March 28, Saturday, to April 2, Thursday, } spring recess.
April 2, Thursday, spring semester resumed, at 8 A.M.
June 17, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

The college during the past year has made its influence felt in the Commonwealth more strongly than ever before. Problems of every kind have been submitted to it for solution. New diseases involving plant and animal life have arisen, and diseased tissue has been sent to its laboratories for examination and remedy. Adulterations in food and impurities in water supply have been brought for analysis, and its aid invoked in a thousand different ways. And what has been done in the single department of experiment and investigation in the physical world, it has in like manner been doing in the spiritual world. To its care has been confided not only the health of the plant and the animal, but also the health of the mind. The training and the care of the plant and animal is comparatively a simple matter, but infinitely more complex and difficult is the training of the human soul. Never has there been a greater need of trained men in its lecture rooms and laboratories, and its resources have been taxed to the very utmost.

The charter under which the college was founded provides that "the leading object shall be — without excluding other scientific and classical studies and including military tactics — to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." The advantages of a good, all-round education, one so thoroughly practical and yet so many-sided that it will give the young men and the young women a greater number of chances in the struggle for existence than those graduating from the so-called classical or professional schools, appeal directly to the practical common sense of the masses. This year the largest freshman class but one in the history of the college was entered. Sixty-seven were admitted and over one-eighth rejected. The short winter courses, too, were largely attended, and thirty-four were present during their continuance. These students come with a fixed purpose, and almost all return to the farm or the dairy, to put in practice what they have learned. The students in the graduate department are about the same in numbers and have done excellent work, but so many opportunities present themselves for employment that it has been found difficult to hold them to the completion of their course. One, last year, within a few months of taking his degree, abandoned his work and accepted a position in India, to start an agricultural and technical training school in the vicinity of Ahmednugger.

Nature Study.

The general awakening to the importance and value of nature studies and their introduction into the schools of lower grades is a subject for congratulation. Other States have long since taken the initiative, New York being conspicuously in the lead. Its Legislature appropriates $70,000 a year for the publication and sending out of nature bulletins for the education of its youth and its teachers and for carrying on a correspondence school, and places the whole under the jurisdiction of the College of Agriculture of Cornell University. No more delightful or instructive studies can be desired. Here the free spirit finds free play, and new thoughts, new ideas and a new world are opened to the wondering child. "We are now convinced," say the authorities at Cornell, "that the greatest good which can be rendered to the agricultural communities is to awaken an interest in nature study on the part of the children. . . . The best way in which to reach the pupils and the teachers is by short and sharp observations upon plants, insects and other natural objects." Three years ago the secretary of our Board of Education, in his annual report, said: "The State Agricultural College, if authorized to do so, might readily give a commendable agricultural tone or value to some phases of nature study in the schools. It might send forth to the teachers of the Commonwealth valuable leaflets on approved themes, scientifically sound on the one hand, and, on the other, adapted in presentation and illustration to the minds of the young." An annual appropriation from the State of a few thousand dollars would enable the college to carry out this wise suggestion. It needs only the funds, not merely to prepare and send out these educational leaflets, but also to open a summer school to which the teachers may come and receive instruction on these subjects.

Opportunities for Women Students.

This movement in the direction of nature studies has awakened attention to the equipment and resources of the college, and the training it gives to its students. The young women of the Commonwealth have shared in this general movement, and shown a disposition to avail themselves of the advantages offered. One attended the winter courses at the opening of the year, two have entered the full four-years course leading to the degree of Bachelor of Science, and four are doing excellent work in the graduate department. To provide for the instruction of women, a special two-years course, in accordance with the vote of the trustees in 1897, has been prepared, in which the following subjects are offered from which to make up courses: zoölogy, entomology, bee culture, dairying, horticulture, floriculture, botany, greenhouse management, landscape gardening, market gardening, chemistry and agriculture. Tuition is free, and every facility offered for work. There is a fine library of twenty-two thousand volumes, selected with special reference to the wants of the student; and a plant, with its farm, orchards, nurseries, laboratories and equipment, representing a quarter of a million dollars. The last census report of Massachusetts tells us that two hundred and sixty-three women were engaged in agriculture and its subdivisions and forty-eight in the care of animals. Why should not this number be increased tenfold, and why should not the young women of the Commonwealth avail themselves of the splendid opportunities offered free at this college, and enter some one of the new avenues of employment thrown open by its training?

Outline of a Two-years Course of Study.

First Year.

First Semester.

Botany (5 *): Classification of plants; plant analysis.
Chemistry (5): Elements of chemistry.
Horticulture:
- Fruit culture (6): Propagation of fruit trees by cuttings and grafting.
- Floriculture (6): Greenhouses and their construction; propagating greenhouse plants from cuttings, etc.

French or German (optional) (3).

Second Semester.

Botany (5): Classification of plants; plant analysis.
Chemistry (5): Practice in chemical analysis.
Horticulture:
- Fruit culture (6): Small fruits; laying out orchards; insecticides and fungicides.
- Floriculture (3): Study of bedding plants; study and care of violets and chrysanthemums.
- Landscape gardening (3): Study of trees and shrubs to be used; laying out roads, walks, etc.

French or German (optional) (3).

Second Year.

First Semester.

Botany (5): Structure and physiology of plants.
Chemistry (5): Chemistry of the kitchen.
Horticulture:
- Floriculture (4): Study and growth of house decorative plants.
- Landscape gardening (4): Grouping trees and shrubs; making and care of the lawn.

Zoölogy (4).
French or German (optional) (3).

Second Semester.

Botany (5): Fungous diseases of plants, and their remedies.
Chemistry (5): Chemistry of the farm and garden.
Horticulture:
- Fruit culture (4): Cover crops; hybridization, and originating of new varieties.
- Landscape gardening (4): Care of the lawn; insects and fungi injurious to ornamentals.

Entomology (4).
French or German (optional) (3).

* Hours per week.

A Massachusetts Garden.

A garden containing all the shrubs and trees of Massachusetts has long been the dream of the college, but the time has never seemed ripe for such undertaking. The point has now been reached when, from an educational stand-point, its establishment seems a necessity, and I present herewith a statement which Professor Stone, chief of the department of botany, has prepared: —

The idea of a Massachusetts garden at the Massachusetts Agricultural College has been contemplated for some years. In 1870 there was made by Ignazt Pilat of New York an elaborate water-color plan of a proposed botanical garden, designed on the most artistic and comprehensive basis. The plan of this garden was to include all of the land east of the Insectary and Botanic Museum to the President Clark boundary. It was also to include a large pond for aquatic specimens, to be situated on land just north-east of the Insectary, and now utilized for market-garden purposes; and a small pond was to be located in the ravine south-east of the upper plant house.

In the thirteenth annual report (January, 1876) President Clark states that he is "still hopefully waiting for the fund of $50,000 for the endowment of the botanic gardens." In 1875 Prof. C. S. Sargent, then a member of the Board of Agriculture and an earnest friend of the college, furnished without charge "some thousands of species, including several hundred trees, shrubs and herbaceous plants, many of which were not obtainable elsewhere." Many of these plants we imagine are still to be found cultivated on the college grounds, while others did not prove hardy, and died. The original plan by Pilat is no longer feasible as a whole, as much of the land is now used for other purposes, and probably that is the best use that can be made of it. The plan recommended is also more elaborate and costly than is required at the present time. To construct the garden as Pilat designed would cost $50,000, and an additional fund of $5,000 per annum would be required to maintain it. It is to be regretted that more effort has not been made in years past to carry out at least some of the ideas formerly entertained by President Clark and Professor Sargent in regard to the establishment of a Massachusetts garden. A few groups of native shrubs could have been set out annually, and cared for at an expense that would scarcely have been noticed. The side hill extending from Professor Brooks' residence to the old creamery is a waste piece of land at the present time, and is of no value for anything else but an arboretum. A few native plants have been set out on this side hill and a few others thrive there spontaneously, which form a nucleus for further grouping. There has been little method in the limited amount of planting done, and no attempt has been made to formulate any permanent scheme or draft any feasible plan.

Plans the First Requisite in establishing a Garden.

The first move in the construction of a garden should consist in the elaboration of working plans. It is extremely important that such plans should bear the stamp of a master mind, for otherwise such a garden when completed would lack dignity, be unworthy of the college, and fail to produce that educational effect upon the mind of the student which is desired. The ennobling influence of a beautiful building or a dignified piece of landscape art from a master's hand on a susceptible mind cannot be estimated. In order, then, for such a garden to have permanent value, it should be largely the creation of one master mind.

Necessity of a Massachusetts Garden at the Present Time.

The botanical department has loug felt the necessity of a Massachusetts garden, in order that students might become familiar with the native trees and shrubs. Some of our students during the past years have gone into landscape work, and certain members of the present senior class are expecting to do likewise. These students have not been qualified to work for landscape gardeners, because they have been ignorant of the common plants of the State; neither has it been possible, with our equipment, to give them this knowledge. If they are sent out by landscape gardeners, as they frequently are, to collect certain species, they are not competent to recognize them. It is very essential, therefore, that students should know at least every native tree and shrub of this State, besides a great many cultivated ones, before they can expect to become efficient men for landscape gardeners. Every student that leaves this institution without that knowledge injures it. With our large collection of ornamental trees and shrubs, and the establishment here of all the native species, the elective courses could be easily arranged so that students desiring to fit themselves for the overseeing of large estates or to become associated with landscape gardeners could be amply qualified for such work. Furthermore, there should be established here at the college strong courses in landscape architecture, forestry and sanitary engineering, to round out and supplement a knowledge of the flora of the State.

Number of Species of Trees and Shrubs in Massachusetts.

There are about one hundred and seventy-five species of trees and shrubs growing wild in this State, a considerable number of which can be found in Amherst or vicinity. Some of these are now set out on the college grounds, but entirely without order or sequence. As a collection should have at least some sequence, it would be necessary to remove a few of these, and others could be duplicated in the proposed garden. Of the one hundred and seventy-five species, about fifty are planted on the grounds in different places, and fifty more could be obtained from the woods and fields without much difficulty. The remaining species would have to be purchased or collected elsewhere.

Plan of Construction.

In our opinion, the Massachusetts garden should contain nothing but our native trees and shrubs. No attempt should be made to include the herbaceous plants. It appears to us that the best plan in starting the garden would be to do a certain amount of transplanting each year, especially those varieties which are not indigenous to this region, in order that our deficiencies may be supplied, and the students have the opportunity of becoming familiar with a greater variety of our native plants than they are at present. In setting out shrubs and trees on the side hill, some portions of which contain rather poor soil, it would only be necessary to dig generous holes, manure well and mulch the plants. We do not believe that there is any necessity for grading, cultivating or enriching the soil, except where the planting is done. This leaves the hill in its natural condition, and does away with the necessity of a large expense.

Educational Value of a Synoptical Collection.

There is no feature so valuable in a collection of plants from an educational stand-point as a collection following a natural sequence, or, in other words, a synoptical collection. The Arnold Arboretum has about four acres devoted to this purpose, and one can obtain a better idea of shrubs from this collection than from any other in the United States. Such a collection at the college would be desirable, and should contain a large number of the herbaceous plants, such as our most important asters, golden rods, old-fashioned herbs and flowers, medicinal plants, etc. This collection should not be limited to native plants, nor should it in any way be connected with the Massachusetts garden. It should be near the greenhouse and Botanic Museum, and its object should be not only to illustrate the natural sequence of the relationship of one group to another, but to indicate the families to which they belong, as well as to display certain interesting species not cultivated here at the present time. A collection of this nature is not as urgent as a unique collection of Massachusetts trees and shrubs. It is, moreover, a much more costly collection to attend to, as the plants should be set in open beds, which require frequent cultivation and attention.

Dining Hall and Dormitory.

A good, substantial dining hall, well lighted and well ventilated, and large enough to provide ample accommodations for all the students of the college, has been a long-felt want. The present hall was erected in the earlier days of the college, about the year 1869. At best it was very poorly adapted for the purpose, and during its thirty-two years of service it has rapidly deteriorated. From time to time it has been patched up, until it is hard to locate the original structure. It was visited last year by members of several committees and one whole committee of the Legislature, and was unanimously condemned. If the surroundings of a man are not such as to uplift his character, he will almost of necessity go backward rather than forward. The present building is out of repair, gloomy, ill ventilated and badly lighted. There is nothing about it cheerful and inspiring, — nothing to tempt a man to step within its doors. Furthermore, there is no place where classes or the alumni can hold their annual reunions. A more modern structure, with some of the conveniences of civilized life, is imperatively demanded. Plans have been drawn making adequate provision for undergraduates and alumni, and the sum of $55,000 is asked to carry them out and provide the necessary equipment, and $1,000 annually for a maintenance fund.

Central Heating and Lighting Plant.

There are now on the college grounds twenty-seven buildings. On the west side we find a group of nine, consisting of the veterinary laboratory and stable hospital, the drill hall, the chapel library, north and south dormitories, the chemical laboratory, the dining hall and barn, with adjacent structures. All these can be heated from one central plant to advantage. It would result, first, in economy in fuel; second, economy in labor; third, great economy in the expense of light, by using the exhaust steam from the dynamo engines; fourth, diminution of the rate of insurance; fifth, great decrease of dust and ashes working upwards from the cellars; and sixth, it would largely eliminate the danger from fire. For the installation of such a plant a better location could hardly be desired, the power house being built into the ravine and concealed from view, the coal pockets being below the hill so that the coal can be discharged directly from above, and the ground sloping from every building but one down to this heating centre. There are, then, no natural difficulties in the way, and all the returns except those from the barn will drain to the boiler by gravity.

For the installation of this plant we ask for the sum of $35,000, this amount being understood to cover all material, labor, contingencies and engineer's fees, and also all connections to both heating and lighting systems of our present buildings.

The following vote was passed by the trustees at their annual meeting: —

Voted, That the recommendation of the committee on new buildings, that the sum of $90,000 be asked of the Legislature, for the building of a central heating and electric light plant, at a cost of $35,000, and a dining hall and dormitory, including equipment and furnishing, at a cost of $55,000, and that an annual appropriation of $1,000 be asked for the maintenance of the dining hall and dormitory, be accepted and adopted, and that these sums be inserted in the president's report.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 1, 1902.

THE CORPORATION.

	TERM EXPIRES
JAMES DRAPER of Worcester,	1903
SAMUEL C. DAMON of Lancaster,	1903
HENRY S. HYDE of Springfield,	1904
MERRITT I. WHEELER of Great Barrington,	1904
WILLIAM R. SESSIONS of Springfield,	1905
CHARLES L. FLINT of Brookline,	1905
WILLIAM H. BOWKER of Boston,	1906
GEORGE H. ELLIS of Boston,	1906
J. HOWE DEMOND of Northampton,	1907
ELMER D. HOWE of Marlborough,	1907
NATHANIEL I. BOWDITCH of Framingham,	1908
WILLIAM WHEELER of Concord,	1908
ELIJAH W. WOOD of West Newton,	1909
CHARLES A. GLEASON of New Braintree,	1909

Members Ex Officio.

His Excellency Governor W. MURRAY CRANE,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*

FRANK A. HILL, *Secretary of the Board of Education.*

JAMES W. STOCKWELL, *Secretary of the Board of Agriculture.*

HENRY S. HYDE of Springfield,
Vice-President of the Corporation.

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

WILLIAM R. SESSIONS, J. HOWE DEMOND,
HENRY S. HYDE, SAMUEL C. DAMON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER, ELMER D. HOWE,
CHARLES L. FLINT, GEORGE H. ELLIS,
WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticultural Department.*

JAMES DRAPER, ELMER D. HOWE,
N. I. BOWDITCH, MERRITT I. WHEELER,
WILLIAM R. SESSIONS, GEORGE H. ELLIS,
ELIJAH W. WOOD, *Chairman.*

Committee on Experiment Department.*

JAMES W. STOCKWELL, ELIJAH W. WOOD,
WILLIAM H. BOWKER, WILLIAM WHEELER,
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER, SAMUEL C. DAMON,
CHARLES L. FLINT, N. I. BOWDITCH,
JAMES DRAPER, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

Examining Committee of Overseers.

JOHN BURSLEY (*Chairman*), .	of West Barnstable.
C. K. BREWSTER, ...	of Worthington.
WESLEY B. BARTON, . . .	of Dalton.
ALVAN BARRUS, ...	of Goshen.
GEORGE P. SMITH, . . .	of Sunderland.

* The president of the college is ex officio a member of each of these committees.

The Faculty.

HENRY H. GOODELL, LL.D., *President.*
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

SAMUEL T. MAYNARD, B.Sc.,
Professor of Horticulture.

CHARLES WELLINGTON, M.A., Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

HERMAN BABSON, M.A.,
Assistant Professor of English.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

RICHARD S. LULL, M.S.,
Assistant Professor of Zoölogy.

RALPH E. SMITH, B.Sc.,
Assistant Professor of Botany.
(Instructor in German.)

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

——— ———

Professor of Landscape Gardening.

JOHN ANDERSON, Captain, U. S. A.,
Professor of Military Science and Tactics.

GEORGE F. BABB, M.A.,
Instructor in French.

DANIEL L. CLEAVES, B.S.,
Instructor in Chemistry.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law.

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, M.S.,
Registrar.

ELISHA A. JONES, B.Sc.,
Farm Superintendent.

Graduates of 1901.*

Master of Science.

Howard, Samuel Francis, . . .	Wilbraham.

Bachelor of Science.

Barry, John Cornelius, ...	Amherst.
Bridgeforth, George Ruffin (Boston Univ.),	Westmoreland, Ala.
Brooks, Percival Cushing (Boston Univ.),	Brockton.
Casey, Thomas (Boston Univ.), . .	Amherst.
Chickering, James Henry (Boston Univ.),	Dover.
Cooke, Theodore Frederic (Boston Univ.),	Austerlitz, N. Y.
Dawson, William Alucius (Boston Univ.),	Worcester.
Dickerman, William Carlton (Boston Univ.), ...	Taunton.
Gamwell, Edward Stephen (Boston Univ.),	Pittsfield.
Gordon, Clarence Everett, . . .	Clinton.
Graves, Jr., Thaddeus (Boston Univ.), .	Hatfield.
Henry, James Buel (Boston Univ.), .	Scitico, Conn.
Hunting, Nathan Justus, . . .	Shutesbury.
Leslie, Charles Thomas (Boston Univ.), .	Pittsfield.
Macomber, Ernest Leslie (Boston Univ.),	Taunton.
Ovalle Barros, Julio Moises (Boston Univ.), ...	Santiago, Chili.
Pierson, Wallace Rogers (Boston Univ.),	Cromwell, Conn.
Rice, Charles Leslie (Boston Univ.), .	Pittsfield.
Root, Luther Augustus, ...	Deerfield.
Schaffrath, Max, ...	Waterbury, Conn.
Smith, Ralph Ingram (Boston Univ.), .	Leverett.
Tashjian, Dickran Bedross (Boston Univ.),	Kharpoot, Turkey.
Todd, John Harris (Boston Univ.), .	Rowley.
Whitman, Nathan Davis (Boston Univ.),	South Boston.
Wilson, Alexander Cavassa (Boston Univ.), ...	Boston.

Total, ... 26

Senior Class.

Belden, Joshua Herbert, . . .	Newington, Conn.
Blake, Maurice Adin, ...	Millis.
Bodfish, Henry Look, ...	Tisbury.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1901.

Carpenter, Thorne Martin,	Foxborough.
Church, Frederick Richard,	Ashfield.
Claflin, Leander Chapin,	Philadelphia, Pa.
Cook, Lyman Adams,	Millis.
Cooley, Orrin Fulton,	South Deerfield.
Dacy, Arthur Lincoln,	Boston.
Dellea, John Martin,	North Egremont.
Dwyer, Chester Edwards,	Lynn.
Gates, Victor Adolph,	Memphis, Tenn.
Hall, John Clifford,	Sudbury.
Hodgkiss, Harold Edward,	Wilkinsonville.
Kinney, Charles Milton,	Northampton.
Knight, Howard Lawton,	Gardner.
Lewis, Claude Isaac,	Unionville.
McCobb, Edmund Franklin,	Milford.
Morse, Ransom Wesley,	Belchertown.
Paul, Herbert Amasa,	Lynn.
Plumb, Frederic Henry,	Bridgeport, Conn.
Saunders, Edward Boyle,	Southwick.
Smith, Samuel Leroy,	South Hadley.
West, David Nelson,	Northampton.
Total,	24

Junior Class.

Allen, William Etherington,	Winthrop.
Bacon, Stephen Carroll,	Leominster.
Barrus, George Levi,	Goshen.
Bowen, Howard Chandler,	Rutland.
Brooks, Philip Whitney,	Cambridge.
Cook, Joseph Gershom,	Clayton.
Franklin, Harry James,	Bernardston.
Halligan, Charles Parker,	Roslindale.
Hood, William Lane,	Vandiver, Ala.
Jones, Gerald Denison,	South Framingham.
Monahan, Neil Francis,	South Framingham.
Nersessian, Paul Nerses,	Marash, Turkey.
Parsons, Albert,	North Amherst.
Peebles, William Warrington,	Washington, D. C.
Poole, Elmer Myron,	North Dartmouth.
Proulx, Edward George,	Hatfield.
Robertson, Richard Hendrie,	Malden.
Snell, Edward Benaiah,	Lawrence.
Tinkham, Charles Samuel,	Roxbury.

Tottingham, William Edgar,	Bernardston.
Tower, Winthrop Vose,	Melrose Highlands.
Webster, Frank Wallace,	Bay State.
West, Myron Howard,	Belchertown.
Total,	23

Sophomore Class.

Ahearn, Michael Francis,	Framingham.
Back, Ernest Adna,	Florence.
Baker, Perez Raymond,	Amherst.
Barnes, Hugh Lester,	Stockbridge.
Bowler, Patrick Henry,	Bondsville.
Couden, Fayette Dickinson,	Amherst.
Cummings, John Francis,	Brockton.
Ellsworth, Frank Lawrence,	Holyoke.
Elwood, Clifford Franklin,	Green's Farms, Conn.
Esip, Edward Thomas,	Amherst.
Fahey, John Joseph,	Pittsfield.
Fulton, Erwin Stanley,	Lynn.
Gay, Ralph Preston,	Stoughton.
Gilbert, Arthur Witter,	Brookfield.
Graves, George Augustus,	Northampton.
Gregg, John William,	South Natick.
Griffin, Clarence Herbert,	Winthrop.
Handy, Robert Sylvan,	Bourne.
Harris, Frederick Arnold,	Amherst.
Haskell, Sidney Burritt,	Southbridge.
Henshaw, Fred Forbes,	Templeton.
Kelliher, Justin,	Brockton.
Kirby, Daniel Webster,	Webster.
Lewis, Clarence Waterman,	Melrose Highlands.
Martin, Henry Thomas,	Amherst.
Newton, Howard Douglas,	Curtisville.
O'Hearn, George Edmund,	Pittsfield.
Parker, Sumner Rufus,	Brimfield.
Pease, James Arthur,	Greenfield Hill, Conn.
Peck, Arthur Lee,	Hartford, Conn.
Pierce, Hervey Cushman,	West Millbury.
Quigley, Raymond Augustine,	Brockton.
Raymoth, Reuben Raymond,	Goshen.
Smith, Walter Abbe,	Springfield.
Staples, Parkman Fisher,	Westborough.

Thompson, Clarence Loomis,	South Natick.
Tinker, Clifford Albion,	West Tremont, Me.
White, Howard Morgan,	Springfield.
Total,	38

Freshman Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Bartlett, Francis Alonzo,	Belchertown.
Belden, William Lucius,	North Hatfield.
Brett, Clarence Elmer,	Brockton.
Brigham, Fred Washington,	Ashburnham.
Bruce, Ernest Charles,	Westborough.
Carter, Chester Merriam,	Leominster.
Craighead, William Hunlie,	Boston.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Northampton.
Filer, Harry Burton,	Belchertown.
Gardner, John Joseph,	Milford.
Goodenough, Herbert Harold,	Worcester.
Graves, Edwin Langdon,	Hatfield.
Haffenreffer, Adolf Frederick,	Jamaica Plain.
Hall, Jr., Arthur William,	North Amherst.
Hamblin, John Howland,	Falmouth.
Hatch, Walter Bowerman,	Falmouth.
Hill, Louis William Barlow,	Greenfield Hill, Conn.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Amherst.
Huntington, Raymond Edwards,	Newton Centre.
Hutchings, Frank Farley,	South Amherst.
Ingham, Norman Day,	Granby.
Kelton, James Richard,	Orange.
Knight, John Henry,	Middleton.
Ladd, Edward Thorndike,	Winchester.
Ladd, Jr., Joseph Hartwell,	Watertown.
Lyman, John Franklin,	Amherst.
Lyman, Richard Rowe,	Montague.
Merrill, Jr., Charles Edward,	Melrose.
Monahan, James Valentine,	South Framingham.
Munson, Willard Anson,	Aurora, Illinois.
Newhall, Jr., Edwin White,	San Francisco, Cal.
O'Neil, William James,	Ayer.
Paige, George R.,	Amherst.

Patch, George Willard,	Lexington.
Paul, Augustus Russell,	Framingham.
Peck, Louis Edward,	South Egremont.
Pray, Fry Civille,	Natick.
Porter, Charles Allen,	Boston.
Ransehousen, Lyman Arthur,	Springfield.
Rhodes, Elmer Elliot,	North Attleborough.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Smith, Robert Edward,	South Hadley Falls.
Sprague, Charles Eugene,	West Springfield.
Straw, Harold Douglass,	Guilford, Me.
Swain, Allen Newman,	New Dorchester.
Sykes, Charles Sumner,	Suffield, Conn.
Taylor, Albert Davis,	Westford.
Tinkham, Henry Buffinton,	South Swansea.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth,	Natick.
Walsh, Thomas Frederick,	Ayer.
Whitaker, Chester Leland,	Somerville.
Williams, Franklin Kinne,	Collinsville, Conn.
Williams, Percy Frederic,	Natick.
Willis, Grenville Norcott,	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	63

Short Winter Courses.

Allen, George Howard,	Auburndale.
Bartlett, Dwight Stebbins,	Belchertown.
Billings, Harry Holmes,	Amherst.
Chase, Frank Wendell,	Westborough.
Child, William Chapin,	Woodstock, Conn.
Crouch, Archie Albert,	Worcester.
Dickinson, Robert Joseph,	Woodbridge, Conn.
Dunbar, Charles Earl,	Orange.
Eaton, Benjamin Ellis,	Brockton.
Gillette, Dwight Laing,	Cheshire, Conn.
Gilson, Howard Luther,	Groton.
Hammond, Merle Kimball,	Onset.
Harlow, Ward Alvin,	Cummington.
Hunt, Thomas Francis,	Weston.

Mead, Philip Henry,	Silver Creek, N. Y.
Munson, Edward Malcolm,	South Dartmouth.
Purves, Geoffrey Vaughan,	Bedford.
Raddin, Charles Marsh,	Groton.
Richardson, Charles Henry,	West Acton.
Richardson, Harlan Lewis,	West Acton.
Richardson, Harry Gardner,	Woburn.
Sawin, Ralph Dana,	Boston.
Scott, Alexander,	Boston.
Smith, Lawrence Burleigh,	Groton.
Stackpole, Benjamin Hawes,	Hallowell, Me.
Streeter, Charles William,	Ludlow Centre.
Tupper, Bertram,	Barre Plains.
Whitney, Frank James,	North Amherst.
Williams, Carl Leslie,	North Orange.
Willis, George Washburn,	North Amherst.
Wood, Leroy Elisha Shore,	Upton.
Wright, Charles Wesley,	Worcester.
Yale, Walter Levi,	Meriden, Conn.
Young, Alla Frances,	Gloucester.
Total,	34

Graduate Courses.

For Degrees of M.S. and Ph.D.

Babb (A.M., Bates College, '01), George Francis,	Amherst.
Ballou (B.Sc., M.A.C., '95), Henry Arthur,	West Fitchburg.
Billings (B.Sc., M.A.C., '95), George Austin,	North Amherst.
Eaton (A.B., Harvard Univ., 1900), Theodore Hildreth,	St. Louis, Mo.
Haskins (B.Sc., M.A.C., '90), Henri Darwin,	Amherst.
Hinds (B.Sc., M.A.C., '99), Warren Elmer,	Townsend.
Ikeda (A.B., Univ. of Tokyo, '91), Hidezo,	Tokyo, Japan.
Knight (B.Sc., M.A.C., '92), Jewell Bennett,	Belchertown.
Monahan (B.Sc., M.A.C., 1900), Arthur Coleman,	South Framingham.

Morrill (B.Sc., M.A.C., 1900), Austin Winfield,	Tewksbury.	
Paull (M.A., Brown Univ., '98), Charles Leslie Fairbanks,	Somerset.	
Smith (B.A., Smith College, 1900), Elizabeth Hight,	Amherst.	
Walker (B.Sc., M.A.C., '99), Charles Morehouse,	Amherst.	
Wiley (B.Sc., M.A.C., '98), Samuel William,	Amherst.	
Total,		14

Special Students.

Billings, Minerva Ferrabee,	North Amherst.	
Russell, Ida Josephine,	Amherst.	
Sanderson, Carolyn May,	Amherst.	
Total,		3

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	14	
Four-years course: —		
Graduates of 1901,	26	
Senior class,	24	
Junior class,	23	
Sophomore class,	38	
Freshman class,	63	
Winter course,	34	
Special students,	3	
Total,		225
Entered twice,		1
Total,		224

The leading object of the Massachusetts Agricultural College is "to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

ADMISSION.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Four-years Course.

Candidates for admission to the freshman class will be received on certificate, as explained below, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject-matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1902 are these: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;"

Cooper's "The Last of the Mohicans;" Lowell's "The Vision of Sir Launfal." In 1903 and 1904: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Tennyson's "The Princess;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1902 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 19 and 20, and on Tuesday and Wednesday, September 16 and 17, as follows: —

First Day.

8.30 A.M. — Registration.
9 A.M. — English.
11 A.M. — General History.
2 P.M. — Geometry.

Second Day.

9 A.M. — Civil Government.
10 A.M. — Algebra.
2 P.M. — Physiology.
3 P.M. — Physical Geography.

Entrance examinations in June will be held on the same days and in the same order as in Amherst, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston, at Horticultural Hall, Worcester, and at Sedgwick Institute, Great Barrington, but candidates may be examined and admitted at any other time in the year.

Admission on Certificate.

Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year, when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

GRADUATE COURSES FOR THE DEGREES OF MASTER OF SCIENCE AND DOCTOR OF PHILOSOPHY.

1. Honorary degrees are not conferred.

2. Applicants are not eligible to the degree of Master of Science until they have received the degree of Bachelor of Science or its equivalent.

3. The college offers a course of study in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

4. Candidates for the degree of Master of Science devote not less than one year and a half after graduation to the prosecution of two studies for the degree of Master of Science, one year of which must be in residence at the Massachusetts Agricultural College.

5. The degree of Doctor of Philosophy is conferred upon graduates of this college or other colleges of good standing, who spend three years at this institution and satisfactorily complete a major subject and two minor subjects. Botany, chemistry or entomology may be selected as the major subject, and the minors available are botany, chemistry, entomology and zoölogy. The amount and the quality of the work done must be satisfactory to the professors in charge of the respective subjects before the degree is conferred.

6. The fee for the degree of Master of Science is ten dollars and for the degree of Doctor of Philosophy twenty-five dollars, to be paid to the treasurer of the college before the degree is conferred.

Fees are also charged for the use of laboratories.

COURSES OF INSTRUCTION FOR THE DEGREE OF BACHELOR OF SCIENCE.

Agriculture.

The various courses in this department aim to inculcate a knowledge of the scientific principles on which the various operations of the farm depend. Expressed more definitely, the aim is (*a*) to familiarize the student with the appearance, use and adaptability of each of the types of farm animals, their management, the principles of breeding and the economic handling of the more important products; and (*b*) to acquaint the student with the various facts concerning soils, methods of improvement of same, fertilization, crops, rural economy and farm management. While industrial training is by no means overlooked, it is however, upon scientific and theoretical training that especial emphasis is laid.

Instruction is given by means of mimeograph lecture notes, and text books when suitable, and by practical demonstration through the use of models, photographs, charts, lantern slides, live stock and modern dairy apparatus; also by occasional excursions to the best neighboring herds.

The courses are as follows: —

Freshman year, second semester, four hours per week: rural economics; history of agriculture; zoötechny, — breeds of horses, cattle, sheep, swine. (Professor Cooley.)

Sophomore year, first semester, three hours per week: zoötechny, — stock breeding, poultry farming, dairy farming. Shaw's "Animal Breeding." (Professor Cooley.)

Second semester, four hours per week: agronomy, — soils, formation, characteristics (chemical, physical and biological) and methods of improvements, including drainage, tillage, irrigation. (Professor Brooks.)

Junior year, first semester, three hours per week: agronomy, — manures and fertilizers, green manuring, crop rotation. (Professor Brooks.)

Senior year (elective), first semester, five hours per week: agronomy, — study of results of experiments (four weeks). (Professor Brooks.) Zoötechny, — feeding animals and advanced dairy farming. Armsby's "Manual of Cattle Feeding," Wing's "Milk and its Products." (Professor Cooley.)

Second semester, five hours per week: agronomy, — the crops of the farm, ensilage, rural economy, farm management. (Professor Brooks.)

Horticulture.

The aim of this department is to teach the principles which relate to success in the cultivation of vegetables, fruits, flowers, and ornamental plants, shrubs and trees; to fit the student for the supervision of laborers engaged in the several branches of horticulture; to train those students who wish to make horticulture their life work. Especial attention is given to the practical training of students in the art of constructing and managing greenhouses; in the propagation of plants and trees, either by means of seeds or cuttings or by grafting or budding; in laying out, ornamenting and caring for public or private grounds; and in forestry as adapted to the conditions in New England and in other parts of our country. New methods and the latest ideas are discussed, and, so far as approved by experience, recommended.

Instruction in all the lines of horticulture is given by lectures, text books being used only as books of reference. Application of theory and methods is made in the field and greenhouses, as far as the time covered will allow.

The course is as follows: —

Sophomore year, second semester, three hours per week: study of fruits and their culture. (Professor Maynard.)

Junior year, both semesters, three hours per week: study of vegetables, market gardening, greenhouse construction and management, landscape gardening and forestry. Green's "Vegetable Gardening." (Professor Maynard.)

Senior year (elective), both semesters, eight hours per week: special instruction in fruit culture, market gardening, floriculture, landscape gardening and forestry. The senior subjects are taken under the heading of a "general course" in horticulture, or all of the time may be devoted to one or two particular subjects. (Professor Maynard.)

Chemistry.

This course aims to inculcate accurate observation, logical thinking, systematic and constant industry, together with a comprehensive knowledge of the subject. Instruction is given by text books, lectures, and a large amount of laboratory work under adequate supervision. The laboratory work at first consists of a study of the properties of elementary matter, analysis of simple combinations and their artificial preparation. This is followed by a qualitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products. The advanced instruction takes up the chemistry of various manufacturing industries, especially those of agricultural interest, such as the production of sugar, starch and dairy products; the preparation of animal and plant foods, their digestive assimilation and economic use; the official analysis of fertilizers, fodders and foods; and the analysis of soils, waters, milk, wine and other animal and vegetable products.

The courses are as follows: —

Freshman year, second semester, two hours per week: general chemistry, part 1, principles of chemistry, non-metals. Newth's "Inorganic Chemistry." (Professor Howard.)

Sophomore year, first semester, four hours per week: general chemistry, part 2, metals. (Professor Howard.)

Second semester, five hours per week: subject continued, dry analysis. (Professor Howard.)

Junior year, first semester, four hours per week: qualitative and quantitative analysis, organic chemistry. (Professor Wellington.)

Second semester, six hours per week: organic chemistry. Remsen's "Organic Chemistry." (Professor Wellington.)

Senior year (elective), first semester, three hours per week: chemical industries. (Professor Goessmann.)

Eight hours per week: quantitative analysis and chemical physics. Reychler-McCrae's "Physical Chemistry." (Professors Wellington and Howard.)

Second semester, eight hours per week: advanced work with lectures. (Professor Wellington.)

Geology.

This course is divided into two parts, — mineralogy and geology.

Junior year, second semester, seven weeks, three hours per week: mineralogy, — a course of systematic determinative mineralogy, based on Brush's "Manual." This work is carried on in the laboratory, and consists in determining the minerals by a study of lustre, fusibility, hardness, color, streak, specific gravity, etc., and by some of the simpler chemical tests. (Professor Howard.)

Eleven weeks, three hours per week: geology, — dynamical, structural and historical, based on Scott's "Text Book of Geology," illustrated by charts and fossils, and by field excursions in the Connecticut valley. (Professor Lull.)

Senior year, second semester, five hours per week: an extension of the course outlined above. More time is spent in the field, and special attention is given to road-building materials, soils and the important soil-forming rocks, and, as far as time permits, to general economic geology. (Professor Howard.)

Zoölogy.

Sophomore year, first semester, three hours per week: Martin's "The Human Body" (advanced course) is used as a text book, from which recitations are assigned, supplemented by lectures and demonstrations illustrated by means of anatomical models and charts. (Professor Lull.)

Junior year, one semester and a half, six hours per week: laboratory study of the morphology of a series of typical animals, parallelling a course of recitations based upon Parker and Haswell's "Manual of Zoölogy," amplified and illustrated with charts, and the very complete series of specimens contained in the museum. (Professor Lull.)

Political Science.

The purpose of the entire course is to fit the student to understand the economic and political movements of his time, so that he may successfully solve the problems confronting him.

Economics, senior year, first semester, five hours per week: (1) The elements of political economy are taught by means of text book (this year, F. A. Walker's "Political Economy, Briefer Course") and lectures, the aim being to make the student familiar with the generally accepted facts, definitions, principles and laws of the science, and to train him to criticise theories, scrutinize facts and weigh arguments. (2) The industrial history of England and of the United States is studied. Gibbins' "Industrial History of England" is used. (3) The following elective courses are offered: economics of agriculture; banks and banking; problems of the currency; trusts, or monopolistic corporations; transportation; socialism. (4) Practical economics. Each member of the class selects a question for investigation, in which he is interested, and devotes two or three months to its solution.

Second semester, first seven weeks, five hours per week: Papers, giving the results of research, prepared by members of the class, are read, and discussed by the students; each student is asked to explain and defend from criticism the statements and conclusions made in the paper he presents. The department has at its disposal a working library and a collection of material for the use of the student electing the course.

Constitutional history, ten weeks, five hours per week: (1) Political institutions. By use of text book (Woodrow Wilson's "The State") and lectures the student is led to understand what is the government, municipal, State and federal, now existing in the United States. This government is compared and contrasted with the governments of England, France and Germany. Care is taken to familiarize the student with the practical methods of legislation, of nominating conventions, of elections and of administration. (2) Constitutional history of England and of the United States, with discussions relating to the origin, nature, scope and purpose of government. (Professor Walker.)

Lectures on law, second semester, one hour per week: This course treats of laws relating to business, especially to business connected with rural affairs, citizenship, domestic relations, farming contracts, riparian rights, real estate and common forms of conveyance. Practical work is required, such as may fit one to perform the duties of a justice of the peace. (Mr. Lyman.)

English.

This department aims to secure: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present, logically and forcibly, oral and written arguments on propositions assigned for debate.

Five courses are offered, ranging, as explained below, from freshman year to senior year. The courses are as follows: under (*a*), rhetoric and oratory; under (*b*), literature, American and English; under (*c*), argumentation; lastly, a special elective course in the senior year.

(1) *Rhetoric.* — This course extends through the two semesters of freshman year, three hours per week. It comprises, first, a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph and the whole composition, in its plan, arrangement and development. The text book used is Genung's "Outlines of Rhetoric." Exercises and compositions are assigned suitably to enforce the principles taught. Secondly, a study of the literary types, description, narration, exposition and argumentation, in which special attention is given to the training of the inventive ability of the student. The text book used is Genung's "Working Principles of Rhetoric." (Professor Babson.)

(2) *Oratory.* — Individual drill in declamation, first in private and then before the class, is given during both semesters of freshman and sophomore years. The choice of speakers for the Burnham prizes is based upon this work. In the junior year at least three orations, upon subjects assigned or chosen, are written, and delivered before the class. Every oration is criticised by the instructor before it is committed to memory by the student. The choice of speakers for the Flint prizes in oratory is based upon this work. (Professor Babson.)

(3) *Literature.* — American literature is studied in the first semester of sophomore year, three hours per week. The course comprises, first, the careful study of a text book (Pattee's "History of American Literature"), together with recitations based upon same; secondly, the taking of notes from lectures, dwelling upon topics not fully treated in the text book; and thirdly, the reading outside of the class room of assigned selections from the prose and the poetical works of standard American authors. (Professor Babson.)

The history of English literature, — first semester, four hours per week; second semester, two hours per week, — is studied during the junior year. The work is based upon some text book, this year, Halleck's "History of English Literature." The topical method is followed in recitation, and, instead of formal lectures, there are informal discussions of points requiring a fuller development than the text book gives. Collateral readings of literature are required. Frequent written tests are given, in which particular attention is given to (*a*) the definition of words used in the text book; (*b*) the use of English in the development of the topics unfolded in the text book or discussed in the class room. (Professor Mills.)

(4) *Argumentation.* — Two hours per week during the two semesters of senior year are given to written and oral argumentation. The course is outlined as follows: (*a*) principles of argumentation, as laid down in a text book (this year, McEwan's "Essentials of Argumentation"); (*b*) briefs and brief making; (*c*) briefs developed into forensics and submitted for personal criticism; (*d*) debates. (Professor Mills.)

Senior elective course, two hours per week. The work in this course is upon the following subjects: (*a*) English language, its origin, history and development, with particular attention to the study of words as outlined in Johnson's "English Words;" (*b*) English literature, principally of the eighteenth and the nineteenth centuries, with a view to becoming familiar with the style and thought of a few of their representative writers. (Professor Mills.)

Veterinary Science.

The course of instruction in veterinary science has been arranged to meet the demands of the students who, after graduation, purpose following some line of work in practical agriculture. Particular stress is laid upon matters relating to the prevention of disease in animals. In addition, the interests of prospective students of human and comparative medicine have been taken into account in the arrangement of the course of study. The subject is taught by lectures, laboratory exercises, demonstration and clinics.

Senior year (elective), first semester, five hours per week: veterinary hygiene, comparative (veterinary) anatomy, general pathology. (Professor Paige.)

Second semester, five hours per week: veterinary materia medica and therapeutics; theory and practice of veterinary medicine; general, special and operative surgery; veterinary bacteriology and parasitology; medical and surgical clinics. (Professor Paige.)

Botany.

The object of this course is to teach those subjects which have a bearing upon economic and scientific agriculture. The undergraduate work extends through five semesters. The first three semesters are required. An outline of the course follows : —

Freshman year, first semester, three hours per week : laboratory work and lectures ; study of the lower forms of plant life. (Professor Smith.)

Second semester, three hours per week : laboratory work, lectures and text book. Outlines of classification and morphology of the higher plants. Gray's "Manual of Botany." (Professor Smith.)

Sophomore year, first semester, four hours per week : laboratory work and lectures ; the structure and physiology of the higher plants. (Professor Smith.)

Senior year (elective), both semesters, eight hours per week : laboratory work, lectures and text book ; (*a*) plant physiology, Darwin's and Acton's "Practical Plain Physiology ;" (*b*) plant pathology. Either course is optional. (Professor Stone.)

Mathematics, Physics and Engineering.

This department has charge of the instruction in mathematics, physics, civil engineering and drawing. The aim is to secure thorough work in the fundamental principles, and train the mind in clear and logical thinking. The application of the subjects to practical problems is given special attention. The work of the department extends over the four years, as outlined below : —

Freshman year, first semester, five hours per week : higher algebra, including ratio and proportion, progressive binomial theorem, series undetermined coefficients, logarithms, continued fractions, permutations. Well's "College Algebra." (Professor Hasbrouck.)

Free hand drawing, four hours per week. (Mr. West.)

Second semester, two hours per week : solid geometry. Well's "Solid Geometry." (Professor Hasbrouck.)

Plane trigonometry, two hours per week. Phillips' and Strong's "Elements of Trigonometry." (Professor Ostrander.)

Sophomore year, first semester, four hours per week : elementary mechanics, including uniform and accelerated motion ; composition and resolution of forces ; friction, work and energy ; statics and simple machines. Dana's "Elementary Mechanics." (Professor Ostrander.)

Second semester, four hours per week: plane surveying, with field work, including the use of the usual surveying instruments. Carhart's "Plane Surveying." (Professor Ostrander.)

Mechanical drawing, including elementary projection and shadows, four hours per week. Faunce's "Mechanical Drawing." (Professor Hasbrouck.)

Junior year, first semester, three hours per week: physics, including mechanics of liquids, gases, sound and heat. Carhart's "University Physics." (Professor Hasbrouck.)

Second semester, light and electricity, with laboratory work. (Professor Hasbrouck.)

Senior year (elective), first semester, five hours per week: analytic geometry and calculus. Nichol's "Analytic Geometry." (Professor Ostrander.)

Engineering, — roads and pavements, railroads, elementary mechanics of materials, five hours per week. (Professor Ostrander.)

Descriptive astronomy, four hours per week. Young's "General Astronomy." (Professor Ostrander.)

Second semester, five hours per week: differential and integral calculus. Osborn's "Calculus." (Professor Ostrander.)

Engineering, — elementary structures, hydraulics, sanitary engineering and masonry construction, five hours per week. (Professor Ostrander.)

Entomology.

The importance of a knowledge of insects in every department of life is recognized by placing an introductory course in this subject as a required study in the junior year. For those who desire a further knowledge of it, because of its importance to their future occupations, a senior elective is offered, so shaped as to be of especial value for those who expect to take up agriculture, horticulture, landscape gardening, forestry or science teaching, as life occupations.

Junior year, last half of second semester, six hours per week: lectures, laboratory and field work; general consideration of insect structure and life histories; systematic study of the groups of insects, with particular reference to those of economic importance; methods for preventing or checking their ravages; insecticides and apparatus for their use; the collecting, mounting and naming of insects, and examination of the work of insects in the field and laboratory. (Prof. H. T. Fernald.)

Senior year (elective), first and second semesters, eight hours per week: lectures, laboratory and field work; advanced morphology of insects; economic entomology; training in the determination of insects; use of literature on entomology; study of life histories; value and application of insecticides; thesis on insects most closely related to future occupation of the student. (Prof. C. H. Fernald.)

Modern Languages.

French and German are required for one year, French occupying the freshman year, German the sophomore year. An elective in advanced French and one in advanced German are offered in senior year.

French.

Course I. — Required for the two semesters of freshman year, four hours per week, first semester; three hours per week, second semester. The aim of this course is to enable the student to read at sight ordinary French, especially that as found in scientific journals. The first six weeks are devoted to securing a working knowledge of the essentials of grammar. Reading is then begun, and is continued throughout the year. The foundation in grammar is further strengthened by weekly exercises, with constant drill in composition. (Mr. Babb.)

Course II. — Elective for the two semesters of senior year, five hours per week. The aim of this course is to furnish a general knowledge of classical French literature. The reading is confined to masterpieces. Lectures on the history of French literature are offered. Drill is also furnished in composition, principles of syntax and sight translation.

Edgren's "Complete French Grammar" is used as a guide in both courses.

Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. (Mr. Babb.)

German.

Course I. — Required for the two semesters of sophomore year, three hours per week. Facility in translation is the main object in view, with particular reference to scientific writings. The work consists of a study of the rudiments of grammar and of translation. (Professor Smith.)

Course II. — Elective for the two semesters of senior year, five hours per week. In this course special attention is given to the reading of German literature, particularly the literature pertaining to several branches of natural science. A student taking this course in connection with any science is expected to gain the ability to avail himself of the German literature of his subject, within reasonable limits.

Different books are used from year to year, but the following list will give an idea of the nature of the work: *Course I.* Joynes Meissner's "German Grammar," Guerber's "Märchen und Erzählungen," Hauff's "Das Kalte Herz," Moser's "Der Bibliothekar." *Course II.* Lessing's "Emilia Galotti," and "Minna von Barnhelm," Hodge's courses in "Scientific Reading."

Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. (Professor Smith.)

Military Science.

In compliance with the provisions of an act of Congress of July 2, 1862, military instruction under a regular army officer, detailed for this purpose, is required of all able-bodied male students.

The object of such instruction is clearly to disseminate the elements of military knowledge throughout the country, that, in case of sudden emergency, a sufficient number of well-trained, educated men can be found to command and properly to instruct volunteer troops. Military drill also has the object in view of giving the student physical exercise, teaching respect and obedience to those in authority without detracting from pride of manhood, and developing a military bearing and courtesy becoming in a citizen as in a soldier.

Course I. — Out of doors, an exercise of one hour, three times per week, Mondays, Tuesdays and Thursdays; infantry drill by squad, company and battalion; artillery drill by detachment; target practice; dress parade; review and guard duty.

All drills are in drill hall during the winter months or inclement weather.

Students assigned to the college band receive instruction and practice in band music and band evolutions, in place of drills and recitations.

Course II. — Theoretical instruction for freshmen, one hour each week for both semesters, comprises recitations in infantry drill regulations. "United States Service Manual."

Course III. — Theoretical instruction for seniors for both semesters, one hour each week, embraces drill and army regulations; duties of sentinels and post duty; elements of military science; preparation of necessary reports and returns pertaining to a company of infantry; and a thesis on some military subject. Wagner's "Elements of Military Science." (Captain Anderson.)

SYNOPSIS OF THE COURSES OF INSTRUCTION.

[Numbers indicate hours per week; those in parentheses, laboratory exercises.]

Freshman Year.

First Semester.		*Second Semester.*	
Rhetoric,	3	History of agriculture and breeding,	4
Declamation,	1	General chemistry,	2
Structural botany,	3	Rhetoric,	3
Advanced algebra,	5	Declamation,	1
Free-hand drawing,	(4)	Analytical botany,	3
French,	4	Geometry and trigonometry,	4
Military tactics,	1	French,	4

Sophomore Year.

First Semester.		*Second Semester.*	
Agriculture, breeding and live stock,	3	Soils, drainage, grasses,	4
General chemistry,	(4)	Horticulture,	4
Anatomy and physiology,	3	Quantitative analysis,	(5)
American literature,	3	Declamation,	1
Declamation,	1	Surveying,	3
Economic botany,	(4)	Mechanical drawing,	(4)
Mechanics,	2	German,	3
German,	3		

Junior Year.

First Semester.		*Second Semester.*	
Manures, fertilizers, rotation of crops,	3	Landscape gardening,	3
Market gardening,	3	Organic chemistry,	1 (5)
Qualitative and quantitative analysis,	4	Geology,	3
Zoölogy,	2 (4)	Zoölogy and entomology,	2 (4)
English literature,	4	English literature,	2
Oratory,	1	Oratory,	1
		Physics,	2 (2)

Senior Year.

First and Second Semesters.

English 2, military science 1, and any one of the following combinations of subjects: —

Agriculture,	5	Agriculture,	5
Political science,	5	Chemistry,	(8)
Veterinary science,	5	German or French,	5
Horticulture,	(8)	Chemistry,	(8)
Entomology,	(8)	Astronomy (one semester),	4
Agriculture,	5	Geology (one semester),	4
		Horticulture,	(8)
Mathematics,	5	Veterinary science,	5
Engineering,	5	Chemistry,	(8)
Political science,	5	German or French,	5

Botany,	(8)	Botany,	(8)
Horticulture,	(8)	Chemistry,	(8)
English,	5	Veterinary science,	5
Entomology,	(8)	English,	5
Botany,	(8)	Latin, *	5
German or French,	5	Mathematics,	5

When the schedule will permit, other combinations of the above subjects, if approved by the faculty, may be taken.

Military drill, 3, required throughout the four years.

DEGREES.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni.

Those completing the prescribed graduate course receive the degree of Master of Science or Doctor of Philosophy.

WINTER COURSES.

For the benefit of those who are unable to take the regular four-years course, the college offers a series of short courses in agriculture, horticulture, botany, chemistry, zoölogy and dairying; and for these, examinations are not required. These courses are offered during the eleven weeks immediately following the Christmas vacation. They are open to persons of both sexes, and are all optional. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

A tabulated outline of the courses, all of which are optional, follows: —

* The choice of Latin as an elective presupposes at least two years' study of the subject.

Agriculture.

General Agriculture.

1. Soils, and operations upon them, drainage, irrigation, etc.
2. Farm implements and machinery.
3. Manures and fertilizers.
4. Crops of the farm, characteristics, management, etc.
5. Crop rotation.
6. Farm book-keeping.
7. Agricultural economics.
8. Farm, dairy and poultry management.

Total hours, ... 64

Animal Husbandry.

1. Introduction.
2. Location and soil.
3. Building.
4. Breeds of cattle.*
5. Breeds of horses.
6. Grain and fodder crops.*
7. Foods and feeding.*

Total hours, ... 64

Horticulture.

Fruit Culture.

1. Introduction.
2. Propagation of fruit trees by seed, budding, grafting, forming the head, digging, planting, pruning, training, cultivation, etc.
3. Insects and fungous diseases.

Total hours, ... 32

Market Gardening.

1. Introduction, equipment, tools, manures, fertilizers, etc.
2. Greenhouse construction and heating.
3. Forcing vegetables under glass.
4. Seed growing by the market gardener.
5. Special treatment required by each crop.
6. Insects and fungi, with remedies.

Total hours, ... 27

Floriculture.

1. Greenhouse construction and heating.
2. Propagation of greenhouse and other plants by seed, cuttings, grafting, etc.
3. Cultivation of rose, carnation, chrysanthemum and orchids.
4. Propagation and care of greenhouse and bedding plants.
5. Insects and fungi which attack greenhouse plants.

Total hours, ... 33

Botany.

Injurious Fungi of the Farm, Garden, Greenhouse, Orchard and Vineyard.

1. Introduction.
2. Nature and structure of rusts.
3. Nature and structure of smuts.
4. Nature and structure of mildews.
5. Nature and structure of rots.
6. Beneficial fungi of roots.
7. Edible mushrooms.

Total hours, ... 22

Structure and Function of Plants.

1. Introduction.
2. The parts of a plant.
3. Structure of the cell and plant in general.
4. Functions of root, stem and leaves.
5. Food of plant obtained from air.
6. Food of plant obtained from soil.
7. Transference and elaboration of food.
8. Growth of plants.
9. Effects of light, moisture, heat and cold.
10. Root tubercles on pea and clover.
11. Cross fertilization of flowers.

Total hours, ... 22

* With dairy course.

Chemistry.

General Agricultural Chemistry.

1. Introduction.
2. The fourteen elements of agricultural chemistry.
3. Rocks and soils.
4. The atmosphere.
5. The chemistry of crop growing.
6. Fertilizers.
7. Animal chemistry.

Total hours, ... 55

Chemistry of the Dairy.

1. Introduction.
2. The fourteen elements of agricultural chemistry.
3. The physical properties of milk.
4. Analysis of milk, butter, cheese and other dairy products.
5. Chemistry of the manufacture of dairy products.

Total hours, ... 55

Zoölogy.

General Zoölogy.

Total hours, ... 22

Entomology.

1. Elementary principles.
2. The important insect groups from an economic point of view.
3. Serious insect pests of New England, and how to control them.

Total hours, ... 33

Dairying.

Especial emphasis is laid upon this course, the purpose of it being to give thorough training in the production and the management of home dairy products, as well as to equip butter makers for factory work. At the conclusion of this course certificates are given to students satisfactorily completing the assigned work.

Lectures and Class Room Work.

1. The soil and crops.
2. The dairy breeds and cattle breeding.
3. Stable construction and sanitation, care of cattle.
4. Common diseases of stock, their prevention and treatment.
5. Foods and feeding.
6. Book keeping for the dairy farm and butter factory.
7. Pasteurization and preparation of milk on physicians' prescriptions.
8. Composition and physical peculiarities of milk; conditions which affect creaming, churning, methods of testing, and preservation.
9. Milk testing.
10. Butter making.
11. Practice in aeration, pasteurization.

Total hours, ... 156

For further information regarding these winter courses, address Prof. William P. Brooks.

SPECIAL COURSES FOR WOMEN.

By vote of the trustees, the college offers special elective courses open to women in such branches as botany, entomology, floriculture, fruit culture, market gardening and the dairy.

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables are stocked with the best breeds of horses, cattle, sheep and swine. Attached to the barn is a dairy building equipped with the latest machinery driven by an electric motor. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution of agriculture. Three large lecture rooms, one in south college and two in the dairy building, have been assigned to this department.

Horticulture.

For illustration of the science and the practice of horticulture the department possesses about one hundred acres, devoted to orchards, planted with all the leading old and all new varieties of apples, pears, peaches, plums, Japanese and American cherries, quinces, chestnuts, hickory nuts and walnuts; vineyards containing nearly two hundred named varieties of grapes, for sale, beside several hundred seedlings, and about an acre devoted to a commercial crop of a few market varieties; nurseries, containing all kinds of fruit and ornamental trees, shrubs and plants, in all stages of growth, from the seed and cuttings to those ready for planting in the orchard or field; small fruit plantations, containing valuable varieties, and showing the modern methods of training, pruning and cultivation; extensive greenhouses, that contain not only valuable collections of specimen plants, representing types of the flora of the world, but also the most valuable economic plants, such as the orange, banana, lemon, guava, pomegranate, sago palm, arrow-root, tapioca, ginger, pepper, tea, coffee, camphor, India rubber, Manila hemp, banyan tree, etc. All the common greenhouse and outdoor decorative plants are found, and small quantities of roses, carnations, chrysanthemums and other commercial flowering plants are grown, to illustrate the business of horticulture. All vegetable crops, now so largely grown under glass, are grown in limited quantities for purposes of instruction and for market.

For illustration in the work of landscape gardening, the grounds about the greenhouses, as well as that part of the grounds known as the Clark Park, are planted with a very large and complete collection of ornamental trees, shrubs and plants.

For forestry there are two large groves of trees of varying ages, from those of almost primeval growth to the youngest seedlings, besides several plantations of younger growth either natural or planted; and in the Botanical Museum there is a very complete collection of woods of Massachusetts.

All kinds of pumps and other appliances for distributing insecticides and fungicides, as well as various modern tools and implements, are in constant use.

A small cold storage room makes possible the keeping of the products beyond their natural season, and illustrates one of the most important adjuncts to the business of modern horticulture.

Chemistry.

This department has fourteen rooms, well adapted to their special uses. They are supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor has a seating capacity for seventy students. Immediately adjoining it are four smaller rooms, used for storing apparatus and preparing materials for the lecture table. The laboratory for beginners is a large room on the first floor, furnished with forty working tables. Each table is provided with reagents and apparatus for independent work. A well-filled laboratory for advanced work is also provided on the first floor. A weighing room has six balances, and improved apparatus for determining densities of solids, liquids and gases. The apparatus includes, besides balances, a microscope, a spectroscope, a polariscope, a photometer, a barometer, and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milking products, fibres and other vegetable and animal products, and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished product.

Geology.

Geological teaching is illustrated by a very complete series of minerals, the State collection of rocks of Massachusetts, a series of Ward's fossils and casts of fossils, models and charts.

Zoölogy.

Zoölogical Laboratory. — A large, well-lighted room, situated in the old chapel building, is fitted with necessary tables, trays and general apparatus, microscopes, dissecting instruments, hand lenses and the like. There have lately been added aquaria, in which, as far as possible, the various types studied may be seen in their natural environment. A reference library is kept in the laboratory.

Zoölogical Lecture Room. — An ample lecture room is situated in south college, adjacent to the museum. It is supplied with a set of Leuckart charts and many special ones as well, and with a complete set of Auzoux models, illustrative both of human and comparative anatomy. A special set of typical specimens are being set apart for class illustration, although the more extensive museum collection is drawn upon for the same purpose.

Museum of Zoölogy. — The museum is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth, and those types which show the evolution and the relationship of the members of the animal kingdom. The total number of specimens contained in the museum now exceeds eleven thousand. The museum is open to the public from 3.30 to 5.30 P.M., each week day.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glass ware. One portion of the building is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over forty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject. This is supplemented by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. As the laboratory is directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room, fitted up for the analysis of insecticides and other chemico-entomological work; and a greenhouse, where plants infested by injurious insects are under continual observation and experimental treatment, — all these are available to the student. In addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large greenhouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for study of the attacks of injurious insects under natural conditions.

Veterinary Science.

The department has for its sole use a commodious and modern laboratory and hospital stable, erected in 1899. Both buildings are constructed according to the latest ideas as regards sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The laboratory building contains a large working laboratory for student use, and several small private laboratories for special work. In addition, there is a lecture hall, museum, demonstration room, photographing room and work shop. The hospital stable contains a pharmacy, operating hall, post-mortem and disinfecting room, besides a section for poultry, one for cats and dogs, and six sections, separated from each other, for the accommodation of horses, cattle, sheep, swine and other domestic animals.

The laboratory equipment consists of a dissecting Auzoux model of the horse, Auzoux models of the foot and the legs, showing the anatomy and the diseases of every part. There are skeletons of the horse, cow, sheep, dog and pig, and, in addition, a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams, which are made use of in connection with lectures and demonstrations.

The laboratories are supplied with the most modern high-power microscopes, microtomes, incubators, sterilizers, for the use of students taking the work in bacteriology and parasitology.

Botany.

The botanical department possesses a general laboratory, furnished with tables and benches for microscopical and physiological work, and with a dark closet for photographic purposes. There are forty compound microscopes, twenty-three dissecting microscopes, a micro-photographic and landscape camera and various accessories; also microtomes, paraffine baths, etc., for histological work; a large and useful collection of physiological apparatus for the study of photo-synthesis, respiration, metabolism, transpiration, heliotropism, geotropism, hydrotropism, galvanotropism, chemotropism, and other irritable phenomena connected with plants; a set of apparatus for the study of the mechanical constituents of the soil, and for experimental work in soil physics; a large and unique outfit of electrical appliances for the study of all phenomena related to electricity and plant growing; various devices for the study of mechanics of plant structure; numerous contrivances to determine the power exerted by living plant organisms; several types of self-registering auxanometers, used to measure the rate of growth of plants; self-registering thermometers, and hygrometers for recording constant changes in conditions.

A small special laboratory for graduate students is equipped with microscopes and other apparatus and reagents for advanced work.

Botanical Lecture Room. — The botanical lecture room adjoining the laboratory is adapted for general work in morphology and flower analysis, with opportunity to use dissecting microscopes. It contains a movable chart system, arranged to display over three thousand figures relating to the structure and function of plants.

Library.

This now numbers 22,640 volumes, having been increased during the year, by gift and purchase, 975 volumes. It is placed in the lower hall of the chapel-library building, and is made available to the general student for reference or investigation. It is especially valuable as a library of reference, and no pains will be spared to make it complete in the departments of agriculture, horticulture, botany and the natural sciences. It is open from eight o'clock to half-past five in the afternoon, and an hour and a half in the evening.

ENTRANCE EXAMINATION PAPERS USED IN 1901.

The standard required is 65 per cent. on each paper.

Algebra.

1. Divide $\frac{x^2 - y^2}{x^2 - 2xy + y^2}$ by $\frac{x^2 + xy}{x - y}$.

2. $x + \frac{3}{y} = \frac{7}{2}$ and $3x - \frac{2}{y} = \frac{26}{3}$, to find x and y.

3. $(a + b)x - (a - b)y = 4ab$ and $(a - b)x - (a + b)y = 0$, to find x and y.

4. Find the square root of $4x^n + 9x^{-n} + 28 - 24x^{-\frac{n}{2}} - 16x^{\frac{n}{2}}$.

5. $\frac{1}{x + \sqrt{2 - x^2}} + \frac{1}{x - \sqrt{2 - x^2}} = \frac{x}{2}$, solve for x.

6. $x\,(x + y) = 40$ and $y\,(x - y) = 6$, to find x and y.

7. $\frac{1}{x} + \frac{1}{y} = \frac{7}{12}$, and $xy = 12$, to find x and y.

8. Find the sum of the following series to 19 terms: 5, 9, 13.

Geometry.

Prove the following propositions: —

1. The angle between two secants, intersecting without the circumference, is measured by one-half the difference of the intercepted arcs.

2. In any triangle, the bisector of an angle divides the opposite side into segments proportional to the adjacent sides.

3. If through a fixed point without a circle a tangent and a tangent and a secant be drawn, the product of the whole secant and its external segment is equal to the square of the tangent.

4. The triangles having an angle of one equal to an angle of the other are to each other as the products of the sides including the equal angles.

5. A circle can be circumscribed about, or inscribed in, any regular polygon.

Physical Geography.

1. Define the terms alluvial plain, water-shed, estuary, delta and river terrace.

2. What three methods of mountain formation are there? Illustrate.

3. What is a thermal spring? What is a geyser? Where would you go to see the finest examples of each?

4. What is an earthquake? Have they any connection with any other great phenomena? What is the probable cause of each?

5. Compare the climates of Labrador and England, and tell wherein they differ, and why.

6. Name the great continents, and describe in full the continental plan of structure.

Civil Government.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the merit of your paper.

1. Why is any government needed in Massachusetts to-day? Explain the distinction between civil government and military government.

2. What is a township? What is a city? Using "town government" or "city government" as a subject, write an essay of at least two hundred words, covering the following points: —

(*a*) Principal officers and their duties.

(*b*) Manner of choosing these officers.

(*c*) Prominent excellencies of this government.

(*d*) Prominent defects of this government.

3. What is meant by an *executive* officer? What is the official title of the chief executive officer of Massachusetts? What is his name? How chosen? For how long? What is meant by *the referendum?* What is a *veto?*

4. Using "The Congress of the United States" as a subject, write an essay of at least two hundred words, covering the following points: —

(*a*) Number of bodies of which it is composed, and why this number was selected.

(*b*) The number of men who represent Massachusetts in Congress, and the way in which they are chosen.

(*c*) The powers of Congress.

5. What are the principal courts of the United States? What kinds of cases can be brought before the United States courts?

6. What persons are citizens of the United States? What privileges belong to a citizen of the United States? What duties devolve upon him?

Physiology.

1. What do you mean by physiological division of labor? Give a complete illustration.

2. Of what materials is a bone composed, and how does the proportion of these materials vary with age?

3. What sorts of energy are manifest in the living body? What is the law of the conservation of energy? What is the source of all our energy?

4. What is the blood? Describe a drop of blood as seen under the microscope. What causes clotting of the blood?

5. Describe the kidneys very fully, both as to their anatomy and physiology. Are they important organs? Why?

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper. The time allowed is two hours.

1. Choose two of the following topics, and write clearly and interestingly upon them. Let each essay be about two hundred words in length.

(*a*) A brief outline of Shakespeare's life.

(*b*) Goldsmith, — the man.
(*c*) The life and work of Sir Walter Scott.
(*d*) What Cooper did for American literature.
(*e*) The life of James Russell Lowell.

2. Write critically upon any three of the following. Do not choose more than one topic from any particular group. Give title in each case.

Group (*a*), " *The Merchant of Venice.*"

The friendship of Antonio and Bassanio.
Portia and the caskets.
The trial scene.
Was Shylock a wicked man?
What we learn of Antonio from the trial scene.
Upon whom in this play does the interest centre, — Antonio, Portia or Shylock?

Group (*b*), " *The Vicar of Wakefield.*"

The moral lesson in the " Vicar of Wakefield."
The courage and optimism of Dr. Primrose.
" Mr. Burchell" and the Primrose family.
Olivia Primrose.
Weak traits in the Vicar's wife.
Is the " Vicar of Wakefield" an interesting story?

Group (*c*), " *Ivanhoe.*"

Early England as shown in " Ivanhoe."
Cedric's dining hall.
Friar Tuck.
What we learn of Robin Hood and his band from " Ivanhoe."
The hero of Scott's " Ivanhoe."
An outline of the plot of " Ivanhoe."
Richard Coeur de Lion.

Group (*d*), " *The Last of the Mohicans.*"

The scene of the story.
Cora and Alice, — a comparison.
The funeral of Cora and Uncas.
David the singer, — his part in the story.
The skirmish at Glen's Falls.
" La Logue Carabine."
" Le Renard Subtil."

Group (*e*), "*The Vision of Sir Launfal.*"

The story of the poem.
Summer and winter in "Sir Launfal."
Sir Launfal and the leper.
The lesson of the poem.
Sir Launfal, before and after the vision.

EXPENSES.

Room rent, in advance, $12 to $24 per semester,	$24 00	$48 00
Board, $2.50 to $5 per week,	95 00	190 00
Fuel, $5 to $15,	5 00	15 00
Washing, 30 to 60 cents per week,	11 40	22 80
Military suit,	15 75	15 75
Expenses per year,	$151 15	$291 55

In addition to the above expenses, $80 tuition is charged to foreigners.

Board in clubs has been about $2.45 per week; in private families, $4 to $5. The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $15 per semester used; zoölogical, $4 per semester used; botanical, $2 per semester used by sophomore class, $3 per semester used by senior class; entomological, $3 per semester used. Some expense will also be incurred for lights and text books.

Tuition is free to citizens of the United States. Citizens of Massachusetts, however, in accordance with an act of the Legislature, must make application to the Senator of the district in which they live for a free scholarship that covers the charge for tuition. Blank forms of such application may be obtained from the president of the college.

ROOMS.

It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere.

For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. This building is heated by steam. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. A coal stove is furnished with each room. Aside from this, all rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq , of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator from his district for a scholarship. Blank forms of application will be furnished by the president.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Samuel T. Maynard, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

For the best herbarium collected by a member of the class of 1902 a prize of twenty dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of native woods.

The botanical department offers in 1902 a prize of five dollars for the best collection of pathogenic fungi, and also a prize of five dollars for the best collection of lichens.

The prizes in 1901 were awarded as follows: —

Burnham Rhetorical Prizes: William W. Peebles (1903), first; Harry J. Franklin (1903), second; Fayette D. Couden (1904), first; John W. Gregg (1904), second.

Flint Oratorical Prizes: Howard L. Knight (1902), first; John C. Hall (1902), second.

Grinnell Agricultural Prizes: Nathan J. Hunting (1901), first; Ralph I. Smith (1901), second.

Hills Botanical Prizes: Clarence E. Gordon (1901), first; Nathan J. Hunting (1901), second. Best collection of economic fungi, D. B. Tashjian (1901).

Prizes for the greatest improvement in the study of chemistry during the junior year: Edward B. Saunders (1902), first; Edmund F. McCobb (1902), second.

Dairy Prizes, given by the Massachusetts Society for Promoting Agriculture: First set, — first prize, Bertram Tupper; second prize, Benjamin Hawes Stackpole; third prize, Harlan Lewis Richardson. Second set, — first prize, Archie Albert Crouch; second prize, Harry Gardner Richardson; third prize, Thomas Francis Hunt.

RELIGIOUS SERVICES.

Chapel services are held every week day at 8 A.M. and public worship in the chapel every Sunday at 9.25 A.M. Further opportunities for moral and religious culture are afforded by Bible classes taught by one of the professors and other teachers for an hour every Sunday afternoon, and by a religious meeting Thursday evening under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of four hundred acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, Jan. 1, 1901, to Jan. 1, 1902*

	Received.	Paid.
Cash on hand Jan. 1, 1901, ...	$8,440 56	–
State Treasurer, Morrill fund, . . .	16,666 66	–
State Treasurer, endowment fund, . .	11,003 34	–
State Treasurer, maintenance appropriation,	5,000 00	–
State Treasurer, maintenance appropriation, special, ...	8,000 00	–
State Treasurer, scholarship appropriation, .	10,000 00	–
State Treasurer, labor appropriation, . .	5,000 00	$5,604 44
Gassett scholarship fund, income, . .	40 00	66 60
Mary Robinson scholarship fund, income, .	36 13	32 25
Whiting Street scholarship fund, income, .	50 40	29 25
Grinnell prize fund, income, ...	50 00	50 00
Hills fund, income, ...	358 87	375 65
Library fund, income, ...	421 84	421 84
Burnham emergency fund, income, . .	139 98	144 98
Salary, ...	33 33	30,343 47
Extra instruction, ...	–	252 25
Botanical laboratory, ...	120 34	153 35
Chemical laboratory, ...	750 95	810 99
Entomological laboratory, ...	29 50	28 20
Veterinary laboratory, ...	1,247 00	1,207 83
Zoölogical laboratory, ...	145 72	166 46
Term bill, ...	3,078 38	944 72
Advertising, ...	–	490 75
Electric plant, ...	659 23	2,992 42
Agricultural department, ...	836 27	2,172 19
Farm, ...	8,008 07	11,075 59
Horticultural department, ...	4,452 76	6,541 96
Expense, ...	1,869 61	10,988 32
Insurance, ...	–	554 00
Investment, ...	5 00	–
Cash on hand Jan. 1, 1902, ...	–	10,996 43
	$86,443 94	$86,443 94

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1901, to Jan. 1, 1902, and find the same correct and properly kept. All disbursements are vouched for, the balance being ten thousand, nine hundred ninety-six dollars and forty-three cents ($10,996.43), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor*.

Amherst, Dec. 24, 1901.

CASH ON HAND, AS SHOWN BY THE TREASURER'S STATEMENT, BELONGS TO THE FOLLOWING ACCOUNTS:

Gassett scholarship fund,	$39 82
Mary Robinson scholarship fund,	16 16
Whiting Street scholarship fund,	45 26
Grinnell prize fund,	40 00
Hills fund,	101 12
Labor appropriation,	346 41
Burnham emergency fund,	110 56
Veterinary laboratory,	144 06
College,	10,153 04
	$10,996 43

BILLS RECEIVABLE JAN. 1, 1902.

Farm,	$856 72
Horticultural department,	329 79
	$1,186 51

BILLS PAYABLE JAN. 1, 1902.

Advertising,	$300 00
Horticultural department,	103 31
Electric plant,	209 00
	$612 31

INVENTORY — REAL ESTATE.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 00	
Farm house,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding-house,	2,000 00	
Amounts carried forward,	$174,575 00	$44,350 00

Amounts brought forward,	$174,575 00	$44,350 00
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		213,775 00
		$258,125 00

EQUIPMENT.

Botanical department,	$4,210 00
Horticultural department,	13,151 72
Farm,	18,250 90
Chemical laboratory,	3,487 00
Botanical laboratory,	2,656 53
Entomological laboratory,	15,250 00
Zoölogical laboratory,	2,000 00
Zoölogical museum,	6,000 00
Veterinary laboratory,	5,351 75
Physics and mathematics,	5,500 00
Agricultural department,	3,500 00
Library,	22,473 00
Fire apparatus,	600 00
Band instruments,	350 00
Furniture,	950 00
Text books,	250 00
Tools, lumber and supplies,	352 80
Electric equipment and supplies,	6,639 20
	$110,972 90

SUMMARY.

Assets.

Total value of real estate, per inventory,	$258,125 00
Total value of equipment, per inventory,	110,972 90
Bills receivable,	1,186 51
Investments, New York Central & Hudson River Railroad stock,	100 00
Cash on hand,	10,153 04
	$380,537 45

Liabilities.

Bills payable,	$612 31	
Burnham emergency fund,	3,008 75	
		3,621 06
		$376,916 39

	Fund.	Income in 1901.
Maintenance Funds.		
Technical educational fund, United States grant,*	$219,000 00	$7,300 00
Technical educational fund, State grant,* .	141,575 35	3,703 34
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890, ...	–	16,666 66
Hills fund, ...	8,542 00	358 87
Maintenance Appropriations.		
State appropriation made by Legislature of 1900 for four years, ...	–	5,000 00
Labor appropriation made by Legislature of 1900 for four years, ...	–	5,000 00
State appropriation made by Legislature of 1900 for four years ($8,000), ...	–	8,000 00
Scholarship Funds.		
Whiting Street fund, ...	$1,260 00	50 40
Gassett fund, ...	1,000 00	40 00
Mary Robinson fund, ...	858 00	36 13
Scholarship Appropriations.		
State appropriation by the Legislature of 1886, ...	–	10,000 00
Prize Fund.		
Grinnell prize fund, ...	$1,000 00	50 00
Miscellaneous Funds.		
Library fund, ...	$10,546 12	421 84
Burnham emergency fund, ...	5,000 00	139 98
		$56,767 22

* The above is two-thirds of the income from these funds.

GIFTS.

From John H. Jackson, Albany, N. Y., four draining tools.

Propaganda for Nitrate of Soda, New York, five tons nitrate of soda; fifty magic lantern slides.

German Kali Works, New York, three and one-half tons muriate of potash; two and one-half tons high-grade sulfate of potash; one-fourth ton kainite; two hundred and fifty pounds low-grade sulfate of potash.

W. J. Decker & Co., Leonia, N. J., one set Decker's novelty leg-bands.

Charles N. Page, Iowa Seed Company, Des Moines, Iowa, Farmers' Reliance and Husk or Primitive seed corn.

Hunt & Co., Boston, sample of sheep guano.

National Milk-sugar Company, New York, three hundred pounds milk albumen.

Pasteur Vaccine Company, Chicago, Ill., one gallon Lincoln dip; one quart Lincoln disinfectant.

Massachusetts Society for Promoting Agriculture, Boston, one hundred and fifty dollars in prizes for dairy school; fifty dollars for special lectures for dairy school.

Bowker Fertilizer and Chemical Company, Boston, insecticides, fungicides and chemicals.

Tobacco Warehousing and Trading Company, Louisville, Ky., sample of nicoticide.

J. H. Putnam (M. A. C., '94), Litchfield, Conn., specimen for the veterinary museum.

H. M. Thomson (M. A. C., '92), Amherst, specimen for the veterinary museum.

Howard Baker (M. A. C., 1900), Philadelphia, Pa., specimen for the veterinary museum.

M. B. Landers (M. A. C., 1900), Bondsville, specimen for the veterinary museum.

Y. H. Canto (M. A. C., 1900), New York, specimen for the veterinary museum.

R. E. Huntington (M. A. C., '05), Boston, green heron; two Dekay's brown snakes.

Newton Wallace, Amherst, striped snake.

LOANS TO THE COLLEGE AND EXPERIMENT STATION.

From the DeLaval Separator Company, New York, five separators.

the Vermont Farm Machine Company, Bellows Falls, Vt., six separators, one steam pressure regulator, one hand tester.

Creamery Package Manufacturing Company, Chicago, Ill., one Ideal milk weigher.

A. H. Reid, Philadelphia, Pa., one hand separator.

J. S. Biesecker, New York, one Childs' bottle filler, one strainer.

Rice & Adams, Buffalo, N. Y., one bottler.

U. S. Butter Extractor Company, Newark, N. J., one separator and stand.

the Cyphers Incubator Company, Wayland, N. Y., two Cyphers incubators, one out-door brooder.

the Star Incubator and Brooder Company, Lincoln, N. J., one incubator.

Le Roy Plow Company, Le Roy, N. Y., one bean harvester.

FARM REPORT.

The operations of the college farm for the past year have followed the same general lines as those of the last few years. Owing to the necessity of holdiug expenses at the lowest possible point, few improvements have been made. The usual system of cropping has been followed, and about the same amounts and kinds of live stock have been kept as in recent years. No extensive improvements of any kind have been made. The effort to make the operations of the farm as instructive as circumstances permit has been continued. The nature of the operations on all of the important fields and crops is indicated by means of field labels posted for the purpose. These give particulars as to variety, manuring and date of planting. Representatives of the most important pure breeds of cattle are kept, while horses are represented by a good breed each of the draft and heavy harness type, and sheep by the one breed which seems likely to prove, under average conditions, the most valuable in the State.

The nature of the farm operations and the financial results with the several crops are shown in the following table : —

College Farm Crops, 1901.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.*	Labor and Seed.			
Carrots,	½	–	11¼	$11 93	$32 85	$80 50	$35 72	–
Cabbages,	1½	8,500 heads.	–	27 00	80 15	170 00	62 85	–
Celery,	2	200 doz. bunches.†	–	68 85	206 29	250 00	–	$25 14
Corn,	34	1,000 on ear at 40 c.	300 ensilage. 20 dry fodder.	410 14	545 76	1,550 00	594 10	–
Hay,	–	–	118	–	–	2,124 00	–	–
Japanese millet,	5	50	10 straw.	66 04	90 66	167 50	10 80	–
Mangels,	½	–	10¼	16 43	18 70	36 13	1 00	–
Onions,	2	380 large. 91 small.	–	30 83	171 54	408 40	206 03	–
Potatoes,	6	1,110 large. 81 small.	–	69 02	249 63	856 80	538 15	–
Rowen,	–	–	60	–	–	900 00	–	–
Soy beans,	6	168	5 straw.	108 11	85 55	398 00	204 34	–
Turnips,	1½	575	–	28 00	39 00	115 00	48 00	–
Totals,	59	–	524½	$836 35	$1,520 13	$7,056 33	$1,700 99‡	$25 14

* One-half the value of manure and three-fourths the value of the fertilizers. † Estimated. ‡ Hay not included.

System of Manuring.

The manures made upon the farm have been handled as described in the last annual report. In view of results obtained in the experiment department under my direction, it would seem that there is reason to doubt the expediency of spreading manure during the late fall and winter, to remain upon the surface until spring. An experiment upon a larger scale to test this point upon one of the most level fields of the farm has been begun. Fertilizers have been used to about the same extent and in the same way as in recent years. Unmixed chemicals are employed, rather than special mixed fertilizers. The greater part of the more insoluble materials, such as tankage and dried fish, is spread broadcast after ploughing, and harrowed in. A considerable proportion of the potash and phosphate, which are not believed to be subject to waste by leaching, is applied in the same way; while nitrate of soda, the dried blood and part of the acid phosphate and potash salts are mixed and applied in the drill. The following table shows the cost and amounts of manure and fertilizers used for our various crops: —

Manures and Fertilizers for the Several Crops, per Acre, 1901.

FERTILIZERS.	Cabbages, One and One-half Acres.	Mangels, One-half Acre.	Carrots, One-half Acre.	Onions, Two Acres.	Corn, Thirty-four Acres.	Celery, Two Acres.	Soy Beans, Six Acres.	Potatoes, Six Acres.	Barnyard Millet, Five Acres.	Old Mowings.
Manure (cords),	6	8	8	–	5	12	4	–	–	–
Nitrate of soda (pounds),	–	300	150	150	–	125	125	125	125	150
Acid phosphate (pounds),	–	600	300	800	–	300	300	400	400	–
Dried blood (pounds),	–	–	–	250	–	150	–	175	200	–
Tankage (pounds),	–	–	–	–	–	200	–	250	–	–
Muriate of potash (pounds),	–	500	–	–	–	–	–	–	–	175
Sulfate of potash, high grade (pounds),	–	–	150	300	125	250	250	250	250	–
Dried fish (pounds),	–	–	–	300	–	–	–	–	250	–
Lime (pounds),	–	–	–	–	–	–	–	–	–	2,000

Live Stock.

We have been fortunate during the past year in the high degree of exemption from disease of all our different classes of live stock. An incursion of dogs resulted in the loss of two sheep. These have been paid for under the State law, and the flock as a whole was fortunately not seriously frightened or injured.

The kinds and numbers of the several classes of live stock are as follows: —

Horses. — French Coach, 2 stallions, 1 mare, 1 yearling stallion, 1 colt; Percheron, 1 stallion; French Coach, half-blood, 1 colt; three-year grade colts, 3; work horses, 7; total, 16.

Neat Cattle. — Jersey, 1 bull, 3 cows; Short-horn, 2 bulls, 1 cow, 1 heifer; Holstein-Friesian, 2 bulls, 4 cows, 1 bull calf; Guernsey, 1 bull; Ayrshire, 1 bull, 2 cows, 1 heifer; grade, 52 cows, 16 heifers, 7 heifer calves; total, 95.

Sheep. — Southdown, 1 male, 40 breeding ewes, 34 lambs; total, 75.

Swine. — Middle Yorkshire, 4 breeding sows; Belted, 1 boar, 1 sow; Poland-China, 1 boar, 1 sow; Berkshire, 2 boars, 2 sows; Tamworth, 1 boar, 22 shoats; small pigs of various breeds.

Improvements.

The chief improvements of the year are as follows: —

The lane leading south to the pasture from the barn has been given up, the fence separating it from one of the fields of the farm has been removed, and the area has been added to that of the field. The fence thus removed has been set further west in such a manner as to enclose an area of about six acres, which will be used, in alternation with the area just south of the barn, as a night pasture. The area which for the past few years has been used as night pasture was broken up last spring, and has produced during the past season a heavy yield of ensilage corn. After one more year this field will be reseeded, the grass will be cut for hay for two years, and then this will once more be pasture for some four or five years. Until this area is thus ready for use as a night pasture, the newly enclosed area farther west will be used for that purpose, when that in turn will be broken up.

During the past year a new ensilage cutter, Ross No. 20, with self-feeding table, has been installed in the barn. The work of filling the silo was more cheaply accomplished than ever before. The work of harvesting the corn and taking it to the cutter was, however, far more expensive than usual, on account of the severe storm which came just before work was to begin, and which blew down and tangled the heavy crop in such a manner as greatly to increase the difficulty of handling it.

A machine for spraying the potato crop, four rows at a single operation, has been purchased. It was successfully used throughout the season, and no doubt in part because of its use the crop of potatoes was a good one.

The Milk Record.

During the past year the total number of different cows in milk for a portion or for all the year is 66. A considerable number of these animals are heifers with their first calf, and many of these have been milked but a small part of the year. A considerable number of animals also — the more unsatisfactory animals of the herd — have been fattened during the year and sent to the butcher. We have accordingly a very large proportion of what we may call partial records. Out of the 66, 4 animals have been milked under 50 days, 2 from 50 to 100 days, 4 from 100 to 150 days, 6 from 150 to 200 days, and 15 from 200 to 250 days; it would, then, be manifestly misleading to present as an average record the figure which would be obtained by dividing the total amount of milk by the number of cows. It seems preferable to compute the total number of days by adding the numbers for all cows in the herd, and to divide the total product by this number of days, for the purpose of obtaining the average daily yield per cow. The number of days so obtained is 15,871; the total number of pounds of milk for the year is 247,435; dividing this figure by the number of days, we have 15.6 pounds daily as the average yield per cow. Three cows in the herd have given yields of over 7,000 pounds in the year; 5, yields of from 6,000 to 7,000 pounds; 9, yields of from 5,000 to 6,000 pounds, and 11, yields of from 4,000 to 5,000 pounds. The yield of the herd is not altogether satisfactory; but it must be remembered that heifers with first or second calf comprise a considerable proportion, and that the balance of the herd is composed largely of grade Short-horn cows, purchased in the west as a foundation for a dairy herd, — not in the belief that these animals would make a large milk record, but in the hope that a healthy herd could be built up from this foundation stock. Our expectations in the latter respect have been thus far realized. The improvement in milking qualities has been less than was hoped for. It is believed that this is in some considerable measure due to the difficulty of properly developing young animals when they must be milked the greater part of the time by student labor. Thus far such labor has been practically the only kind employed. Our experience indicates that a change in policy in this regard should be made.

Financial Outcome.

The cash receipts for the year amount to $8,008.07, and there is due for produce and work $856.72. The cash and bills receivable for last year amounted to $7,828, in round numbers; similar returns for this year amount to $8,864, in round numbers; there is an increase for the year, therefore, of $1,036. The inventory this year is almost to a dollar the same as last. The total expenses this year have amounted to $10,897.38; the expenses last year were $9,205.84; the expenses of this year, therefore, exceed those of last to the amount of $1,691.54.

The cash received during the year has come from the following sources: milk and cream, $2,703.97; cattle, including calves for veal, $1,017.52; horses, including fees for use of stallions, $342.50; swine, $412.99; sheep, $496.40; hay, $122.14; potatoes, $744.58; celery, $351.79; team labor, $377.70; manual labor, $280.88; millet seed, $343; onions, $382.43; cabbages, $99.60; manure, $29.29; carrots, $30.57; sundries, $302.71. There is an increase in almost all items, as compared with last year, with the exception of the returns for milk and cream, in which there is a decrease of a little more than $700. With the exception of this particular, which has been elsewhere commented upon, the returns of the year must be regarded as satisfactory. The increased expenses of the year are in considerable measure accounted for by much larger investment for machines and tools, and by the higher price of grain.

In conclusion, my most hearty thanks are tendered both to members of the board of trustees, the farm superintendent, and those in subordinate positions, for hearty co-operation and interest.

WM. P. BROOKS,
Director of College Farm.

Amherst, Dec. 28, 1901.

MILITARY DEPARTMENT.

AMHERST, MASS., Dec. 31, 1901.

To President H. H. GOODELL, *Massachusetts Agricultural College.*

SIR: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1901.

I have been on duty in charge of the department of military instruction during the entire year, have labored zealously in the performance of such duty and in carrying out the regulations of the War Department and the rules adopted by the authorities of the college.

Drill exercises have been conducted much the same as in former years, one hour each on Mondays, Tuesdays and Thursdays of each week. All students have been required to attend, unless prevented by sickness or excused by proper authority for good and sufficient reasons. Students who absent themselves without proper authority are required to appear for extra drill Saturday mornings, the time for which is double the hour of regular drill. The same rule applies to those who absent themselves from the inspection of rooms Saturday morning, when rooms are not in a neat and orderly condition, or when students appear at any military exercise not dressed in proper uniform.

Practical instruction has been in infantry drill by squad, company and battalion; light artillery drill, manual of the piece only, by detachment. Recently instruction of squads has been given in "Butt's Manual of Physical Drill." It is proposed to continue this during the coming winter months as far as space and the equipment of the drill hall will permit. This being something entirely new to the students, the progress will at first be rather slow; but good results will eventually be obtained, as it is considered a most excellent system for developing and strengthening the muscles, besides giving elasticity and pliancy to those who have become stiffened from work or lack of proper exercise. A thorough and frequent practice in this manual will have a salutary effect in keeping students in a healthy, athletic condition, and will vary the monotony of indoor drill. More enthusiasm could be infused into it if the drill hall were furnished with proper equipments, which I recommend be purchased whenever funds are available for such a purpose.

One hundred and twenty-nine students have received instruction in target practice at the short ranges, and, considering the limited time at my disposal, the results obtained have been fairly satisfactory. Target practice can be held only during the regular drill hour. About half of this time is taken up in preparation, going to and returning from the target range, thus leaving but little time for individual instruction. It is my purpose during the coming winter to make up, in a measure, for this deficiency by giving instruction in gallery practice, providing the gun shed, which is the only suitable place, can be put in proper condition for use in cold weather. This is only a rough board building, erected for the protection of the field guns, but poorly serves this purpose, as the cold dampness creates rust, thus necessitating the detail of one squad from drill as often as once a week for the purpose of cleaning them. I earnestly recommend that the gun shed be floored, connected with steam from the drill hall, and otherwise put in proper condition for use during the winter; this appears important and absolutely necessary, not only as providing a place for gallery practice, but in giving more space for physical exercise, the drill hall being too small for the present student body. There are, furthermore, other purposes which this building has to serve, making heating of some kind a necessity as well as a comfort.

At the time of making my last report, the band had just been organized, and its future success was problematical. The several members had purchased instruments, agreeing to pay for them by instalments. This plan failed to work well, and would at best have served only a temporary purpose. The General Court, however, generously made an appropriation of four hundred dollars for the purchase of band instruments. The benefit of this measure has been fully demonstrated, as it not only placed the band on a permanent footing as an organization, but has proved an incentive to greater efficiency. In expressing grateful acknowledgments for this appropriation, I am sure it also expresses the sentiment of every student in college. The money appropriated, with the exception of about fifty dollars, has been expended for the purpose for which it was intended. The band, under the leadership of one of the students, M. H. West, has made marked improvement, and has succeeded beyond my most sanguine expectations. As organized at present, it consists of twenty-one pieces. The members are not required to perform any other military duty, the regular drill hours being devoted to band practice.

Two hours each week have been devoted to theoretical instruction, one each for the senior and freshman classes. The course for the former has been elements of military science, military law and courts martial, extended order drill, and the preparation of the ordinary reports and returns required of a company of infantry. Several very good essays have been written by students, campaigns were illustrated by drawings, and the problems intelligently discussed. The freshman class has been instructed only in the service manuals. All the exercises are given by me personally, or under my personal supervision.

In his report for the present year the Inspector-General of the Army approves the recommendation that "Cadet corps be required to go into camp at least one week during the year, and they should be required as far as possible to do regular field service. Target practice should be held at the same time, and the camps subject to inspection of regular army officers." The benefits to be derived from such an encampment would be unquestionable, but the obstacle that has heretofore stood in the way still confronts us, viz., the difficulty of obtaining the necessary tentage, camp and garrison equipage. The general government does not furnish it, and my effort of last year to borrow from the State did not meet with success. In reply to my application to the Adjutant-General of the Commonwealth, I was advised that it was impossible for the State to loan any, as it was all required for the use of State troops going into camp. If this difficulty can be overcome, I recommend an encampment of the cadet battalion at such time and place as may appear most suitable and practicable.

The autumn drills are by company, squad, individual instruction and target practice. During the spring and early summer the exercises are mostly battalion drill, reviews and parades. Of these exercises the officer detailed by the War Department last June to inspect the battalion reported as follows: "On this occasion dress parade, review, inspection and battalion drill of four companies in single rank, first by the military instructor and later by the cadet major, occurred in the order named continuously for one hour and twenty minutes; nearly all the battalion movements laid down in the tactics were executed with steadiness and precision, and with only a single noticeable error, caused by the band playing in close proximity to the battalion at the time. There was silence in the ranks throughout; there was very little cautioning in undertone; the guides were always accurately and promptly placed; the commands of the captains were promptly given; and towards the end of the drill, very long for any but seasoned soldiers, I could not detect any sign of weariness in the dressing, step, manual or any of the movements."

Improvements have been made in the drill hall and armory during the past summer. Hot water heat has been changed to steam supplied from the furnaces in the chapel, shower baths and toilet put in, and the whole exterior of the building painted. The old shingles have pretty much gone to decay, so that the roof leaks badly in places. I recommend slating instead of reshingling.

The two dormitories stand in need of some repairs. Nearly every closet used for hanging clothes needs kalsomining or painting, — in some both are needed; most of the window casings need refitting and painting.

I renew the recommendation made by me last year in relation to the mess hall. Instead of repairing the old mess hall, I recommend the erection of a new building, with modern improvements, whenever funds can be obtained for the purpose.

The results obtained and the progress made in the military department during the past year have been encouraging. It is hoped that during the coming year a still greater proficiency can be attained. The time the college was without an officer was a detriment to the military department, the effects of which are still felt.

The following-named cadets of the last graduating class were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown "special aptitude" for the military service, viz.: Nathan D. Whitman, Alexander C. Wilson, William C. Dickerman.

The following is a list of United States ordinance property now on hand: —

2	3.2-inch breech-loading steel guns, with implements complete.
2	8-inch mortars, with implements.
2	mortar beds.
2	carriages and limbers for 3.2-B. L. steel rifles.
147	Springfield cadet rifles, model 1884.
147	sets of infantry accoutrements.
51	headless shell extractors.
1	set reloading tools.
6	non-commissioned officers' swords, steel scabbards.
14	non-commissioned officers' waist belts and plates.
14	sliding frogs for waist belts.
50	blank cartridges for field guns.
3,000	metallic blank cartridges.
1,000	metallic rifle ball cartridges, cal. 45.
150	friction primers for field guns.
25,000	cartridge primers, small arms.
16,000	round balls, cal. 45.
48	pounds of powder for small arms, reloading.
4,000	pasters, black and white, for targets.
120	paper targets.

There is no signal property on hand.

The battalion organization is as follows, two companies of infantry, which, for the purpose of battalion drill or ceremonies, are equalized into four companies, and the band: —

Commandant.

Capt. JOHN ANDERSON, ... U. S. Army.

Staff.

Cadet Adjutant, ...	LEANDER C. CLAFLIN.
Cadet Quartermaster, ...	EDWARD B. SAUNDERS.
Cadet Sergeant-Major, ...	HOWARD L. KNIGHT.
Fire Marshal and Range Officer, . .	FREDERIC H. PLUMB.
Armorer, ...	RALPH P. GAY.

Company A.

Cadet Captain, ...	HERBERT A. PAUL.
Cadet First Lieutenant, ...	RANSOM W. MORSE.
Cadet Second Lieutenant, ...	JOHN C. HALL.
Cadet First Sergeant, ...	VICTOR A. GATES.
Cadet Sergeant, ...	LYMAN A. COOK.
Cadet Sergeant, ...	CLIFFORD A. TINKER.
Cadet Sergeant, ...	GEORGE L. BARRUS.
Cadet Sergeant, ...	HAROLD E. HODGKISS.
Cadet Corporal, ...	FAYETTE D. COUDEN.
Cadet Corporal, ...	WINTHROP V. TOWER.
Cadet Corporal, ...	NEIL F. MONAHAN.
Cadet Corporal, ...	WILLIAM W. PEEBLES.

Thirty-seven privates; aggregate, 49.

Company B.

Cadet Captain, ...	ARTHUR L. DACY.
Cadet First Lieutenant, ...	EDMUND F. MCCOBB.
Cadet Second Lieutenant, ...	JOHN M. DELLEA.
Cadet First Sergeant, ...	CHESTER E. DWYER.
Cadet Sergeant, ...	JOSHUA H. BELDEN.
Cadet Sergeant, ...	FREDERICK R. CHURCH.
Cadet Sergeant, ...	CLAUDE I. LEWIS.
Cadet Sergeant, ...	HENRY L. BODFISH.
Cadet Corporal, ...	WILLIAM E. ALLEN.
Cadet Corporal, ...	CHARLES M. KINNEY.
Cadet Corporal, ...	ELMER M. POOLE.
Cadet Corporal, ...	EDWARD B. SNELL.

Thirty-eight privates; aggregate, 50.

Band.

Cadet Second Lieutenant, ...	Myron H. West.
Cadet First Sergeant, ...	David N. West.
Cadet Sergeant, ...	Samuel L. Smith.
Cadet Corporal, ...	William E. Tottingham.
Cadet Drum Major, ...	Charles P. Halligan.

Sixteen privates; aggregate, 21.
Aggregate of the military department, 125.

Respectfully submitted,

JOHN ANDERSON,
Captain, U. S. Army, Commandant.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Condition and Progress of the Institution, Year ended June 30, 1901.

There have been few changes during the year ended June 30, 1901. Increased instruction in French and German has been provided, and one addition has been made to the faculty. The chair of military science and tactics, temporarily made vacant by the exigencies of the Spanish war, has been again filled, by the detail of Capt. John Anderson, U. S. Army. Out of the additional income for the maintenance of the college appropriated by the State, a librarian has been provided, and means for binding and purchase of books. The library now numbers 22,240 volumes. There has this year been appropriated by the State, for repairs, and providing apparatus in the department of chemistry, $8,500.

II. Receipts for and during the Year ended June 30, 1901.

1. Balance on hand July 1, 1900,	–
2. State aid: —	
(a) Income from endowment,	$2,770 01
(b) Appropriation for current expenses,	25,000 00
3. Federal aid: —	
(a) Income from land grant, act of July 2, 1862,	7,300 00
(b) Additional endowment, act of Aug. 30, 1890,	16,666 66
(c) For experiment stations, act of March 2, 1887,	15,000 00
4. Fees and all other sources,	3,691 90
Total,	$70,428 57

III. Expenditures for and during the Year ended June 30, 1901.

1. Instruction in the subjects specified in section 1, act of Aug. 30, 1900,	$24,666 66
2. Instruction in all other subjects, if any, not mentioned in question 1 of this series,	1,612 25
3. Administrative expenses (president's, secretary's, treasurer's, librarian's salary, clerical service, fuel, light, etc.),	8,291 48
4. For buildings and repairs,	736 38
5. Experiment station,	15,000 00
Total,	$50,306 77

IV. Property, Year ended June 30, 1901.

Value of buildings,	$213,775 00
Value of other equipment,	110,972 90
Total number of acres,	425
Acres under cultivation,	325
Acres used for experiments,	75
Value of farm lands,	$41,500 00
Amount of all endowment funds,	360,575 35
Number of bound volumes June 30, 1901,	22,240

V. Faculty during the Year ended June 30, 1901.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	22
2. Number of staff of experiment station,	20

VI. Students during the Year ended June 30, 1901.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	181
2. Graduate courses,	14
Total, counting none twice,	195

FOURTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1902.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

HENRY H. GOODELL, LL.D., ...	. *Director.*
WILLIAM P. BROOKS, Ph.D., ...	. *Agriculturist.*
GEORGE E. STONE, Ph.D., ...	. *Botanist.*
CHARLES A. GOESSMANN, Ph.D., LL.D.,	. *Chemist* (fertilizers).
JOSEPH B. LINDSEY, Ph.D., ...	. *Chemist* (foods and feeding).
CHARLES H. FERNALD, Ph.D., ...	. *Entomologist.*
SAMUEL T. MAYNARD, B.Sc., ...	. *Horticulturist.*
J. E. OSTRANDER, C.E., ...	. *Meteorologist.*
HENRY T. FERNALD, Ph.D., ...	. *Associate Entomologist.*
HENRY M. THOMSON, B.Sc., ...	. *Assistant Agriculturist.*
RALPH E. SMITH, B.Sc., ...	. *Assistant Botanist.*
HENRI D. HASKINS, B.Sc., ...	. *Assistant Chemist* (fertilizers).
DANIEL L. CLEAVES, B.Sc., ...	. *Assistant Chemist* (fertilizers).
JAMES E. HALLIGAN, B.Sc., ...	. *Assistant Chemist* (fertilizers).
EDWARD B. HOLLAND, M.Sc., ...	. *First Chemist* (foods and feeding).
PHILIP H. SMITH, B.Sc., ...	. *Assistant Chemist* (foods and feeding).
——— ———	. *Assistant Chemist* (foods and feeding).
GEORGE A. DREW, B.Sc., ...	. *Assistant Horticulturist.*
——— ———	. *Assistant Horticulturist.*
HENRY L. BODFISH, ...	. *Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 59. Fertilizer analyses.
No. 63. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 71. Concentrated feed stuffs; condimental stock and poultry foods.
No. 72. Summer forage crops.
No. 73. Orchard experiments; fertilizers for fruits; thinning fruits; spraying fruits.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

An outline of the more important work undertaken and the results secured is all the limits of our space will allow. From a series of experiments on the effect of feed on the compounds of milk and on the consistency of butter, particularly the effect of cotton-seed meal with a minimun amount of oil and likewise with the addition of cotton-seed oil on the relative properties of the several ingredients in milk and butter fat and on the body of the butter, the results seemed to be as follows: —

1. Cotton-seed meal with a minimum percentage of oil did not alter the percentage composition of the milk.

2. The addition of one-half to three-fourths of a pound of cotton-seed oil to the cotton-seed meal appeared to increase the fat percentage in the milk about .4 of 1 per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

3. The substitution of Cleveland flax meal for the cotton-seed meal and oil resulted in a decrease of the butter fat to about the percentage found in the first period, while the nitrogen percentage was increased. This change in composition was probably due to the removal of the cotton-seed oil from the ration, and not to the influence of the flax meal.

4. Cotton-seed meal with minimum oil caused no marked variation in the chemical composition of the butter fat.

5. The addition of cotton-seed oil to the cotton-seed meal ration produced a noticeable increase in the melting point and iodine number of butter fat.

6. Cotton-seed meal with a minimum oil produced a firm butter.

7. The addition of cotton-seed oil, while it increased the melting point of the butter fat, produced a softer, more yielding butter than that produced by either the cotton-seed meal or the standard ration.

8. An excess of cotton-seed oil in the ration is likely to affect the health of the animal.

Close attention was paid to the composition of concentrated feeds, and the farmers were warned of the following adulterations: cotton-seed meal mixed with fine ground hulls for genuine meal; finely ground corn-cobs for middlings in mixed feeds; finely ground rice hulls in the adulteration of standard grains; and oat offal instead of ground oats in mixing the so-called provender or cracked corn and ground oats.

In experiments with green crops, wheat and winter vetch were found preferable to winter rye for early forage; the chief value of barnyard millet was found to lie in its use as green fodder, by successive seedings using it until September. It was found to be not suitable for hay and taking the place of corn for silage when impossible to secure a crop of corn. Experiments were also made in growing mixtures of legumes and non-legumes, in order to increase the amount of protein in the several forage crops, in the hope that the farmer would not require to purchase so much grain. Longfellow corn and black cow peas were sown, yielding at the rate of 23 tons to the acre.

The entomological division has been chiefly occupied with the elm-leaf beetle; the brown-tail moth, which now covers an area of twelve hundred square miles, extending into Maine and New Hampshire; the gypsy moth, which, since the abandonment of the crusade against it, is now reappearing in the places from which it was surely being driven out; and the San José scale, which is now found in fifty-two localities in Massachusetts, and is attacking not only nurseries but all deciduous trees and shrubs. In one place, covering an area of five square miles, nearly every tree and shrub are affected. It would seem as if these four pests had come to stay, and three of them are spreading over the State with great rapidity. How to preserve our noble trees and fruitful orchards is the question that comes to all of us.

The botanical division has pursued its investigations in the sterilization of soil, examining into the various methods in use and the cost of the same. Desiccation or drying of the soil was found to increase the activity of the drop fungus, and on lettuce resulted in a stunted growth and an abnormally colored and worthless crop. The chrysanthemum rust, though very widely spread, is not considered of serious consequence, because it passes through only one stage, the uredo, and hence does not gain a strong foothold. The remedy seems to lie in selection of rust-free stock and inside cultivation, the latter being due to avoidance of mist and dew on the foliage, and therefore furnishing a less favorable opportunity for the spores to germinate and cause injury.

Three melon diseases have been recognized and studied, one a leaf blight, and two affecting both leaves and fruit. They have been particularly severe the past year, complaints coming from every part of the State. In general, the remedies seem to lie in maturing the crop as early as possible by selecting early varieties or by transplanting, and spraying with Bordeaux mixture. The last mentioned is open to objection, from the difficulty of spraying both sides of the leaf.

Various stem rots, affecting the chrysanthemum, carnation and aster, have been the subject of careful investigation. These rots are produced by fungous growths clogging up the pores of the stem, and resulting in decay. In the aster the disease can be entirely averted by starting plants in the open ground, or otherwise avoiding "damping-off" conditions. In the chrysanthemum and carnation reliance is placed upon the use of hardy propagating stock and sterilized soil.

In the agricultural division the problems have been chiefly those connected with the nutrition of plants and the selection and use of fertilizers and manures. The results of the year's work seem to show (*a*) that sulfate of potash is superior to the muriate for clovers, while for cabbages the muriate is slightly superior; (*b*) that, used in connection with manures for garden crops, the sulfate of potash is better for early crops, while for late crops the muriate is of equal value; (*c*) that, in determining the relative value of phosphates applied on the basis of equal quantities of actual phosphoric acid, their relative standing was in the following order: raw bone, phosphatic slag, South Carolina rock, apatite, dissolved bone meal, dissolved bone-black, Tennessee phosphate, acid phosphate, steamed bone meal, Florida phosphate; (*d*) that, in a comparison of different varieties of ensilage corn, in the total yield they stood in the following order: Eureka, Boston Market, Rural Thoroughbred, Leaming Field, but in actual food value the Leaming Field, when ensiled, was superior; (*e*) that, in soil tests with grass, grass showed a marked dependence upon a liberal supply of fertilizer nitrogen and clover a still closer dependence upon a liberal supply of fertilizer potash; (*f*) that, in soil tests with onions, that crop showed a close dependence upon a liberal supply of potash, an abundant supply of lime for promoting the healthy growth of the crop and a liberal supply of readily available phosphate for promoting the satisfactory ripening of the crop; (*g*) that, on a moderately sloping field, it was found better to haul manure in the late autumn to large piles and spread and plough in the spring than to haul in the autumn and apply directly to the field, as the crops were increased more than enough to cover the extra cost of rehandling the manure. Growing alfalfa for a forage crop has proved quite unsuccessful, after a number of years' trial, the crop being exceedingly small. Mand's Wonder Foreign Crop, Brazilian millet and Pearl millet prove identical in every respect, and farmers are warned not to pay, under a new name, the high prices demanded for the old and well-known Pearl millet.

The details of the experiments thus briefly outlined may be found in the reports of the several divisions herewith submitted.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1901.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$8,157 57	
for labor,	2,941 04	
for publications,	1,436 30	
for postage and stationery,	269 33	
for freight and express,	99 82	
for heat, light, water and power,	259 63	
for seeds, plants and sundry supplies,	621 30	
for fertilizers,	182 21	
for feed stuffs,	135 08	
for library,	221 31	
for tools, implements and machinery,	52 58	
for furniture and fixtures,	75 59	
for scientific apparatus,	5 49	
for live stock,	20 25	
for travelling expenses,	84 39	
for contingent expenses,	147 52	
for building and repairs,	290 59	
		$15,000 00

Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,490 25	
from farm products,	2,091 08	
from miscellaneous sources,	2,050 50	
		$18,831 83
Cash paid for salaries,	$11,099 76	
for labor,	1,620 38	
for publications,	681 28	
for postage and stationery,	318 65	
for freight and express,	102 49	
for heat, light, water and power,	434 12	
Amount carried forward,	$14,256 68	

Amount brought forward,		$14,256 68	
Cash paid	for chemical supplies,	534 45	
	for seeds, plants and sundry supplies,	428 27	
	for fertilizers,	510 88	
	for feed stuffs,	691 99	
	for library,	130 38	
	for tools, implements and machinery,	122 28	
	for furniture and fixtures,	22 25	
	for scientific apparatus,	435 41	
	for live stock,	318 00	
	for travelling expenses,	663 12	
	for building and repairs,	718 12	
			$18,831 83

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1901; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,831.83 and the corresponding disbursements, $33,831.83. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1901.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 1, 1901.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the experiment station for the past year has followed the general lines of investigation already undertaken. The problems chiefly engaging attention are those connected with the nutrition of plants and the selection and use of manures and fertilizers. These problems are of fundamental importance in the agriculture of the State; and, as our lines of inquiry are followed up from year to year, it is believed that little by little the results must contribute to the sum of our knowledge pertaining to many vital points.

It may possibly have been thought by some that, as comparatively few of our farmers yet use unmixed fertilizers, it can scarcely benefit them greatly to know the relative values of many of the materials dealt with in our experiments. This view is superficial, for, even though farmers may not yet largely employ chemicals, the manufacturers of mixed materials, always on the lookout for new light as to the needs of the various crops, are gradually modifying their goods in accordance with *well-established results of experiments.*

To cite one or two examples: one of the best-known brands of potato fertilizers, as made twelve years ago, had the following percentage composition: nitrogen, 4.12; soluble and available phosphoric acid, 7.59; total phosphoric acid, 12.17; potash, 5.23. As made last year, the same brand of fertilizer contained: nitrogen, 2.92; soluble and available phosphoric acid, 6.45; total phosphoric acid, 8.27; potash, 10. Twelve years ago most potato fertilizers contained potash in the form of muriate; they now very generally contain this element in the form of sulfate. Such changes are in the interest of the farmers who use these fertilizers; and they are in line with suggestions based upon experiments here as well as in other stations.

The experiments with fertilizers are conducted in three distinct methods, — the plot method in the open field, the plunged cylinder method with equal weights of thoroughly mixed soil to the depth of four feet, and the pot method. The last two are valuable as checks on the results in the field, and in increasing the possible range and scope of inquiry. In our work in the field we have employed two hundred and twenty-two plots, we have one hundred and fifty-three of the cylinders in use, while in our pot experiments we have cared for two hundred and ninety-four pots.

The results of cylinder and pot experiments, being rather of scientific than of immediate practical interest, will not be presented in this report. Variety tests with corn and potatoes have engaged a considerable share of attention, but the varieties under trial have been tested but a single year, and results will not be reported. Our experiments with poultry have been directed, as in recent years, to a study of the best methods of feeding for eggs. The results, not being regarded as decisive and in some respects at variance with those of earlier years, will not be discussed in this report. This report, then, will deal only with the results of some of our more important plot experiments. The nature of the subjects of inquiry and the more salient features of our results will be made clear by the following statement: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. The crop of this year, soy beans, gives yields on the basis of which the materials rank in the following order: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The average to date ranks the materials in the following order: nitrate of soda, barnyard manure, sulfate of ammonia, dried blood.

II. — To determine the relative value of muriate and high-grade sulfate of potash for field crops. Results of the year indicate sulfate to be superior to the muriate for clovers; for cabbages, the muriate proves slightly superior.

III. — *A.* To determine the relative value of nitrate of soda, sulfate of ammonia and dried blood, used in connection with manure as sources of nitrogen for garden crops. Results indicate these materials used in amounts furnishing equal nitrogen to rank in the following order: nitrate of soda, dried blood, sulfate of ammonia. *B.* To determine the relative value of sulfate of potash and muriate of potash, used in connection with manures for garden crops. Results of the year indicate the sulfate to be the better for early crops, while for late crops the muriate is equally good.

IV. — To determine the relative value of different phosphates used in equal money's worth. The results of the year rank the materials employed in the following order: phosphatic slag, South Carolina rock, Mona guano, dissolved bone-black, Florida rock phosphate.

V. — To determine the relative value of phosphates, applied on the basis of equal quantities of actual phosphoric acid. The relative standing of the several phosphates was in the following order: raw bone, phosphatic slag, South Carolina rock, apatite, dissolved bone meal, dissolved bone-black, Tennessee phosphate, acid phosphate, steamed bone meal, Florida phosphate.

VI. — To determine the relative value of different potash salts for field crops. The results of the year with wheat and corn are not very decisive, but indicate a high rate of availability for the new materials, — silicate and carbonate of potash.

VII. — Comparison of different varieties of ensilage corn. In total yield the varieties under trial rank in the following order: Eureka, Boston Market, Rural Thoroughbred, Leaming Field. In actual food value the Leaming Field when ensiled is superior.

VIII. — *A.* Soil test with grass. Results of the year indicate the close dependence of grass upon a liberal supply of fertilizer nitrogen, and the still closer dependence of clover upon a liberal supply of fertilizer potash. They also establish the possibility of raising profitable hay crops by the use of fertilizers only, and indicate that in grass mixtures where clover is sown exceedingly profitable crops can be grown by the combination of a potash salt and an available phosphate. *B.* Soil test with onions. Results indicate the close dependence of this crop upon a liberal supply of potash, the vital importance of an abundant store of lime for the healthy growth of the crop, and of a liberal supply of readily available phosphate for promoting satisfactory ripening of the crop.

IX. — To determine the relative value for production of corn and grass in rotation of a large application of manure alone, as compared with a smaller application of manure with a moderate amount of potash salts. The crop of this year is mixed grass and clover. The result of the experiment was the production of nearly equal total weights of hay under the two systems, and hay of superior nutritive quality, because containing a larger proportion of clover, on the combined manure and potash.

X. — To determine the relative value for crop production of two fertilizer mixtures, one furnishing the important elements of plant food in the same proportions as in "special" corn fertilizers, the other furnishing less phosphoric acid and more potash, for corn and grass in rotation. The crop of this year is grass, and the mixture containing less phosphoric acid and more potash and costing the smaller sum per acre gives a larger yield both of hay and rowen, and in both cases of superior nutritive value on account of the large proportion of clover.

XI. — To determine the economic result of using in rotation on grass lands: the first year, ashes; the second, ground bone and muriate of potash; and the third, barnyard manure. The yields are large, amounting under these several systems of manuring to from rather over 3¼ to nearly 3¾ tons per acre. These yields are produced on a good margin of profit.

XII. — To determine whether the use of nitrate of soda for rowen is profitable. The results on an old sod consisting chiefly of Kentucky blue-grass is an increased rowen crop, resulting from the application of nitrate of soda at a fair profit; on a Timothy sod the results on different plots vary widely, and the average is a small increase, produced at a cost greater than its value.

XIII. — To determine which is the better practice: to haul manure and spread directly on the field during late autumn or winter, or to haul at the same time to large piles in the field, to be spread and immediately ploughed in in the spring. The results indicate that on land sloping moderately the spring application is to be preferred, as the crops are more than sufficiently large to cover the extra cost of rehandling the manure.

XIV. — To determine the value of alfalfa as a forage crop for this locality. The results of a number of years are quite discouraging, as, with the most careful attention to tillage, manuring and keeping free from weeds, the crops are exceedingly small, — hardly one-half what might confidently be expected from clover under similar conditions.

XV. — To determine whether Mand's Wonder Forage Crop and Brazilian millet are different from Pearl millet. Results indicate that these three crops are identical in every respect, and that it will not pay farmers to give the high prices demanded for the old and long-known Pearl millet under a new name.

I. — The Relative Value of Manures furnishing Nitrogen. (Field A.)

A detailed description of the plan of experiment followed in this field will be found in the twelfth annual report. The materials under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. These wherever used are applied in such quantities as to furnish equal amounts of nitrogen. There are three plots in the field to which no nitrogen in any form has been applied. All the plots in the field receive the same amounts of phosphoric acid and potash. This experiment was begun in 1890, and the crops which have been grown previous to this year, in the order of succession, are: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover and potatoes. As a result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100
Barnyard manure,	90
Sulfate of ammonia,	89
Dried blood,	86
The plots receiving no nitrogen,	68

The crop for this year was soy beans. Growth was vigorous and healthy, the crop on all plots good. The yields are shown in the following table: —

Yield of Soy Beans per Acre.

Plots.	Nitrogen Fertilizer.	Beans (Bushels).	Straw (Pounds).
Plot 0,	Barnyard manure,	32.75	2,700
Plot 1,	Nitrate of soda,	31.55	2,750
Plot 2,	Nitrate of soda,	32.75	2,500
Plot 3,	Dried blood,	28.62	2,600
Plot 4,	No nitrogen,	28.97	2,600
Plot 5,	Ammonium sulfate,	28.10	2,300
Plot 6,	Ammonium sulfate,	31.03	3,050
Plot 7,	No nitrogen,	25.86	2,350
Plot 8,	Ammonium sulfate,	28.97	2,550
Plot 9,	No nitrogen,	27.93	2,200
Plot 10,	Dried blood,	33.28	2,600

The average results are as follows: —

Fertilizer.	Beans (Bushels).	Straw (Pounds).
Average of the no-nitrogen plots (3),	27.59	2,386.7
Nitrate of soda plots (2),	32.15	2,650.0
Dried blood plots (2),	30.95	2,600.0
Sulfate of ammonia plots (3),	29.37	2,633.3

The relative standing of the different manures in the yield of grain is: —

	Per Cent.
Manure,	100.0
Nitrate of soda,	98.1
Dried blood,	94.5
Sulfate of ammonia,	89.7
No nitrogen,	84.3

In yield of straw the rank is: —

	Per Cent.
Barnyard manure,	100.0
Nitrate of soda,	98.1
Sulfate of ammonia,	97.5
Dried blood,	96.3
No nitrogen,	88.4

It will be seen that the different materials stand more nearly together this year than is the average of preceding years. The manure stands relatively higher than in former years, but the fertilizers stand in the same relative order, nitrate of soda proving the most efficient of the nitrogen fertilizers, and sulfate of ammonia the least as measured by grain production, while it is slightly ahead of the blood in the yield of straw. The comparatively even results of this year are doubtless to be accounted for chiefly by the fact that the crop of this season, the soy bean, is one capable of drawing upon the atmosphere for a considerable share of the nitrogen it requires. The development of nodules upon the roots of the crop this year was very abundant. In spite of this fact, it will be noticed that the crop on the no-nitrogen plots stands considerably below that on the other plots. It is, however, doubtless much more nearly on an equality with them than would have been the case with a crop not belonging to the clover family.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

This experiment has been in progress since 1892. The object is to determine the relative value for different crops of the two leading potash salts, muriate and sulfate, when used in equal quantities continuously upon the same land. The field contains eleven plots, of one-eighth of an acre each. Six of these have been yearly manured with muriate of potash and five with the high-grade sulfate of potash. These salts were used at the rate of 400 pounds per acre from 1892 to 1899 inclusive; in 1900 and 1901 the rate of application has been 250 pounds per acre. All plots receive yearly an application of fine-ground bone, at the rate of 600 pounds per acre. The crops grown in the field are rotated, and the following have been included: potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. The crops have been almost uniformly large. The results were summarized in the report of last year as follows: —

Among the crops grown, the potatoes, clovers, cabbages and soy beans have with very few exceptions done much the best on the sulfate of potash; while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate. The *quality* of the crops of potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on muriate of potash. Taking all the crops except the clovers into consideration, if we represent the efficiency of the high-grade sulfate of potash by the number 100 that of the muriate of potash is 98.1. Taking into account only those crops showing the preference for the sulfate of potash, and representing the efficiency of that salt by the number 100, the efficiency of the muriate of potash is 88.6.* The present difference in price between the two salts is only about $5 per ton. The conclusion, therefore, appears to be warranted that, under conditions similar to those prevailing in this experiment, the selection of the sulfate rather than the muriate is wise.

The crops of the past year have been clovers of three kinds, and cabbages.

A. — Clovers (Sulfate v. Muriate of Potash).

The growth of the clover on the sulfate of potash was considerably better than on the muriate. The yields are shown below: —

* Clovers not included, because weeds have not been separated in harvesting.

Muriate v. High-grade Sulfate of Potash. — Clover Hay per Acre (Pounds).

Variety.	Muriate of Potash.	High-grade Sulfate of Potash.
Common red clover,	6,600	7,387.5
Mammoth red clover,	7,312	7,612.0
Alsike clover (a portion weighed green),	10,840	14,290.0

It should be stated, in commenting upon these results, that the crops, as in former years, were considerably mixed with weeds. The weights, however, while not affording an accurate basis of comparison for determination of the precise effects of the different potash salts on the clovers, are not misleading as to the nature of the effect. This is not magnified by the figures, but rather the reverse, for the reason that where the growth of the clover is less luxuriant the growth of the weeds is proportionally more so.

In this connection attention is called to the fact that two other plots in the field are now in clover which was sown in July. These plots have not been cut, but there is at the present time a great difference in favor of the sulfate of potash in the condition of the clover on the two plots.

In conclusion, concerning the merits of these two potash salts for clovers, it is believed that the sulfate is much the safer. Our experiments with these crops have extended over many years, and while sometimes the yield on the muriate of potash is as great as that on the sulfate, there have been many more instances when the yield on the sulfate has been much the better. The difference in favor of this salt appears to be greater in proportion as the rainfall is abundant. It seems probable that this fact is due to the greater loss of lime, which, in association with the acid of the muriate, is washed out of the soil in considerable quantities whenever climatic conditions favor soil leaching.

B. — Cabbages.

The crop of cabbages on both the potash salts used was good, at the rate per acre of 33,680 pounds on muriate of potash and 30,600 pounds on sulfate. The yield on the muriate is somewhat better than on the sulfate, — a result which is at variance with results which have been obtained in some previous years. Clearly, climatic conditions have an important influence in determining the manurial effect of these salts.

III. — Fertilizers for Garden Crops. (Field C.)

The experiments upon which the conclusions now presented are based have been in progress since 1891. Up to 1898, chemical fertilizers alone were used. During the past four years stable manure has been applied in equal quantities (at rate of 30 tons per acre) to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. The crops grown during this series of years have included all important outdoor garden crops, viz., spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn and celery; and one small fruit, — strawberries. The experiments have been planned with reference to throwing light especially upon two points: —

A. — The relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen.

B. — The relative value of sulfate of potash and muriate of potash.

These two points will be separately discussed: —

A. — The Relative Value for Garden Crops of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers used as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot, and each fertilizer is always applied to the same plot. Each of the nitrogen fertilizers is used on two plots, — on one with sulfate of potash, on the other with muriate. Dissolved bone-black, as a source of phosphoric acid, is applied in equal quantities to all plots. The results previous to this year were thus summarized in the last annual report: —

Taking into account the periods when chemical fertilizers only were used, and the crops (spinach, lettuce, onions, table beets, garden peas and early cabbages) whose period of growth is the comparatively early part of the season, we find the relative efficiency of the different materials used as the source of nitrogen: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	86.6
Sulfate of ammonia,	83.6

For the same periods, and taking into account those crops (tomatoes, garden beans and sweet corn) making much of their growth after hot weather fairly sets in, we find the relative standing as follows: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	103.5

For the period since manure has been applied, and taking into account the early crops only (spinach, lettuce, table beets, onions, garden peas and potatoes), the relative standing is: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	88.8
Sulfate of ammonia,	61.7

For the same period, taking into account the aggregate yield of all the late crops (tomatoes, cabbages, turnips, squashes and celery), the relative standing is: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	91.9

The crops for the past year have been onions, lettuce, table beets, late cabbages, garden peas, celery and English turnips (both as second crops) and strawberries. The average rates of yield per plot for each of the nitrogen fertilizers is shown in the following table: —

Nitrogen Fertilizers compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

Average of Two Plots.	Onions.	Lettuce.	Table Beets.		Cabbages.	Garden Peas.		Strawberries.	Turnips.		Celery.
			Roots.	Tops.		Peas.	Vines.		Roots.	Tops.	
Nitrate of soda,	425.0	110.0	151.0	125	868.75	54.1	68.8	41.25	1,167.5	550.0	1,067.5
Sulfate of ammonia,	207.5	40.0	65.3	73	785.50	64.6	81.3	44.87	1,072.5	580.0	455.0
Dried blood,	365.0	97.5	136.0	115	915.50	55.8	67.5	75.46	1,102.5	627.5	945.0

It will be seen that for most of the crops the results are similar to the average results of preceding years. Combining the results of this year with those of previous years, the relative standing of the different fertilizers used as sources of nitrogen is as follows: —

For the early crops, *i.e.*, crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, and strawberries: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	92.7
Sulfate of ammonia,	54.8

For late crops, including cabbages, turnips and celery: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	98.7
Sulfate of ammonia,	77.5

The superiority of nitrate of soda as a source of nitrogen for most garden crops, indicated by the results of preceding years, is still further confirmed in the case of most of the crops by the results of this year. Nitrate of soda, among the various nitrogen fertilizers, furnishes a pound of nitrogen at present prices at lower cost than any other fertilizer which is fairly available. These facts make it evident that it should usually be selected, especially for early crops. Experiments here and elsewhere indicate that, if soil on which sulfate of ammonia is used is heavily limed, its rate of availability is much increased. The purchase and application of lime, however, adds to the cost of the crop; and, even disregarding the lime, as the pound of actual nitrogen at current prices for sulfate of ammonia costs more than the same quantity at current prices for nitrate of soda, the latter is clearly economically preferable, if simply equally effective. We have found it more so.

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The history of the plots where these two potash salts are under comparison has been given under section *A*. The crops are of course the same as those which have been named under that section. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results of the past year are shown in the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

Average of Three Plots.	Onions.	Lettuce.	Table Beets.		Cabbages.	Garden Peas.		Strawberries.	Turnips.		Celery.
			Roots.	Tops.		Peas.	Vines.		Roots.	Tops.	
Sulfate of potash, high grade.	360	86.66	116.3	100.0	827.0	54.3	68.3	47.74	1,091.7	536.7	831.7
Muriate of potash, . .	305	78.33	118.1	108.7	886.2	62.1	76.7	59.98	1,136.7	635.0	813.3

In commenting upon the results obtained in comparing these two fertilizers last year, the following tables were presented: —

Before Manure was used, — 1891–97.

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	91.3	91.5

After Manure was used, — 1898–1900.

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	86.1	98.8

Including the crops of the past year, the standing is shown below; under the headings early and late crops respectively are included those specified in section *A*: —

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	92.6	103.0

It will be noticed that for the early crops the sulfate of potash is superior to the muriate, while for the late crops, including those of this year, muriate stands slightly ahead. This has not been the case in earlier years, but the nature of the difference has always been the same. The sulfate should undoubtedly be preferred for early crops, unless the soil is heavily limed, in which case results here and in many other places indicate that the muriate may answer equally well.

IV. — The Relative Value of Different Phosphates. (Field F.)

The object of this experiment is to determine whether it is more profitable to employ cheaper natural phosphates, or one of the higher priced dissolved phosphates. The articles compared are dissolved bone-black, ground South Carolina rock, ground Florida rock, Mona guano and phosphatic slag. These phosphates were applied during the years 1890 to 1893, on the basis of equal money's worth. The amounts of phosphoric acid supplied to the several plots on this basis have of course varied widely, as the prices of the materials differ greatly. The actual amounts of phosphoric acid supplied the several plots are as follows: —

Plots.	Fertilizer.	Pounds.
Plot 1,	Phosphatic slag,	96.72
Plot 2,	Mona guano,	72.04
Plot 3,	Ground Florida rock phosphate,	165.70
Plot 4,	Ground South Carolina rock,	144.48
Plot 5,	Dissolved bone-black,	45.36

Since 1893 no phosphate has been applied to any part of the field. The object in view in withholding phosphates has been to test the lasting qualities of the several materials. At the beginning of the present season, supposing the crops harvested to have been of average composition, and that there has been no loss of phosphoric acid by leaching (which is improbable), there must have remained of the total phosphoric acid applied to the several plots the following amounts in each : —

	Pounds.
Phosphatic slag,	53.6
Mona guano,	·29.7
Florida phosphate,	132.4
South Carolina rock phosphate,	102.0
Dissolved bone-black,	9.5

Throughout the entire period of the experiment (1890 to date), materials supplying nitrogen and potash have been applied in equal amounts to all plots. Since 1893 the quantities applied have been made very large, in order to make it certain that the crops grown may find in the soil all the nitrogen and potash they can possibly need. All the plots in the field were limed at the rate of one ton to the acre of quick-lime, slaked, spread after ploughing and deeply worked in with a harrow in the spring of 1898. The crops which have been raised on the field previous to this year, in the order of their succession, are potatoes, wheat, serradella, corn, barley, rye, soy beans, Swedish turnips, corn, oats and cabbages. Representing the yield on the plot giving the highest returns by 100, the relative efficiency* of the different phosphates at the beginning of this year stood as follows : —

	Per Cent.
Phosphatic slag,	100.0
Ground South Carolina rock,	92.3
Dissolved bone-black,	90.7
Mona guano,	88.3
Florida phosphate,	71.5

Taking into account the crops grown since 1895, when for the first time a plot to which no phosphate was applied was included, the phosphates have the following relative rank :* —

* Swedish turnips, grown in 1897, have not been included in computing these percentages as that crop was affected by disease not apparently connected with the fertilizers used.

	Per Cent.
Ground South Carolina rock,	100.0
Phosphatic slag,	99.0
Dissolved bone-black,	97.7
Mona guano,	95.4
Florida phosphate,	64.2
No phosphate,	55.4

The crop this year has been oats, of the Early Race-horse variety. The soil was well prepared, the crop sown May 6. The growth was, so far as could be seen, unaffected by accidental conditions. There were, however, more weeds on plots 3 and 4 than elsewhere; and, as it was impossible to separate these completely in handling the crop, some of them were weighed with the straw. The figures representing weights of straw for these plots, especially for plot 3, on which weeds were most abundant, are therefore without doubt to some extent misleading. The several plots produced yields at the following rates per acre: —

Comparison of Phosphates.—Yield of Oats per Acre.

Plots.	Fertilizer.	Grain (Bushels).	Straw (Pounds).
Plot 0,	No phosphate,	18.24	365
Plot 1,	Phosphatic slag,	21.00	1,208
Plot 2,	Mona guano,	17.59	1,059
Plot 3,	Ground Florida rock,	13.98	1,447
Plot 4,	Ground South Carolina rock,	19.96	1,201
Plot 5,	Dissolved bone-black,	16.63	1,058

Representing the yield of grain on plot 1 by the number 100, the relative standing of the other plots is shown by the following table: —

Plots.	Fertilizer.	Per Cent.
Plot 0,	No phosphate,	86.8
Plot 1,	Phosphatic slag,	100.0
Plot 2,	Mona guano,	83.8
Plot 3,	Ground Florida rock,	66.6
Plot 4,	Ground South Carolina rock,	95.0
Plot 5,	Dissolved bone-black,	79.2

The plots which stand highest this year are the same as those standing highest in the general averages which have been shown above, viz., the ones receiving phosphatic slag and ground South Carolina rock phosphate. The low standing of the plot which received Florida phosphate is, as in former years, very striking; it stands this year below the no-phosphate plot. It should be remembered, however, that the latter has not been included in this experiment as long as the Florida phosphate plot; and it may well be that the original store of phosphoric acid in the soil of the no-phosphate plot is to a much less degree exhausted than is the case on the other plots. It must be concluded that the phosphoric acid supplied by the Florida phosphate is in a form of combination rendering it exceedingly unavailable.

In the writer's opinion, the oat crop is a much less certain indicator as to the condition of the soil as regards available phosphoric acid than are the crops belonging to the cabbage and turnip family. This is indicated by the fact that the differences in yields with oats this year are much less than were the differences with turnips and cabbages. As the turnips, as already stated, were badly affected by disease, figures for this crop are not presented. The relative yields with cabbages last year were as follows: —

	Per Cent.
South Carolina rock phosphate,	100.0
Dissolved bone-black,	73.0
Phosphatic slag,	60.0
Mona guano,	55.3
Florida rock phosphate,	14.7
No phosphate,	6.9

It should be noticed that the relative position of the several phosphates is nearly the same as this year, but the differences are far greater.

In conclusion, attention is called to the fact that the crops on this field in recent years have not been satisfactory in amount, even on the best plot. The fact that no phosphoric acid in any form has been applied during the last nine years sufficiently accounts for the relatively small yields. Our results, however, indicate a relatively high degree of availability for the phosphoric acid contained in the South Carolina rock and in phosphatic slag. There can be no doubt that profitable crops of most kinds can be produced by liberal use of these natural phosphates; and in a long series of years there would be a considerable money saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates. It may, however, be doubted whether, under the conditions prevailing in ordinary farm or garden practice, it is ever wise to depend exclusively upon the natural phosphates. The best practice would probably be found to consist in using one of these in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

V. — The Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The phosphates under comparison on this basis include apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved boneblack, raw bone, dissolved bone, steamed bone and acid phosphate. The experiments have been in progress five years, each phosphate being applied yearly to the same plot. There are three no-phosphate plots, which serve as a basis for comparison. The plots are one-eighth of an acre each in area.

The phosphates yearly applied are used in quantities sufficient to furnish actual phosphoric acid at the rate of 96 pounds to the acre. All plots are manured alike with materials furnishing nitrogen and potash in available forms and in equal amounts to each. The materials used furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. The preceding crops have been: corn, cabbages, corn, and in 1900 oats for hay, and Hungarian grass, also cut for hay. The yields of all these crops have been large, even on the three plots in the field which received no phosphate. The results have been rendered somewhat obscure by the natural variation in the productiveness of the plots in different parts of the field. Plot 1, which receives no phosphoric acid, is naturally much more fertile than any other plot in the field, and in estimating the significance of the results this plot should be disregarded. The crop for the present year has been onions. As has been the case throughout this part of the State, the onion crop suffered from blight. Our yields of sound and merchantable onions are therefore comparatively small. The results are shown in the table : —

Onions on Plots manured with Equal Amounts of Phosphoric Acid.

Plots.	Fertilizer.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
Plot 1,	No phosphate,	278.5	1,280
Plot 2,	Apatite,	222.3	1,840
Plot 3,	South Carolina rock phospate,	235.4	1,800
Plot 4,	Florida soft phosphate,	150.6	2,280
Plot 5,	Phosphatic slag,	251.8	1,160
Plot 6,	Tennessee phosphate,	205.7	1,720
Plot 7,	No phosphate,	141.4	2,000
Plot 8,	Dissolved bone-black,	209.5	600
Plot 9,	Raw bone,	252.3	640
Plot 10,	Dissolved bone meal,	213.2	600
Plot 11,	Steamed bone meal,	187.8	560
Plot 12,	Acid phosphate,	187.8	920
Plot 13,	No phosphate,	123.4	1,800

The conclusions stated last year were as follows : —

1. The phosphatic slag evidently furnished phosphoric acid in an exceedingly available form, the yield this year being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate is apparently a very inferior material, the phosphoric acid evidently becoming available only with great slowness.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

The results of this year are in most particulars similar. Phosphatic slag, it is true, is exceeded, by a small fraction of a bushel of merchantable onions, by raw bone meal, but it gives a larger total crop. Dissolved bone-black stands relatively lower than last year. Raw bone meal, as last year, is superior to steamed bone meal. The Florida soft phosphate gives a very inferior crop, — the poorest, indeed, in merchantable onions of any phosphate used. This result is strikingly confirmatory of the results obtained in the field where phosphates are under comparison on the basis of equal money's worth.

VI. — Comparison of Different Potash Salts for Field Crops. (Field G.)

Since 1898 the following potash salts have been under comparison for various field crops: kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such quantities as to furnish equal potash to each plot. All plots are equally manured with materials furnishing nitrogen and phosphoric acid. There are forty plots, in five series of eight plots each, each series including a no-potash plot and one for each potash salt used. The area per plot is about one-fortieth of an acre. The crops the present year have been wheat on one series of eight plots, and corn of four different varieties on the other four series.

A. — Wheat.

The variety of wheat was the Turkish Red Winter, seed of which was received from the United States Department of Agriculture. The soil is rather heavy, and the seed was received so late that it was got in somewhat later than desirable, viz., October 13. It was sown broadcast at the rate of five pecks to the acre, and covered with the Acme harrow. Owing no doubt chiefly to the lateness of sowing, there was some winter-killing. This was most severe on the no-potash, kainite and the two sulfate plots. The whole field was harrowed about the middle of May. The growth was unusually healthy for this section, although all plots were slightly affected by rust. The grain was plump, hard and of good quality. The yields were as follows: —

Wheat.—Yield per Acre.

Plots.	Potash Salt.	Grain (Bushels).	Straw (Pounds).
Plot 1,	No potash,	8.19	1,609
Plot 2,	Kainite,	10.43	1,475
Plot 3,	High-grade sulfate of potash,	14.15	1,877
Plot 4,	Low-grade sulfate of potash,	14.15	2,595
Plot 5,	Muriate of potash,	15.64	1,877
Plot 6,	Nitrate of potash,	16.38	3,083
Plot 7,	Carbonate of potash,	14.89	2,458
Plot 8,	Silicate of potash,	17.13	2,055

B. — Corn.

As already stated, the corn was of four varieties. These varieties were as follows: Eureka, a large dent corn, seed obtained from Ross Bros.; Boston Market Ensilage, a large dent variety, seed obtained from Joseph Breck & Sons; Leaming Field, a moderately large dent variety, seed obtained from Gregory; Rural Thoroughbred, a large and late white flint variety, seed obtained from Landreth. All varieties were planted June 6. The field was given good care throughout the season, growth was normal and healthy, unaffected by accidental conditions which influenced results, though all varieties were somewhat broken down by a storm which occurred on September 11. The corn was cut September 13 and 14, and weighed within twenty-four hours. The average for the several fertilizers was as follows: —

Corn. — Average Yield of Four Varieties.

Potash Salt.	Pounds per Acre.
No potash,	37,810
Kainite,	40,610
High-grade sulfate of potash,	37,530
Low-grade sulfate of potash,	39,375
Muriate of potash,	40,490
Nitrate of potash,	40,435
Carbonate of potash,	40,155
Silicate of potash,	39,240

The only feature of the results to which especial attention is called is the comparatively large yields obtained on the muriate and nitrate, and the good yields on the comparatively new fertilizers, carbonate and silicate, which it would seem must possess a high degree of availability.

VII. — Varieties of Ensilage Corn compared.

The varieties of ensilage corn used in the comparison of potash salts, viz., Eureka, Boston Market, Leaming Field and Rural Thoroughbred, were grown under conditions which make it possible to compare them accurately the one with the other; and this comparison seems worth while, on account of the diversity in the practice of farmers, many of whom cultivate excessively large and late varieties of ensilage corn, on account of the heavy yields obtained. The aggregate yield of the varieties under trial was at the following rates per acre: —

	Pounds.
Eureka,	47,960
Boston Market,	38,200
Leaming Field,	34,520
Rural Thoroughbred,	36,150

The following notes were taken on the several varieties just previous to harvest: —

Eureka: a late dent; average height, about 15 feet; very heavily leaved; stalks, 1¾ to 2 inches in diameter; ears just forming.

Boston Market: late dent; height, 11 to 12 feet; stalks, 1½ to 1¾ inches in diameter; ears large, roasting stage; leaves quite abundant.

Leaming Field: medium dent; average height, 10 feet; leaves comparatively few; stalks medium; ears large, beginning to dent; the earliest of the four varieties.

Rural Thoroughbred: late white flint; average height, about 10 feet; stalks large, many 1¼ inches in diameter; heavily leaved; a few suckers (these increase weight but little, and are troublesome to handle); ears large, heavy, often two per stalk; not quite in milk.

The Eureka, giving the best yield, at the rate of almost 24 tons to the acre, would be preferred by many farmers, but in view of the results of analyses it seems doubtful whether this preference is justified by the facts. The table shows the total food substance per acre afforded by each of the varieties: —

Field G. — Varieties of Ensilage Corn, Food Substance per Acre (Pounds).

Variety.	Dry Matter.	Ash.	Protein.	Crude Fibre.	Nitrogen-free Extract Matter.	Fat.
Eureka,	8,944	468.7	613.5	2,951.0	4,790.0	120.8
Boston Market,	6,864	369.3	505.9	2,183.0	3,701.0	104.3
Leaming Field,	7,524	343.9	616.2	1,839.5	4,547.0	176.8
Rural Thoroughbred,	7,923	423.1	626.7	2,140.0	4,614.0	118.8

Examination of the table shows that the variety giving the heaviest yield (green weight) also furnishes the greatest number of pounds total dry matter; but when we compare the figures of the other columns in the table, it will be seen that this excess of dry matter is made up entirely of fibre and nitrogen-free extract, which are the least valuable constituents. In total yield of protein (the most valuable constituent) the Eureka is exceeded by two varieties, — Leaming Field and Rural Thoroughbred; in yield of fat it is much exceeded by the Leaming Field. It would seem the last-named variety, though giving the smallest yield, should be preferred. One pound of digestible fat is commonly considered to have a food value equal to two and one-half pounds of digestible fibre, or extract matter. Fat is commonly equally as digestible as nitrogen-free extract, and is less affected by the fermentations which go on in the silo than are the starches and sugar (extract matter). It is more digestible than fibre. In corn which is approaching maturity the proportion of starch is comparatively high; this food substance is at that time abundantly stored in the grain. As corn approaches maturity, while the starch increases, the proportion of sugar in the juice of the plant decreases. Sugar in green corn fodder is a valuable food substance, but in the silo the sugar is largely converted into acid, and acid has no food value. Starch, while it may suffer some loss in the silo, is far less affected than is sugar. Other things being equal, the immature corn will make, under average silo conditions, a more acid silage than corn which is nearer ripe. The large proportion of water in immature corn, as well as the relatively large amount of sugar, favor development of acid. Silage from immature corn, then, is likely to be excessively sour, and is for that reason less desirable than silage from more mature corn.

The chief points, then, which may be urged against the selection of excessively late varieties of corn for ensilage, are as follows: —

1. Much greater bulk and water in proportion to actual food value.

2. Greater probable waste in the manger, on account of the refusal of the animals to eat the very thick and coarse stalks.

3. Such corn, while furnishing more dry matter, contains in larger proportion the less valuable food substances (fibre and sugar) and a smaller proportion of protein, fat, and (though not proved by our analyses) we may safely say starch as well.

4. The immature corn produces a very sour silage, on account of the relatively large proportion of sugar and of water.

5. Though this point is not always important, grass and clover are apt to make but a poor start when seeded in fields planted with excessively large and late varieties. As a large proportion of farmers in some sections now usually seed in ensilage corn, this point should not be disregarded.

VIII. — Soil Tests.

During the past season two soil tests have been carried out on our own grounds, both in continuation of previous work upon the same fields. The same kinds of fertilizers have been applied to each plot, and in the same amounts as last year. The fertilizers in these experiments are used in accordance with the co-operative plan for soil tests adopted in Washington in 1889. Each fertilizer, wherever employed, is applied at the same rates per acre. The following table shows the kinds and usual amounts: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Grass. (South Acre.)

This acre has been used in soil tests for thirteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn, followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, corn, and grass and clover in 1900. The field has not been ploughed this year but received fertilizers as usual. During the entire thirteen years four of the fourteen plots have received neither manure nor fertilizer; three plots have received yearly a single important manurial element, viz., one of them nitrogen, another phosphoric acid and another potash, — every year the same; three have received each year two of these elements; one has received all three yearly; and one each has yearly lime, plaster or manure. Much of the field, having been either entirely unmanured or supplied with only a portion of the elements ordinarily considered as essential, is now much exhausted. The four nothing plots this year produced an average yield of 375 pounds of hay to the acre at the first cut and 313 pounds at the second cut. The table shows the rate of yield of the several plots: —

Hay and Rowen. — South Acre Soil Test, 1901.

Plots.	Fertilizers used.	Yield per Acre (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.
1	Nitrate of soda,	900	550	+500	+310
2	Dissolved bone-black,	300	370	—100	+130
3	Nothing,	400	240	-	-
4	Muriate of potash,	600	700	+233.33	+450
5	Lime,	500	360	+166.67	+100
6	Nothing,	300	270	-	-
7	Manure,	3,600	2,700	+3,300	+2,340
8	Nitrate of soda and dissolved bone-black.	1,200	530	+800	+170
9	Nothing,	400	360	-	-
10	Nitrate of soda and muriate of potash,	2,100	900	+1,700	+533.50
11	Dissolved bone-black and muriate of potash.	1,900	1,500	+1,500	+1,126.67
12	Nothing,	400	380	-	-
13	Plaster,	200	200	—200	—180
14	Nitrate of soda, dissolved bone-black and muriate of potash.	3,300	1,100	+2,900	+720

The effect of each of the three elements of plant food — nitrogen, phosphoric acid and potash — is more clearly brought out in the tables which follow : —

	Results of the Addition of Nitrogen to —				
	Nothing.	Dissolved Bone-black.	Muriate of Potash.	Dissolved Bone-black and Potash.	Average Result.
Hay (pounds per acre), .	+500	+900	+1,466.67	+1,400	+1,066.67
Rowen (pounds per acre), .	+310	+40	+83.33	—406.67	+26.67

Value of increase, ... $8 59
Financial result (gain), ... 5 39

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Potash.	Average Result.
Hay (pounds per acre), .	—100	+300	+1,266.67	+1,200	+666.67
Rowen (pounds per acre), .	+130	—140	+676.67	+186.67	+213.33

Value of increase, ... $7 04
Financial result (gain), ... 3 84

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Dissolved bone-black.	Nitrate and Dissolved Bone-black.	Average Result.
Hay (pounds per acre), .	+233.33	+1,200	+1,600	+2,100	+1,283.33
Rowen (pounds per acre), .	+450	+233.33	+996.67	+550	+555

Value of increase, ... $14 71
Financial result (gain), ... 11 51

	Results of the Addition to Nothing of —			
	Manure.	Complete Fertilizer.	Plaster.	Lime.
Hay (pounds per acre), ...	+3,300	+2,900	—200	+166.67
Rowen (pounds per acre), ...	+2,430	+720	—180	+100
Value of increment, ...	$45 84	$28 96	-	$2 12
Value of decrease, ...	-	-	$3.04	-
Financial result, ...	$20 84*	$19 36*	$4 84†	$0 92*

* Gain. † Loss.

It will be noticed that the employment of nitrate of soda alone results in a considerable increase both in the first and second cuttings, but its effect in increasing the crop is comparatively small here, no doubt because the soil of that plot must be quite deficient in both phosphoric acid and potash. It will be noticed that the increase produced by the nitrate of soda is greater where it is used with other fertilizers. It gives the greatest increase where used with potash alone, though much the best crop is secured where it is used in combination with both potash and dissolved bone-black. The effect of the dissolved bone-black when used alone amounts to nothing; when combined with potash, or with both nitrate and potash, it appears to be very useful. This is undoubtedly due to the fact that its presence is favorable to the growth of clover, which, as will be seen from the tables below, is very abundant on those plots where bone-black and potash are used together. The ability of clover to thrive in the presence of suitable amounts of bone-black, potash and lime is well known. The crops on the plot where the dissolved bone-black and potash have been so long used, and without any addition of either manure or fertilizer which furnishes nitrogen during the entire thirteen years, afford a striking object lesson. Here we have a yield at the rate of 1,900 pounds of hay to the acre in the first crop and 1,500 pounds in the second. Such crops are far above the average under much more expensive systems of manuring. They are accounted for by the capacity which clover grown under such soil conditions as must exist on this plot possesses to draw the needed nitrogen from the air. It will be noticed that the potash alone gives but a moderate crop, but when used in combination with either of the other fertilizers or with both of them the result is a large increase. As will be seen from the table below, the plots where the potash is used are characterized by relatively large percentages of clover, while there is no clover on the plots to which no potash has been applied. Especially striking is the large increase in the rowen crop where potash is used in connection with dissolved bone-black, — an increase due almost entirely to the large percentage of clover found on that plot. Attention is further called to the fact that the first cutting of hay on the plot receiving nitrate, dissolved bone-black and potash is almost equal to that on the plot which has yearly received a dressing of barnyard manure at the rate of 5 cords per acre.

The analysis of the manure used is shown below: —

	Per Cent.
Water,	66.61
Total phosphoric acid,	.40
Potash,	.61
Nitrogen,	.52

At the rate at which it was applied, the manure supplied, per plot: nitrogen, 4.86 pounds; phosphoric acid, 3.74 pounds; potash, 5.70 pounds. The fertilizers used on plot 14 supplied: nitrogen, about 1.2 pounds; phosporic acid, about 1.6 pounds; potash, 4.0 pounds.

As was stated in the last annual report, this field was seeded with mixed grass and clover seeds. The clover soon disappeared from all except those plots to which potash has been yearly applied. In order more clearly to show the relation of the fertilizers to the growth of the clover, the product of an average square yard was carefully cut in June and separated into three parts in each case, viz., grass, clover and weeds (including all plants other than true grasses and clover). The material thus secured was allowed to dry until November 16. It was then weighed, with results shown below: —

Effect of Fertilizer on Proportion of Clover. — Product of One Square Yard, Air Dry.

	No Fertilizer.	Nitrate of Soda.	Dissolved Bone-black.	Muriate of Potash.	Nitrate and Dissolved Bone-black.	Nitrate and Muriate of Potash.	Dissolved Bone-black and Muriate of Potash.	Nitrate, Dissolved Bone-black and Muriate of Potash.
Grass (grams),	28.7	84.2	22.6	49.80	74.5	76.5	131.5	133.5
Clover (grams),	–	–	–	30.50	–	45.0	108.0	75.5
Weeds (grams),	–	2.8	–	–	–	–	–	–
Percentage of clover,	–	–	–	37.98	–	37.0	45.1	36.1

When it is remembered that the clover seed which was sown in large quantities came up abundantly upon all plots, it is surely striking that it should have entirely disappeared from every plot except those on which the potash fertilizers have been applied.

B. — Soil Test with Onions (North Acre).

This experiment was conducted upon land which has been used twelve years in soil test work. Each year each plot in the field has been manured in the same manner. The last four crops have been onions, and during the time that the field has been used in experiments with onions it has received double the quantities of fertilizers usually used in soil tests; viz., for each fertilizer, wherever it is used, at the following rates per acre: nitrate of soda, 320 pounds; dissolved bone-black, 640 pounds; muriate of potash, 320 pounds. The plots in this field are long and narrow, about 210 feet by 10½ feet. One-half of each plot was limed in the spring of 1899 at the rate of one ton per acre of quicklime, slaked, spread evenly after ploughing and harrowed in. The crops grown in this field previous to the onions, in the order in which they have been raised, are: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The variety of onions grown this year was Danvers Yellow Globe. The seed germinated well; but the plants on most of the plots made little growth, and many soon died, especially on the unlimed portions of plots which had received an application of muriate of potash, or nitrate of soda, or a combination of these without bone-black. The following tables show the results, bulbs and tops being weighed together: —

Onions. — North Acre Soil Test, 1901.

Plots.	Fertilizers used.	Yields per Acre of Bulbs and Tops (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing,	1,680	3,200	-	-
2	Nitrate of soda,	2,400	4,200	+813.33	+1,333.33
3	Dissolved bone-black,	1,880	2,600	+386.67	+66.67
4	Nothing,	1,400	2,200	-	-
5	Muriate of potash,	3,000	11,200	+1,750	+8,930
6	Nitrate of soda and dissolved bone-black.	8,800	8,000	+7,700	+5,660
7	Nitrate of soda and muriate of potash.	2,400	13,800	+1,450	+11,390
8	Nothing,	800	2,480	-	-
9	Dissolved bone-black and muriate of potash.	10,000	13,200	+9,050	+10,660
10	Nitrate of soda, dissolved bone-black and muriate of potash.	18,600	22,600	+17,500	+20,000
11	Plaster,	1,400	2,960	+150	+300
12	Nothing,	1,400	2,720	-	-

Onions.	Results of the Addition of Nitrogen to —				
	Nothing.	Dissolved Bone-black.	Muriate of Potash.	Dissolved Bone-black and Potash.	Average Result.
Unlimed (pounds),	+813.33	+7,313.33	—300	+8,450	+4,064.17
Limed (pounds),	+1,333.33	+5,593.33	+2,460	+9,340	+4,681.67

Onions.	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Muriate of Potash.	Average Result.
Unlimed (pounds),	+386.67	+6,886.67	+7,300	+16,050	+7,630.83
Limed (pounds),	+66.67	+4,326.67	+1,730	+8,610	+3,683.33

Onions.	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Dissolved Bone-black.	Nitrate and Dissolved Bone-black.	Average Result.
Unlimed (pounds),	+1,750	+636.67	+8,663.33	+9,800	+5,212.5
Limed (pounds),	+8,930	+10,056.67	+10,593.33	+14,340	+10,980.0

Onions.	Results of the Addition to Nothing of —	
	Complete Fertilizer.	Land Plaster.
Unlimed (pounds),	+17,500	+150
Limed (pounds),	+20,000	+300

The results of this experiment for this year are exactly similar in kind to those of the last two years, but the yield on the limed portion of the plots shows a falling off as compared with last year. A chemical test of the soil taken from this portion of these plots indicated that it is once more acid on all plots where muriate of potash and nitrate of soda have been used. There can be no doubt that the heavy applications of these fertilizers have again brought about conditions such that lime is once more needed. The principal points to which attention is called are: —

1. The need of lime is the most striking where the muriate of potash and nitrate of soda are the only fertilizers used.

2. The necessity for lime is strikingly evident where the muriate of potash alone is used.

3. Where dissolved bone-black is used in connection either with muriate of potash alone or with muriate of potash and nitrate of soda there is apparently far less need of lime. The dissolved bone-black, containing a considerable proportion of land plaster, supplies this element.

4. The best ripened crop was found where the dissolved bone-black was used, and attention is called to the desirability of using either this or acid phosphate freely wherever onions fail to ripen well.

5. The results make it evident that potash in abundance is highly essential for this crop. Potash alone in combination with lime gives a much better crop than either of the other fertilizers alone under similar conditions.

In conclusion, the belief is expressed that the soil of this field would be much benefited by an increase in its store of humus. Having received applications of fertilizers only for twelve years, and not having been in grass for six years, the stock of humus in the soil is very low and its physical condition is poor. It is much inclined to crust, and soon becomes so compact after tillage that aeration is very imperfect. The results of this year lead to the conclusion that the practical advice as to the selection of fertilizers for onions given in the last annual report will be found suited to the conditions existing in a majority of instances.

IX. — Manure Alone v. Manure and Potash.

This experiment, intended to illustrate the relative value in crop production of an average application of manure as compared with a smaller application of manure in connection with some form of potash, was begun in 1890. Full accounts will be found in preceding annual reports and summaries in the reports of 1895 and 1900.

The field contains one acre, and is divided into four plots of one-fourth acre each. The crop for the years 1890 to 1896 was corn; for the years 1897 and 1898, mixed grass and clover; for the years 1899 and 1900, corn. For this year the field has been in grass and clover, having been seeded in corn in the latter part of July, 1900. Neither manure nor fertilizer was applied this year previous to the harvesting of the rowen crop, as it was judged that the application of manures would cause the crop to lodge seriously. In previous years plots 1 and 3 have received manure at the rate of 6 cords per acre; plots 2 and 4, manure, a part of the time 3 cords and for the last year 4 cords, and potash. For the last few years potash has been used at the rate of 160 pounds per acre of the high-grade sulfate. The past season was very favorable for the hay crop. The field was cut twice, July 2 and August 28. The yields are shown in the table: —

Yield of Hay and Rowen (Pounds).

Plots.	Hay.	Rowen.
Plot 1,	1,375	370
Plot 2,	1,380	355
Plot 3,	1,170	415
Plot 4,	990	470

It should be noticed that plots 1 and 3 — manure alone — gave most hay, while plots 2 and 4 produced most rowen. This is undoubtedly due to the larger proportion of clover on these plots. Attention has been repeatedly called in previous reports to the fact that the free use of potash invariably tends to increase the percentage of clover in mowings. Combining the yields of hay and rowen, we find that manure alone has produced crops at the rate of 6,660 pounds per acre, while the lesser quantity of manure and potash has yielded 6,390 pounds. Here is a difference at the rate of 270 pounds per acre in favor of the larger quantity of manure alone. It is estimated that the manure alone, if purchased, is applied at the rate of $30 worth to the acre; the lesser quantity of manure and the potash used with it are applied at a cost of $23.60. We have, then, 270 pounds more hay produced where the annual cost of manuring amounts to $6.40 per acre more than where the smaller crop is produced. Our results, then, for the past year are clearly favorable to the lesser manure and potash. The results of the two systems of manuring up to date may be briefly summarized as follows: —

1. The corn crops have been substantially equal in value.
2. The hay crops have been slightly larger on the plots receiving the more liberal application of manure alone; but these increases have been produced at a cost, where manure is estimated at $5 per cord in the field, greater than their value.

X. — Special Corn Fertilizer *v.* Fertilizer Richer in Potash.

The object of this experiment, as has been fully explained in previous reports, is to determine the most profitable combination of fertilizers to be used for the growth of corn in rotation with grass and clover, and especially to test the question as to whether the "special" corn fertilizers offered in our markets have such composition as is best suited for the production of corn under such conditions. The field is divided into four plots, and two of these plots — 1 and 3 — have yearly received an application of mixed fertilizers, furnishing the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer having the average composition of the "special" corn fertilizers analyzed at this Experiment Station in 1899. This average is as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5- 3.7
Phosphoric acid,	9.0-13.0
Potash,	1.5- 9.5

The other two plots — 2 and 4 — received annually an application of materials practically the same in kind and quantity as those recommended in Bulletin No. 58 for corn on soils poor in organic matter. These plots are supplied with a much larger quantity of potash and with less phosphoric acid than the other plots in the field. The fertilizers applied to the several plots are shown in the following table: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

During the past year this field has been in grass, having been seeded in the corn crop of last year in the latter part of the month of July. The season has been favorable to the hay crop, and the field has been cut twice, July 1 and August 28. The hay was housed in good condition. The tables show the yields: —

Yield of Hay and Rowen, 1901 (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (lesser potash),	1,450	125
Plot 2 (richer in potash),	1,460*	260
Plot 3 (lesser potash),	1,250	125
Plot 4 (richer in potash),	1,460*	255

* Plots 2 and 4 weighed together on account of threatened storm; but, so far as could be determined by the eye, the yields of the two plots were substantially equal.

Average Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3,	5,400	500
Plots 2 and 4,	5,840	1,030

It will be noticed that the yields both of hay and rowen, but especially of the latter, were considerably heavier on plots 2 and 4 (*i.e.*, the plots which received fertilizer richer in potash) than on the others. The first crop on these plots was excessively heavy, and lodged to a considerable extent. The proportion of clover was much larger than on plots 1 and 3. The fact that the rowen crop on these plots was rather more than double that on the others was due chiefly to this difference in the proportion of clover.

The cost per acre of fertilizers applied at the rates used on plots 1 and 3 exceeds the cost per acre of fertilizers applied at the rates used on plots 2 and 4 by about $4. We have, then, as a result of this year considerably larger yields at less cost. This field has been used continually in this experiment since 1891. The crop was corn for the years 1891 to 1896 inclusive, in 1897 and 1898 the field was in mixed grass and clover, in 1899 and 1900 in corn. The results of this experiment to date may be briefly summarized as follows: —

1. The crop of corn has been substantially equal on the two systems of manuring.

2. The crops of hay have been larger on the plots where more potash has been used, and the quality has been better.

3. The clover is relatively much more abundant on the plots where more potash is used. This difference is much

more striking at the present time than when the field was in grass in 1897 and 1898. In view of the well-known fact that the clover sod when turned is exceedingly favorable for succeeding crops, it is confidently anticipated that the differences in yields under the two systems of manuring will increase from year to year, and that the superiority of the mixture of fertilizers containing more potash will therefore become increasingly evident.

XI. — Experiment in manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure, in rotation upon grass land has been continued upon the same basis as last year. There are three large plots, varying in size between about 2½ and 4 acres. It may be remembered that according to the system followed each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre; and the third year, manure at the rate of 8 tons. Both this year and last there has been used, on the plots receiving ashes, and ground bone and muriate of potash, respectively, nitrate of soda at the rate of 150 pounds per acre. This year, as last, a small application of nitrate of soda has been made to about one-half of the plot receiving wood ashes after the cutting of the first crop, for the purpose of determining to what extent such application is beneficial to the rowen crop. The system of manuring is so planned that each year we have one plot under each of the three manurings. The barnyard manure is always applied in the fall, the ashes, and the bone and potash, in early spring. The nitrate of soda used on two of the plots was applied to one April 18, to the other April 19. The past season has been favorable to the hay crop. All these plots have been cut three times. The total yields were at the following rates per acre: —

	Pounds.
On barnyard manure,	7,367
On wood ashes and nitrate of soda,	5,817*
On bone, muriate of potash and nitrate of soda,	6,815

* Actual yield, 6,679 pounds; above figure obtained by making reduction equal to increase believed to have been produced by application of nitrate of soda for rowen.

The average yield of the entire area for this year is 6,859 pounds. The average for the period 1893 to the beginning of the present year was 6,615 pounds per acre. The plots when dressed with manure have averaged 6,878 pounds per acre; when dressed with bone and potash, 6,649 pounds; and when receiving wood ashes, 6,309 pounds per acre. The average yields obtained on this field are surely very satisfactory. They are obtained at a cost for fertilizing materials applied which renders the hay crop decidedly profitable.

XII. — Nitrate of Soda for Rowen.

We began last year experiments calculated to show to what extent a small application of nitrate of soda applied after the removal of the first crop of hay would benefit the crop of rowen. The results last year showed increase in the rowen crop sufficient to render the application a paying one. These experiments have been continued this year, and have been carried out on two fields: —

1. On an old sod seeded in 1887, where the prevailing species is Kentucky blue grass, and which received in the spring an application of wood ashes at the rate of 1 ton to the acre and nitrate of soda at the rate of 150 pounds per acre. The first crop was cut June 17. The nitrate of soda was applied to two sub-plots, constituting about one-half of the field, at the rate of 150 pounds per acre on July 3. The results are shown in the table: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

Plots.	Nitrate used.	Rowen, First Crop.	Rowen, Second Crop.	Total Rowen Crop.
Plot 1,	No nitrate,	1,148	627	1,775
Plot 2,	150 pounds per acre,	1,599	732	2,331
Plot 3,	No nitrate,	1,260	711	1,971
Plot 4,	150 pounds per acre,	1,676	880	2,556

The average rates of yield per acre are: —

	Pounds.
No nitrate,	1,873
Nitrate,	2,444

The average increase due to the application of 150 pounds of nitrate of soda is therefore 571 pounds. At the current price for nitrate of soda, this increase has cost a little more than one-half a cent per pound.

2. Nitrate was tried upon a timothy sod seeded in 1899. Four equal plots were laid off, and to two of them nitrate was applied at the rate of 150 pounds per acre. The first crop was cut July 8; the nitrate was applied July 17; the rowen crop was cut September 16. The table shows the calculated results per acre: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

Plots.	Nitrate applied.	Yield of Rowen.
Plot 1,	No nitrate,	436
Plot 2,	150 pounds per acre,	953
Plot 3,	No nitrate,	463
Plot 4,	150 pounds per acre,	463

The average rates of yield per acre were: —

	Pounds.
No nitrate,	449
Nitrate,	709

The average increase is therefore 259 pounds, which, at the current price for nitrate of soda, costs about 1⅙ cents a pound. The use of nitrate for rowen is therefore profitable in the case of the Kentucky blue grass sod, unprofitable in the case of the timothy. Neither the blue grass nor the timothy, however, are varieties characterized by a free or abundant second growth. The results of the application of nitrate of soda for rowen are likely to be better for other varieties, such as orchard grass, the fescues and rye grasses.

XIII. — Experiment in Application of Manure.

Observation of the results obtained for a number of years from the application of manures spread in late fall or winter and allowed to lie upon the surface until spring had led to the conclusion that an experiment was needed to determine whether that practice is wise. The previous history of one of our fields had left it in such condition that we could compare two methods only of application. This field had previously been divided into five plots, each of which had for some ten years received different manurial treatment. These plots were comparatively wide, and it was proposed to divide each in the middle, designating one-half of each plot north, the other south. The original plots had been numbered 1 to 5. The previous manurial treatment had been as shown in the table: —

Plots.	Fertilizer used.
Plot 1, ...	Barnyard manure, 10 tons per acre.
Plot 2, ...	Wood ashes, 1 ton per acre.
Plot 3, ...	No manure.
Plot 4, ...	Fine-ground bone, 600 pounds per acre; muriate of potash, 200 pounds per acre.
Plot 5, ...	Fine-ground bone, 600 pounds per acre; sulfate of potash, low grade, 400 pounds per acre.

In 1899 the entire field was evenly manured with manure from well-fed milch cows. The topography of the field is such that there is considerable slope lengthwise of the plots, although the lay of the land makes it possible that under exceptional circumstances there may also be a little wash from one plot to another. The crop in 1899 and 1900 was corn, — in 1899 for the silo, in 1900, husked; in 1901 the crop was Japanese barnyard millet.

The plan of manuring followed during 1900 and 1901 may be thus described: —

Four of the plots — 1, 2, 3 and 4 — receive an application of carefully saved manure from milch cows at the rate of 10 tons to the acre. Plot 5 receives an application of stable manure at about the same rate. The cow manure when applied is comparatively fresh and unfermented. The four plots receive this manure each at a different date, our practice being to remove the manure from the pits as it accumulates as soon as the quantity made is sufficient for one plot.

Whenever a plot is manured, the loads as hauled are placed alternately one on the north and the other on the south half of the plot. The load for the north half is spread, that for the south half is put into a heap, all the manure for that half being placed in one large, well-shaped heap. The weight of manure for each half is the same. The manure for plot 1 is applied in late fall, plot 2 in early winter, plots 3 and 4 in the order named, at dates still later in the winter. The stable manure used on plot 5 has been handled in a similar way, the application to this plot commonly being made rather late in the winter; and the manure when applied has been partially rotted, and hot and steaming at the time it was hauled. Our practice has been to plough the field in mid-autumn, and then to sow a cover crop, — usually rye. The manure which is put into heaps is spread in spring shortly before the ground is to be planted, and the whole area is immediately ploughed, the manure applied during the winter as well as that just spread from the heaps being at that time turned in. The results for the three years, viz., the first, when all plots were treated alike, and the last two, when the manure was applied as just described, are concisely shown in the tables: —

Yield of Corn and Millet, in Pounds per Plot.

Plots.	Previous Manuring.	1899 Corn, Green (Both Halves manured alike).		1900 Corn, Ears and Stover.		1901 Barnyard Millet Hay.	
		North Half.	South Half.	North Half (Manure spread).	South Half (Manure piled).	North Half (Manure spread).	South Half (Manure piled).
1	Barnyard manure, . .	5,995	6,320	1,920	1,983	1,375	1,625
2	Wood ashes, . . .	6,020	5,785	1,825	1,955	1,050	1,380
3	No manure, . . .	2,900	4,215	1,380	1,725	740	1,310
4	Bone and muriate of potash.	5,010	4,590	1,630	1,795	1,040	1,515
5	Bone and sulfate of potash.	4,805	5,470	1,645	2,015	1,130	1,680

Relative Yield of Corn and Millet, in Percentages.

Plots.	1899 Corn (Both Halves manured alike).		1900 Corn.		1901 Millet.	
	North Half.	South Half.	North Half (Manure spread).	South Half (Manure piled).	North Half (Manure spread).	South Half (Manure piled).
Plot 1,	100	105.4	100	103.4	100	118.1
Plot 2,	100	96.1	100	107.1	100	131.4
Plot 3,	100	145.3	100	125.0	100	177.0
Plot 4,	100	91.7	100	110.4	100	145.6
Plot 5,	100	113.8	100	122.5	100	148.7

It will be seen that the two halves of the several plots were not quite even in fertility, as indicated by the yields of the first year, at the start. The greatest difference was found on plot 3. The north half of this plot suffers from spring or ooze water to a greater extent than the south part. We must be cautious, therefore, in attaching importance to the largely increased difference in yield on that half of this plot manured in spring for the past season. It will be noticed, however, that, while there are differences in the degree, there is a marked tendency to increased superiority in favor of spring application on the other plots of the field as well as on this.

This experiment will be continued; but it has seemed wise to call attention to the results so far obtained, for the reason that the conditions on this field as regards the nature of the surface are similar to those existing in the fields on many farms, and for the further reason that the results certainly indicate that there is grave reason to doubt whether application of fresh manure during the winter and allowing it to lie upon the surface until spring is wise. In conclusion, I should perhaps call attention to the fact that, while the difference between the south and the north half of plot 3 may be to a considerable degree due to the different natural conditions, it seems only reasonable to conclude that it may be in part also due to the fact that the fertility of this plot at the start was much lower than that of the others, as it had been cropped for many years without application of manure or fertilizer of any kind. On the other plots, which had been well manured in preceding years, it would not be strange should a good yield be obtained on the north half, even although the manure spread there during the winter may have suffered serious loss. The fact that the difference between the north and south halves of plot 1 during the past two years is less than on any of the other plots, serves to confirm this view; for it will be remembered that plot 1 had yearly received a fairly liberal application of barnyard manure for a long series of years previous to the beginning of this experiment.

XIV. — Alfalfa as a Forage Crop.

There is at the present time so much interest in alfalfa as a forage crop that attention is called to the fact that the results obtained at this station have been distinctly unfavorable. Alfalfa has been under trial in a small way for a considerable number of years, and we have never succeeded in obtaining results encouraging to its general introduction.

It is well known that alfalfa thrives best on soils where the water level is well below the surface, and where the texture of the sub-soil is not too compact. We have not perhaps an ideal soil for alfalfa on the college estate. It has been tried, however, on a considerable number of fields, some of which it would seem must possess soil with the right characteristics. It is known, further, that for success with alfalfa the soil must be rich in lime. Our soils are not naturally rich in this constituent. In one of the experiments of the past few years which will now be briefly described we have made a heavy application of lime to one-half of the plot.

A. — Alfalfa on Campus Slope.

The field known as campus slope falls off gradually toward the west, affording perfect surface drainage. The surface soil is fine, medium loam, which gives excellent crops of potatoes, corn or clover. The sub-soil to the depth of three or four feet is of the same general character as the surface soil, though containing, of course, less humus. At the depth of five to six feet begins a somewhat open-textured gravel, — a quality of gravel which makes quick-bedding road material, but which as it lies is not at all of the nature of a hardpan. The water level of this field is well below the surface. In 1899 the field produced a crop of potatoes; for the two previous years it was in mixed grass and clover. It was manured in the spring of 1900, at the rate of 4 cords to the acre; the manure was ploughed in. The plot, which was 40 feet in width and 152 feet long, was divided into two strips, and to one of these lime was applied at the rate of 1½ tons (air-slaked) per acre. After ploughing, fertilizers were applied at the following rates per acre: —

	Pounds.
Sulfate of potash, high grade,	250
Acid phosphate,	400
Steamed bone,	200

The seed was sown in rows ten inches apart on May 22. The plot was hand-weeded and hoed several times throughout the summer. The growth was very slow, and no crop was harvested. This alfalfa passed through the winter in good condition. The plot was lightly harrowed on April 16; on May 1, it was hoed. On May 6, fertilizers were applied in the same amounts as in 1900. Early in the summer it was noticed that the alfalfa was somewhat better on the limed half of the plot. To the west end of both limed and unlimed portions a small application of soil from an alfalfa field in Kansas was made in the spring of 1900. This was for the purpose of testing whether deficiency of bacteria of the right kind was the probable cause of the slow growth of the crop. It was believed that the Kansas soil would furnish these. No particular difference was noticed during the first season; but by the middle of June the past season it could be plainly seen that the growth where the Kansas soil had been spread was superior to that on the other parts of the plot. The plot was cut three times during the season, June 20, July 21 and September 6, each time when in early bloom. The yields per plot were as follows: —

Yield of Alfalfa (Pounds).

	June 20.	July 21.	September 6.	Total Crop.
Without lime, ...	175	70	130	375
With lime, ...	290	105	170	565

The total yield was at the following rates per acre: unlimed, 5,374 pounds; limed, 8,088 pounds. These are green weights, and they represent a very small and unprofitable product. It is of course possible that the poor growth may be largely the result of the absence of bacteria of the right species in suitable numbers; but the yield even on that part of the plots to which the Kansas soil was applied was exceedingly small.

B.—Alfalfa on Field B.

The second plot on which we now have alfalfa is one of those in field B, which has been yearly manured with bone meal at the rate of 600 pounds, and muriate of potash, for the last two years, at the rate of 250 pounds per acre. The soil of this field is a moderately heavy loam. It is tile-drained, by means of one line of tiles running through the middle of the plot; the depth of this drain varies between three and four feet. This plot has recently produced good yields of a number of our common farm crops. The seed was sown on this field in the spring of 1900, in drills, as in the other field, and the crop was very carefully cared for. Nothing was harvested in 1900; but the crop, which was just begining to bloom, was cut on July 1, as it showed signs of blight. That which was cut was allowed to remain on the ground. It may be here remarked that this practice has been strongly recommended by farmers who have had experience in the growth of alfalfa in New York, where, as here, the crop is somewhat subject to a rust-like blight. The experience of these farmers has led them to conclude that when this blight shows itself the crop must be immediately cut; otherwise, as the leaves are soon destroyed, the vitality of the plants is seriously lowered. Their experience is that, if the crop be promptly cut and allowed to remain on the ground, a healthy growth soon takes place. Such observations as we have been able to make here indicate that this practice is beneficial.

In the spring of the past year it was found that most of the plants had been lifted from one to two inches by the frosts of winter and spring. Nearly all of them, however, appeared to be alive, and they soon started fairly well, though the growth did not present a good color. On April 13, fertilizers in the usual amounts were applied broadcast. On April 16, the field was harrowed lightly with a smoothing harrow. The crop was cut three times, as follows: —

June 20, just coming into bloom, 2 to 2½ feet in height, the lower leaves beginning to show spots, and turning yellow. Yield, green, 910 pounds.

July 22, in bloom, showing a little blight. Weight, green, 465 pounds.

September 6, beginning to blossom, slightly affected by blight. Weight, green, 440 pounds.

The area of the plot is about two-fifteenths of an acre. The total green weight is 1,815 pounds, which is at the rate of 13,610 pounds per acre. The crop has been once hand-hoed during the past season. The yield of rather less than 7 tons to the acre is much less than could have been obtained from clover, at far lower cost for labor.

In conclusion, these results are presented not as conclusive, but rather to indicate the need of caution on the part of our farmers in the direction of experiments with this crop. True, it is the most valuable forage crop known in the United States in many sections; but it cannot be regarded as by any means certain that it can be made to succeed on the average soils of this State. If successful anywhere, it seems likely to be on deep, mellow soils, of alluvial or drift formation, and where the water table is well below the surface.

XV. — An Old Crop under New Names.

Pearl millet has been advertised by seedsmen for many years, and has been occasionally grown by some of our farmers. Within the past two or three years seedsmen in different parts of the country have advertised what, as a result of our comparisons, it is concluded is precisely the same variety under new names. The names which have been brought to our attention are Mand's Wonder Forage Crop and Brazilian Millet. Seed offered under these names was procured in preparation for this season's work from the so-called originators or introducers. We also secured seed from some of our prominent seedsmen who in turn had secured it from would-be introducers. The most careful comparisons throughout the entire season failed to disclose any difference. Mand's Wonder and Brazilian millet, so called, appear to be identical in every way with Pearl millet. The latter seed can usually be obtained of seedsmen at about 10 cents per pound, while under the new names the prices charged are much in excess of this figure. Such trials of Pearl millet as have been made here have led to the conclusion that it is not a crop which is likely to prove of any considerable value, unless it may be upon very light, dry and warm soils. The crop has been described and commented on at length in previous reports.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The dying of cut-leaved birches.
The present status of chrysanthemum rust in Massachusetts.
The effects of desiccation on soil.
Melon failures.
Stem rots and wilt diseases.
The present status of asparagus rust in Massachusetts.
Sterilization of soil in greenhouses for fungous diseases.

Similar lines of routine work and investigation have been followed in this department as outlined in former reports. During the summer, $400 was expended on repairs and improvements of the building, including part of the greenhouse, and more particularly upon the trucks and tracks utilized for pot experiments. The shed and large unheated greenhouse which were designed for truck experiments have been retracked and concreted, and the original trucks, which were rather primitive in construction, have been remodelled and provided with roller bearings.

Certain species of fungi affecting shade trees and economic crops have been rather common during the year. Among these may be mentioned the *Glœosporium* (*G. nervisequum* (Fckl.) Sacc.), which caused more or less defoliation of the white oak throughout the State. In some instances the foliage was affected to such an extent that half of it fell off which was, as usual, replaced later on by a new growth of leaves. So far as I am aware, no treatment has ever been given the oak for this disease. The fungus appears to be confined to the lower portion of the tree, and no doubt a good spraying of this part with some standard fungicide as soon as the leaves have unfolded and more or less developed would control this outbreak. This treatment is only recommended where such trees occur in valuable situations, such as on lawns, etc., and where the expense of spraying would equal the utility and value of the trees for shade or æsthetic purposes.

The sycamore has also shown, as it is very likely to each year, more or less defoliation from a similar fungus.

The *Glœosporium* on the maple, previously mentioned in our reports, has been more or less common, causing some injury to the foliage, and a leaf-scorch entirely due to a lack of water supply, causing a drying up of the leaves, has been observed to some extent.

This division frequently received specimens and letters relating to these diseases. They do not constitute very serious maladies, as a rule, and the question of treatment is usually one based upon the utility of the tree under consideration.

Many elm leaves are frequently subject to the fungus known as *Dothidea Ulmi*, (Duv.) Fr., and the European linden in some localities suffers from the effect of a leaf spot (*Cercospora microsora*, Sacc.). Both of these fungi cause the foliage to become spotted and to fall prematurely. It would not be a bad idea once in three or four years to spray badly affected trees, so that they may at least once in a while have a clean crop of foliage, which would exert considerable influence on the growth of the tree.

Other fungi which have been more or less common are the tomato spot or mildew, leaf blight and leaf spot, the quince rust, melon blight, bean anthracnose and asparagus rust. Bacterial rot on cabbage has caused some loss to this crop, and it was noticed in fields that had been planted to cabbages for the first time.

The Dying of Cut-leaved Birches.

The dying of cut-leaved birches became quite a noticeable feature in some places in the eastern part of the State this past summer. The cause of this trouble was incidentally due to borers, but in all probability it was primarily brought about by the drought last season. Probably many of these trees could have been saved if they had been cut back in time, in order to correlate top growth with that of the roots. Many of our maple trees, when grown on dry, gravelly soil, suffer greatly during a season of drought, and the effect of this suffering is usually increased by the presence of borers in the following years. In cities the restricted growth of roots, caused by pavements, sidewalks, regrading, etc., induces similar pathological conditions in the tree, which are sooner or later followed by the same mischief-makers.

The Present Status of Chrysanthemum Rust in Massachusetts.

The chrysanthemum rust was first noticed in this State in the fall of 1896,* this being the first recorded instance of the appearance of the rust in the United States. The following year it became more widely disseminated in Massachusetts, and has since extended over the larger portion of the United States.† We have never, however, regarded its appearance in this State as a matter of very serious consequence; nevertheless, we have felt it necessary to keep a watchful eye over its presence in our midst. During the past fall we have made an effort to obtain, by means of circulars, whatever information could be secured; and in so far as its occurrence in this State is concerned, this information has borne out our conception of it.

Only one stage of the rust, the uredo, has been found on the plants affected in Massachusetts. In the absence of the other stages which are characteristic of rusts, it might be expected that it would not obtain a very strong foothold. Upon this point Dr. Arthur ‡ writes as follows: "Another circumstance much in the cultivator's favor is the propagation of the disease without the formation of the customary teleuto spores or third stage. Not only does this render the disease far less persistent, but without doubt indicates that it is less vigorous in its attacks. In general, when a rust is confined

* Annual report of the Hatch Experiment Station for 1896, pp. 276-279.

† For details connected with the spread of the rust, etc., consult Bulletin No. 85, October, 1900, Indiana Agricultural Experiment Station.

‡ Bulletin No. 85, p. 128, Indiana Agricultural Experiment Station.

to the uredo forms for a number of generations, its vitality is much reduced, and also its power of injuring the crop. So long as the teleuto spores do not make an appearance in this country, the careful cultivator may feel assured that a moderate amount of timely effort will enable him to rid his establishment of the rust."

From data contained in this circular, it appears that the rust was most prevalent during the years 1897 and 1898, or, in other words, during the first year or two of its outbreak. At this time it became more generally distributed over the State, and of course there was more infection as a whole. It also affected the individual plants more severely during the first outbreak than in the later ones. During the last three years it has shown, as a whole, a marked tendency to decrease in this State. There are, to be sure, individual growers who report an increase; but this increase is perhaps due to their methods of cultivation, and not taking sufficient care to propagate from clean stock. One-third of the growers state that they never had the rust on their plants, and were familiar with it only as they had seen it on other stock, while others have only experienced a slight infection one year. One florist who cultivates 40,000 plants, states that he has not had the rust for three years, or since 1898, and at that time he had it only to a very slight extent. The amount of infection which has been prevalent varies from .1 per cent. to 50 per cent., the latter figure being exceptionally high, for very few have had even 25 per cent. as a maximum amount of infection. The financial damage to the crop is far less than the above, and in most instances it amounts to nothing. The worst injury appears to be to the gardeners' pride, inasmuch as a large percentage of the plants are grown for competition in shows, and even a slight blemish caused by two or three rust pustules on a single leaf, is very annoying to skilful gardeners, who take pride in exhibiting their plants. Most gardeners agree that weak stock is the most susceptible to rust; and if weak, infected plants are allowed to remain in close proximity to strong, healthy ones, they too will subsequently become infected. The variety known as the Queen is singled out as the one most susceptible to infection. One grower believes that pot-grown plants are more susceptible to rust than those planted in benches.

The remedies suggested by the different growers consist in hand-picking the affected leaves, selecting clean, strong stock, discarding susceptible varieties, and inside culture. These suggestions appear to us very reasonable, and if they are carefully carried out there is at present little reason to doubt that it can be practically eliminated. In regard to the practice of inside culture during the summer, we find that many excellent growers lay much stress on this practice, and from what we have seen of it we consider it very essential in order to obtain plants free from rust. The reason that inside culture results in less infection is probably due to the avoidance of mists and dews on the foliage, hence furnishing less favorable opportunity for rust spores to germinate and cause infection. Care should also be taken to keep all unnecessary water off the foliage in cultivating in the greenhouse. One successful grower makes the following statement: "I have found that when plants were planted in benches in a good house, where plenty of air could be admitted and the soil kept in good physical condition, they were almost never troubled with rust."

Most growers are unanimous in considering the chrysanthemum rust of little consequence, and others look upon it as a thing of the past. There are a few, however, who have not succeeded in subduing it, who still think it a serious disease. Some have resorted to spraying, with results that amount to little more than partial suppression. It appears from our own observations, as well as from those obtained from the most successful growers of this plant, that the proper remedy lies in the judicious selection of healthy, rust-free stock, and inside cultivation. If, however, any of the leaves become infected, they should be removed and burned immediately; and if a plant is badly affected, it should be destroyed. In whatever manner the plants are cultivated, whether in-doors or out-doors, endeavor to keep the dew and moisture off the foliage as much as possible.

The Effects of Desiccation on Soil.

The practice of desiccation or drying greenhouse soils by aid of the heat of the summer sun has been in vogue with us for some time, for the purpose of observing what effect such treatment would have on certain organisms. We have already shown that the *Sclerotinia* or the drop fungus when dried is greatly accelerated in its activity, which increases to a great extent the amount of infection in the succeeding crop of lettuce. The resting spores of many other plants are undoubtedly affected in the same way. There are other effects of drying on the soil which prove very destructive to the development of lettuce plants, although we have not observed this effect upon other species. On lettuce we have observed this repeatedly, and the characteristic results of such drying are manifested in a stunted growth and abnormally colored and worthless crop. The crop scarcely ever attains more than one-third of its size. The texture of the plants is poor, being thick and tough, and inclined to crinkle. That this is caused by desiccation alone is shown by the fact that wherever any drip from the roof fell upon the soil during the summer rains, the plants growing in such places were always normal. Distinctly sharp lines can be observed in a lettuce crop grown under such conditions, owing to the difference in development brought about by desiccation and the presence of a small amount of water due to dripping. Instances have come to our notice where large houses devoted to lettuce have been allowed to become quite dry, with the same result on the crop as noted above. The remedy for this trouble is obvious; namely, not to allow the house to become too dry in summer, but to keep the soil more or less supplied with water. If such drying occurs, the soil can be entirely renovated by applying hot water or steam to it, as we have already shown more than once.

Melon Failures.

No trouble with plants has been more general in New England the past season than that attending the growing of muskmelons. In a great many cases this crop has been a total loss, and almost without exception the yield has been greatly diminished and the quality of much of the fruit put on the market impaired. In two previous reports (1899 and 1900) we have mentioned this subject, but the trouble has never been so general before. The melon blight described in our report for 1898 was found to be due to a leaf spot fungus of the form called *Alternaria*. This disease appeared in the latter part of August, as the fruit was approaching maturity, and soon killed the vines so completely that the crop in the affected field was a total loss. The trouble was not at the time general throughout the State or even in the immediate region, though it had previously been known in other States. The following year the same disease occurred quite abundantly, and along with it the well-known cucumber anthracnose (*Colletotrichum lagenarium*) was very prevalent on muskmelons and watermelons. This second disease appeared earlier in the season than the *Alternaria*, coming on in July. Between the two diseases and the gradual spread of the trouble the damage to the melon crop was considerably greater in 1899 than during the previous year, and many growers determined to give up this crop. In 1890 more or less trouble was experienced, but not to a marked degree. In that year, however, there appeared in the State upon greenhouse cucumbers for the first time, so far as known, since 1889, the downy mildew of the melon, cucumber and similar plants. During the past season of 1901 complaint has been general from all sections of the State of the complete failure of the muskmelon crop. Examination of the first material sent in revealed the fact that still a third disease had come upon this unfortunate plant, — the downy mildew was abundant on every affected leaf. This proved to be the case in every instance. Affected plants from Amherst, South Amherst, Belchertown, Worcester, Lancaster, Fitchburg, Belmont, Andover and other towns in the State all showed the downy mildew (*Plasmopara cubensis*), while in most instances one or both of the other two fungi were also present on the same leaves.

The consideration of this trouble is therefore a complex one, and each of these destructive fungi must be taken into account. It must be remembered that each is a definite organism, growing parasitically upon the leaves of the melon, and having its regular course of development.

Taking up each disease separately, we find the *Alternaria* less abundant this year than when it first appeared. No instances have been found, as was certainly the case in 1898, of this fungus alone being the cause of the trouble. It may be mentioned here, however, that specimens of the melon blight, now so prevalent in the extensive Colorado melon districts about Rocky Ford, sent by Mr. H. H. Griffin of the Colorado Experiment Station, show only a fungus apparently identical with our *Alternaria*. All our experience indicates that trouble from this source alone is not to be looked for until comparatively late in the season, — not, probably, before August 1.

The anthracnose (*Colletotrichum*) causes a well-known leaf blight on greenhouse cucumbers, and has been very common on melons the past season. It is more usual on watermelons than muskmelons, having often been the cause of serious damage to the former. On both species it attacks the fruit as well as the leaves, causing spotting and decay. This fungus is not, apparently, as definite in the time of its appearance upon melons as either of the others, but is liable to come on earlier, and generally does so when abundant.

The downy mildew has been comparatively unknown in this State up to the present outbreak. It is now abundant on greenhouse cucumbers, and occurred everywhere on muskmelons last summer. Farther south it has been well known on these plants for some time. The appearance of the fungus on melons is not to be looked for here before August 1 and quite commonly it did not become destructive last season until September 1.

A typical case of the simultaneous occurrence of these three diseases occurred at Mr. A. A. Marshall's place at Fitchburg, Mass., where the growing of muskmelons is made a specialty. Eight acres were grown, all in one field, and all of one variety, the Miller's Cream. At one end of the field the ground was slightly rising, and on this portion the same crop had been grown the preceding year, the rest of the field being new to melons. About July 22 it was first noticed that a blight was appearing on the vines on the old ground. This did not increase very rapidly or cause any serious damage for some time. When visited, on August 17, picking had just commenced, and the crop was mostly in excellent condition. In the most affected part a few plants were dead or had been pulled out, and many leaves were spotted; some of the fruit also showed spotting and decay. Examination of the badly affected plants, *i.e.*, those which had been earliest attacked, showed the presence of the anthracnose in great abundance, some *Alternaria*, while the downy mildew appeared to be just coming on. The decay of the fruit was due entirely to the anthracnose. From this time on the trouble spread rapidly to other parts of the field, and in this later attack the mildew was almost entirely the cause of the trouble. In other places also, where no disease appeared until about September 1, the rapid destruction which followed was due to the same cause.

From all the cases reported it is evident that, except for the rather unusual case of the anthracnose becoming abundant in July, the chief trouble with the melon crop comes on about September 1, or in the last days of August, just as the fruit begins to mature. The appearance of a badly blighted field is a most discouraging one to the melon grower, the ground being covered with good-sized but mostly flavorless worthless melons among the dead vines. It therefore comes about that a saving of the vines for two weeks at this time is of supreme importance, and even one week means often the difference between profit and loss to the grower.

Treatment. — In order to gain this period in the life of the plant, the most obvious methods are by getting an early start, by the use of early varieties, and by protecting the plant by spraying. Each of these is of practical importance. The first is often practised by starting the plants in hot-houses or frames, and transplanting later to the open field. This method has been used with promising results, and deserves a trial wherever practicable. The choice of varieties is largely a matter of personal taste in this crop, many growers having their own strains, from which they would depart only with great reluctance. It can only be said that the earliest varieties which are otherwise satisfactory should be grown. From the present outlook, the early fruit must form the bulk of the melon crop.

Spraying. — Considerable success in preventing the attacks of all these fungi has been obtained in various experiments and places by spraying melons and cucumbers. No very extensive results have been obtained, however, with the melon crop in this State. Mr. Marshall's fields were sprayed seven or eight times during the season with various copper fungicides. All the plants were sprayed, so that it is impossible to say just what was gained, and whether the anthracnose which appeared in July would otherwise have proved more destructive. Judged by the case described in our 1900 report, there was a decided gain in this respect. Certainly Mr. Marshall's vines kept alive some time longer than the average in the State or vicinity, and the spraying appeared to have been of advantage. Mr. L. W. Goodell, the Pansy Park seedsman, sprayed with Bordeaux mixture, and in his field a gain of from one to two weeks in the life of the most thoroughly sprayed portions was plainly apparent. Thorough spraying of melons is difficult, for two reasons, — the prostrate position of the plant, making it almost impossible to spray the under side of the leaves, and the rough, hairy surface of the leaf, to which the spray does not readily adhere.

At present the following recommendations seem advisable for this trouble: try, by the methods suggested above, to mature the crop as early as possible; spray with Bordeaux mixture with great thoroughness throughout the season, beginning as early as July 1.

Stem Rots and Wilt Diseases.

Troubles of this sort, in which affected plants show a wilting and withering of the leaves, caused by a more or less rapid decay of the stem, appear to be largely on the increase in cultivated plants. Three such diseases are of special importance at present, owing to their rapid increase.

These are the stem rots of the chrysanthemum, carnation and aster, all of comparatively recent occurrence, but becoming more and more serious each year.

Chrysanthemum Stem Rot. — This disease has been known in Massachusetts only during the past two years, but has rapidly increased, and is considered by many growers as the most serious trouble threatening this important plant. It is characterized by a slow fading and withering of the leaves, beginning towards the bottom and gradually working up the stem. The flower develops poorly or not at all, and the whole plant finally dies prematurely. The cause of the disease is a fungus which grows in the stem and fills up the large ducts or vessels through which the water must pass in coming up from the roots. The development of this fungus has not yet been closely followed; but, since it is a species of *Fusarium*, similar forms of which cause like diseases in other plants, there can be but little doubt that the plant is first attacked from the soil, whence the fungus spreads into the stem and on up through it to a considerable height. As the pores become more and more clogged with the fungous growth, the water supply to the leaves is diminished, and consequently they gradually die and wither away. It is noticeable that this disease appears most commonly as a result of conditions favoring "damping off." Where young plants are crowded in flats or beds, those in the centre are generally the ones to show the trouble. This is likewise true with the other diseases of this class mentioned here, and such conditions should be avoided. The soil is to be looked upon as the chief source of infection in all such troubles. There is no danger of contagion in well-rooted plants by spores in the air, as with rusts, mildews and similar diseases. Healthy propagating stock, fresh soil, or that which has been sterilized,* and hygienic conditions, are the most effectual means of controlling such a trouble as this.

Carnation Stem Rot. — This disease has been longer and more generally known than that of the chrysanthemum, but

* One florist who grew 125,000 chrysanthemums sterilized the soil in ten houses, 200-300 feet long and 20-30 feet wide. Three and one-half houses, 300 feet long and 18-40 feet wide, in which carnations are growing, were also sterilized. The result of this experiment has not as yet been ascertained.

it is of comparatively recent occurrence. Most growers, however, know and fear it more than the rust or any other carnation disease. It has been found that there are in reality two distinct stem rots of the carnation, caused by two different fungi. In one a soft rotting of the whole stem occurs just at the surface of the ground, thus killing the plant quickly and completely. This is caused by the *Rhizoctonia* fungus described in our Bulletin No. 69 as the cause of a lettuce rot, and what is said there in regard to this destructive parasite applies equally well in the carnation disease. Since this fungus produces no spores to disseminate it in the air, but is limited to growth in the soil, sterilization by means of steam gives absolute results in preventing the disease, if healthy propagating stock is used. Another carnation stem rot is caused by a *Fusarium* similar to that in the chrysanthemum. In this case a soft, rapid decay does not occur, as in the *Rhizoctonia* disease, but the fungus works up through the pores of the stem, gradually clogging them, and the plant slowly fades away and dies. The stem goes to pieces in the last stages of the disease, but may be badly affected some time before this, the first symptoms appearing in the wilting of the plant. The use of healthy stock and fresh or sterilized soil is to be strongly urged where this disease has appeared, as well as the removal of all affected plants and the soil near them from the bed.

Aster Stem Rot. — A *Fusarium* stem rot of the China aster is very common and destructive, and seems to be on the increase. This disease will be more fully described in a bulletin of this division. Our investigations have shown that it is always first contracted as a "damping off" in the seed bed. Some plants die at this stage, but many live to be set out in the bed. Here the disease manifests itself at almost any time, by a gradual wilting, fading and death of the plant. Only in the last stages does the rotting of the stem appear; long before this the pores are clogged by the fungus, and wilting produced as in the other diseases. So far as our results go, it is possible to entirely avoid the trouble by starting the plants in the open ground, or otherwise avoiding "damping off" conditions. Thousands of plants thus started have been grown on land badly infected with the disease, without a single case of stem rot. In this case, however, some other troubles with a similar effect must also be considered, particularly the attacks of root lice, one of the worst pests with asters. All of these will be fully discussed in the forthcoming bulletin.

The Present Status of Asparagus Rust in Massachusetts.

The asparagus rust made its appearance as usual in either one form or another during the summer and early fall. In July and August outbreaks of the uredo stage were perhaps not so severe, as a whole, as in some other years; nevertheless, it was severe enough to be likely to cause damage to the crop next year. The distribution of the rust in this State remains nearly the same as it has for some years, although within the last two years there has been a slight tendency for the uredo stage to show itself on some beds which heretofore have never presented anything but the teleuto spore stage. These beds appear to be in soil presenting more water retentivity than those soils upon which the rust has caused the most injury in years past. In this connection it should be stated that, while the uredo stage has shown on them, it does not occur nearly so early or so severely as on the lighter soils. The uredo spore stage occurred in the latter part of August on these beds. Other than these few instances, the distribution of the uredo spore stage, which constitutes that form of the rust causing practically the only injury, is about the same as it has been.

The rust constitutes a very serious factor to asparagus growers, especially to those who have a large number of acres located in infested regions. On account of the high prices of asparagus in the market last spring, the financial returns were not so unfavorable as they might have been, considering the small yield due to the effect of rust. The great difficulty that now exists with those growing asparagus on dry soils subject to rust infection is in starting new beds. The young beds rust so much earlier than the old ones that they suffer more severely as a consequence, and in many cases are so weakened that it looks questionable whether they will ever develop into anything of value.

We have previously attempted to show that the outbreak of the uredo spore stage in this State bears a direct relationship to the water retentivity of the soil; that is to say, during a season of drought, soil capable of holding a small percentage of water becomes exceedingly dry, and it is on these soils that plants suffer. There has been nothing observed to disprove this idea, as we still find the uredo or injurious stage of the rust usually occurring on those soils which are light, and we do not get this stage on plants grown on other soils. We have made a great many additional analyses of soils of the State during the past two years, and the results obtained from such analyses bear out these conclusions. It is also noticeable that in those regions where the soil is lighter and more porous the uredo spore infection shows itself earliest each season, and where the soil is heavier and more compact infection is later, hence doing less damage. Beds situated in regions where the latter conditions prevail have not been damaged nearly so much in the last five years as those situated in the lighter and more porous soils.

The foundation of the idea of the relationship existing between the soil and the uredo outbreak is based upon vigor. In seasons of drought plants become very much weakened, hence they become infected; while those plants grown in neighboring towns, which are characterized by much heavier soil, never have anything but the teleuto spore stage occurring in September or October. The teleuto spore stage appears to be widely distributed in the State, and has been so from the very first. The question naturally arises, Why do these teleuto spore infected beds not have a summer stage? There are certainly plenty of beds which do not have it, and their distribution is wide. All the theories relating to the influence of such factors as dew, elevation, points of compass, shelter, utterly fail to account for a lack of uredo spore infection on these beds. The principal and most important difference found in these beds which are subject to the summer and fall infection is the one of soil texture and water-retaining capacity, which enables the plants, other conditions being equal, to remain vigorous during seasons of drought. When the asparagus rust first made its appearance, there could be seen beds in which one portion was infected, while the other showed not the slightest trace of disease. The only differences existing in the plants were in their age and treatment. The differences of infection in these cases were due to different degrees of vigor. But such beds, being in regions where the soil is very sandy, subsequently became rusted. One bed on the college ground has had the fall stage since 1896, it usually appearing between September 15 and October 1. It has, however, never shown any trace of the rust in summer, or previous to September. Other beds, both young and old, situated close by, have been entirely free at times, and only insignificant teleuto spore pustules have been found on them very late in the fall. All the beds are situated on soils possessing high water-retaining properties, as well as an abundant supply of water from below.

Some attention was given to the rust problem by this division during the summer, and many localities have been examined. We have also, as usual, sent out a series of circulars, asking for information on certain points. Among other questions asked were those relating to the effect of dew, elevation and shelter from tree growths, etc., on infection. Not a single instance has been brought to our attention where the shelter produced by forest growths or crops has exerted any influence. As to the effect of elevation, considerable differences have always been observed by us in the amount of rust on a single bed, and such instances have been reported by asparagus growers in their correspondence. Where a bed runs down a little elevation, and where there are more moisture and organic matter contained in the soil, the plants are larger, more luxuriant, and there is less infection. No grower has been able to give us the slightest hint that plants are prone to show more infection in regions that are subject to dews. Since there is likely to be more dew deposited on the lower part of a bed than on the upper part of it, and if this factor is alone responsible for infection, we would expect to find more rust on those plants grown on the low portions of the bed than on the upper part. This is, however, as we have stated, not borne out by our observations; on the other hand, the reverse is true. In general, elevation is connected with dew only in a relative sense, inasmuch as a location 300 feet above the sea may be subject to less dew than one 600 feet in height. And it is not to be presumed, as one writer has inferred, that the elevation above the sea level necessarily indicates in every instance the amount of dew which ought to be present there; in other words, local conditions affect the amount of dew. On Long Island it is reported that the lower beds rust first, and then those on higher elevations. It may be perfectly true that this takes place in that region and on those soils, although no such instance has come to our knowledge in this State. When plants are not resistant enough to stand uredo spore infection it is not difficult to understand how this might take place; but the presence of any amount of dew fails to infect some beds in this State. The principal bed on the college grounds is located near a pond, and only a few feet above it. If the effect of dew constitutes an important factor for uredo spore infection, then it would seem as if this bed ought to show it, but fortunately it never has.

There is evidence, however, that dew plays an important part in asparagus rust infection in those regions where all of the conditions are favorable for uredo spore outbreak; or, in other words, there are local conditions that exert an influence; but it appears to exert no such influence so far in those beds which show resistance enough to overcome the uredo stage. We have repeatedly seen plants grown under trees, or in any place where they were shaded by some covering, that scarcely showed the rust, whereas those plants just outside of the covering of the limbs, etc., might be badly affected. Our attention has been repeatedly called to this peculiarity by correspondence with asparagus growers, and this freedom from susceptibility in such local instances is undoubtedly caused by the absence of dew. These facts suggest a possible remedy for the rust, — at least in the starting of young plants. The young plants rust much more easily than the old ones; they are much more severely injured, and are a constant source of contamination. If these can be started under cheese cloth covers, such as are now being so extensively used by tobacco growers in the Connecticut valley, it would certainly be an advantage to get such plants started before setting them out into permanent beds; and it would seem that the covering of cheese cloth would be as effectual as the tree covering in keeping off the dew, thus rendering them less susceptible to rust. Some asparagus growers have already considered this method of cultivation.

Experiments in spraying with the formula recommended by the Geneva station were tried during the past summer. This spraying was not done so often or so thoroughly as it could be done with the apparatus recommended for this work. At the close of the season the results of the applications were readily discernible, in the greener color and more vigorous shoots of the treated plants. This method is a costly one to apply, on account of its requiring a special apparatus and a fungicide which is difficult to prepare; thus asparagus growers do not take to it at present.

Fully as favorable results in one instance were obtained by the application of Paris green to a young bed. In this instance a large bed was treated twice for beetles during the summer. About August 18 the uredo stage of the rust commenced to show somewhat on the plants, and at this time one-half of the bed was treated with Paris green early in the morning, when the plants were covered with dew. This treatment seemed to arrest the outbreak of the rust to quite a remarkable extent. This method of treating is a very cheap one, as Paris green is not expensive, and the ease with which it can be put on makes the application far less expensive than by spraying with certain other fungicides. These plants were evidently treated just in the right time to be effective. From the results obtained, it would be worth while to give this method of treatment further trial. It is expected, however, that some experiments along other lines than those heretofore conducted will be tried next year, from which it is hoped that some results of importance will be obtained.

Sterilization of Soil in Greenhouses for Fungous Diseases.

This method of treating soil infected with disease-producing organisms or germs has been frequently dealt with in the publications of this division and elsewhere. We have recommended this method for the extermination of such fungous pests in the soil as cause the drop in lettuce and other plants, the timber rot in cucumbers, the *Rhizoctonia* and damping fungus (*Pythium De Baryanum*), and in part the stem rot in carnations. It has also been recommended for nematode worms, diseases caused by *Heterodera*, which affect indoor cucumbers, tomatoes, roses, violets, cyclamens, muskmelons and other greenhouse plants, and for the aphis and red spider. It is also effective in the destruction of weed seeds. One lettuce grower maintained that it paid to sterilize soil for this purpose alone. Heating of the soil greatly accelerates the growth of plants, and when this method of treatment is applied to lettuce houses affected with the drop and *Rhizoctonia*, it successfully eliminates these diseases, which are all a skilful grower needs concern himself about. This method of treatment has not been recommended for such diseases as top-burn, mildew of lettuce, nor for the damping fungus (*Botrytis*) in propagating pits, or for any other fungi giving rise to diseases which are freely disseminated by spores. Neither does this method, as ordinarily applied, succeed in accomplishing absolute sterilization of the soil. It is merely a sort of pasteurization. Cultures of the soil heated to 212° F. for a short time would show numerous bacteria, and myriads of others subsequently come in from the air and through the water applied to the soil.

The last year has seen quite remarkable strides made in the practice of methods of ridding the soil of parasitic organisms by means of heat. On account of the extensive use of the sterilization method on a large scale by the most efficient and practical gardeners, the process has been made very much cheaper, and hastened to a large degree. At the present time whole ranges of greenhouses owned by single individuals, representing in some cases some acres, are now sterilized, and the method has been employed out of doors to some extent. Many of the houses treated are 300 or more feet in length and from 40 to 50 feet wide. Some market gardeners have practised sterilization of their houses for three years; not, however, for the sole purpose of ridding the soil of certain disease-producing organisms, as that could be accomplished by one treatment when properly done, but largely for the purpose of increasing their crops. A great many experiments have been made by this division during the last six years on various crops, in which the growth of plants in sterilized soil was compared with the growth of the same species of plants in precisely similar earth not sterilized. The effect of sterilization is quite marked in such experiments. W. W. Rawson, one of our largest lettuce growers in the State, who has observed the effect of sterilization on his own crops for two or three years, declared that he would rather have one inch of sterilized soil on his beds than any fertilizer which he had ever tried. For the purpose of determining, on a larger scale than we had heretofore shown, the effect heating the soil had upon the acceleration of a crop of lettuce, we made the following experiment in one of our houses: —

Two beds of nearly equal size were chosen, one of which was treated with hot water until the soil was soaked, and which showed an average temperature of 145° F. at the depth of 4 inches below the surface. The seed and prickers were also planted in boxes of earth which had been heated to 212° F. with steam. The other bed remained untreated, and likewise the soil in which the seed and prickers were started. Other than the hot water treatment given to the previously described bed, no perceptible difference existed. The number of plants in the treated bed was 308; the number in the untreated bed was 264. The results, however, were very marked, as shown below: —

Table showing Difference in Lettuce Plants grown in Sterilized and Unsterilized Soil.

	Plants in Untreated Soil.	Plants in Treated Soil.	Per Cent. of Gain.
Average weight of largest plants (grams), .	137.5	206.6	33
Average weight of typical plants (grams), .	56.2	86.3	33
Excess of water in treated plants over that of untreated.	-	-	2.2

The average weight of the largest plants represented that taken from four specimens selected from each bed in corresponding rows and close proximity. The four typical plants from each bed were selected at random, and they happen to show the same relative weight to each other as the largest ones do. The weights were all taken when the crop was four weeks along in the house and the treated ones were nearly ready for marketing. The plants were selected and weighed, and the amount of water determined in each lot, by Mr. A. L. Dacy, a student of the present senior class, who had charge of the house and who was quite familiar with the crop. The per cent. gain by starting the seed in sterilized soil and also transplanting the prickers in similarly treated soil, then transplanting into soil treated with hot water, was 33 per cent., which is a fair average increase due to this method of treatment.

The writer has made comparisons of lettuce plants grown in a rather poor quality of soil, one lot being sterilized and the other treated with the best possible combination of commercial fertilizers, with the result that the sterilized plants compare most favorably with those treated with fertilizers. This does not imply that sterilization will necessarily dispense with the use of fertilizers in the lettuce crop, if one wishes to apply them; as a matter of fact, however, they are seldom employed. The lettuce plant requires an exceedingly large amount of organic matter in the soil, and for this reason a generous supply of well-rotted horse manure is continually employed, for the double purpose of supplying organic matter and plant food. Plants grown in sterilized soil are always lighter colored and more tender, and it is not a difficult task for an expert to pick out such plants in the market. Neither is it difficult to ascertain, from market specimens, to about what temperature lettuce plants have been subjected. In this respect the differences in plants are marked in a house where the soil has been treated twice as long in one place as in another. A gardener can readily pick out such places. It will be noticed in the table that there is 2.2 per cent. more water in the plants grown in the treated soil than in the untreated soil, and also that there is a corresponding decrease in the unburned residue which represents the organic matter, ash, constituents, etc. From the color and texture of lettuce grown in sterilized soil, this might be expected. The differences as shown in the above figures only represent one analysis.

The effect of sterilization on the soil is well illustrated in the case of a market gardener who picked 31,060 No. 1 cucumbers from 300 plants. The plants of this crop were carried through in treated soil from the beginning, *i.e.*, the seeds were sown in sterilized soil, and the various transplantings were made under similar treatment. The crop was grown after lettuce in the spring, when, it is true, cucumber vines bear heavily. Nevertheless, this was a phenomenal crop at any season of the year, and one which I have never seen equalled. Some allowance must be made in the size of this crop for the strain of cucumbers cultivated, which was a carefully selected stock of heavy bearers. Cucumber plants, nevertheless, respond quite remarkably to the influence of treated soil.

A number of methods of treating soil with heat have been employed by practical greenhouse men, and many experiments on different methods have been made by this division during the last few years. We have been able to observe the efficiency and practical utility of these various methods, and have reported on them at different times. The method of treating the soil by steam to the distance of one foot or more in depth has always appeared to us as the best one to be employed, and, since the cost of such treatment has been greatly reduced of late, there appears to be no longer any reason why it can not be extensively used to eradicate diseases in those cases where there seems to be urgent need. The cost of treatment in badly infested houses proves an excellent financial investment. For example, some houses have had the drop in them to such an extent that 50 per cent. of the plants would succumb, and in some rare cases the whole crop has been lost. In a house containing 4,000 dozen plants at 50* cents per dozen the value of the crop would be $2,000; or, at 25 cents per dozen, $1,000. A loss of 50 per cent. would reduce the value of the crop to $1,000 and $500 respectively. Such a loss is the more provoking, inasmuch as the maximum amount of the drop occurs just about the time when the plants are mature, and all the labor bestowed on the crop in transplanting, the care given to the same, amount of heat utilized and valuable space which they have taken up, are all for nothing.

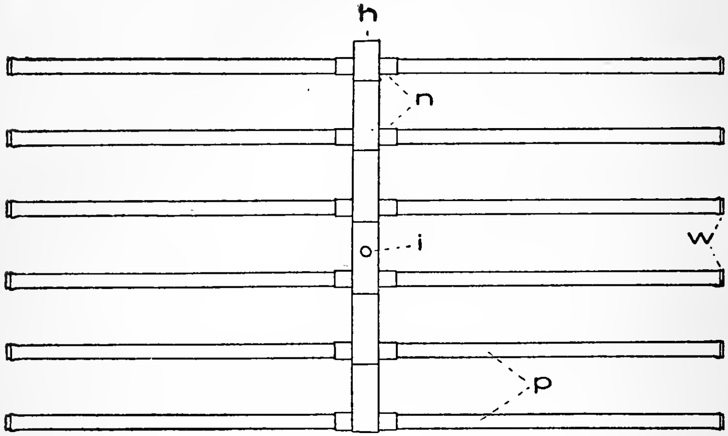
A house of this description was sterilized during the past winter at a cost of $100, and in examining this crop, which was one of the most perfect we have ever seen, there was only one case of disease in the whole house. This one diseased plant occurred near an iron post that supported the house, and there was evidently a small portion of soil in that spot which had not been sufficiently treated. The cost of treating this small neglected area would, however, have been very insignificant. When we observed the crop, it had already been mature for nearly two weeks, and was being held back for a better market, which gave an excellent opportunity for any further drop to develop, if the germs were present. There appears to be no reason why, if a house is once treated as thoroughly as this house was, another treatment should be required for some years, providing care is taken to prevent contamination from old refuse material which contains the drop fungus. By allowing a few contaminated areas to exist in the soil, as a result of imperfect treatment, it would probably be from three to five years before the loss would reach that amount when it would be

* At the present time, December, 1901, a neighboring market gardener is disposing of his lettuce at 65 cents per dozen.

necessary to treat the soil again. It requires no argument to show that the expense of $100 for treatment of the house that would be worth $2,000 at 50 cents per dozen, or even $1,000 at 25 cents per dozen, is a good investment, even if the treatment has to be repeated each year. On the basis of a five-year treatment, which is, in our own estimation, all that is required, the gain is nearly five times as great. The increased value to the soil resulting from such treatment, and the possibility of having less weeds and fewer aphis, should also be taken into consideration in estimating the benefits derived from the use of this method. The oldest, most conservative and intelligent lettuce growers were enthusiastic over the results of this experiment.

Methods of Sterilizing. — The methods employed for heating the soil have been by either hot water or steam, with some variation in the mode of applying the latter. Messrs. Hittenger Bros. of Belmont have made extensive use of the hot-water method, and their later constructed houses have special facilities for applying this in the most economic manner. The hot-water method requires the treatment of the soil previous to the putting in of each crop, and only a few inches of the surface soil are sufficiently heated by this practice to kill the mycelium of the drop fungus.

The heating by steam is now done largely by the aid of perforated pipe, and in some cases use is made of 2 inch porous tile, though this method is not so applicable. If finely perforated tiles could be obtained in the market at a reasonable cost, their use would be much more valuable for this purpose than at present. The various contrivances are made out of perforated pipe, varying from 1 inch to 3 inches in diameter, usually placed from 7 to 12 inches apart, and made up into frames from 10 to 20 feet or more in length and into any desired width. The size and number of the perforations vary much in different appliances. When they are rather large (1/4 inch in diameter) they are frequently covered with burlap. In some appliances the perforations are 1/4 inch in diameter and are only 1 1/2 inches apart each way. In others the perforations may be only 1/8 inch in diameter and from 3 to 6 inches apart, with two or three rows of such holes extending around the circumference of the pipe. Some of these appliances are not made up into



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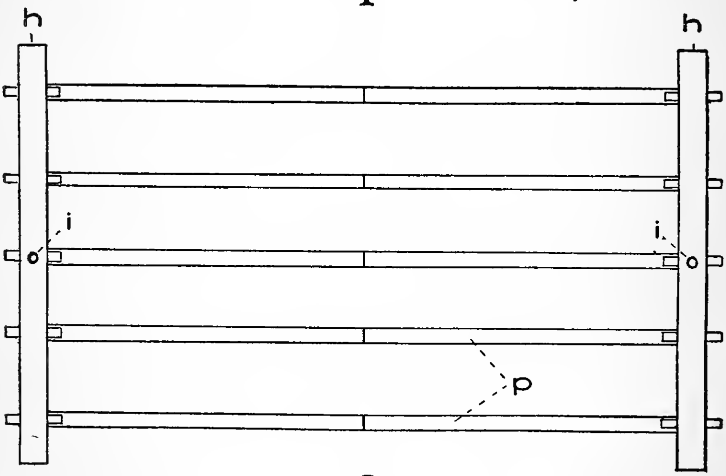

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FIGS. 1 AND 2. — Showing types of sterilization apparatus: *h*, header; *n*, nipple; *w*, wooden plug; *i*, steam inlet; *p*, pipes. Both appliances are 20 feet long and about 8 feet wide.

permanent frames, but are in sections, easily put together or taken apart, and so constructed that they can be readily extended into any length or width desired. These frames are provided with headers placed transversely, which are pipes of larger diameter, containing perforations, and nipples are inserted at intervals which readily fit into the extension pipes (see Figs. 1 and 2). In some instances the headers are placed at each end, thus forming with the extension pipes a frame composed of a series of rectangles (Fig. 2). In this form a complete circulation of the steam can take place. In others the headers are in the middle, and the extension pipes lead off in opposite directions (Fig. 1). In the latter case the ends of the extension pipe are plugged with wood, and a complete circulation of steam does not occur. The material most frequently used is iron pipe. The form devised by Mr. Cartter is constructed out of perforated galvanized-iron tubes, and is very light and easy to handle.

The method generally adopted by lettuce growers in heating their soils is to place the apparatus on the surface of the bed. If the bed is 20 feet wide, then it will be most convenient to have the heating appliance about 10 feet wide and 20 to 30 feet long. This is placed midway between the edges of the bed, and the soil to the depth of 1 foot is dug out on either side of the appliance and thrown on top of it.

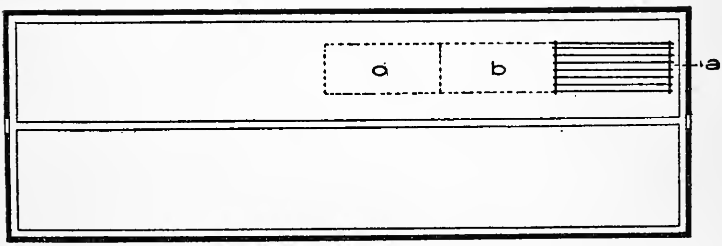

FIG. 3.—Plan of house, showing methods of sterilization: *b*, *c*, successive positions of the apparatus.

This covers the heating apparatus to a depth of 1 foot. The steam is now turned on and the soil heated. After sufficient steaming has taken place, the pipes can be pulled out and set up ready for the next treatment (see Fig. 3). The soil previously treated should be covered up with some old canvas, if available, or, in fact, with anything that will retain the heat, and allowed to stand some hours, after which the top portion is shovelled back to where it was taken from. Not only is the 1 foot of top soil heated by this method, but the soil under which the apparatus rests is equally well done, provided too much haste is not made in removing the treated soil. In one case that was examined, where the steam was left on for one and one-half hours late in the afternoon, and the top coat of soil not disturbed until the next morning, we obtained the following records of soil temperatures at noon on the following day, or nineteen hours after the steam was applied and five hours after the top soil and apparatus had been removed: temperature of soil 2 feet below the surface, 120° F.; temperature of soil 1 foot below the surface, 175° F. Two masses of top soil were heated in this instance during the one and one-half hours, the last one being left on over night. The average pressure of steam applied was only 13 pounds. It always astonishes those who heat soil for the first time to find that steam can penetrate such a distance below the surface in so brief a period. In this particular case the steam was oozing out of the soil 30 inches below the surface, no examination below this depth being made. The most efficient appliances for sterilization are those based upon our recommendations in former publications. A 2 inch pipe is superior to a 1 inch, 1¼ inch or 1½ inch pipe. A high pressure of steam is more effectual than a low pressure, and the larger the number of perforations in the pipe, the more widely and evenly is the steam disseminated and the more quickly and cheaply can the soil be heated. The area of a series of small holes placed uniformly in a given length of pipe would undoubtedly be more effectual than the same area of larger holes in the same length of pipe. In the latter case the holes would be further apart, and allow larger volumes of steam to escape; in the former case they would be nearer together, and would be capable of heating the soil more evenly and in our opinion more effectually. In our judgment, holes ⅛ inch in diameter, when placed near together, would be sufficient for the exit of steam, and the soil would be less likely to go through them than through holes ¼ inch in diameter.

In proportion as the appliances have been improved for sterilizing soils, the cost of the operation has been greatly reduced. From reliable estimates which we have been able to obtain from practical lettuce growers and others who have heated their soil, the cost, including coal, labor, etc., but not the cost of the tile or apparatus used, is as follows: —

In a house 225 feet long by 20 feet wide, one-third of which was heated at a time by steam passing through 2 inch tile placed 8 inches below the surface and 1 foot apart, and forming a continuous circuit, the cost was at the rate of $16 per 1,000 cubic feet, where the pressure of steam used varied from 30 to 80 pounds. This house had been previously sterilized by the same method, excepting that the tiles were placed 18 inches apart, instead of 1 foot, with less favorable results. The heating was continued day and night, as this could be easily done, on account of a night foreman being employed. The estimated cost of removing the soil from a house to the depth of 1 foot, which was actually done in a similar house a few years ago, and placing in new soil without carting the same, was at the rate of $37.50 per 1,000 cubic feet.

Another house, 40 feet wide by 300 feet long, was treated by a lettuce grower with an average pressure of 30 pounds of steam passed through 1 inch iron pipes, furnished with a series of perforations 6 inches apart and 3/16 inches in diameter. These pipes were made up into a frame, 7 inches distant from one another. The estimated cost of sterilizing 1,000 cubic feet of soil, based upon the treatment of the whole house, was $8.33.

A lettuce grower who has a range of houses each about 300 feet long by 36 feet wide has recently treated them all by steam. A boiler house, situated at the most convenient place on the establishment, was constructed, and a new forty horse-power boiler was placed in it, to be used exclusively for the purpose of sterilization. The sterilizing apparatus consisted of a series of 3 inch T's, furnished with 2 inch nipples, which was placed in the centre of the apparatus, thus forming a header. From these nipples there extended in each direction a series of perforated 2 inch iron pipes which were 10 feet in length (see Fig. 2). This made the apparatus when complete about 20 feet long and 8 feet wide. The apparatus was placed on the surface of the soil, the ends of the pipe stopped up with wooden plugs, and the earth from each side to the depth of 1 foot or more was placed upon it. The cost of this appliance was about $20, though Mr. C. R. Learned, who devised it, thinks that he could make a duplicate of it for about $17. It took three days to treat a house 300 feet long and 36 feet wide, and, from the estimated cost of labor, fuel, etc., the treatment was made at the rate of $5.92 per 1,000 cubic feet. This work was done in the summer, when labor was probably more expensive than it would be in winter. Mr. Learned informs me that he expects better results the next time.

A sterilizing machine used by Mr. Cartter is made of 2 inch galvanized-iron tubing, of 20 ply, with 3/16 or 1/4 inch holes, 1 inch apart each way. The headers are 2 to 3 feet long and 3 inches in diameter, and are made up of the same material and perforated in like manner. Galvanized-iron nipples are soldered on both sides of the headers, 8 inches apart. The ends of the 10-foot length pipes are made to fit on to the nipples and also into one another, so that any desired length or width of appliance can be obtained (Fig. 1). This apparatus contains more perforations to the linear foot than any we have seen, and for this reason, and owing to the diameter of the tubing used, it is the most effectual as a heater. We observed one test with this apparatus in which 400 cubic feet of soil were treated at the rate of $2 per 1,000 cubic feet. This includes the cost of labor at 10 cents per hour, which was required to place the apparatus in position and cover it with soil ready for use, and replace the same when heated; also the amount of fuel burned during the treatment, together with the amount of coal it required to bring the same amount of water in the boiler to the same degree of temperature, and the steam to the same pressure as before the treatment was started. Whether this rate of sterilization by the use of this apparatus is actually attained when applied on a large scale, we have not learned.

When soil can be sterilized at $2 per 1,000 cubic feet, or even at $5, there is no longer any question concerning the practical application of this method to rid greenhouses of some of its worst enemies, which interfere with the production of healthy and profitable crops. Even when the cumbersome tile method is employed, the cost of sterilization is less than one-half the cost of removing the old soil from a house and supplying it with new. So universal is this method of treating greenhouses devoted to lettuce, cucumbers, and in some cases to those devoted to violets, carnations, chrysanthemums and roses, that we are unable to give at the present time the number of acres which have been and are being treated. The method, we are told, is to be tried on onions next season grown out of doors. It has already been utilized in the culture of out-door lettuce and celery to a small extent, and tobacco growers are beginning to use sterilized soil in which to start their seedlings. We understand that it costs $65 to weed an onion bed of one acre in extent. It remains to be seen whether the weeds can be eliminated by the use of steam for a less price, to make it an object to use it. Such a treatment would certainly be of great value in the control of smut.

It is not the object of this division to recommend this method too enthusiastically or as a cure for all difficulties. On the other hand, we are desirous of seeing the method tried wherever there is reasonable possibility of its success. In the mean time, we prefer to see the method developed as it is now being done, by practical men who have to reckon with the question of dollars and cents, for, after all, they are the ones who must render the final judgment on any process of treatment. Our facilities have not been sufficient to test this sterilization method on a large scale, neither are we confronted with the economic conditions which commercial men have. For these reasons we have drawn quite extensively on the results obtained by practical men, who apply the method on a large basis, rather than on our own experiments, in discussing this subject at this time.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

The work of the entomological division of the experiment station during the past year has followed the lines of previous reports. The amount of correspondence has been much larger than ever before, being due in a great measure to the appearance of the elm-leaf beetle in the eastern portion of the State in such numbers as to do great damage, and also as an indirect result of the appointment of tree wardens. These officials in the course of their duties have watched the trees and the insects upon them closely, and have frequently communicated with the station concerning their observations. Correspondence of this kind has increased nearly ten per cent. over that of former years, which is of itself a testimonial of the value and success of the tree warden law.

The entire edition of a former publication of the station upon the elm-leaf beetle having become exhausted, a new bulletin on this insect was prepared and published during the summer. This was the only paper from the entomological division published by the station, but others were prepared by the division and published during the year by the secretary of the Board of Agriculture of Massachusetts. The most important of these was a paper on "Three common orchard scales," with figures and half-tones, published in the Crop Report for May, 1901, and which has been in much demand.

The station was represented at the meeting of the Official Horticultural Inspectors of the United States, held at Washington, Nov. 11–13, 1901. At this meeting much uniformity of practice among the nursery inspectors of the different States was established and many results of value obtained.

Nursery inspection for Massachusetts is one of the duties of the entomological division of the station, and requires a total of two or three weeks' time each year. The results of this work are of direct value to the nurserymen only, but in an indirect way lead not only to a more careful watch of the nurseries by their owners, but to the utilization of the facilities of the experiment station as a place of inquiry and reference on subjects connected with insects and plant disease, thus bringing the station into touch with an occupation where its services are of great value.

Insects of the Year.

The year has not been marked by the unusual abundance of any particular insect, except, perhaps, the elm-leaf beetle in the eastern part of the State. This insect has been injuriously abundant in the Connecticut valley for a number of years, but has failed to make its presence felt in the more eastern cities and towns until recently. During the past summer, however, it has made havoc with the foliage of the elms in hundreds of places, and caused a large amount of correspondence with this division, while much of what has been published in the newspapers concerning this insect consisted of remedies and methods of treatment which were inefficient or utterly worthless.

The brown-tail moth has increased in abundance, and in the area which it occupies, until it is probably present in more than twelve hundred square miles in this State, and has extended into Maine and New Hampshire. While in some ways it is an easy insect to control, the assurance that no concerted action will ever be taken by all those persons on whose trees it is present renders it certain that it will remain an important pest; while the serious nature of the irritation caused by the spines of the caterpillars when they touch man has already been a source of much discomfort in the localities where it is most abundant.

The gypsy moth has reappeared at those points in the State where the work of the gypsy moth committee was unfinished when its functions were ended two years ago. It is but a question of time when the area from which it had then been exterminated will become reinfested. The entire responsibility for this unfortunate state of affairs rests upon the Legislature, which discontinued the work of the commission, thereby deliberately wasting all the money previously expended.

The birch *Bucculatrix* has been in evidence during the past year, but, as was predicted in last year's report, has been most abundant in the northern and eastern portions of the State, where little had been seen of it before.

The San José scale has spread rapidly during the year, and is now known to occur in fifty-two localities in Massachusetts. It is not only present in nurseries and orchards, but in several instances it is generally present over areas of several miles. In one place — a residential suburb — nearly every deciduous tree and shrub within an area of five square miles is infested, and many of the plants are already dead, while others are dying. During the summer the scale was found generally distributed through the orchard of the Massachusetts Agricultural College, which consists of over a thousand trees. The origin, distribution and present conditions in this case have been carefully studied, and a special report on the subject has been transmitted to the trustees.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division during the past year has been confined almost entirely to the observation of the various weather phenomena, the tabulation of the data obtained and the computation of the daily and monthly means of the several weather elements. The records of each month are compared with the normals of the ten-year period, 1889–99, and the more important departures from mean conditions obtained.

At the beginning of each month a summary of the weather of the preceding month has been prepared and published as a four-page bulletin. On the inside pages are given a number of the daily means, some of the more important maxima and minima daily records, together with data of the winds and amount of precipitation. On the outside pages a summary of the various weather elements with the monthly means is given, as well as general remarks on the weather for the month. The usual annual summary will be prepared and published with the December bulletin.

The local forecasts for the weather for the following day have been furnished daily, except Sunday, by the New England section of the United States Weather Bureau. In accordance with these predictions, the proper weather flags have been displayed from the flag staff on the tower. At the request of the section director, the weekly snow reports are being sent to the Boston office this season, as heretofore.

Owing to the failure during the past few years to get satisfactory results with our electrical apparatus for the determination of soil moisture, these observations were discontinued this year. This work will be resumed whenever more improved apparatus can be obtained.

The monthly observations of the declination of the magnetic needle, begun last year, have been continued. The results obtained the latter part of the year have not been very satisfactory, probably due to local attraction caused by the line of steam pipe to the drill hall. By changing the true meridian to another location it is expected to remedy this.

No new equipment has been added during the year, but a three years' supply of charts for the Draper instruments has recently been purchased.

At the opening of the college, in September, Mr. C. L. Rice, the observer, retired from the division, and was succeeded by the assistant observer, Mr. H. L. Bodfish.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, SAMUEL W. WILEY, JAMES E. HALLIGAN.

PART I. — Report on Official Inspection of Commercial Fertilizers.

PART II. — Report on General Work in the Chemical Laboratory.

PART III. — Compilation of Analyses of Agricultural Chemicals, Refuse Salts, Ashes, Lime Compounds, Refuse Substances, Guanos, Phosphates and Animal Excrements.

PART IV. — Compilation of Analyses of Fruits, Garden Crops and Insecticides.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1901.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 61; of these, 37 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 7 in Connecticut, 3 in Vermont, 1 in Rhode Island, 2 in Canada, 1 in New Jersey and 1 in Maryland.

Two hundred and sixty-six brands of fertilizer, including chemicals, have been licensed in the State during the year.

Four hundred and forty-nine samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and seventy-one samples were analyzed at the close of November, 1901, representing 230 distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 75, July; and No. 77, November, 1901.

As in previous years, the samples of licensed fertilizers which have not been already analyzed, together with other samples that may be collected, will be analyzed for publication in our March bulletin, 1902. (This includes several samples forwarded by manufacturers at the inspector's request, which were not found in the general markets by our collectors. All such samples are certified by the manufacturers as being an impartial representative of the brands in question.)

For the readers' benefit, the following abstract of the results of our analysis is here inserted: —

	1900.	1901.
(a) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	15	7
Number with two elements above the highest guarantee,	24	15
Number with one element above the highest guarantee,	85	51
Number with three elements between the lowest and highest guarantee,	118	142
Number with two elements between the lowest and highest guarantee,	92	91
Number with one element between the lowest and highest guarantee,	43	39
Number with three elements below the lowest guarantee,	1	–
Number with two elements below the lowest guarantee,	11	8
Number with one element below the lowest guarantee,	50	86
(b) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	5	7
Number with one element above the highest guarantee,	20	12
Number with two elements between the lowest and highest guarantee,	19	24
Number with one element between the lowest and highest guarantee,	6	14
Number with two elements below the lowest guarantee,	–	2
Number with one element below the lowest guarantee,	20	14
(c) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	15	7
Number between lowest and highest guarantee,	9	18
Number below lowest guarantee,	10	9

A comparison of the above-stated results of our inspection with the results of the previous year shows that the manufacturer's standard or guarantee has been as well maintained as in the past; and in nearly all cases where a discrepancy has occurred between the results of analysis and the manufacturer's guarantee, the commercial value of the article has not suffered, the low percentage of one element of plant food having been balanced by a correspondingly high percentage of some one of the other ingredients.

The fertilizer bulletins become of the utmost value when considered from the stand-point of a source of intelligence to the farmer to select his fertilizer for the next year's consumption.

In deciding what brands of commercial fertilizer to purchase for general use, select the one that will furnish the greatest amount of nitrogen, potash and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1900 and 1901 (Cents per Pound).

	1900.	1901.
Nitrogen in ammonia salts,	17.00	16.50
Nitrogen in nitrates,	13.50	14.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	15.50	16.00
Organic nitrogen in fine bone and tankage,	15.50	16.00
Organic nitrogen in medium bone and tankage,	11.00	12.00
Phosphoric acid soluble in water,	4.50	5.00
Phosphoric acid soluble in ammonium citrate,	4.00	4.50
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values for 1900 and 1901 shows a somewhat higher cost of organic nitrogen and nitrogen in form of nitrates, and a corresponding decrease in the cost of ammonia salts. Phosphoric acid soluble in water was given a half cent higher valuation than in the previous year.

The above trade values are, as in years past, based on the market cost, during the six months preceding March, 1901, of standard raw materials which enter largely into the manufacture of commercial fertilizers found in our markets. The following is a partial list of such materials: —

Sulfate of ammonia.	Dissolved bones.
Azotine.	Acid phosphate.
Cotton-seed meal.	Refuse bone-black.
Linseed meal.	Ground phosphate rock.
Bone and tankage.	High-grade sulfate of potash.
Nitrate of soda.	Sulfate of potash and magnesia.
Dried blood.	Muriate of potash.
Castor pomace.	Kainit.
Dry ground fish.	Sylvinite.
Dry ground meat.	Crude saltpetre.

In order to use the table of trade values in calculating the approximate value of a fertilizer, calculate the value of each of the three essential elements of plant food — nitrogen, phosphoric acid and potassium oxide (including the different forms of each wherever different forms are recognized in the table) — in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Per Cent., or Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per Huudred Pounds.	Value per Ton (Two Thousand Pounds).
Four pounds nitrogen, at 16 cents,	$0 64×20	=$12 80
Eight pounds soluble phosphoric acid, at 5 cents,	40×20	= 8 00
Four pounds reverted phosphoric acid, at 4.5 cents,	18×20	= 3 60
Two pounds insoluble phosphoric acid, at 2 cents,	04×20	= 80
Ten pounds potassium oxide, at 5 cents,	50×20	= 10 00
Value per ton,	. . . . .	$35 20

Table A gives the average analysis of officially collected fertilizers for 1901. Table B gives a compilation of analyses of commercial fertilizers for the year 1901, showing the maximum, minimum and average percentages of the different essential elements of plant food found in special crop fertilizers, so called.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1901.*

Nature of Material.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.94	2.77	2.52	4.72	3.35	2.87	10.94	9.48	8.07	6.30	5.21	4.91
Ground bones,	6.58	2.80	2.28	-	10.54	14.69	25.23	24.21	10.54	7.96	-	-
Tankage,	7.01	4.69	4.18	1.47	7.27	9.72	18.46	17.33	8.74	8.35	-	-
Dry ground fish,	8.74	8.51	8.14	-	4.09	6.73	10.82	9.00	4.09	-	-	-
Dissolved bone-black,	12.01	-	-	12.99	2.96	1.50	17.45	16.33	15.95	15.00	-	-
Acid phosphate,	7.41	-	-	7.30	4.72	1.82	13.84	13.50	12.02	12.00	-	-
Wood ashes,	12.39	-	-	-	-	-	1.62	1.25	-	-	5.70	4.75
Cotton-hull ashes,	2.10	-	-	-	-	-	8.76	8.00	-	-	30.12	20.00
Castor pomace,	7.69	4.98	4.74	-	-	-	-	-	-	-	-	-
Cotton-seed meal,	5.88	6.82	7.00	-	-	-	-	-	-	-	-	-
Dried blood,	8.12	9.77	9.12	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.46	15.75	15.43	-	-	-	-	-	-	-	-	-
Muriate of potash,	1.79	-	-	-	-	-	-	-	-	-	49.39	50.01
Sulfate of potash and magnesia,	4.08	-	-	-	-	-	-	-	-	-	24.70	25.50
High-grade sulfate of potash,	.54	-	-	-	-	-	-	-	-	-	48.64	48.17

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1901.*

Name of Fertilizer.	Analyses.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	17	11.52	5.11	1.00	2.59	14.51	9.62	11.53	9.67	5.40	8.23	9.94	1.72	4.02
Fruit and vine fertilizer,	4	8.11	3.24	2.06	2.38	13.64	8.11	10.89	8.98	4.63	6.76	10.52	5.14	7.40
Grain fertilizer,	13	10.00	9.09	1.19	3.44	17.99	6.17	12.18	11.28	4.74	8.65	13.62	2.16	5.73
Grass fertilizer,	15	8.77	5.47	1.19	3.80	17.99	6.17	10.45	10.75	5.07	7.05	13.62	2.22	5.47
Market-garden fertilizer,	16	10.82	4.85	.97	3.15	13.33	6.17	10.38	10.90	5.07	8.06	11.42	2.33	6.27
Potato fertilizer,	39	11.03	5.44	1.22	2.63	13.74	7.37	10.73	10.80	4.00	8.03	10.00	2.30	5.68
Tobacco fertilizer,	10	8.84	6.36	1.16	4.07	13.25	4.35	9.21	11.41	3.48	7.27	17.70	3.34	8.62

From the great variations in the results of analyses of the above special crop fertilizers (see Table B) it will be readily observed that it will be unsafe to be guided by trade names wholly when selecting fertilizers for the growing of special crops.

Local conditions as to the character of the soil and subsoil, the previous management of the soil and the system of crop rotation employed should all enter into consideration when selecting a fertilizer. A study of the soil should be made, to find in what direction the plant food has become depleted; and when these facts have become established, then supply the wants of the soil in the most suitable and economical manner. When the character of a soil is not known and its wants are not manifested, it is advisable to use a fertilizer more nearly corresponding to what a chemical analysis of the crop shows is required for its proper development.

An example is here inserted for the purpose of illustrating how the chemical composition of a crop may serve as a guide in the compounding of a commercial fertilizer, also to serve as an object lesson of how to intelligently use the compilation of analyses which is a part of the annual report of the chemical department for this year. We will take the average composition of cranberries, as this appears first in our table of compilation of fruits, etc.: —

Average Analysis of Cranberries.

	Parts per Thousand.
Phosphoric acid,	.30
Potassium oxide,	1.00
Nitrogen,	.80

The relative proportion of phosphoric acid, potassium oxide and nitrogen present, according to this analysis, is: —

Phosphoric acid,	1.00
Potassium oxide,	3.33
Nitrogen,	2.66

In other words, for every pound of phosphoric acid removed from the soil by a crop of cranberries, there are 3.33 pounds of potassium oxide and 2.66 pounds of nitrogen removed. A fertilizer supplying the essential elements of plant food in this proportion would, therefore, under the above-stated conditions, be more suitable to use.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1901, to May 1, 1902), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Nitrate of Soda.
- Muriate of Potash.
- High-grade Sulfate of Potash.
- Double Manure Salt.
- Dry Ground Fish.
- Fine-ground Bone.
- Dissolved Bone-black.
- Plain Superphosphate.
- Dry Blood.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Top-dressing.
- Bradley's Grass and Lawn Top-dressing.
- Breck's Lawn and Garden Dressing.
- Brightman's Fish and Potash.
- Church's Fish and Potash.
- Grass and Grain.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.
- Clark's Cove Grass Fertilizer.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's New Rival Phosphate.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Blood, Bone and Potash.
- Potato and Root Crop Manure.
- Complete Ten Per Cent. Manure.
- Potato Manure.
- Farm Favorite.
- Animal Fertilizer.

The American Agricultural Chemical Co. (East India Chemical Works, branch), New York, N. Y.: —
- East India Chemical Works' Complete Potato Manure.
- East India Chemical Works' A. A. Phosphate.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Grass and Oats Fertilizer.
- General Fertilizer.
- Garden Special.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Soluble Pacific Guano.
- Pacific Potato Special.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Grass Fertilizer.
- Quinnipiac Havanna Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Special with Ten Per Cent. Potash.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's Practical Potato Special.
- Read's Bone, Fish and Potash.
- Read's Vegetable and Vine.
- Read's High-grade Farmers' Friend.
- Read's Standard.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker, branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Potato Fertilizer.
- Tucker's Imperial Bone Superphosphate.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.

The American Agricultural Chemical Co. — *Con.*
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Animal Fertilizer.
- Eagle Brand.
- Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

Armour Fertilizer Works, Baltimore, Md.: —
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- Grain Grower.
- All Soluble.
- High-grade Potato.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.

Bartlett & Holmes, Springfield, Mass.: —
- Animal Fertilizer.
- Pnre Ground Bone.
- Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
Stockbridge Special Manures.
Bowker's Hill and Drill Phosphate.
Bowker's Farm and Garden Phosphate.
Bowker's Lawn and Garden Dressing.
Bowker's Potato and Vegetable Fertilizer.
Bowker's Fish and Potash, "Square Brand."
Bowker's Potato Phosphate.
Bowker's Sure Crop Phosphate.
Bowker's Market-garden Manure.
Bowker's High-grade Fertilizer.
Bowker's Bone and Wood Ash Fertilizer.
Bowker's Tobacco Starter.
Bowker's Potash or Staple Phosphate.
Bowker's Ammoniated Dissolved Bone.
Bowker's Superphosphate.
Bowker's Ground Bone.
Gloucester Fish and Potash.
Dissolved Bone-black.
Nitrate of Soda.
Muriate of Potash.
Sulfate of Potash-magnesia.
Sulfate of Potash.
Dried Blood.
Tankage.
Wood Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
Tankage.

E. Frank Coe Co., New York, N. Y.: —
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's Tobacco and Onion Fertilizer.
E. Frank Coe's Bay State Phosphate
E. Frank Coe's F.P. Fish and Potash.
American Farmers' Market-garden Special.
American Farmers' Complete Potato.
American Farmers' Corn King.
Farmers' Grass and Grain Fertilizer.
Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
Dow's Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food
Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Unleached Hard-wood Ashes.

Thomas Hersom & Co., New Bedford, Mass.: —
Meat and Bone.
Ground Bone.

F. E. Hancock, Walkerton, Ontario, Can.: —
Pure Canada Unleached Hard-wood Ashes.

C. W. Hastings, Cambridgeport, Mass.: —
Ferti Flora.

John Joynt, Lucknow, Can.: —
Canada Hard-wood Ashes.

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Success Fertilizer.
Lister's Special Corn and Potato Fertilizer.
Lister's High-grade Special for Spring Crops.
Lister's Animal Bone and Potash.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Potato Phosphate.
Swift's Lowell Market Garden.
Swift's Lowell Tobacco Manure.
Swift's Lowell Potato Manure.
Swift's Lowell Animal Brand.
Swift's Lowell Fruit and Vine.
Swift's Lowell Dissolved Bone and Potash.
Swift's Lowell Ground Bone.
Nitrate of Soda.
Muriate of Potash.
Sulfate of Potash.
Acid Phosphate.
Tankage.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- The Mapes' Bone Manures.
- The Mapes' Superphosphates.
- The Mapes' Special Crop Manures.
- Tobacco Ash Constituents.
- Tobacco Manure, Wrapper Brand.
- Complete Manure with Ten Per Cent. Potash.
- Economical Potato Manure.
- Fruit and Vine Manure.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulfate of Potash.

McQuade Bros., West Auburn, Mass.: —
- Ground Bone.

Mitchell Fertilizer Co., Tremley, N. J.: —
- Mitchell's Special Fertilizer.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Complete Fertilizer.

New England Fertilizer Co., Boston, Mass.: —
- Corn Fertilizer.
- Potato Fertilizer.
- High-grade Truck Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.

Parmenter & Polsey Fertilizer Co. — *Con.*
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.
- Hubbard's Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Corn and General Crops.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Potato Phosphate.
- Hubbard's Corn Phosphate.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Tobacco.
- Fine-ground Bone.

N. Roy & Son, South Attleborough, Mass.: —
- Animal Fertilizer No 1.
- Animal Fertilizer No. 2.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X.X.X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Sanderson Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Special Strawberry.
- Sanderson's Formula A.
- Sanderson's Formula B.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

James P. Trainor, Jamesville, Mass.: —
- Ground Bone.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Boue.

E. J. Whitman, Dracut, Mass.: —
- Whitman's Potato Fertilizer, "Plowman's."
- Whitman's Corn Fertilizer, "Success."
- Whitman's Pure Ground Bone.
- Whitman's Pure Ground Meat.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- Complete Bone Superphosphate.
- Potato Manure.
- Fish and Potash.
- Nitrate of Soda.
- Muriate of Potash.

Sanford Winter, Brockton, Mass.: —
- Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. Analysis of Materials sent on for Examination.

During the season of 1901, 217 samples of fertilizing materials of various description have been received from farmers within our State. The results of our examination of these substances have been published in three bulletins: No. 74, March; No. 75, July; and No. 77, November, 1901, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Next in importance to the analysis of licensed commercial fertilizers for inspection purposes is the examination of waste and by-products from different manufacturing industries. It has been the aim of the chemical division to encourage the use of different refuse and by-products for manurial purposes wherever the chemical analysis of such material proves them to be of sufficient value to merit their use.

The value of our work in this direction may be seen from year to year by the increased number of all kinds of waste products that are being forwarded to this department for investigation. The increased consumption of this class of materials for manurial purposes cannot but exert an important influence in favor of the agriculturalist on the consumption of commercial fertilizers. The examination of general fertilizing material is carried on free of charge to the farmers in the State, the material being taken up for analysis in the order of arrival of samples at this office.

Following is a list of materials received during the past season, which shows the great variety of substances which are used and valued for manurial purposes, as well as the great variety of work necessarily employed to keep in close touch with the critical examination of this class of materials : —

Wood ashes,	72	Sulfate of ammonia,	1
Complete fertilizers,	27	Acid phosphate,	1
Cotton-seed meal,	17	Tennessee phosphate,	1
Soils,	15	Superphosphate,	1
Muriate of potash,	8	Plain superphosphate,	1
Onions,	8	Marl,	1
Muck,	7	Sewage,	1
Nitrate of soda,	6	Lime-kiln ashes,	1
Tankage,	4	Carbonate of lime,	1
Cotton-hull ashes,	4	Waste from gas house,	1
Ground bone,	3	Pulverized sheep manure,	1
Dissolved bone-black,	3	Hair waste,	1
Blood, bone and meat,	2	Jadoo fibre,	1
Ground fish,	2	Tobacco stems,	1
Concentrated phosphate,	2	Tobacco dust,	1
Mud,	2	Walnut ashes,	1
Hen manure,	2	Pine-wood ashes,	1
Barnyard manure,	2	Ashes from soft coal and saw-dust,	1
Wool waste,	2	Linseed meal,	1
Raw bone meal,	1	Sal-ammoniac,	1
Steamed bone meal,	1	Salt,	1
Condensed bone steam,	1	Asparagus tops,	1
Fresh-cut bone,	1	Milk casein,	1
Burned bone,	1		
Fleshings,	1		

Under the division of general work in the chemical laboratory may also be classed investigations along various lines which are constantly being carried on, such as : a study of the physical and chemical conditions of soil, and their relation to the solubility of different substances applied for fertilizing purposes; investigations of the availability of the different elements of plant food in the soil; new and improved methods for the ash analysis of plants; critical examination of methods of analysis of insecticides and fungicides found in our market; ammonia absorption tests, to determine the most efficient chemical to be used as a fixer or absorber of ammonia in manure composting; investigation work for the Association of Official Agricultural Chemists, for the establishment of new and improved methods of analyses of agricultural products, etc. The results of the above-stated investigations will be published later, as in the past, whenever the results prove of general interest to the public.

2. Notes on Wood Ashes.

During the season of 1901, 33.1 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 30.8 per cent. the previous year.

The following table shows the general chemical character of wood ashes that have been forwarded for investigation during the season of 1901: —

Analysis of Wood Ashes.

Constituents.	Number of Samples.	
	1900.	1901.
Moisture below 1 per cent.,	1	2
Moisture from 1 to 10 per cent.,	25	28
Moisture from 10 to 20 per cent.,	32	31
Moisture from 20 to 30 per cent.,	13	7
Moisture above 30 per cent.,	1	-
Potassium oxide above 8 per cent.,	1	4
Potassium oxide from 7 to 8 per cent.,	6	5
Potassium oxide from 6 to 7 per cent.,	12	17
Potassium oxide from 5 to 6 per cent.,	25	24
Potassium oxide from 4 to 5 per cent.,	14	10
Potassium oxide from 3 to 4 per cent.,	7	7
Potassium oxide below 3 per cent.,	7	1
Phosphoric acid above 2 per cent.,	6	5
Phosphoric acid from 1 to 2 per cent.,	62	61
Phosphoric acid below 1 per cent.,	4	2
Average per cent. of calcium oxide (lime),	32.51	33.20
Per cent. of mineral matter insoluble in diluted hydrochloric acid: —		
Below 10 per cent.,	15	22
Between 10 and 15 per cent.,	35	24
Between 15 and 20 per cent.,	12	17
Above 20 per cent.,	11	4

From a comparison of the above-stated results of analyses of wood ashes with the results of the previous year, it will be seen that the average standard of composition is somewhat higher than in 1900.

To assist our farmers in selecting the best quality of wood ashes which the market affords, it is imperative that those sending samples for analysis should give us all the general information they possess in regard to the source from which the ashes were obtained, etc. With this idea in view, we caused to be published in our March bulletin, No. 74, a copy of a blank application for free analysis of fertilizing materials, which will hereafter be sent from this office to every applicant for an analysis free of charge. We believe the result of this course will be to impart a more general and intelligent interest in this department of work at the institution, and it will surely make known the names of the licensed as well as the unlicensed dealers in our State. We take this occasion to urge the farmers to patronize the dealers who are on record at our institution, as having complied with our State laws for the regulation of the trade in commercial fertilizers, which includes wood ashes, which are sold in our State for manurial purposes, rather than those who have failed to secure such a license.

In deciding the commercial value of wood ashes, it is well to consider the large quantity of calcium oxide (lime) that is present in a most superior form.

Part III. — Compilation of Analyses of Agricultural Chemicals, Refuse Salts, Ashes, Lime Compounds, Refuse Substances, Guanos, Phosphates and Animal Excrements.

H. D. HASKINS.

1. Chemicals, refuse salts, etc.
2. Ashes, marls, lime compounds, etc.
3. Refuse substances.
4. Guanos, phosphates, etc.
5. Animal excrements, etc.
6. Average per cents. of the different ingredients found in the preceding compilation of analyses, calculated to pounds per ton of 2,000 pounds.

1868 to 1901.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1895, contained in the reports of the secretary of the Massachusetts State Board of Agriculture for these years, and in the bulletins of the department of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

No valuation is stated in this compilation, as the basis of valuation changes from year to year.

In the following compilation of agricultural chemicals, refuse materials, manurial substances, etc., the signification of the star (*) prefixed to the name of the substance is that the compilation is made up of analyses subsequent to the year 1897. It was believed that a compilation made up of more recent analyses would more nearly represent the present general chemical character of the substances, and would therefore be of more practical value.

It must be understood that the chemical character of many of the refuse substances used for manurial purposes is constantly undergoing changes, due to frequent variations in the parent industry.

As a rule, in all succeeding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

1. *Chemicals, Refuse Salts, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Carbonate of potash,	1	26.88	-	-	-	-	-	-	18.48	-	-	-	-	-	-	-	-	19.52	-	-	-	-	.39
Carnalite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	-	.56	-	41.56	-
* Kainit,	5	1.85	-	-	-	-	13.65	10.90	12.74	-	-	-	-	-	-	18.97	2.37	6.37	-	20.25	-	20.64	2.13
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	-	31.94	-	6.63	14.96
* Muriate of potash,	40	1.41	-	-	-	-	54.80	45.40	49.91	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Nitrate of potash,	4	1.30	-	14.58	11.60	12.71	45.62	44.76	45.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	41	1.36	-	16.42	14.14	15.50	-	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50
Nitre salt cake,	2	6.03	-	-	-	2.29	-	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92
Phosphate of potash,	1	3.76	-	-	-	-	-	-	32.55	-	-	37.50	-	37.50	-	-	-	-	-	13.43	-	-	.92
Phosphate of ammonia,	1	6.05	-	-	-	10.37	-	-	-	-	-	43.86	-	-	-	-	-	-	-	12.46	-	-	.82
* Potash refuse from manufacture of cyanide of potash.	1	39.23	-	-	-	.96	-	-	7.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	13	1.10	-	21.44	19.44	20.65	-	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-
* Sulfate of potash,	20	.89	-	-	-	-	53.15	45.70	49.51	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
* Sulfate of potash-magnesia,	13	4.83	-	-	-	-	31.45	19.55	24.91	-	-	-	-	-	-	6.25	2.57	-	-	44.25	-	2.60	1.41
* Silicate of potash,	2	2.07	-	-	-	-	27.62	21.48	24.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Sulfate of magnesia, ...	10	23.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.40	-	36.10	-	-	5.73
* Sulfate of soda, ...	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste, ...	12	2.54	-	3.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-

2. *Ashes, Marls, Lime Compounds, etc.*

Ashes of spent tan bark, ...	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Ashes from cremation of swill, . .	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works, ...	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
* Ashes from cremation of garbage, .	3	3.01	-	-	-	-	6.01	3.72	5.13	10.21	7.16	8.77	-	-	-	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42
* Ashes from hay and straw, . . .	1	.40	-	-	-	-	-	-	1.55	-	-	1.02	-	-	-	-	5.22	-	-	-	-	-	66.35
* Ashes from jute waste, ...	1	.19	-	-	-	-	-	-	.51	-	-	.54	-	-	-	3.84	6.04	.39	7.60	-	-	.57	81.02
* Ashes from peach tree trimmings, .	1	.54	-	-	-	-	-	-	4.92	-	-	2.44	-	-	-	7.53	18.74	-	10.50	2.20	-	-	13.54
Ammoniated marl, ...	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
* Bleachery refuse, ...	2	4.19	-	-	-	-	1.24	.35	.79	-	-	-	-	-	-	11.69	35.79	-	-	-	-	-	23.09
Bituminous coal ashes, ...	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	-	1.88	-	-	-	-	-	74.17
* Brick yard ashes, ...	1	.40	-	-	-	-	-	-	3.59	-	-	1.61	-	-	-	-	23.44	-	-	-	-	-	53.32
* Cotton-seed hull ashes, ...	21	7.97	-	-	-	-	32.80	15.20	23.93	11.00	6.26	8.70	-	6.88	1.28	-	7.20	12.64	-	-	-	-	18.30
Corn-cob ashes, ...	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
* Carbonate of lime, ...	1	.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.98	-	-	-	-	-	-
Gypse, ...	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
* Gas house lime, ...	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05

2. *Ashes, Marls, Lime Compounds, etc.* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
* Lime refuse from soda factory,	1	24.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.86	-	1.36	23.14	-	-	1.63
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
* Lime-kiln ashes,	8	10.83	-	-	-	-	4.73	.43	2.09	1.56	.26	.76	-	-	-	-	38.86	1.30	-	-	-	-	5.68
* Leather scrap ashes,	1	.70	-	-	-	-	-	-	3.36	-	-	3.96	-	-	-	-	2.56	-	-	-	-	-	40.00
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Magnolia ashes (Florida),	1	1.58	-	-	-	-	-	-	2.56	-	-	.45	-	-	-	-	-	-	-	-	-	-	6.12
Massachusetts marls,	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marl (North Carolina),	1	.70	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
* Nova Scotia plaster (gypsum),	17	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.74	.75	-	44.87	-	-	5.79
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
* Picker waste ashes,	1	.28	-	-	-	-	-	-	6.56	-	-	1.18	-	-	-	-	-	-	-	-	-	-	63.43

Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Railroad tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
* Wood ashes,	340	11.17	-	-	-	-	8.86	1.12	5.63	2.82	.06	1.32	-	-	-	-	34.54	3.31	7.43	-	-	-	18.28
* Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Virginia marls,	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23

3. Refuse Substances.

Ammoniate,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
* Blood and bone,	5	5.97	-	7.19	5.70	6.23	-	-	-	12.86	11.38	12.14	-	4.41	7.73	-	-	-	-	-	-	-	-
Bone soup,	1	82.92	7.07	-	-	1.14	-	-	-	-	-	1.26	-	-	-	-	-	-	-	-	-	-	-
* Bone from fish,	1	8.78	-	-	-	4.82	-	-	-	-	-	23.54	-	8.04	15.50	-	-	-	-	-	-	-	-
* Broom-corn seed,	1	7.40	-	-	-	1.51	-	-	.50	-	-	.57	-	-	-	-	-	-	-	-	-	-	-
* Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia Majasculas*),	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
* Concentrated wool washings,	1	41.13	-	-	-	1.09	-	-	10.15	-	-	.10	-	-	-	-	-	-	-	-	-	-	-
* Condensed bone steam,	1	81.75	-	-	-	1.94	-	-	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-
* Castor-bean pomace,	3	7.87	5.70	5.85	4.98	5.47	3.40	.64	1.20	2.26	1.57	2.12	-	-	-	-	.87	.29	-	-	-	-	1.75
* Cotton-seed meal,	67	6.88	-	7.99	3.24	7.04	1.92	1.41	1.64	3.30	1.71	2.56	-	-	-	-	-	-	-	-	-	-	.28
* Cork dust,	1	.74	-	-	-	.59	-	-	.33	-	-	.10	-	-	-	-	.74	.08	-	-	-	-	.24
* Cotton waste, wet,	3	26.35	-	1.21	.84	1.08	.61	.43	.53	.74	.69	.75	-	-	-	-	2.12	-	-	-	-	-	41.90

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Cotton waste, dry,	7	6.45	-	1.60	.91	1.20	1.40	.88	1.21	.66	.17	.39	-	-	-	-	1.12	-	-	-	-	-	20.78
Cotton dust,	2	32.68	50.93	-	-	.78	-	-	.45	-	-	.32	-	-	-	-	-	-	-	-	-	-	42.22
* Dried blood,	22	9.01	6.37	13.55	8.10	9.84	-	-	-	8.70	1.30	2.07	-	-	-	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
* Dry ground fish,	21	9.07	-	10.48	7.44	8.56	-	-	-	16.07	5.70	8.98	-	4.21	4.73	-	-	-	-	-	-	-	-
* Damaged grain,	3	42.15	-	1.97	.84	1.44	.43	.16	.28	.83	.35	.55	-	-	-	-	-	-	-	-	-	-	-
* Deposit from Charles River,	1	21.46	-	-	-	.95	-	-	.59	-	-	.74	-	-	-	-	1.81	-	-	-	-	-	44.27
* Dredgings from Cape Cod,	1	18.99	-	-	-	.99	-	-	.13	-	-	.07	-	-	-	-	-	-	2.06	-	-	.54	-
* Deposit from pond,	1	4.01	-	-	-	.41	-	-	.26	-	-	.32	-	-	-	-	.62	-	-	-	-	-	-
Eel grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Fleshings,	1	6.96	43.14	-	-	7.55	-	-	-	-	-	.31	-	-	-	-	-	-	-	-	-	-	-
* Fresh-cut bone,	1	24.98	-	-	-	3.00	-	-	-	-	-	16.85	-	5.26	11.59	-	-	-	-	-	-	-	-
Fish with 20 to 40 per cent. water,	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than 40 per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35

Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
* Ground tobacco stems,	8	8.84	20.20	2.72	.99	2.02	8.18	3.88	6.15	1.15	.32	.62	-	-	-	-	6.75	-	-	-	-	-	1.30
* Ground bones,	135	5.51	66.14	4.99	1.17	3.10	-	-	-	31.42	16.18	24.30	-	7.55	16.73	-	-	-	-	-	-	-	1.08
Glucose refuse,	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-
* Hoof meal,	1	4.10	-	-	-	15.19	-	-	-	-	-	.77	-	-	-	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	3	10.17	7.63	15.49	11.84	13.25	-	-	-	2.30	1.36	1.83	-	-	-	-	-	-	-	-	-	-	.24
* Hair waste,	1	6.52	22.77	-	-	9.22	-	-	.14	-	-	.51	-	-	-	4.10	-	-	-	-	-	-	-
* Hop refuse,	2	84.56	1.71	.69	.49	.59	.06	.05	.05	.11	.10	.10	-	-	-	-	-	-	-	-	-	-	.83
Ivory dust,	1	11.50	52.63	-	-	6.64	-	-	-	-	-	24.56	.97	17.97	5.62	-	-	-	-	-	-	-	-
* Jadoo fibre,	1	11.53	11.60	-	-	.97	-	-	.48	-	-	1.24	-	-	-	-	3.50	-	-	-	-	-	4.05
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
* Kiln dust from brewery,	1	9.72	-	-	-	4.32	-	-	2.16	-	-	.96	-	-	-	-	.78	-	-	-	-	-	7.11
* Linseed meal,	3	8.23	-	6.42	5.26	5.69	1.58	1.46	1.52	1.59	1.36	1.47	-	-	-	-	-	-	-	-	-	-	.58
Lobster shells,	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
* Meat meal,	1	3.22	8.55	-	-	9.23	-	-	-	-	-	3.08	-	-	-	-	-	-	-	-	-	-	-
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	-	-	-	3.58	.56	2.07	-	-	-	-	-	-	-	-	-	-	.58
Meat scrap,	2	24.79	-	-	-	6.33	-	-	-	-	-	5.79	-	-	-	-	-	-	-	-	-	-	-
Morocco factory waste,	1	22.72	-	-	-	1.16	-	-	.36	-	-	2.56	-	-	-	-	19.60	-	-	1.24	-	-	24.17
* Meat and bone,	6	5.66	-	7.15	4.66	5.30	-	-	-	18.83	14.71	17.15	-	5.61	11.54	-	-	-	-	-	-	-	-
Mill sweepings,	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Mussel mud, wet,	1	60.01	27.29	-	-	.21	-	-	6.17	-	-	.10	-	-	-	.70	.93	.14	3.48	-	-	-	-
Mussel mud, dry,	1	2.24	72.02	-	-	.72	-	-	-	-	-	.35	-	-	-	-	23.39	-	8.26	-	-	-	37.60
* Muck and peat, wet,	13	64.49	13.36	1.11	.13	.55	.16	.02	.07	.13	.02	.08	-	-	-	-	.51	-	-	-	-	-	-
* Muck and peat, dry,	8	6.67	69.54	2.10	.26	.84	-	-	-	-	-	.31	-	-	-	-	.77	-	-	-	-	-	-
Oleomargarine refuse,	1	8.54	14.42	-	-	12.12	-	-	-	-	-	.88	-	-	-	-	-	-	-	-	-	-	.96
* Product from garbage plant,	1	4.14	-	-	-	2.56	-	-	.50	-	-	6.92	-	-	-	-	-	-	-	-	-	-	16.48
Pine barren grass,	1	8.48	2.40	-	-	.16	-	-	.07	-	-	.18	-	-	-	-	-	-	-	-	-	-	1.67
Pine needles,	1	9.48	3.42	-	-	.46	-	-	.03	-	-	.12	-	-	-	-	-	-	-	-	-	-	1.22
Raw wool,	1	6.95	7.54	-	-	12.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.63
Rotten brewers' grain,	1	78.77	-	-	-	.72	-	-	.04	-	-	.43	-	-	-	-	.26	.15	-	-	-	-	.59
Refuse from calico works,	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-
* Refuse from glucose factory,	1	.13	-	-	-	-	-	-	-	-	-	42.76	-	2.88	39.88	-	38.78	-	2.92	3.00	-	-	-
* Refuse from glass factory,	1	16.48	-	-	-	-	-	-	19.50	-	-	-	-	-	-	6.12	-	-	-	-	-	-	-
Rockweed, green,	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	1	10.68	35.75	-	-	1.45	-	-	4.89	-	-	2.75	-	-	-	7.90	7.66	.21	-	-	-	-	10.40
Residue from water filter,	1	94.22	-	-	-	.12	-	-	-	-	-	.05	-	-	-	-	-	-	-	-	-	-	-

Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
* Sizing paste,	1	61.45	5.58	-	-	1.13	-	-	-	-	-	.02	-	-	-	-	-	-	-	-	-	-	-
* Sizing waste,	1	74.00	-	-	-	.01	-	-	40	-	-	.01	-	-	-	-	-	-	-	-	-	-	1.43
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	-	-	-	15.37	11.04	13.21	-	-	-	-	-	-	-	-	-	-	1.29
Soup from horse rendering,	1	92.14	-	-	-	1.12	-	-	-	-	-	.14	-	-	-	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1	73.10	-	-	-	1.23	-	-	.07	-	-	.33	-	-	-	-	-	-	-	-	-	-	-
* Spent bone-black,	1	1.16	-	-	-	-	-	-	-	-	-	31.02	-	1.96	29.06	-	-	-	-	-	-	-	-
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks.	4	37.74	-	1.31	.46	.91	.66	.07	.25	.86	.39	.61	-	-	-	-	3.10	2.19	8.55	.41	4.86	-	28.70
* Sewage,	2	78.07	-	.77	.30	.40	-	-	.27	-	-	.85	-	-	-	-	-	-	-	-	-	.03	20.06
Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
* Soot,	2	8.60	-	-	-	.77	1.57	.17	.87	.72	.23	.47	-	-	-	-	2.92	1.19	6.38	-	-	-	71.07
* Tankage,	40	7.03	-	9.02	4.11	5.95	-	-	-	21.62	5.65	14.46	-	6.21	8.02	-	-	-	-	-	-	-	-
* Tobacco dust,	4	6.08	-	2.25	1.75	2.06	6.81	2.07	4.33	1.28	.36	.72	-	-	-	-	3.09	-	-	-	-	-	16.59
Tobacco leaves,	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
* Tobacco stalks exposed to the action of weather.	1	7.58	-	-	-	1.18	-	-	.52	-	-	.38	-	-	-	-	-	-	-	-	-	-	1.86
* Teopik fibre,	1	56.54	-	-	-	.53	-	-	1.26	-	-	.55	-	-	-	-	5.15	-	-	-	-	-	.75
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	1	29.00	-	-	-	1.06	-	-	-	-	-	3.51	-	2.94	.51	-	-	-	-	-	-	-	-
* Wool waste,	4	6.03	20.10	4.60	.39	2.63	3.74	.29	1.65	1.02	.27	.80	-	-	-	-	2.03	.06	.80	-	-	-	30.69
Wool washings, water,	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	.49	.28	-	-	-	-	-	-

3. *Refuse Substances* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Wool washings, acid,	1	-	-	-	-	-	-	-	4.20	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	-
Wool washings, alkaline,	1	92.03	3.28	-	-	.09	-	-	1.09	-	-	-	-	-	-	.92	.04	-	-	-	-	-	.22
Whale meat, raw,	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
* Whalebone scrapings,	1	6.90	-	-	-	13.01	-	-	-	-	-	.26	-	-	-	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1	99.47	.16	-	-	.004	-	-	.03	-	-	.022	-	-	-	-	.025	-	-	-	-	-	-
4. *Guanos, Phosphates, etc.*																							
* Acid phosphate,	18	11.86	-	-	-	-	-	-	-	17.48	11.60	15.52	9.64	3.74	2.13	-	-	-	-	-	-	-	-
* Apatite,	2	.07	-	-	-	-	-	-	-	37.74	32.62	35.18	-	2.09	33.09	-	-	-	-	-	-	-	-
* Bone ash,	1	.34	-	-	-	-	-	-	-	-	-	39.14	-	-	-	-	-	-	-	-	-	-	-
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00

Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
* Bat guano from Havana, Cuba,	1	6.95	-	-	-	6.96	-	-	.53	-	-	5.04	-	-	-	6.17	10.89	-	5.76	-	-	-	.40
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
* Dissolved bone-black,	18	11.97	-	-	-	-	-	-	-	20.93	15.60	17.66	14.04	2.94	.76	-	-	-	-	-	-	-	-
* Double superphosphate,	2	6.27	-	-	-	-	-	-	-	50.14	45.42	47.78	18.36	20.97	8.45	-	-	-	-	-	-	-	-
* Dissolved bone meal,	7	5.73	-	4.64	1.66	2.56	-	-	-	22.26	15.04	17.93	3.95	8.72	5.26	-	-	-	-	-	-	-	-
* Damaraland guano,	1	17.70	-	-	-	5.79	-	-	3.53	-	-	14.78	4.90	5.79	4.09	7.03	14.21	2.05	-	5.94	-	5.77	9.26
* Florida rock phosphate,	2	.53	-	-	-	-	-	-	-	40.34	33.10	36.72	-	.10	36.62	-	-	-	-	-	-	-	-
* Florida soft phosphate,	1	4.46	-	-	-	-	-	-	-	-	-	26.48	-	.38	26.10	-	-	-	-	-	-	-	-
* Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45
* Novassa phosphate,	1	5.77	-	-	-	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-	-
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
* Phosphatic slag,	2	.95	-	-	-	-	-	-	-	19.80	15.70	17.75	-	6.04	13.76	-	39.24	-	-	-	-	-	9.91
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
* South Carolina rock phosphate,	3	.88	-	-	-	-	-	-	-	31.87	25.58	27.98	-	2.63	23.41	-	-	-	-	-	-	-	-
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
* Tennessee phosphate,	1	.37	-	-	-	-	-	-	.44	-	-	33.00	-	-	-	-	-	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-

5. *Animal Excrement, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Barnyard manure,	25	71.82	-	.69	.24	.44	.88	.26	.59	.52	.13	.34	-	-	-	-	-	-	-	-	-	-	6.95
* Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
* Hen manure,	3	34.66	-	1.83	.42	1.18	2.96	.43	1.62	3.93	.63	1.92	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
* Sheep manure,	4	9.58	17.14	2.97	.85	2.12	3.16	.68	2.03	2.24	.22	1.45	-	-	-	-	-	-	-	-	-	-	33.75

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.*

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc.													
Carbonate of potash,	538	-	-	370	-	-	-	390	-	-	-	-	8
Carnalite,	-	-	-	274	-	153	-	264	-	11	-	831	-
* Kainit,	37	-	-	255	-	379	47	127	-	405	-	413	43
Krugite,	96	-	-	168	-	105	249	176	-	639	-	133	299
* Muriate of potash,	28	-	-	998	-	134	-	11	-	-	-	976	14
Nitrate of potash,	26	-	254	905	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	27	-	310	-	-	710	-	-	-	-	-	10	10
Nitre salt cake,	121	-	46	17	-	591	-	-	-	955	-	-	78
Phosphate of potash,	75	-	-	651	750	-	-	-	-	269	-	-	18
Phosphate of ammonia,	121	-	207	-	877	-	-	-	-	249	-	-	16
* Potash refuse from manufacture of cyanide of potash,	785	-	19	147	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	22	-	413	-	-	-	-	-	-	1,200	-	-	-
* Sulfate of potash,	18	-	-	990	-	89	-	30	-	914	-	-	15

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. *Chemicals, Refuse Salts, etc.* — Con.													
* Sulfate of potash-magnesium,	97	-	-	498	-	125	51	-	-	885	-	52	28
* Silicate of potash,	41	-	-	491	-	-	-	-	-	-	-	-	-
* Sulfate of magnesia,	475	-	-	-	-	-	56	348	-	722	-	-	115
* Sulfate of soda,	28	-	-	-	-	-	-	-	-	1,189	-	-	-
Saltpetre waste,	51	-	44	273	-	741	15	4	-	37	-	925	-
2. *Ashes, Marls, Lime Compounds, etc.*													
Ashes of spent tan bark,	97	-	-	36	27	-	622	68	36	-	-	-	504
Ashes from cremation of swill,	97	-	-	79	283	-	672	37	93	-	-	-	431
Ashes from blue works,	243	1,276	-	180	-	-	-	-	-	-	-	-	246
* Ashes from cremation of garbage,	60	-	-	103	175	313	404	23	184	91	217	95	568
* Ashes from hay and straw,	8	-	-	31	20	-	104	-	-	-	-	-	1,327
* Ashes from jute waste,	4	-	-	10	11	77	121	8	152	-	-	11	1,620
* Ashes from peach tree trimmings,	11	-	-	98	49	151	375	-	210	44	-	-	271
Ammonlated marl,	66	-	32	-	208	-	-	-	-	-	-	-	-

* Bleachery refuse,	84	-	-	16	-	234	716	-	-	-	-	-	462
Bituminous coal ashes,	73	-	-	8	9	-	38	-	-	-	-	-	1,483
* Brick yard ashes,	8	-	-	72	32	-	469	-	-	-	-	-	1,066
* Cotton-seed hull ashes,	159	-	-	479	174	-	144	253	-	-	-	-	366
Corn-cob ashes,	24	-	-	142	47	-	234	-	26	-	-	-	1,042
* Carbonate of lime,	9	-	-	-	-	-	1,060	-	-	-	-	-	-
Gypse,	33	-	-	-	-	-	1,017	-	-	-	-	-	57
* Gas house lime,	446	-	-	-	-	-	873	166	-	415	-	-	121
Green sand marl (Virginia),	25	-	-	23	187	-	516	-	103	-	-	-	826
Hard-pine wood ashes,	15	-	-	203	45	-	499	-	-	-	-	-	598
* Lime refuse from soda factory,	481	-	-	-	-	-	297	-	27	463	-	-	33
Lime waste from sugar factory,	726	-	-	4	45	-	550	-	-	-	-	-	6
Lime,	-	-	-	-	-	-	1,873	-	-	-	-	-	27
* Lime-kiln ashes,	217	-	-	42	15	-	777	26	-	-	-	-	114
* Leather scrap ashes,	14	-	-	67	79	-	51	-	-	-	-	-	800
Logwood ashes,	30	-	-	2	46	-	78	-	-	-	-	-	194
Mill ashes,	11	-	-	32	9	-	699	27	-	-	-	-	727
Magnolia ashes (Florida),	32	-	-	51	9	-	-	-	-	-	-	-	122
Massachusetts marls,	274	-	-	5	21	-	810	13	14	-	571	-	69
Marl (North Carolina),	14	-	-	1	11	-	439	12	-	-	-	-	1,004
* Nova Scotia plaster (gypsum),	129	-	-	-	-	-	675	15	-	897	-	-	116
Olive earth (Virginia),	39	-	-	5	275	-	383	-	120	-	-	-	1,011

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. *Ashes, Marls, Lime Compounds, etc.* — Con.													
Onondaga plaster (New York gypsum),	265	-	-	-	-	-	600	93	-	650	164	-	197
* Picker waste ashes,	6	-	-	131	24	-	-	-	-	-	-	-	1,269
Peat ashes,	93	-	-	9	2	-	46	33	123	-	-	-	903
Railroad tie ashes,	94	-	-	18	11	-	50	-	-	-	-	-	1,604
Sea-weed ashes,	29	-	-	18	6	175	121	87	-	60	-	132	1,273
* Wood ashes,	223	-	-	113	26	-	691	66	149	-	-	-	366
* Waste lime,	16	-	-	-	-	-	1,482	-	-	-	-	-	8
Virginia marls,	320	-	-	10	2	-	145	4	-	13	145	-	1,285
3. *Refuse Substances.*													
Ammoniate,	118	-	227	-	69	-	-	-	-	-	-	-	28
* Blood and bone,	119	-	125	-	243	-	-	-	-	-	-	-	-
Bone soup,	1,658	141	23	-	25	-	-	-	-	-	-	-	-
* Bone from fish,	176	-	96	-	471	-	-	-	-	-	-	-	-
* Broom-corn seed,	148	-	30	10	11	-	-	-	-	-	-	-	-

* Banana skins,	280	-	5	109	36	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*),	325	-	85	16	4	71	41	24	-	-	-	-	111
* Concentrated wool washings,	823	-	22	203	2	-	-	-	-	-	-	-	-
* Condensed bone steam,	1,635	-	39	-	1	-	-	-	-	-	-	-	-
* Castor bean pomace,	157	114	109	24	42	-	17	6	-	-	-	-	35
* Cotton-seed meal,	138	-	141	33	51	-	-	-	-	-	-	-	6
* Cork dust,	15	-	12	7	2	-	15	2	-	-	-	-	5
* Cotton waste, wet,	527	-	22	11	15	-	42	-	-	-	-	-	838
* Cotton waste, dry,	129	-	24	24	8	-	22	-	-	-	-	-	416
Cotton dust,	654	1,019	16	9	6	-	-	-	-	-	-	-	844
* Dried blood,	180	127	197	-	41	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296	168	199	-	11	-	-	-	-	-	-	-	13
Dried soup from rendering cattle feet,	216	150	289	-	9	-	-	-	-	-	-	-	5
* Dry ground fish,	181	-	171	-	180	-	-	-	-	-	-	-	-
* Damaged grain,	843	-	29	6	11	-	-	-	-	-	-	-	-
* Deposit from Charles River,	429	-	19	12	15	-	36	-	-	-	-	-	885
* Dredgings from Cape Cod,	380	-	20	3	1	-	-	-	41	-	-	11	-
* Deposit from pond,	80	-	8	5	6	-	12	-	-	-	-	-	-
Eel grass,	708	312	17	18	6	33	43	2	-	-	-	-	21
Felt refuse,	585	671	105	-	-	-	-	-	-	-	-	-	-
* Fleshings,	139	863	151	-	6	-	-	-	-	-	-	-	-
* Fresh-cut bone,	500	-	60	-	337	-	-	-	-	-	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
Fish with 20 to 40 per cent. water,	604	412	119	-	142	-	-	-	-	-	-	-	34
Fish with more than 40 per cent. water,	909	310	99	-	112	-	-	-	-	-	-	-	27
Fresh-water mud,	807	-	27	4	5	-	25	6	36	-	-	-	365
* Ground tobacco stems,	177	404	40	123	12	-	135	-	-	-	-	-	26
* Ground bones,	110	1,323	62	-	486	-	-	-	-	-	-	-	22
Glucose refuse,	162	-	52	3	6	-	4	4	-	-	-	-	1
Horn shavings,	97	-	306	-	8	-	-	-	-	-	-	-	-
* Hoof meal,	82	-	304	-	15	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	203	153	265	-	37	-	-	-	-	-	-	-	5
* Hair waste,	130	455	184	3	10	82	-	-	-	-	-	-	-
* Hop refuse,	1,691	34	12	1	2	-	-	-	-	-	-	-	17
Ivory dust,	230	1,053	133	-	491	-	-	-	-	-	-	-	-
* Jadoo fibre,	231	232	19	10	25	-	70	-	-	-	-	-	81
Jute waste,	262	-	30	2	14	-	-	-	-	-	-	-	-

* Kiln dust from brewery,	194	-	86	43	19	-	16	-	-	-	-	-	142
* Linseed meal,	165	-	114	30	29	-	-	-	-	-	-	-	12
Lobster shells,	145	-	90	-	70	-	445	26	-	-	-	-	5
* Meat meal,	64	171	185	-	62	-	-	-	-	-	-	-	-
Meat mass,	242	272	209	-	41	-	-	-	-	-	-	-	12
Meat scrap,	496	-	127	-	116	-	-	-	-	-	-	-	-
Morocco factory waste,	454	-	23	7	51	-	392	-	-	25	-	-	483
* Meat and bone,	113	-	106	-	343	-	-	-	-	-	-	-	-
Mill sweepings,	190	-	75	13	24	-	-	-	-	-	-	-	100
Madder,	239	-	18	48	7	-	79	10	-	-	-	-	93
Mussel mud, wet,	1,200	546	4	123	2	14	19	3	70	-	-	-	-
Mussel mud, dry,	45	1,440	14	-	7	-	468	-	165	-	-	-	752
* Muck and peat, wet,	1,290	267	11	1	2	-	10	-	-	-	-	-	-
* Muck and peat, dry,	133	1,391	17	-	6	-	15	-	-	-	-	-	-
Oleomargarine refuse,	171	288	242	-	18	-	-	-	-	-	-	-	19
* Product from garbage plant,	83	51	-	10	138	-	-	-	-	-	-	-	330
Pine barren grass,	170	48	3	1	4	-	-	-	-	-	-	-	33
Pine needles,	190	68	9	1	2	-	-	-	-	-	-	-	24
Raw wool,	139	151	258	-	-	-	-	-	-	-	-	-	73
Rotten brewers' grain,	1,575	-	14	1	9	-	5	3	-	-	-	-	12
Refuse from calico works,	81	-	86	-	239	-	-	-	-	-	-	-	-
* Refuse from glucose factory,	3	-	-	-	855	-	776	-	58	60	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Refuse from glass factory,	330	-	-	390	-	122	-	-	-	-	-	-	-
Rockweed, green,	1,370	474	12	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214	715	29	98	55	148	153	4	-	-	-	-	208
Residue from water filter,	1,884	-	2	-	1	-	-	-	-	-	-	-	-
Sponge refuse,	145	-	49	-	64	-	79	25	-	-	-	-	781
* Sizing paste,	1,229	112	23	-	.4	-	-	-	-	-	-	-	-
* Sizing waste,	1,480	-	.2	8	.2	-	-	-	-	-	-	-	29
Soap-grease refuse,	585	1,028	22	-	3	-	-	-	-	-	-	-	26
Soup from horse rendering,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent bone-black,	23	-	-	-	620	-	-	-	-	-	-	-	-
Sumac waste,	1,261	136	24	65	-	-	23	65	-	-	-	-	45
Starch waste from rubber factory,	200	5	.4	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks,	755	-	18	5	12	-	62	44	171	8	97	-	574

* Sewage,	1,561	-	8	5	17	-	-	-	-	-	-	1	401
Salt mud,	1,067	824	8	7	-	19	18	7	83	-	-	-	698
* Soot,	172	-	15	17	9	-	58	24	128	-	-	-	1,421
* Tankage,	141	-	119	-	289	-	-	-	-	-	-	-	-
* Tobacco dust,	122	-	41	87	14	-	62	-	-	-	-	-	332
Tobacco leaves,	261	420	55	145	9	-	83	43	6	-	-	-	83
* Tobacco stalks exposed to action of weather,	152	-	24	10	8	-	-	-	-	-	-	-	37
* Teopik fibre,	1,131	-	11	25	11	-	103	-	-	-	-	-	15
Turf,	386	127	39	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	580	-	21	-	70	-	-	-	-	-	-	-	-
* Wool waste,	121	402	53	33	16	-	41	1	16	-	-	-	614
Wool washings, water,	-	-	-	78	-	10	6	-	-	-	-	-	-
Wool washings, acid,	-	-	-	84	-	8	12	4	-	-	-	-	-
Wool washings, alkaline,	1,841	66	2	22	-	18	1	-	-	-	-	-	4
Whale meat, raw,	890	21	97	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	682	-	14	-	13	-	452	-	-	-	-	-	138
* Whale bone scrapings,	14	-	260	-	5	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1,989	3	.08	.6	.44	-	.5	-	-	-	-	-	-
4. Guanos, Phosphates, etc.													
* Acid phosphate,	237	-	-	-	310	-	-	-	-	-	-	-	-
* Apatite,	1	-	-	-	704	-	-	-	-	-	-	-	-
* Bone ash,	7	-	-	-	783	-	-	-	-	-	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Concluded.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
4. *Guanos, Phosphates, etc.* — Con.													
Bone-black,	92	-	-	-	566	-	-	-	-	-	-	-	73
Brockville phosphate,	50	-	-	-	704	-	-	-	-	-	-	-	129
Bat guano from Texas,	802	365	129	26	75	-	-	-	-	-	-	-	40
Bat guano from Florida,	313	-	195	35	67	-	-	-	-	-	-	-	387
* Bat guano from Havana, Cuba,	139	-	139	11	101	123	218	-	115	-	-	-	8
Cuban guano,	485	-	33	-	267	-	-	-	-	-	-	-	63
Caribbean guano (orchilla),	146	-	-	-	535	-	799	66	-	54	-	-	25
* Dissolved bone-black,	239	-	-	-	353	-	-	-	-	-	-	-	-
* Double superphosphate,	125	-	-	-	956	-	-	-	-	-	-	-	-
* Dissolved bone meal,	115	-	51	-	359	-	-	-	-	-	-	-	-
* Damaraland guano,	354	-	116	71	296	141	284	41	-	119	-	115	185
* Florida rock phosphate,	11	-	-	-	734	-	-	-	-	-	-	-	-
* Florida soft phosphate,	89	-	-	-	530	-	-	-	-	-	-	-	-
* Mona Island guano,	266	-	15	-	438	-	750	-	-	-	-	-	49

* Novassa phosphate,	115	-	-	-	491	-	-	-	-	-	-	-	-
Odorless phosphate,	60	-	-	8	391	-	1,028	-	-	-	50	-	183
* Phosphatic slag,	19	-	-	-	355	-	785	-	-	-	-	-	198
Peruvian guano,	296	752	157	52	305	-	-	-	-	-	-	-	132
Rat guano from Florida,	206	-	66	137	46	-	-	-	-	-	-	-	23
* South Carolina rock phosphate,	18	-	-	-	560	-	-	-	-	-	-	-	-
South Carolina floats,	17	-	-	-	468	-	-	-	-	-	-	-	403
South American bone ash,	140	-	-	-	718	-	898	-	-	-	-	-	90
* Tennessee phosphate,	7	-	-	9	660	-	-	-	-	-	-	-	-
Upton phosphate,	181	-	-	-	803	-	-	-	-	-	-	-	-
5. Animal Excrement, etc.													
* Barnyard manure,	1,436	-	8.8	11.8	6.8	-	-	-	-	-	-	-	139
* Compost,	34	-	15.8	19.4	11.2	-	-	-	-	-	-	-	-
Drainage from manure heap,	1,864	73	19.6	17.6	4.8	-	-	-	-	-	-	-	-
Goose manure,	978	-	4.2	16.2	19	-	-	-	-	-	-	-	-
* Hen manure,	693	-	23.6	32.4	38.4	-	23.8	17.8	-	24.8	-	-	470
Hen house refuse,	147	-	14.2	20.6	20.4	-	-	-	-	-	-	-	1,421
Horse manure,	225	-	14.8	56.4	29.2	-	-	-	-	-	-	-	252
Poudrette, dry,	105	709	71.6	9.8	115	-	-	-	-	-	-	-	93
* Sheep manure,	192	343	42.4	40.6	29	-	-	-	-	-	-	-	675

Part IV. — Compilation of Analyses of Fruits, Garden Crops and Insecticides.

H. D. HASKINS.

1. Analyses of fruits.
2. Analyses of garden crops.
3. Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. (C. A. Goessmann.)

1. Analyses of Fruits.

Fertilizing Constituents of Fruits (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
* Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
* Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
* Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
* Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
* Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–

Fertilizing Constituents of Fruits — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Rosaceæ — *Con.*										
* Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
* Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
* Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Viticeæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. Analyses of Garden Crops.

Fertilizing Constituents of Garden Crops (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ: —										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
* Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
* Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — *Con.*										
* Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
* Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositæ: —										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
* Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
* Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–

Convolvulaceæ: —										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ: —										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
* White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
* Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
* White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
* Corn, whole plant, green,	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Corn, kernels,	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
* Corn, kernels,	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
* Corn, whole ears,	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
* Corn stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–

Leguminosæ: —										
Hay of peas, cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
* Cow-pea (*Dolichos*), green,	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
* Small pea (*Lathyrus Sylvestris*), dry,	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Peas, seed,	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans, seed,	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw,	166	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
* Velvet beans, kernel,	111.6	31.1	–	13.2	–	–	–	7.7	–	–
* Velvet beans, with pod,	115.2	19.6	–	13.1	–	–	–	8.4	–	–
* Leaves and stems of velvet beans,	58.8	28.6	–	–	–	–	–	–	–	–
Liliaceæ: —										
* Asparagus,	942	3.3	–	3.29	–	–	–	1.08	–	–
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
* Onions,	892	–	4.9	1.8	.1	.4	.2	.7	–	–

Fertilizing Constituents of Garden Crops — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Solanaceæ : —										
Potatoes,	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
* Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–
Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
* Tomatoes,	940	1.7	–	3.6	–	.3	.2	.4	–	–
Tobacco leaves,	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
* Tobacco, whole leaf,	103.1	24.3	–	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
* Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–

Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
* Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
* Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Many of the foregoing analyses were compiled from the tables of E. Wolff. Those marked with a star (*) are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass., and since 1895, at the chemical division of the Hatch Experiment Station of the Massachusetts Agricultural College.

3. Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits and Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits.			
Ericaceæ: —			
* Cranberries,	1	3.0	-
* Cranberries,	1	3.33	2.66
Rosaceæ: —			
Apples,	1	2.7	2.0
* Apples,	1	1.9	1.3
* Peaches,	1	1.3	-
Pears,	1	3.6	1.2
Strawberries,	1	1.4	-
* Strawberries,	1	2.6	-
* Strawberry vines,	1	.7	-
Cherries,	1	3.3	-
Plums,	1	4.3	-
Saxifragaceæ: —			
* Currants, white,	1	2.8	-
* Currants, red,	1	2.1	-
Gooseberries,	1	1.9	-

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits — Con.			
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
Garden Crops.			
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
* Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
* Sugar beets,	1	4.8	2.2
Sugar beet tops,	1	2.3	1.7
Sugar beet leaves,	1	5.7	4.3
Sugar beet seed,	1	1.5	-
* Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
* Spinach,	1	19.2	6.8
Compositæ: —			
Lettuce, common,	1	5.3	-
Head lettuce,	1	3.9	2.2
* Head lettuce,	1	7.7	4.0
Roman lettuce,	1	2.3	1.8
Artichoke,	1	.63	-
* Artichoke, Jerusalem,	1	2.8	2.7

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Convolvulaceæ: —			
Sweet potato, ...	1	4.6	3.0
Cruciferæ: —			
White turnips, ...	1	3.6	2.3
* White turnips, ...	1	3.9	1.8
White turnip leaves, . . .	1	3.1	3.3
* Ruta-bagas, ...	1	4.1	1.6
Savoy cabbage, ...	1	1.9	2.5
White cabbage, ...	1	4.1	1.7
* White cabbage, ...	1	11.0	7.6
Cabbage leaves, ...	1	4.1	1.7
Cauliflower, ...	1	2.3	2.5
Horse-radish, ...	1	3.9	2.2
Radishes, ...	1	3.2	3.8
Kohlrabi, ...	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers, ...	1	2.0	1.3
Pumpkins, ...	1	.6	.7
Gramineæ: —			
Corn, whole plant, green, . .	1	3.7	1.9
* Corn, whole plant, green, . .	1	2.2	2.8
Corn kernels, ...	1	.6	2.8
* Corn kernels, ...	1	.6	2.6

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Gramineæ — *Con.*			
* Corn, whole ears,	1	.8	2.5
* Corn stover,	1	4.4	3.7
Leguminosæ : —			
Hay of peas, cut green,	1	3.4	3.4
* Cow-pea (*Dolichos*), green,	1	3.1	2.9
* Small pea (*Lathyrus Sylvestris*), dry.	1	3.4	4.2
Peas, seed,	1	1.2	4.3
Pea straw,	1	2.8	4.0
Garden beans, seed,	1	1.2	4.0
Bean straw,	1	3.3	–
* Velvet beans, kernel,	1	1.7	4.0
* Velvet beans, with pod,	1	1.56	2.3
* Leaves and stems of velvet beans,	–	–	–
Liliaceæ : —			
* Asparagus,	1	3.05	3.06
Asparagus,	1	1.3	3.6
Onions,	1	1.9	2.1
* Onions,	1	2.6	–
Solanaceæ : —			
Potatoes,	1	3.6	2.1
* Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Solanaceæ — *Con.*			
Potato tops, unripe,	1	3.7	5.3
* Tomatoes,	1	8.7	4.5
Tobacco leaves,	1	6.2	5.3
* Tobacco, whole leaf,	1	13.46	5.65
Tobacco stalks,	1	3.1	2.7
* Tobacco stems,	1	10.7	3.8
Umbelliferæ: —			
Carrots,	1	2.7	2.0
* Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
Carrot tops, dry,	1	8.0	5.1
Parsnips,	1	3.8	2.8
* Parsnips,	1	3.3	1.2
Celery,	1	3.5	1.1

4. Analyses of Insecticides.

	Moisture.	Arsenious Oxide.	Copper Oxide.	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Insoluble Matter in Hydrochloric Acid.
Average of twelve analyses, Paris green,	1.22	57.91	32.08	-	-	-	4.74	-	-	-	-	-	-	-	-	.20
Average of four analyses, "Lion brand new-process Paris green."	4.64	54.91	7.93	-	-	-	-	-	-	-	6.65	-	15.76	.35	-	1.00
Average of fourteen analyses of Paris green collected in the general markets in 1900-1901.	.81	57.73	29.45	-	-	-	-	-	-	-	-	-	-	-	-	-
Pink arsenoid (lead arsenite),	.35	40.16	-	53.83	-	-	-	-	-	-	-	-	-	-	-	-
Green arsenoid (copper arsenite),	1.44	50.77	31.90	-	-	-	-	-	-	-	-	-	-	-	-	-
White arsenoid (barium arsenite),	2.35	31.90	-	.96	-	48.31	-	-	-	-	-	3.19	-	-	-	-
Laurel green,	7.64	7.34	13.50	-	-	-	-	-	-	-	-	-	26.31	-	-	-
Bug death,	.03	-	-	1.58	78.86	-	-	-	-	-	-	-	-	-	3.80	-
Sulphatine,	1.40	-	2.61	-	-	-	-	-	-	48.28	4.73	-	18.60	-	-	1.63
Death to rose bugs,	2.95	-	1.05	-	-	-	-	-	-	34.53	4.35	-	17.76	-	-	.49
Professor De Graff's carpet bug destroyer,	95.81	-	-	-	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
Oriental fertilizer and bug destroyer,	87.14	2.38	-	-	-	-	-	-	-	-	.64	3.00	-	3.50	-	-
Non-poisonous potato bug destroyer,	-	-	-	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	40.89	-	-	-	-	-	-	.53	-	-	-	-	1.47	16.34	.01	-
Tobacco liquor,	-	-	-	-	-	-	-	4.68	-	-	-	-	-	-	-	-
Nicotina,	10.00	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.12
Peroxide of silicate,	1.65	.57	.33	-	-	-	-	-	-	-	49.66	-	41.18	-	-	2.31

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, JR., J. W. KELLOGG.

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Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The general correspondence of this division has increased considerably during the last five years, due especially to the establishment of the feed control, and to the work in connection with the dairy law. More than the usual number of inquiries have been received relative to milk, cream, water, feed stuffs and methods of feeding. Some letters can be answered very quickly, while others require time and study. The total number of letters written during the year ending December 15 has been 2,186.

B. Extent of Chemical Work.

In the last report attention was called to the fact that the ever-increasing demand on the chemists' time for work of a routine character — the analyses of water, milk, cream and feed stuffs — very seriously interfered with the extent of experimental work. This has been particularly the case the past year, due largely to the amount of time required in connection with the dairy law. In fact, the work of investigation has been seriously curtailed, which is much to be regretted.

There have been sent in for examination 242 samples of water, 164 of milk, 1,557 of cream, 15 of pure and process butter, 48 of oleomargarine, 106 of feed stuffs and 5 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 148 samples of milk and cream, 80 of butter fat and 563 of fodders and feed stuffs.

There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 694 samples of concentrated feed stuffs. This makes a total of 3,622 substances analyzed during the year, as against 3,036 last year and 2,045 in the previous year. Work on the pentosans and galactan, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, forty-five candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 5,041 pieces of glassware have been tested for accuracy.

C. Character of Chemical Work.

(*a*) *Water.* — It has been the custom, ever since the establishment of the Massachusetts State Experiment Station, in 1882, to make sanitary analyses of drinking waters free of cost to all citizens of Massachusetts. Work of this character has increased until it has become quite burdensome. Acting with the approval of the Experiment Station committee, the following rules were adopted, and went into effect July 1: —

1. Hereafter, all parties wishing to secure a sanitary analysis of water at the Hatch Experiment Station must make known their desire by postal or letter, whereupon a glass bottle, securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express to the applicant.
2. According to a recent official ruling, no party shall be allowed to have more than *two* samples of water tested at this station free of cost in a single month. Additional analyses may be obtained within this time at a cost of two dollars each, providing the resources of the station permit.

Heretofore, parties have been allowed to send in any number of samples, at any time, in any kind of vessel. One result of this custom was, that the station often received more samples than could be properly handled, and other work was crowded to one side. Now it is possible to regulate the number of samples by the time at our disposal. Because of the large amount of work on hand, it has become necessary to refuse water samples during the months of November and December of the present year. Again, many persons had only an imperfect understanding of the method of taking and shipping a sample; consequently, the water was often received in improper condition, rendering the results of very questionable value. At present, a clean, glass-stoppered bottle is shipped the applicant, together with full instructions. The chemist, therefore, feels reasonably sure that the sample under examination is a fair one, and the results obtained are of a more positive character.

Samples are received not only from farmers, but from persons following various trades and professions. They are practically all from wells, springs and ponds in towns and villages not having a public water supply. Many are of fair quality, others quite suspicious, while some are entirely unfit for use. Some samples have been found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning, as many persons have found, to their sorrow. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.* It is not considered necessary to publish the results of the various analyses made, as they convey no particular information that could be of general interest.

(*b*) *Dairy Products and Feed Stuffs.* — More than the usual number of samples of milk and cream have been received during the past year. They were sent largely for the purpose of determining the amount of butter fat they contained. Some farmers are desirous of knowing the quality of milk produced by their animals, while others, who sell cream to the different creameries, wish to ascertain how closely the station tests agree with those made by the local creamery. Quite frequently samples of milk are received from milkmen whose product has been found to be below the standard by the inspector or milk contractor. In such cases the determination of both total solids and fat is made. The results of all analyses are returned within a few days, together with as full information as possible.

Printed circulars are also sent, containing information concerning the quality of the milk produced by different breeds of animals, and the necessary instruction relative to the best methods to be used in estimating the butter producing capacity of dairy herds.

In addition to the above, this division examines milk, cream and butter collected in western Massachusetts by the agent of the Dairy Bureau. The work is confined largely to the detection of oleomargarine, and is paid for by the Bureau, at a definite price for each determination.

The number of feed stuffs sent for examination was a trifle less than usual, due to the fact that quite thorough information of this character is now furnished in the feed bulletins issued from time to time by this division. During the winter and early spring a considerable number of samples of cotton-seed meal were received, tested, and the results returned without delay.

(*c*) *Chemical Investigation.* — So far as possible, it is the intention of this division to continue its investigation of some of the various dairy and feeding problems demanding solution. At present the time is devoted to the examination of butter fat, the manufacture of butter, and the digestibility of concentrated feed stuffs and summer forage crops. Work of this character is to be found in connection with Part II. of this report.

D. Cattle Feed Inspection.

The inspection of cattle feeds has been carried on in much the same manner as in previous years. Bulletin No. 71, comprising forty pages, was issued early in the year. This contains analyses of 653 cattle feeds, 33 poultry feeds, 46 so-called condimental foods for horses, cattle and poultry, together with full discussion of the results obtained. The interested reader is referred to it. When warranted, additional information is issued as press bulletins and sent to about one hundred newspapers in the State. Should any material be found seriously adulterated, a special circular is sent at once to the grain dealers in every town. Two complete inspections have been made during the present year, resulting in the collection of 698 samples. They are now under examination, and the results thus far obtained allow the following deductions: —

(*a*) The larger part of the *cotton-seed meal* is now guaranteed, and is of excellent quality. A few unguaranteed meals were found mixed with more or less hulls. *Farmers are strongly urged to buy only guaranteed meals.*

(*b*) *Gluten meal* and *feed* are nearly always accompanied with a guaranty, and are free from any foreign admixtures.

(*c*) *Wheat bran* and *middlings* are seldom adulterated. Purchasers are recommended, however, to give preference to those articles branded with the name of reputable manufacturers, or to examine the article closely before buying, in order to note its quality.

(*d*) *Mixed feed*, so called, consists of the entire wheat offal or mixtures of bran, coarse and flour middlings. The larger the proportion of flour middlings, the more valuable the feed. Different brands show noticeable variations in the proportions of the several ingredients. Farmers can obtain a very *desirable* mixed feed by mixing equal parts by weight of bran and flour middlings or red dog flour. Such a feed will be decidedly preferable to many of the brands now on the market, and the cost will not be increased. Most mixed feeds are entirely free from adulteration. A few samples were found containing a considerable quantity of ground corn cobs. Some were marked Kentucky Milling Company, others Kentucky, and a few were without brand. Several samples contained a noticeable amount of wheat screenings. Mixed feed containing cobs can generally be recognized by the hard, woody nature of the material when chewed. A close inspection of the feed will reveal the presence of screenings. Consumers are *especially cautioned* against such feeds.

(*e*) Oat offal, the refuse from the oat meal mills, contains large quantities of oat hulls. Two brands, namely, "X" and "Boston," were practically all hulls. The price of the offal varied from $16 to $27 a ton. It is relatively a *very expensive feed.*

(*f*) Dried brewers' grains and malt sprouts offer cheap sources of protein, provided they can be obtained.

In general, it can be said that the number of brands is increasing each year, practically all of which are the by-products from different manufacturing industries. The better class of feed stuffs, as put out by firms of established reputation, are not adulterated; irresponsible firms, however, are making systematic attempts to put out inferior goods. This is noticed especially in the persistent attempt to sell cotton-seed meal mixed with fine-ground hulls for genuine meal; in the substitution of fine-ground corn cobs for middlings in mixed feeds; in the offering of fine-ground rice hulls to dealers for the purpose of adulterating standard grains; and in the use of oat offal rather than ground oats in the mixing of the so-called provender (cracked corn and ground oats).

The following is the text of the present feed stuff law: —

[CHAPTER 117, ACTS AND RESOLVES OF 1897.]

SECTION 1. The director of the Hatch Experiment Station of the Massachusetts Agricultural College is hereby authorized and directed, in person or by deputy, to take samples not exceeding two pounds in weight from any lot or package of concentrated commercial feed stuff, used for feeding any kind of farm live stock, which may be in the possession of any manufacturer, importer, agent or dealer, cause the same to be analyzed for the amount of crude protein and crude fat contained therein, as well as for other ingredients if thought advisable, and cause the results of the analyses to be published from time to time in especially prepared bulletins, with such additional information as circumstances advise: *provided, however*, that in publishing the results of the analyses, the name of the jobbers or local dealers selling the said feed stuffs shall not be used, but the commodity analyzed shall be identified and described by the name of the manufacturer, or the commercial name or designation by which it is known in the trade.

SECTION 2. Whenever requested, said samples shall be taken in the presence of the party or parties in interest or their representative, and shall in all cases be taken from a parcel or number of packages which shall not be less than five per cent. of the whole lot inspected, shall be thoroughly mixed and then divided into two equal samples and put in glass vessels and carefully sealed, and a label placed on each vessel stating the name or brand of the feed stuff or material sampled, the name of the manufacturer when possible, the name of the party from whose stock the sample was taken, and the time and place of taking; said label shall be signed by the director, or his deputy, and by the party or parties in interest or their representative if present at the taking and sealing of the samples. One of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled.

SECTION 3. To defray the expenses of collecting and analyzing the samples and of publishing the results, the sum of twelve hundred dollars shall be allowed and paid annually in semi-annual payments from the treasury of the Commonwealth into the treasury of the Massachusetts Agricultural College.

SECTION 4. This act shall take effect on the first day of July in the year eighteen hundred and ninety-seven.

The above law simply provides for collecting and analyzing the samples and for the publication of the results. It prevents the publication of the names of the jobbers or local dealers selling the feed stuffs. It was the best that could be procured at the time. In the light of our experience, it is believed that this law should be changed and a more comprehensive one made, with the following points emphasized: —

1. An explicit statement of those feed stuffs included and those not included within the law.

2. The tagging of each package with the brand, name and place of business of the manufacturer or sponsor, net weight, and a guaranty of protein, fat and fibre.

3. The prohibiting of adulteration of any grain or recognized by-product with any foreign material whatsoever, unless the name and quantity of said material is clearly specified on the package.

4. The filing upon request by each manufacturer of a certified sample of each distinct brand of feed stuff offered for sale.

5. Instructions concerning the collection and analyzing of the feed stuffs and the publication of the results.

6. A penalty for obstructing an agent in the collecting of samples, and for selling articles which are not as represented.

7. The appropriation from the State treasury of at least double the sum now appropriated for the purpose of carrying out the provisions of the new law.

Laws similar to the one outlined are now in operation in Maine, New Hampshire, Vermont, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland and Wisconsin. It is believed that the enactment of a law including the points outlined above would be for the true interest of producers and consumers alike.

E. Dairy Legislation.

The Massachusetts Legislature during the session of 1901–1902 passed the following law: —

[Chapter 202.]

An Act to provide for the protection of dairymen.

Be it enacted, etc., as follows:

Section 1. All bottles, pipettes or other measuring glasses used by any person, firm or corporation, or by any employee or agent thereof, at any creamery, cheese factory, condensed milk factory, milk depot, or other place, in this state, in determining by the Babcock test, or by any other test, the value of milk or cream received from different persons or associations at such creameries, factories or milk depots as a basis of payment for such milk or cream, shall before use be tested for accuracy. Such bottles, pipettes or measuring glasses shall bear in ineffaceable marks or characters the evidence that such test has been made by the authority named in section two of this act. No inaccurate bottles, pipettes or glasses shall bear such marks or characters, but when found inaccurate shall be marked "Bad."

Section 2. It is hereby made the duty of the director of the Hatch Experiment Station of the Massachusetts Agricultural College, or of some competent person designated by him, to test all bottles, pipettes or other measuring glasses, as required by section one of this act. The director of the experiment station shall receive for such service the amount of the actual cost incurred, and no more, the same to be paid by the persons or corporations for whom it is rendered.

Section 3. Within six months after this act takes effect, and once each year thereafter, the director of the Hatch Experiment Station, or his authorized agent, shall inspect at the expense of the owners all centrifugal or other machines used by any person, firm or corporation, or by any agent or employee thereof, for the testing of milk or cream in fixing the value thereof; and the director of the experiment station or his authorized agent shall cause all such machines to be put into condition to obtain accurate results with the Babcock test or other tests, at the expense of the owners thereof. Such machines may be replaced by new ones at the option of the persons to whom they belong.

SECTION 4. No person shall, either by himself or in the employ of any other person, firm or corporation, manipulate the Babcock test, or any other test, whether mechanical or chemical, for the purpose of measuring the butter fat contained in milk or cream as a basis for determining the value of such milk or cream, or of butter or cheese made from the same, without first obtaining a certificate from the director of the Hatch Experiment Station that he or she is competent to perform such work. Rules governing applications for such certificates and the granting of the same shall be established by the said director. The fee for issuing such a certificate shall in no case exceed two dollars, the same to be paid by the applicant to the said director, to be used in meeting the expenses incurred under this act.

SECTION 5. It shall be the duty of the director of the Hatch Experiment Station to test farmers' samples of milk or cream by the Babcock method, and report the results of each test, the cost of such test to be paid by the farmer. The director shall also test by the Babcock method, samples of milk or cream sent from any creamery, factory or milk depot in the state by its proper representative, the actual cost of such tests to be borne by the sender. The experiment station shall publish and distribute such information concerning the Babcock test, and the taking and forwarding of samples, as it deems necessary under this section.

SECTION 6. Any person violating any provision of this act shall be fined not more than twenty-five dollars for the first offence and not more than fifty dollars for each subsequent offence.

SECTION 7. This act shall take effect on the first day of July in the year nineteen hundred and one. [*Approved March 26, 1901.*

The execution of the above law having been referred to this division, a circular was prepared, giving the text of the law, together with such rules and regulations as it seemed wise to make for the carrying out of its several provisions. There seeming to be doubt in some instances as to whom the law applied, the following interpretation was made, which is believed to be correct and in accordance with the spirit of the law: —

1. All parties employing the Babcock or similar test

simply as a protection against adulteration, the results of which in no way affect the price of milk or cream to either the producer or consumer, shall be considered exempt from the law.

2. All parties employing the Babcock or similar test (as described in section 4) for the purpose of measuring the butter fat contained in the milk or cream, as a basis for determining or fixing the value of such milk or cream (to either producer or purchaser), shall be considered subject to the requirements of the law.

The law practically resolves itself into three sections: (1) the testing of glassware for accuracy of graduation; (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — The scale on the neck of the cream, whole and skim milk bottles is tested for accuracy of graduation by the mercury method, as described by Farrington & Woll in their work entitled "Testing milk and its products." Pipettes and acid measures are tested for accuracy by carefully measuring the amount of water they deliver. The following limits of error were adopted: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30-35-40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	.25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.10
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	-	.10
Pipettes, milk,	17.60	-	.10
Acid measures,	17.50	-	.20

All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast, working under twenty-five pound pressure. The necessary air pressure for the blast is obtained by a double-acting power air pump,* with a thirty-gallon reservoir.

It became necessary at first to test the ware in use by all creameries and milk depots. Now, practically none is received from these sources, but rather from the large supply houses, who furnish tested ware whenever requested. There has been examined to date 5,041 pieces, of which 291 pieces, or 5.77 per cent., have been found to be incorrect. One order from a large supply house, numbering 441 pieces, contained 149 pieces, or 33.8 per cent., incorrectly graduated. The wisdom, therefore, of this section of the law is apparent without further argument.

Manufacturers are now inclined to be more careful concerning the quality and accuracy of glassware supplied, for the reason that a large part is examined by the several experiment stations before coming into the hands of the users.

Examination of Candidates.† — It seemed wise to require candidates to present themselves at the station laboratory for examination. In all, 45 candidates have been examined to date. Scarcely any were found to be free from faults, but the larger number appeared to understand the general principles of manipulation. A few were noticeably careless, and had but an imperfect understanding of the process. As much instruction as possible was given in the time at our disposal, an especial effort being made to correct the serious faults. In furtherance of this idea, the following circular concerning the points especially to be observed in making the test was printed, and a copy given to each party examined : —

1. Milk or cream should be carefully and thoroughly mixed, — *never* by shaking the sample, but by gently rotating it and by pouring from one vessel to another. All cream adhering to the

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* No. 3, A. Babcock & Bishop Company, New York.

† The inspection of the glassware and the examination of candidates were largely in charge of Mr. E. B. Holland, who gave these matters very careful attention.

sides and stopper of the retaining vessel must be incorporated, and the resulting mixture should show no solid particles of fat. A small fine wire sieve is of great value in detecting the imperfect (lumpy) condition of a sample and in preparing the same for pipetting.

2. Pipette immediately after preparing the sample, filling the pipette *slowly*, and taking care to avoid air bubbles. Hold the pipette in a *vertical* position when lowering the liquid to the mark, and always read with the entire meniscus above the line. In transferring milk or cream to the test bottles, avoid, so far as possible, the smearing of the entire neck with the liquids.

3. Cream testing above 25 per cent. of fat should always be weighed, as accurate results cannot be secured with the pipette.

4. In adding the acid, turn the bottle so as to wash down all milk or cream adhering to the sides of the neck, and mix at once. Rotate the bottle until all the lumps of casein are thoroughly dissolved, and the resulting mixture is *black* in color. Never slight the mixing, and avoid throwing the fat up into the neck.

5. Whirl at least five, two, and two minutes. In filling with hot water, allow the water to run down the sides of the neck, and thus avoid stirring up the contents of the bottle.

6. In reading the column of fat, it is safer to use a pair of dividers than to trust to the unaided eye ; read the *centre* of the fat column from the *lowest* to the *highest* limit.

Inspection of Machines. — The inspection of Babcock machines, in accordance with section 3 of the law, is now in progress. Mr. Nathan J. Hunting, a graduate of the college in the class of 1901, is charged with the execution of this work. It is not possible at present to make any definite report, other than to state that a number of machines have thus far been condemned and others have been ordered repaired.

F. Miscellaneous.

Under this heading it is desired to call attention to the compilation of analyses of cattle feeds and dairy products prepared by Messrs. Holland and Smith, and published as Part III. Tables of a similar character were printed in the ninth report of this station. The present compilation — representing the analysis of different substances made since the establishment of the Massachusetts State Experiment

Station — has been thoroughly revised, and some feeds that are no longer on the market or were of only temporary interest have been omitted. This is especially true of a number of concentrated by-products, where the process of manufacture has been noticeably changed and improved.

Tables showing the coefficients of digestibility of all American feed stuffs, similar to those published in the ninth report, are also presented. Work of this nature requires a great amount of time, and severely taxes the resources of the station staff.

Part II. — Dairy and Feeding Experiments.

J. B. LINDSEY.*

A. Effect of Feed on the Composition of Milk and on the Consistency or Body of Butter.

Experiments of this character have been in progress since 1898. A general outline of those previously completed will be found in the preceding (thirteenth) report of this station (pages 14–33).

During the autumn and winter of 1900–1901 another series was conducted, for the purpose of noting particularly the effect of cotton-seed meal with a minimum amount of oil, and likewise with the addition of cotton-seed oil, on the relative proportions of the several ingredients in milk and butter fat and on the body of the butter. It is intended at present only to briefly outline the character of the experiment, and to call attention to a few of the more important facts; the full data will be published later.

Plan of Experiment. — Ten cows were divided into two herds of five each. During the first period both herds received the same or so-called standard ration. During the three subsequent periods Herd I. continued to receive the standard ration as in the first period, and in case of Herd II. a portion of the standard ration was replaced by cotton-seed meal, cotton-seed oil and Cleveland flax meal.

Table I. — *Duration of Experiment.*

Periods.	Dates of Experiment.	Length in Weeks.
First period, both herds standard ration,	Nov. 17 through Dec. 7,	3
Second period, Herd II., cotton-seed ration,	Jan. 5 through Feb. 8,	5
Third period, Herd II., cotton-seed oil ration,	Feb. 23 through April 6,	6
Fourth period, Herd II., Cleveland flax meal ration.	April 20 through May 16,	4

* Together with E. B. Holland, P. H. Smith, Jr., and J. W. Kellogg.

Table II. — *Approximate Daily Rations (Pounds).*

First period: both herds, standard ration.

Herds.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I., ...	9	–	–	–	8–12	10
Herd II., ...	9	–	–	–	8–12	10

Second period: Herd I., standard ration; Herd II., cotton-seed ration.

Herds.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I., ...	9	–	–	–	8–12	10
Herd II., ...	5	3	–	–	8–12	10

Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.

Herds.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I., ...	9	–	–	–	8–12	10
Herd II., ...	5	3	.5	–	8–12	10

Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.

Herds.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I., ...	9	–	–	–	8–12	10
Herd II., ...	4	–	–	3	8–12	10

The standard ration consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meal. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter. It was intended to secure cotton-seed meal with a minimum percentage of oil, but, in spite of all efforts, the lowest obtainable contained 8 per cent. The extra cotton-seed oil fed in the third period was mixed with the grain ration.

TABLE III. — *Average Composition of Milk.*

First period: both herds standard ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.15	5.00	9.15	.538	.73
Herd II., ...	14.27	4.93	9.34	.546	.72

Second period: Herd I., standard ration; Herd II., cotton-seed ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.16	5.06	9.10	.550	.73
Herd II., ...	14.30	4.98	9.32	.562	.71

Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.22	5.05	9.17	.557	.73
Herd II., ...	14.75	5.40	9.35	.565	.72

Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.32	5.12	9.21	.565	.74
Herd II., ...	14.81	5.06	9.75	.616	.74

Composite samples of milk were taken from each herd for five days in each week, and tested for total solids, fat, nitrogen and ash. The milk from each herd showed no noticeable variations in composition during the first two periods. In the third, or cotton-seed oil period, the milk of Herd I. remained as in the preceding periods, while the total solids and fat of Herd II. showed an increase of about .40 per cent. at the beginning of the period, and this increase maintained itself until the close of the period. The solids not fat, nitrogen and ash remained unchanged. In the fourth, or Cleveland flax meal period, the milk from Herd I. remained practically unchanged, increasing a trifle in all ingredients, due to advanced lactation. In case of the milk from Herd II. the fat decreased to the percentage produced in the second period (before the cotton-seed oil was fed), while the total solids remained as high as in the cotton-seed oil period. The solids not fat and the nitrogen showed a noticeable increase. The increase of the nitrogen percentage apparently explains why the total solids did not show the same relative decrease as did the total fat. The ash remained unaffected.

TABLE IV. — *Average Analysis of Butter Fat.*

First period: both herds standard ration.

Number Samples, Each Herd.	Saponification Equivalent.		Insoluble Acids.		Reichert Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
6 samples, .	229.3	231.8	88.95	88.72	29.02	30.54	33.44	32.46	28.28	29.29
Second period: Herd I., standard ration; Herd II., cotton-seed meal ration.										
10 samples, .	228.7	230.3	88.03	87.81	29.08	30.32	33.75	34.10	27.98	29.58
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.										
12 samples, .	233.3	225.3	88.19	88.57	28.97	28.82	34.04	36.46	27.35	33.78
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.										
8 samples, .	228.9	228.4	-	-	28.08	26.81	34.04	33.42	29.21	29.87

It will be seen that, excepting for minor variations, the butter fat produced by Herd I. remained unchanged throughout the several periods. In the cotton-seed meal period the fat produced by Herd II. increased a little in its melting point, but otherwise no particular change is noted. In the cotton-seed oil period the fat in case of Herd II. showed a decrease in its Reichert Meissl number and a noticeable increase in the melting point and iodine number, as compared with previous periods. In the Cleveland flax meal period the butter fat produced by Herd II. became similar in composition to that produced by Herd I., excepting the Reichert

Meissl number, which somewhat decreased. This decrease in volatile acids was also noticed in a previous experiment, when linseed meal was fed with apparently unsatisfactory results, so far as the quality of the butter was concerned.

Two lots of butter were made weekly, the same conditions prevailing in case of each herd. These butters were scored by W. A. Gude of New York and O. Douglass of Boston : —

TABLE V. — *Average Butter Scores.*

First period: both herds standard ration.

Scorers.	Flavor.		Body.		Color.		Salt.		Style.		Total.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Gude, .	36.5	38.0	24.8	24.6	15.0	15.0	10	10	5	5	91.3	92.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.6	93.7
Second period: Herd I., standard ration; Herd II., cotton-seed meal ration.												
Gude, .	36.8	37.3	24.5	24.8	14.9	14.8	10	10	5	5	91.2	91.9
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.8	94.1
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.												
Gude, .	36.9	37.0	24.1	24.6	14.9	15.0	10	10	5	5	90.9	91.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	92.7	93.1
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.												
Gude, .	36.0	35.0	25.0	24.7	15.0	15.0	10	10	5	5	91.0	89.7
Douglass, .	-	-	-	-	-	-	-	-	-	-	91.6	90.1
Standard Score.												
Gude, .	45.0	45.0	25.0	25.0	15.0	15.0	10	10	5	5	100.0	100.0
Douglass, .	50.0	50.0	20.0	20.0	15.0	15.0	10	10	5	5	100.0	100.0

So far as the judgment of practical scorers is concerned, little difference was noted in the flavor and body of the butter made from the different rations. The butter made from the cotton-seed meal and from the cotton-seed oil rations appears to have been a trifle more satisfactory, on the whole, than that made from the standard ration, and that made from the Cleveland flax meal ration a trifle less so. Judging from the remarks of Mr. Gude, the tendency of the standard ration and the cotton-seed meal ration was to produce a hard, crumbly butter, which the cotton-seed oil counteracted, causing it to become softer and more yielding in its nature.

The observation of the writer was that the butter produced by the cotton-seed meal ration was a little softer than that produced by the standard ration.

The butter produced by the cotton-seed oil ration was noticeably softer and more yielding than that produced by the standard ration. The difference was not sufficient to render the former butter objectionable, from a commercial stand-point. At a temperature of 80° F. the standard ration butter stood up well and could be handled, although somewhat soft; while the cotton-seed oil butter was handled with difficulty, appearing to have lost its consistency or body.

The butter produced by the flax meal ration was not noticeably different from that produced by the standard ration butter. Most of the cows during this period were in advanced stage of lactation, so that the results obtained are not particularly satisfactory.

TABLE VI. — *Average Degrees of Penetration (Millimeters).*

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.7	4.6	4.5	4.4	4.4	5.0	5.2	5.4

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped from a definite height. No differences were noted excepting in the third period, when the plunger penetrated deeper into the butter produced by the cotton-seed oil, showing its more yielding character.

Results. — The following are the most important results :—

1. Cotton-seed meal with a minimum percentage of oil did not alter the percentage composition of the milk.

2. The addition of one-half to three-fourths of a pound of cotton-seed oil to the cotton-seed meal appeared to increase the fat percentage in the milk about four-tenths of one per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

3. The substitution of Cleveland flax meal for the cotton-seed meal and oil resulted in a decrease of the fat in the milk to about the percentage found in the first period, while the nitrogen percentage was increased. This change in composition was probably due to the removal of the cotton-seed oil from the ration, and not to the influence of the flax meal.

4. Cotton-seed meal with minimum oil caused no marked variation in the chemical composition of the butter fat.

5. The addition of cotton-seed oil to the cotton-seed meal ration produced a noticeable increase in the melting point and iodine number of butter fat.

6. Cotton-seed meal with a minimum oil produced a firm butter.

7. The addition of cotton-seed oil, while it increased the melting point of the butter fat, produced a softer, more yielding butter than that produced by either the cotton-seed meal or the standard ration.

8. An excess of cotton-seed oil in the ration is likely to affect the health of the animal.

B. Notes on Summer Forage Crops.

J. B. LINDSEY.

This division has carried on experiments with green crops for a number of years, in order to ascertain those best suited to local conditions for summer forage. The results of these observations were published in Bulletin No. 72, issued in the spring of 1901. Observations with a number of crops have been continued the past season.

Wheat and Winter Vetch. — This is one of the earliest spring forage crops. It has been grown at this station for two consecutive years, with very satisfactory results. A full description of the crop and method of cultivation is found in the above bulletin. About one-third of an acre was seeded the first of the present September, and has made an excellent growth and promises well for the coming season. The experience obtained with this mixture leads to the conclusion that it is decidedly preferable to winter rye for early forage, although not ready to cut until a week later. The vetch thus far has proved perfectly able to withstand the winter. The digestibility of this mixture, both green and in the form of hay, has been made, but the results are not yet available for publication.

Corn and Cow Peas. — It has been the intention, so far as practicable, to grow mixtures of legumes and non-legumes, in order to increase the amount of protein in the several forage crops. For a number of years corn and medium green soy beans have been grown together quite successfully. The past season Longfellow corn and black cow-peas were sown together in rows three and one-half feet apart, with an Eclipse corn planter, at the rate of ten quarts of corn and seven quarts of peas to the acre. The soil was rather of a light loam, and somewhat sensitive to drought. The rainfall proved sufficient, and the yield was heavy, being at the rate of twenty-three tons to the acre. The peas spread out, nearly covering the space between the rows, twining themselves at the same time about the stalks of corn. The crop was harvested with some difficulty, because of its tangled condition, but proved quite satisfactory for green fodder. This mixture, as well as that of corn and soy beans, will be grown again the coming season. It is believed that such fodder combination will enable the farmer to get along with less purchased grain.

Barnyard Millet. — Several plots of this fodder were grown and fed the past season. The results fully confirm the opinion concerning this crop expressed in last year's report. Its chief value is unquestionably for green forage. The first crop, sown about the middle of May, can be cut as early as July 15 to 20, and if successive seedings are made, green forage may be had until into September. Cutting should begin just before the heads appear, and the crop is at its best for eight to ten days thereafter. After it is headed it becomes tough, and animals refuse quite a portion of it. In order, therefore, to secure green fodder from such a source for a considerable period, it is necessary that small pieces of ground be seeded every ten days. This millet succeeds best upon warm, rather heavy, moist, fertile soils. Such conditions favor the production of sixteen to twenty tons to the acre, and even larger yields have been reported. Upon light soils the writer prefers corn, or corn and beans, for a soiling crop, after August 15. The millet when in blossom is probably as nutritious as corn fodder at the same stage of growth. Corn fodder, however, can be grown until more or less eared, and still be readily eaten, and in this condition the corn will naturally have a superior feeding value.

Barnyard millet is unsuited for hay, and is only to be preferred to corn for silage when for any reason it is not possible to secure a crop of corn.

Part III. — Compilation of Analyses of Fodder Articles and Dairy Products, made at Amherst, Mass., 1868–1901.

Prepared by E. B. HOLLAND and P. H. SMITH, JR.

A. Composition and Digestibility of Fodder Articles.
- I. — Green fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Mixed and miscellaneous.
- II. — Silage.
- III. — Hay and dry, coarse fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Straw.
  - (*e*) Mixed and miscellaneous.
- IV. — Vegetables, fruits, etc.
- V. — Concentrated feeds.
  - (*a*) Protein.
  - (*b*) Starchy.
  - (*c*) Poultry.

B. Fertilizer Ingredients of Fodder Articles. (For classification, see A and C.)

C. Analyses of Dairy Products.

A. Composition and Digestibility of Fodder Articles.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I.—Green Fodders.																			
(a) Meadow Grasses and Millets.																			
Johnson grass (*Andropogon halepensis*),	1	75*	1.4	1.2	8.9	13.2	0.3	4.6	35.7	53.0	1.2	-	-	-	-	-	-	-	-
Orchard grass, ...	7	70	2.1	2.9	10.4	13.7	0.9	9.7	34.8	45.6	3.0	-	-	-	-	-	-	-	-
Tall oat grass, ...	4	70	1.6	2.3	10.8	14.7	0.6	7.5	36.0	49.0	2.2	-	-	-	-	-	-	-	-
Japanese millet (variety uncertain), .	3	80	1.1	1.2	7.1	10.2	0.4	6.0	35.4	50.9	2.1	-	-	-	-	-	-	-	-
Pearl millet (*Pennisetum spicatum*), .	1	75	1.7	1.8	8.6	12.6	0.3	7.2	34.4	50.5	1.0	-	-	-	-	-	-	-	-
Fox-tail millets. Common millet (*Chætochloa italica*), .	16	75	1.2	1.9	8.1	13.2	0.6	7.4	32.4	52.7	2.5	1.2	5.8	9.0	0.4	4.7	23.0	35.8	1.7†
Fox-tail millets. Canary bird seed millet (*Chætochloa italica*).	1	80	1.6	1.0	7.1	10.0	0.3	5.0	35.5	50.0	1.5	-	-	-	-	-	-	-	-
Fox-tail millets. Early harvest millet (*Chætochloa italica*),	1	80	1.4	1.1	7.4	9.7	0.4	5.5	37.0	48.5	2.0	-	-	-	-	-	-	-	-
Fox-tail millets. Golden millet (*Chætochloa italica*), . .	1	75	1.5	1.0	8.7	13.4	0.4	4.0	34.8	53.4	1.6	-	-	-	-	-	-	-	-
Fox-tail millets. Hungarian grass (*Chætochloa italica*), .	3	75	1.8	2.4	7.2	13.1	0.5	9.8	28.6	52.3	2.0	1.5	5.1	8.9	0.3	6.3	20.3	35.6	1.3
Fox-tail millets. Japanese millet (*Chætochloa italica*), .	12	80	1.2	1.7	6.2	10.5	0.4	8.2	31.2	52.5	2.0	1.0	4.1	7.1	0.3	5.0	20.6	35.7	1.3‡
Barnyard millet (*Panicum crus-galli*), .	7	80	1.7	1.9	6.5	9.5	0.4	9.5	32.5	47.6	1.9	1.2	4.3	6.5	0.3	5.8	21.5	32.4	1.2

Broom-corn millets: Millet (*Panicum miliaceum*),	1	80	1.1	1.1	5.3	11.7	0.8	5.8	26.5	58.4	3.8	-	-	-	-	-	-	-	-
Broom-corn millets: Broom-corn millet (*Panicum miliaceum*),	1	80	1.2	1.3	6.4	10.7	0.4	6.5	32.0	53.5	2.0	-	-	-	-	-	-	-	-
Broom-corn millets: Japanese broom-corn millet (*Panicum miliaceum*).	2	80	1.2	0.9	6.2	11.4	0.3	4.5	31.0	57.0	1.5	-	-	-	-	-	-	-	-
Broom-corn millets: Hog millet (*Panicum miliaceum*),	1	80	1.4	1.5	6.5	10.2	0.4	7.5	32.5	51.0	2.0	-	-	-	-	-	-	-	-
(*b*) *Cereal Fodders.*																			
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	12.9	37.6	38.1	2.8	2.3	5.7	6.8	0.4	9.3	22 9	27.1	1.7
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	10.4	29.0	52.8	2.8	1.9	4.5	9.4	0.4	7.5	17.7	37.5	1.7§
Corn fodder,	39	80	0.9	1.6	4.5	12.6	0.4	8.0	22.5	63.0	2.0	1.0	2.7	9.3	0.3	4.8	13.5	46.6	1.5
Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	7.1	24.4	60.0	2.4	-	-	-	-	-	-	-	-
Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	13.8	30.0	45.0	3.1	2.5	4.0	7.1	0.6	9.9	15.9	28.4	2.1
Oats in bloom,	1	75	1.7	1.6	9.0	12.0	0.7	6.5	36.0	48.1	2.8	-	-	-	-	-	-	-	-
Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	10.9	34.4	45.9	2.7	-	-	-	-	-	-	-	-
Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	6.1	36.4	48.7	2.6	-	-	-	-	-	-	-	-
Rye,	2	75	1.4	1.9	8.0	13.2	0.5	7.5	31.8	52.9	2.1	1.4	4.6	8.8	0.3	5.4	18.1	35.4	1.3‖
Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	10.7	33.0	47.3	2.6	-	-	-	-	-	-	-	-
(*c*) *Legumes.*																			
Alfalfa (*Medicago sativa*),	6	75	2.0	3.4	7.7	11.4	0.5	13.6	30.7	45.8	1.9	-	-	-	-	-	-	-	-
Horse bean (*Faba vulgaris*),	1	85	0.9	2.5	4.3	6.9	0.4	16.7	28.6	46.0	2.7	-	-	-	-	-	-	-	-
Soy bean (*Glycine hispida*),	14	75	2.6	4.4	6.8	10.1	1.1	17.5	27.1	40.4	4.6	3.3	3.2	7.4	0.6	13.1	12.7	29.5	2.5¶
Soy bean (early white),	4	75	3.2	4.2	5.6	11.3	0.7	16.7	22.3	45.3	2.7	3.2	2.6	8.3	0.4	12.5	10.5	33.1	1.5

* Water in green fodders varies with stage of growth and rainfall.
† Same coefficients used as for Hungarian grass.
‡ Same coefficients used as for barnyard millet.
§ Same coefficients used as for barley.
‖ Average coefficients for barley and oats.
¶ Same coefficients applied to all soy beans.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — Green Fodders — *Con.*																			
(*c*) *Legumes* — Con.																			
Soy bean (medium green),	1	75	3.3	4.8	5.9	10.0	1.0	19.3	23.7	40.0	4.0	3.6	2.8	7.3	0.5	14.5	11.1	29.2	2.2
Soy bean (medium black),	2	75	3.1	4.7	5.9	10.0	1.3	18.9	23.4	39.9	5.2	3.5	2.8	7.3	0.7	14.2	10.1	29.1	2.8
Soy bean (late),	4	75	3.3	5.7	5.3	10.0	0.7	22.7	21.1	40.0	2.7	4.3	2.5	7.3	0.4	17.0	9.9	29.2	1.5
Alsike clover (*Trifolium hybridum*),	8	75	2.9	4.1	6.8	10.6	0.6	16.5	27.2	42.4	2.5	-	-	-	-	-	-	-	-
Crimson clover (*Trifolium incarnatum*),	2	75	3.5	3.9	7.5	9.5	0.6	15.8	29.8	38.1	2.4	3.0	4.2	7.0	0.4	12.2	16.7	28.2	1.6
Mammoth red clover (*Trifolium medium*),	4	75	2.4	3.8	7.2	11.1	0.5	15.4	28.7	44.2	2.1	-	-	-	-	-	-	-	-
Medium red clover (*Trifolium pratense*),	5	75	2.1	3.5	7.7	11.0	0.7	13.9	30.6	44.1	2.7	2.4	4.1	8.6	0.5	9.3	16.2	34.4	1.7
Sweet clover (*Melilotus alba*),	4	75	2.4	4.7	7.9	9.3	0.7	18.8	31.6	37.2	2.8	-	-	-	-	-	-	-	-
Sand lucern,	1	75	2.4	4.1	5.3	12.5	0.7	16.4	21.2	50.0	2.6	-	-	-	-	-	-	-	-
Cow-pea (*Vigna catjang*),	3	80	1.9	3.4	4.3	9.6	0.8	17.2	21.7	47.8	3.9	2.6	2.6	7.8	0.5	13.1	13.0	38.7	2.3
Canada beauty pea (*Pisum arvense*),	1	80	1.6	3.2	5.8	8.9	0.5	16.1	29.0	44.3	2.7	2.6	3.6	6.3	0.3	13.2	18.0	31.5	1.4*
Canada field pea (*Pisum arvense*),	1	80	1.8	3.9	6.3	7.5	0.5	19.7	31.6	37.2	2.7	3.2	3.9	5.3	0.3	16.2	19.6	26.4	1.4
English gray pea (*Pisum arvense*),	1	80	1.9	4.1	6.1	7.3	0.6	20.6	30.2	36.4	3.2	3.4	3.8	5.2	0.3	16.9	18.7	25.8	1.7

Prussian blue pea (*Pisum arvense*),	1	80	1.8	3.7	6.0	7.8	0.7	18.7	30.0	39.1	3.4	3.0	3.7	5.5	0.4	15.3	18.6	27.8	1.8
Flat pea (*Lathyrus sylvestris wagneri*),	2	80	1.8	5.8	4.9	6.6	0.9	29.0	24.8	32.9	4.3	-	-	-	-	-	-	-	-
Sainfoin (*Onobrychis sativa*),	1	75	2.1	4.4	6.0	11.6	0.9	17.4	24.0	46.5	3.5	-	-	-	-	-	-	-	-
Serradella (*Ornithopus sativus*),	3	80	2.1	2.9	5.9	8.7	0.4	14.4	29.5	43.3	2.2	-	-	-	-	-	-	-	-
Sulla (*Hedysarum coronarium*),	2	75	2.3	4.3	5.2	12.5	0.7	17.1	20.7	50.2	2.7	-	-	-	-	-	-	-	-
Scotch tares (*Vicia sativa*),	1	80	2.4	3.9	5.7	7.7	0.3	19.5	28.3	38.3	1.7	-	-	-	-	-	-	-	-
Spring vetch (*Vicia sativa*),	3	80	1.7	3.5	6.0	8.3	0.5	17.4	30.2	41.6	2.4	2.5	2.6	6.3	0.3	12.3	13.3	31.6	1.4
Hairy or sand vetch (*Vicia villosa*),	1	80	1.7	4.0	6.3	7.8	0.2	20.0	31.6	38.9	1.1	3.3	3.8	5.9	0.1	16.6	19.3	29.6	0.8
Kidney vetch (*Anthyllis vulneraria*),	1	80	2.7	3.7	3.1	9.8	0.7	18.4	15.3	48.9	3.7	-	-	-	-	-	-	-	-
(*d*) *Mixed and Miscellaneous.*																			
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	13.8	33.8	41.2	3.1	2.2	2.9	5.0	0.4	10.6	14.5	25.1	1.9
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	13.8	32.4	45.2	2.3	-	-	-	-	-	-	-	-
Corn and soy bean,	1	80	1.3	2.7	4.3	11.2	0.5	13.8	21.3	56.1	2.4	-	-	-	-	-	-	-	-
Millet and peas,	1	80	1.8	2.4	7.5	8.0	0.3	12.0	37.5	39.9	1.5	-	-	-	-	-	-	-	-
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	14.4	30.0	44.1	3.0	2.0	4.0	6.7	0.3	10.1	20.4	33.5	1.7
Vetch and oats (1-1),	3	80	1.8	3.0	6.3	8.4	0.5	15.1	31.4	42.1	2.7	2.3	4.3	5.7	0.2	11.3	21.4	28.6	1.3
Vetch and oats (1-4),	1	80	1.8	2.7	6.0	8.8	0.7	13.3	30.0	43.8	3.8	-	-	-	-	-	-	-	-
Wheat and vetch,	2	80	1.5	3.2	6.5	8.2	0.5	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
Apple pomace,	3	83	0.4	1.2	2.9	11.7	0.8	7.1	17.0	68.8	4.7	-	-	-	-	-	-	-	-

* Same coefficients applied to all Canada peas.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-Dry Substance.						Water-Free Substance.				Fresh or Air-Dry Substance.				Water-Free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — Green Fodders — *Con.*																			
(*d*) *Mixed and Miscellaneous* — Con.																			
Sugar beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	14.0	25.0	59.0	1.0	0.9	2.1	5.0	-	8.8	20.7	49.6	-
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	19.7	14.3	36.8	1.9	-	-	-	-	-	-	-	-
Carrot tops,	1	80	2.8	4.2	2.7	9.9	0.4	21.2	13.6	49.3	2.0	-	-	-	-	-	-	-	-
Prickley comfrey (*Symphytum asperrimum*),	1	87	2.8	2.3	1.5	6.1	0.3	17.7	11.5	46.9	2.4	-	-	-	-	-	-	-	-
Purslane (*Portulaca oleracea*),	1	91	1.5	2.3	1.6	3.4	0.2	25.1	17.7	37.4	2.7	-	-	-	-	-	-	-	-
Dwarf Essex rape (*Brassica napus*),	1	85	2.4	1.9	2.9	7.2	0.6	12.9	19.3	47.8	4.3	1.7	2.5	6.6	0.3	11.5	16.8	43.9	2.1*
Summer rape (*Brassica napus*),	1	85	2.8	2.1	2.7	6.9	0.5	14.3	17.8	45.7	3.6	1.9	2.4	6.4	0.2	12.7	15.5	42.0	1.7
Winter rape (*Brassica napus*),	1	85	3.3	2.3	1.8	7.1	0.5	15.0	12.1	47.1	3.6	2.1	1.6	6.5	0.2	13.4	10.5	43.3	1.7
Sorghum (*Andropogon sorghum*),	6	80	1.4	1.8	5.4	11.0	0.4	8.8	27.0	55.3	1.8	-	-	-	-	-	-	-	-
Spurrey (*Spergula arvensis*),	1	72	2.6	2.9	7.0	15.4	0.1	10.3	25.0	55.0	0.4	-	-	-	-	-	-	-	-
Teosinte (*Euchlæna Mexicana*),	2	70	2.3	2.3	9.4	15.6	0.4	7.6	31.3	52.1	1.2	-	-	-	-	-	-	-	-

II. — SILAGE.																			
Apple pomace,	1	85	0.6	1.2	3.3	8.8	1.1	8.0	22.0	58.7	7.3	-	-	-	-	-	-	-	-
Corn,	45	80	1.1	1.7	5.4	11.1	0.7	8.5	26.8	55.7	3.5	1.0	3.8	8.4	0.6	4.8	18.8	42.3	2.9
Corn and soy bean,	4	76	2.4	2.5	7.2	11.1	0.8	10.4	30.0	46.3	3.3	1.6	4.7	8.3	0.7	6.8	19.5	34.7	2.7
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	6.5	28.8	52.3	3.1	-	-	-	-	-	-	-	-
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	13.3	34.3	34.3	4.8	1.6	5.0	4.3	0.7	7.7	23.7	20.2	3.5
III. — HAY AND DRY COARSE FODDERS.																			
(a) Meadow Grasses and Millets.																			
Barnyard grass (*Panicum crus-galli*),	1	14	8.6	13.1	29.0	33.6	1.7	15.2	33.7	39.1	2.0	-	-	-	-	-	-	-	-
Barnyard millet (*Panicum crus-galli*),	7	14	7.3	8.2	28.0	40.9	1.6	9.5	32.5	47.6	1.9	5.3	17.4	21.3	0.7	6.1	20.2	24.8	0.9
Canada blue grass (*Poa compressa*),	1	14	4.8	5.9	31.3	42.1	0.9	6.9	36.4	48.9	2.2	-	-	-	-	-	-	-	-
Hungarian grass (*Chætochloa italica*),	3	14	6.3	8.4	24.6	45.0	1.7	9.8	28.6	52.3	2.0	5.0	16.7	30.2	1.1	5.9	19.4	35.0	1.3
Italian rye grass (*Lolium italicum*),	4	14	6.4	7.1	28.6	42.2	1.6	8.4	33.2	49.0	1.9	-	-	-	-	-	-	-	-
Kentucky blue grass (*Poa pratensis*),	3	14	6.4	7.7	30.5	39.7	1.7	8.9	35.5	46.1	2.0	4.4	19.2	21.0	0.7	5.1	22.4	24.4	0.9
Meadow fescue (*Festuca elatior pratensis*),	7	14	7.1	5.8	32.2	39.3	1.6	6.8	37.4	45.6	1.9	3.0	21.6	23.2	0.9	3.5	25.1	26.9	1.0
Orchard grass (*Dactylis glomerata*),	7	14	5.9	8.3	29.9	39.3	2.6	9.7	34.8	45.6	3.0	4.9	17.9	21.6	1.4	5.7	20.9	25.1	1.6
Perennial rye grass (*Lolium perenne*),	4	14	7.9	10.1	25.4	40.5	2.1	11.8	29.5	47.1	2.4	-	-	-	-	-	-	-	-
Red top (*Agrostis alba vulgaris*),	6	14	4.6	6.5	28.5	44.9	1.5	7.6	33.2	52.2	1.7	4.0	17.4	27.8	0.8	4.6	20.3	32.4	0.9
Red top (early cut),	1	14	4.3	5.8	30.9	43.3	1.7	6.8	35.9	50.3	2.0	3.5	18.9	26.9	0.9	4.1	21.9	31.2	1.0
Red top (late cut),	1	14	4.1	6.0	31.0	43.2	1.7	7.0	36.0	50.2	2.0	3.7	18.9	26.8	0.9	4.3	21.9	31.1	1.0
Tall oat grass (*Arrhenatherum elatius*),	4	14	4.6	6.4	30.9	42.1	1.9	7.4	36.0	49.0	2.2	3.3	17.0	24.4	1.1	3.8	19.8	28.4	1.2

* Same coefficients applied to all varieties of rape.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—Hay and Dry Coarse Fodders — *Con.*																			
(*a*) *Meadow Grasses and Millets* — Con.																			
Timothy (*Phleum pratense*),	8	14	4.2	8.4	28.1	43.4	1.9	9.7	32.7	50.5	2.2	4.0	14.6	26.9	1.0	4.6	17.0	31.3	1.1
Timothy (early cut),	1	14	4.0	5.7	31.0	43.5	1.8	6.6	36.1	50.6	2.1	3.3	18.3	27.8	1.0	3.8	21.3	32.4	1.2
Timothy (late cut),	1	14	3.9	5.2	29.7	45.2	2.0	6.0	34.6	52.6	2.3	2.3	13.9	27.1	1.0	2.7	16.3	31.6	1.2
White top (*Agrostis vulgaris var*),	1	14	6.0	11.2	24.4	41.5	2.9	13.0	28.4	48.2	3.4	6.8	14.9	25.7	1.5	7.9	17.3	29.9	1.7
English hay (mixed grasses),	81	14	5.2	7.9	27.5	43.1	2.3	9.2	31.9	50.1	2.7	4.6	16.5	25.4	1.1	5.3	19.1	29.6	1.3
Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	7.1	32.7	52.4	2.4	-	-	-	-	-	-	-	-
Rowen,	20	14	6.1	10.9	23.6	42.3	3.1	12.7	27.4	49.2	3.6	7.5	15.8	27.9	1.5	8.8	18.4	32.5	1.7
Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	8.3	31.0	51.8	2.2	2.4	8.8	20.5	0.8	2.8	10.2	23.8	1.0
Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	9.8	29.5	50.8	2.6	-	-	-	-	-	-	-	-
Black grass (*Juncus Gerardi*),	3	16	7.4	7.0	24.3	43.1	2.2	8.3	28.9	51.3	2.7	4.1	14.3	22.4	1.0	4.8	17.1	26.7	1.2
Branch grass (*Distichlis spicata*),	2	16	7.6	6.8	22.4	45.1	2.1	8.1	26.6	53.7	2.5	3.8	12.1	22.1	0.7	4.5	14.4	26.3	0.9
Flat sage (*Spartina stricta maritima var?*),	1	16	8.2	6.6	25.0	41.8	2.4	7.8	29.7	49.8	2.9	3.4	15.0	23.0	0.9	4.1	17.8	27.4	1.0

High grown salt hay (largely *Spartina patens*).	1	16	7.0	6.3	22.2	46.4	2.1	7.5	26.4	55.3	2.5	3.8	11.8	24.6	0.8	4.5	13.9	29.3	0.9
Fox grass (*Spartina patens*),	2	16	5.8	6.7	22.5	46.9	2.1	8.0	26.8	55.8	2.5	4.0	11.9	24.9	0.8	4.8	14.2	29.6	0.9
Cove mixture (black grass and red top),	1	16	6.0	7.4	23.2	45.6	1.8	8.8	27.6	54.3	2.1	3.6	13.9	24.2	0.7	4.2	16.6	28.8	0.8
Mixed salt hay (largely fox grass and branch grass).	1	16	8.4	5.5	22.5	45.5	2.1	6.5	26.8	54.2	2.5	2.3	13.1	23.7	0.6	2.7	15.5	28.2	0.7
Salt hay (variety uncertain),	2	16	4.3	3.4	24.0	49.8	2.5	4.0	28.6	59.3	3.0	1.4	13.9	25.9	0.7	1.7	16.6	30.8	0.8
(*b*) *Cereal Fodders.*																			
Corn stover, from field,	41	40	3.9	4.6	20.6	30.1	0.8	7.6	34.2	50.2	1.4	1.7	13.2	17.5	0.5	2.7	21.9	29.1	1 0
Corn stover, very dry,	41	20	5.2	6.1	27.4	40.2	1.1	7.6	34.2	50.2	1.4	2.2	17.5	23.3	0.8	2.7	21.9	29.1	1.0
Oats,	6	15	6.9	11.7	25.5	38.3	2.6	13.8	30.0	45.0	3.1	6.8	12.8	13.4	1.6	8.0	15.0	15.8	2.0
(*c*) *Legumes.*																			
Alsike clover,	8	15	9.7	14.0	23.1	36.1	2.1	16.5	27.2	42.4	2.5	9.2	12.2	25.6	1.1	10.9	14.4	30.1	1.3
Mammoth red clover,	4	15	8.2	13.1	24.4	37.6	1.7	15.4	28.7	44.2	2.1	-	-	-	-	-	-	-	-
Medium red clover,	5	15	7.4	11.8	26.0	37.5	2.3	13.9	30.6	44.1	2.7	6.8	14.0	24.0	1.3	8.1	16.5	28.2	1.5
(*d*) *Straw.*																			
Barley,	2	15	4.8	6.5	32.2	39.0	2.5	7.7	37.9	45.9	2.9	-	-	-	-	-	-	-	-
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	9.8	41.4	37.8	1.5	-	-	-	-	-	-	-	-
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	5.5	42.5	42.7	2.1	-	-	-	-	-	-	-	-
Millet (*Chætochloa italica*),	1	15	5.3	3.6	35.2	39.5	1.4	4.2	41.4	46.5	1.7	-	-	-	-	-	-	-	-
Millet (*Panicum crus-galli*),	1	15	4.6	5.2	30.4	42.7	2.1	6.1	35.8	50.2	2.5	-	-	-	-	-	-	-	-
Millet (*Panicum miliaceum*),	1	15	5.2	3.3	35.9	38.1	2.5	3.9	42.2	44.8	3.0	-	-	-	-	-	-	-	-
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	4.9	41.8	45.1	1.4	-	-	-	-	-	-	-	-
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	7.3	35.9	50.4	1.6	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Fodder Articles* — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III. — Hay and Dry Coarse Fodders — *Con.*																			
(e) *Mixed and Miscellaneous.*																			
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	14.4	30.0	44.1	3.0	7.3	16.8	20.3	0.5	8.6	19.8	23.8	0.6
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	15.1	31.4	42.1	2.7	7.7	17.6	19.3	0.4	9.1	20.7	22.7	0.5
Wheat and vetch,	2	15	6.4	13.8	27.7	35.0	2.1	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	7.8	36.1	46.7	2.4	-	-	-	-	-	-	-	-
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	14.8	19.8	54.2	3.0	-	-	-	-	-	-	-	-
IV. — Vegetables, Fruits, etc.																			
Apples,	2	78	0.7	1.0	1.5	18.3	0.5	4.5	6.8	83.2	2.3	-	-	-	-	-	-	-	-
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	13.1	4.1	76.9	0.9	-	-	-	-	-	-	-	-
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	25.7	9.3	54.8	2.3	-	-	-	-	-	-	-	-
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	12.5	5.8	71.7	0.8	-	-	-	-	-	-	-	-

Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	11.0	6.7	75.1	0.7	1.5	0.9	10.5	0.05	10.0	6.7	75.1	0.4
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	11.8	9.1	68.2	1.8	1.0	-	4.2	-	9.1	-	65.5	-
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	11.7	6.7	70.8	0.8	1.0	0.3	7.7	-	8.8	2.9	64.4	-
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	9.1	10.0	70.9	1.8	-	-	-	-	-	-	-	-
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	4.5	10.9	77.3	5.5	-	-	-	-	-	-	-	-
Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	6.5	7.5	75.0	3.5	-	-	-	-	-	-	-	-
Potatoes,	22	80	0.9	2.1	0.5	16.4	0.1	10.2	2.6	82.0	0.5	1.0	-	14.8	-	4.6	-	7.3	.07
Potatoes,	93	80	-	-	-	14.3*	-	-	-	71.5*	-	-	-	-	-	-	-	-	-
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	7.1	10.0	71.5	1.4	-	-	-	-	-	-	-	-
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	11.0	12.0	66.0	2.0	1.4	1.2	6.3	0.2	9.9	12.0	63.4	1.7
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	10.9	11.8	65.5	1.8	1.0	1.0	6.8	0.2	8.7	8.7	62.2	1.5
V. — CONCENTRATED FEEDS.																			
(*a*) *Protein.*																			
Cotton-seed meal,	129	7.0	6.5	45.1	6.1	24.2	11.1	48.5	6.6	26.0	11.9	39.7	3.4	14.8	9.4	42.7	3.6	15.9	11.1
Cotton-seed meal (low grade),	31	8.0	4.7	27.1	17.6	35.2	7.4	29.5	19.1	38.3	8.0	-	-	-	-	-	-	-	-
Cleveland flax meal,	19	9.0	5.3	38.3	8.8	36.2	2.4	42.1	9.7	39.8	2.6	32.4	7.0	31.1	2.3	35.8	7.8	34.2	2.5
Linseed meal (new process),	8	9.0	5.8	35.8	8.5	38.0	2.9	39.3	9.3	41.8	3.2	30.4	6.8	32.7	2.8	33.4	7.4	36.0	3.1
Linseed meal (old process),	55	8.5	5.2	35.3	8.5	36.5	6.0	38.6	9.2	39.9	6.6	31.4	4.9	28.5	5.3	34.4	5.2	31.1	5.9
Chicago gluten meal,	49	9.5	1.0	37.2	2.2	47.9	2.2	41.1	2.4	52.9	2.5	32.7	-	43.1	2.1	36.2	-	47.6	2.4
Cream gluten meal,	50	9.0	0.9	34.3	2.2	51.6	2.0	37.7	2.4	56.7	2.2	30.2	-	46.4	1.9	33.2	-	51.0	2.1
King gluten meal (new process),	3	9.0	-†	32.0	-†	-†	2.9	35.2	-	-	3.2	28.2	-	-	2.7	31.0	-	-	3.0

* Starch by inversion. † Not determined.

A. *Composition and Digestibility of Fodder Articles* — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — Concentrated Feeds — *Con.*																			
(*a*) *Protein* — Con.																			
King gluten meal (old process),	6	7.0	1.2	33.3	1.8	43.6	13.1	35.8	1.9	46.9	14.1	29.3	-	39.2	12.3	31.5	-	42.2	13.3
Buffalo gluten feed,	55	8.5	2.2	26.5	7.2	52.6	3.0	29.0	7.9	57.4	3.3	22.8	5.6	46.8	2.5	24.9	6.2	51.1	2.8
Davenport gluten feed,	2	8.5	1.9	26.2	6.3	53.8	3.3	28.6	6.9	58.8	3.6	22.5	4.9	47.9	2.8	24.6	5.4	52.3	3.0
Glen Cove gluten feed,	11	8.5	0.6	27.2	5.3	55.4	3.0	29.7	5.8	60.5	3.3	23.4	4.1	49.3	2.5	25.8	4.5	53.9	2.8
Golden gluten feed,	1	8.5	0.9	29.4	5.0	53.5	2.7	32.1	5.5	58.5	2.9	25.3	3.9	47.6	2.3	27.6	4.3	52.1	2.4
Marshalltown gluten feed,	3	8.5	-*	27.1	-*	-*	3.2	29.6	-	-	3.5	23.3	-	-	2.7	25.5	-	-	2.9
Bockford Diamond gluten feed,	15	8.5	1.1	25.2	7.1	54.9	3.2	27.5	7.8	60.0	3.5	21.7	5.5	48.9	2.7	23.7	6.1	53.4	2.9
Waukegan gluten feed,	13	8.5	1.1	26.5	7.7	52.8	3.4	29.0	8.4	57.7	3.7	22.8	6.0	47.0	2.9	24.9	6.6	51.4	3.1
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	24.9	10.3	50.4	11.5	15.7	-	37.2	10.1	17.2	-	40.8	11.2
Dried brewers' grains,	5	8.0	3.8	23.1	10.8	49.4	4.9	25.1	11.7	53.7	5.4	18.3	5.7	28.6	4.5	19.8	6.2	31.2	4.9
Wet brewers' grains,	1	77.0	0.7	6.7	3.8	9.8	2.0	29.0	16.7	42.5	8.5	5.3	2.0	5.7	1.8	22.9	8.9	24.7	7.7
Dried distillers' grains (average different brands).†	5	8.0	2.0	27.3	11.1	42.2	9.4	29.7	12.1	45.8	10.2	20.2	-	34.6	8.8	22.0	-	37.6	9.6

Atlas gluten meal,	9	8.0	1.7	31.4	10.9	35.5	12.5	34.1	11.9	38.6	13.6	23.2	-	29.1	11.8	25.2	-	31.7	12.8
Malt sprouts,	2	11.0	5.2	24.6	13.0	43.6	2.6	27.6	14.6	49.0	3.0	19.7	4.3	29.7	2.6	22.1	4.8	33.3	3.0
Wheat middlings (fine and flour),	50	10.0	3.2	18.8	3.2	60.1	4.7	20.9	3.6	66.7	5.2	16.0	1.2	52.9	4.0	17.8	1.3	58.7	4.4
Wheat middlings (coarse, so-called standard).	177	10.0	4.3	17.8	7.0	55.8	5.1	19.8	7.8	61.9	5.7	14.2	2.3	45.2	4.4	15.8	2.6	50.1	4.9
Mixed feed,	368	10.0	5.4	16.8	8.6	54.5	4.7	18.7	9.5	60.6	5.2	-	-	-	-	-	-	-	-
Mixed feed (low grade),	6	9.0	4.3	12.1	16.1	55.4	3.1	13.3	17.7	60.9	3.4	-	-	-	-	-	-	-	-
Wheat bran,	209	10.0	6.4	16.0	10.0	53.0	4.6	17.8	11.1	58.9	5.1	12.5	2.9	36.6	3.1	13.9	3.2	40.6	3.5
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	17.9	11.7	58.4	5.6	-	-	-	-	-	-	-	-
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	17.0	9.6	63.3	3.2	-	-	-	-	-	-	-	-
H-O dairy feed,	10	8.0	3.6	18.0	13.0	53.3	4.1	19.6	14.1	57.9	4.5	14.0	5.3	37.3	3.5	15.3	5.8	40.5	3.8
Buckwheat feed,	1	9.0	5.0	32.3	7.5	37.7	8.5	35.5	8.2	41.4	9.4	-	-	-	-	-	-	-	-
Buckwheat middlings,	1	11.0	4.8	22.7	4.6	50.2	6.7	25.5	5.2	56.4	7.5	-	-	-	-	-	-	-	-
Cocoanut meal,	2	8.0	3.7	20.0	12.0	39.4	16.3	22.4	13.1	42.8	17.7	-	-	-	-	-	-	-	-
Gluten flour,	1	9.0	0.7	38.4	0.2	50.8	0.9	42.2	0.2	55.8	1.0	-	-	-	-	-	-	-	-
Atlantic gluten meal,	1	7.0	1.2	41.1	1.5	46.9	2.3	44.2	1.6	50.4	2.5	-	-	-	-	-	-	-	-
Proteina,	4	8.0	2.5	21.8	10.0	51.1	6.6	23.7	10.9	55.5	7.2	-	-	-	-	-	-	-	-
Sucrene dairy feed,	6	9.0	6.6	16.8	11.7	52.8	3.1	18.4	12.9	58.0	3.4	-	-	-	-	-	-	-	-
Sucrene oil meal,	3	9.0	5.7	23.2	10.7	48.6	2.8	25.5	11.7	53.4	3.1	-	-	-	-	-	-	-	-
Horse beans,	1	14.0	3.8	25.8	7.0	48.6	0.8	30.0	8.1	56.5	1.0	-	-	-	-	-	-	-	-
Red adzinki beans,	2	14.0	3.6	21.0	4.0	56.7	0.7	24.4	4.7	65.9	0.8	-	-	-	-	-	-	-	-
Saddle beans,	1	14.0	5.3	13.0	4.1	49.4	14.2	15.1	4.8	57.4	16.5	-	-	-	-	-	-	-	-

* Not determined.

† See thirteenth report, p. 44.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—Concentrated Feeds — *Con.*																			
(*a*) *Protein* — Con.																			
Soy beans (variety uncertain),	4	14.0	5.1	30.8	4.9	28.2	17.0	35.8	5.7	32.8	19.8	-	-	-	-	-	-	-	-
Soy bean meal,	1	14.0	4.7	32.9	3.7	29.2	15.5	38.3	4.3	33.9	18.0	29.6	1.9	21.0	13.2	34.5	2.2	24.4	15.3
Ground flax seed,	2	7.0	3.5	23.5	5.5	23.3	37.2	25.3	5.9	25.0	40.0	-	-	-	-	-	-	-	-
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	21.0	19.4	54.9	1.8	15.7	4.6	46.4	0.9	17.4	5.0	51.6	1.0
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	53.3	3.8	26.8	11.8	44.6	0.8	22.7	9.6	48.5	0.9	24.7	10.5
(*b*) *Starchy.*																			
Barley kernels,	1	11.0	2.7	10.3	5.5	68.6	1.9	11.6	6.2	77.1	2.1	-	-	-	-	-	-	-	-
Ground barley,	5	13.0	2.3	11.3	5.7	65.8	1.9	13.0	6.5	75.6	2.2	7.9	2.9	60.5	1.7	9.1	3.3	69.6	2.0
Broom-corn seed,	1	14.0	2.2	9.6	7.1	63.6	3.5	11.2	8.3	73.9	4.0	-	-	-	-	-	-	-	-
Broom-corn meal,	1	14.0	2.0	9.6	6.9	64.0	3.5	11.2	8.0	74.3	4.1	-	-	-	-	-	-	-	-
Buckwheat kernels,	1	12.0	1.9	9.9	10.3	63.5	2.4	11.3	11.7	72.1	2.7	-	-	-	-	-	-	-	-
Corn kernels,	32	11.0	1.4	10.8	1.9	70.2	4.7	12.1	2.1	78.9	5.3	-	-	-	-	-	-	-	-
Corn meal,	56	14.0	1.4	9.5	1.9	69.9	3.3	11.0	2.2	81.3	3.9	6.5	-	66.4	3.0	7.5	-	77.2	3.6

Sweet corn kernels,	3	11.0	1.9	12.5	2.4	64.9	7.3	14.0	2.7	72.9	8.2	-	-	-	-	-	-	-	-
Corn and cob meal,	37	11.0	1.4	8.9	6.7	68.4	3.6	10.0	7.5	76.8	4.1	5.0	3.1	60.2	3.0	5.6	3.1	67.6	3.4
Barnyard millet seed,	1	11.0	3.3	12.2	7.6	60.3	5.6	13.7	8.6	67.7	6.3	-	-	-	-	-	-	-	-
Millet seed (variety uncertain),	4	12.0	2.6	11.1	7.7	62.9	3.7	12.5	8.8	71.5	4.2	-	-	-	-	-	-	-	-
Oat kernels,	5	11.0	2.9	12.9	8.5	59.6	5.1	14.5	9.6	66.9	5.7	11.1	2.6	47.1	4.2	12.5	3.0	52.9	4.7*
Ground oats,	3	12.0	3.3	11.4	8.7	60.8	3.8	13.0	9.9	69.1	4.3	8.9	1.7	46.2	3.2	10.1	2.0	52.5	3.6†
Wheat kernels,	7	11.0	1.8	12.4	2.3	70.8	1.7	13.9	2.6	79.6	1.9	-	-	-	-	-	-	-	-
Ground wheat,	1	12.0	1.9	12.1	2.9	69.2	1.9	13.7	3.3	78.6	2.2	-	-	-	-	-	-	-	-
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	9.2	0.4	72.4	6.4	-	-	-	-	-	-	-	-
Cassava starch refuse,	1	12.0	1.6	0.8	6.1	78.8	0.7	0.9	6.9	89.6	0.8	-	-	-	-	-	-	-	-
Cerealine,	4	11.0	2.6	11.1	4.9	62.7	7.7	12.5	5.5	70.5	8.6	8.9	4.0	59.6	6.2	10.0	4.5	67.0	7.0
Cocoa dust,	1	7.0	6.3	14.4	5.5	42.7	24.1	15.5	5.9	45.9	25.9	-	-	-	-	-	-	-	-
Cocoa shells,	1	5.0	8.4	18.0	15.9	50.9	1.8	18.9	16.7	53.6	1.9	-	-	-	-	-	-	-	-
Cocoanut meat,	1	1.0	0.8	9.9	7.5	15.3	65.5	10.0	7.5	15.1	66.1	-	-	-	-	-	-	-	-
Chop feed,	3	11.0	0.8	10.2	12.7	60.1	5.2	11.5	14.3	67.5	5.8	6.8	7.9	50.5	4.3	7.7	8.9	56.7	4.8
Corn bran,	2	11.0	2.0	10.8	12.4	59.8	4.0	12.1	13.9	67.2	4.5	-	-	-	-	-	-	-	-
Corn cobs,	6	8.0	1.3	2.7	31.3	56.2	0.5	2.9	34.0	61.1	0.6	0.5	17.8	27.0	-	0.6	19.4	29.3	-
Corn screenings,	1	11.0	2.1	7.4	2.9	72.6	4.0	8.3	3.3	81.5	4.5	-	-	-	-	-	-	-	-
Corn and oat feed,	47	10.0	3.0	9.1	10.0	64.7	3.2	10.1	11.1	71.9	3.6	6.5	4.8	53.7	2.8	7.2	5.3	59.7	3.1
Corn, oat, and barley feed,	8	10.0	3.1	11.4	8.3	62.4	4.8	12.7	9.2	69.3	5.3	-	-	-	-	-	-	-	-
Cotton hulls,	5	11.0	2.6	5.3	39.7	39.0	2.4	6.0	44.6	43.8	2.7	-	15.9	16.0	2.1	-	17.8	18.0	2.3
Cotton-hull bran,	1	11.0	1.9	2.3	35.0	48.7	1.1	2.6	39.3	54.7	1.2	-	-	-	-	-	-	-	-

* Horses. † Ruminants.

A. Composition and Digestibility of Fodder Articles — Concluded.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — Concentrated Feeds — *Con.*																			
(*b*) *Starchy* — Con.																			
Cotton-seed feed,	4	11.0	3.1	10.5	36.0	35.9	3.5	11.8	40.5	40.3	3.9	5.4	16.6	19.8	3.0	6.0	18.6	22.2	3.4
Flax-seed screenings,	1	7.0	5.4	15.7	16.5	44.5	10.9	16.9	17.8	47.8	11.7	-	-	-	-	-	-	-	-
Hominy meal,	28	9.0	2.6	11.2	4.4	64.5	8.3	12.3	4.8	70.9	9.1	-	-	-	-	-	-	-	-
H-O horse feed,	12	9.0	3.1	12.6	9.8	62.0	3.5	13.8	10.8	68.1	3.9	9.3	3.4	49.0	2.9	10.2	3.8	53.8	3.0
Maizeline,	1	5.0	2.7	10.0	7.9	66.0	8.4	10.5	8.3	69.5	8.9	-	-	-	-	-	-	-	-
Mellin's Food refuse,	1	7.0	3.9	11.4	7.1	67.2	3.4	12.3	7.6	72.2	3.7	-	-	-	-	-	-	-	-
Canada oat feed,	2	7.0	5.4	13.2	24.8	44.7	4.9	14.2	26.7	48.1	5.3	-	-	-	-	-	-	-	-
Oat feed (average quality),	86	7.0	5.2	8.2	20.9	55.7	3.0	8.8	22.5	59.9	3.2	6.6	9.0	37.3	2.7	7.1	9.7	40.1	2.8
Oat feed (low grade),	2	7.0	4.6	2.7	30.2	54.4	1.0	2.9	32.5	58.5	1.1	1.7	9.7	18.0	0.9	1.8	10.4	19.3	1.0
Oat meal,	1	9.0	1.9	16.8	1.1	64.5	6.7	18.4	1.2	70.9	7.4	-	-	-	-	-	-	-	-
Oat middlings,	1	11.0	4.2	10.8	17.4	53.3	3.3	12.1	19.5	59.9	3.7	-	-	-	-	-	-	-	-
Parson's "Six-dollar" feed,	1	11.0	7.9	10.0	17.9	51.1	2.1	11.2	20.1	57.4	2.4	-	-	-	-	-	-	-	-

Pea bran,	2	11.0	2.7	10.0	39.7	35.6	1.0	11.3	44.5	40.0	1.2	-	-	-	-	-	-	-	-
Peanut feed,	2	10.0	2.6	8.9	56.4	16.6	5.5	9.9	62.7	18.4	6.1	6.3	6.2	8.1	5.0	7.0	6.9	9.0	5.5
Peanut husks,	1	13.0	1.2	5.0	66.0	13.1	1.7	5.7	75.9	15.1	1.9	-	-	-	-	-	-	-	-
Quaker dairy feed,	32	8.0	4.6	13.2	16.8	54.3	3.1	14.3	18.3	59.0	3.4	10.7	7.2	36.4	2.8	11.6	7.9	39.5	3.0
Louisiana rice bran,	1	11.0	9.4	8.7	13.3	49.0	8.6	9.8	14.9	55.0	9.7	-	-	-	-	-	-	-	-
Rice meal,	2	11.0	8.2	11.8	5.3	50.8	12.9	13.2	6.0	57.0	14.6	7.3	-	46.7	11.7	8.2	-	52.4	13.3
Rye bran,	2	11.0	4.1	15.6	3.5	63.5	2.3	17.8	4.0	71.3	2.6	-	-	-	-	-	-	-	-
Rye feed,	3	11.0	2.7	13.1	3.2	67.4	2.6	14.7	3.6	75.7	2.9	10.5	-	59.3	2.3	11.8	-	66.6	2.6
Rye middlings,	1	11.0	3.6	11.7	3.3	65.4	5.0	13.2	3.7	73.5	5.6	-	-	-	-	-	-	-	-
Schumacher's stock food,	14	8.0	4.0	11.3	11.8	60.3	4.6	12.3	12.8	65.5	5.0	-	-	-	-	-	-	-	-
Stalk, corn, and cob feed,	1	10.0	2.7	7.5	17.2	60.5	2.1	8.3	19.2	67.2	2.3	-	-	-	-	-	-	-	-
Starch refuse,	2	12.0	1.8	4.8	3.8	76.3	1.3	5.4	4.3	86.7	1.5	-	-	-	-	-	-	-	-
Sucrene chop feed,	1	9.0	6.4	11.4	13.9	56.9	2.4	12.5	15.3	62.5	2.7	-	-	-	-	-	-	-	-
Victor corn and oat feed,	39	10.0	3.5	8.6	11.3	62.9	3.7	9.6	12.6	69.9	4.1	6.1	5.4	52.2	3.2	6.8	6.1	58.0	3.6
Wheat flour,	2	12.0	0.4	9.9	0.1	76.8	0.8	11.2	0.1	87.3	0.9	-	-	-	-	-	-	-	-
(c) *Poultry.*																			
American poultry food,	14	8.0	2.9	13.1	6.5	63.6	5.9	14.2	7.1	69.1	6.4	-	-	-	-	-	-	-	-
Cut bone,	1	26.0	21.5	20.7	-	0.2	31.6	28.0	-	0.3	42.6	-	-	-	-	-	-	-	-
Raw ground bone,	1	8.0	64.4	23.9	-	3.4	0.3	26.0	-	3.7	0.3	-	-	-	-	-	-	-	-
Cut clover,	2	10.0	6.8	17.9	20.5	41.8	3.0	19.9	22.8	46.4	3.4	-	-	-	-	-	-	-	-
H-O poultry food,	3	9.0	2.7	17.4	4.4	60.2	5.3	19.1	5.9	66.2	5.8	-	-	-	-	-	-	-	-
Meat and bone meal,	26	6.0	37.5	40.6	-	7.5	10.2	43.1	-	8.0	10.9	-	-	-	-	-	-	-	-
Meat scrap,	4	9.0	15.3	49.5	-	5.0	21.2	54.4	-	5.5	23.2	-	-	-	-	-	-	-	-

B. Fertilizer Ingredients of Fodder Articles.*

[Figures equal percentages or pounds in 100.]

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I.—Green Fodders.					
(a) Meadow Grasses and Millets.					
Hungarian grass,	1	75	0.38	0.52	0.15
Japanese millet,	3	80	0.33	0.22	0.10
Barnyard millet,	3	80	0.30	0.67	0.10
Millet,	1	80	0.29	0.43	0.11
Orchard grass,	4	70	0.43	0.56	0.13
(b) Cereal Fodders.					
Corn fodder,	21	80	0.39†	0.27	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
(c) Legumes.					
Alfalfa,	4	75	0.55	0.39	0.14
Horse bean,	1	85	0.41	0.21	0.05
Soy bean,	1	75	–	0.49	0.14
Soy bean (early white),	1	75	0.71	0.69	0.16
Soy bean (medium green),	1	75	0.70	0.59	0.17
Soy bean (medium black),	1	75	0.88	0.62	0.20
Soy bean (late),	1	75	0.75	0.85	0.18
Alsike clover,	6	75	0.66	0.62	0.19
Mammoth red clover,	3	75	0.63	0.34‡	0.15
Medium red clover,	2	75	0.59	0.62	0.12
Sweet clover,	1	75	0.54	0.50	0.15
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09
Cow-pea,	1	80	0.36	0.20	0.11
Flat pea,	1	80	1.00	0.43	0.13
Small pea,	1	80	0.53	0.41	0.12
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	80	0.48	0.49	0.16

* Most of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably, depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations, rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

† Too high; 0.26 nearer correct. ‡ Evidently below normal.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. — GREEN FODDERS — *Con.*					
(*c*) *Legumes* — Con.					
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	80	0.48	0.60	0.13
Kidney vetch,	1	80	0.59	0.37	0.10
(*d*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	80	0.30*	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver hull buckwheat,	1	85	0.29	0.39	0.14
Carrot tops,	1	80	0.69	1.08	0.13
Prickly comfrey,	1	87	0.37	0.76	0.12
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	7	80	0.27	0.27	0.11
Teosinte,	1	70	0.47	1.18	0.06
II. — SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11
III. — HAY AND DRY COARSE FODDERS.					
(*a*) *Meadow Grasses and Millets.*					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	12	14	1.29	1.52	0.29
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23

* Too low; 0.43 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III.—HAY AND DRY COARSE FODDERS — *Con.*					
(*b*) *Cereal Fodders.*					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45*	1.90	0.65
(*c*) *Legumes.*					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16†	0.52
Medium red clover,	2	15	2.01	2.11	0.41
(*d*) *Straw.*					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(*e*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	15	1.29‡	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41
IV.—VEGETABLES, FRUITS, ETC.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17
Beets, red,	8	88	0.24	0.44	0.09
Sugar beets,	4	86	0.24	0.52	0.11
Yellow fodder beets,	1	89	0.23	0.56	0.11
Mangolds,	3	88	0.15	0.34	0.14
Carrots,	3	89	0.16	0.46	0.09
Cranberries,	1	89	0.08	0.10	0.03
Parsnips,	1	80	0.22	0.62	0.19
Potatoes,	5	80	0.29	0.51	0.08
Japanese radish,	1	93	0.08	0.40	0.05
Turnips,	4	90	0.17	0.38	0.12
Ruta-bagas,	3	89	0.19	0.49	0.12

* Too high; 1.90 nearer correct. † Evidently below normal.
‡ Too low; 1.80 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — Concentrated Feeds.					
(*a*) *Protein.*					
Cotton-seed meal,	24	7.0	7.22	1.85	2.50
Linseed meal (new process),	5	9.0	5.77	1.24	1.68
Linseed meal (old process),	4	8.5	5.36	1.20	1.77
Chicago gluten meal,	2	9.5	6.05	0.06	0.43
King gluten meal,	1	7.0	5.74	0.08	0.70
Gluten meal (brand uncertain),	5	8.5	5.09	0.05	0.42
Buffalo gluten feed,	5	8.5	4.24	0.06	0.34
Dried brewers' grains,	2	8.0	3.68	0.86	1.06
Atlas gluten meal,	1	8.0	4.97	0.17	0.24
Wheat middlings,	2	10.0	2.79	0.76	1.27
Wheat bran,	10	10.0	2.36	1.40	2.10
Proteina,	1	8.0	3.04	0.58	1.02
Red adzinki bean,	1	14.0	3.27	1.55	0.95
White adzinki bean,	1	14.0	3.45	1.53	1.00
Saddle bean,	1	14.0	2.08	2.09	1.49
Soy bean (variety uncertain),	2	14.0	5.58	2.10	1.97
Soy bean meal,	1	14.0	5.68	2.15	1.51
Pea meal,	1	10.0	3.04	0.98	1.81
Peanut meal,	1	8.0	7.84	1.54	1.27
(*b*) *Starchy.*					
Ground barley,	1	13.0	1.56	0.34	0.66
Corn kernels,	13	11.0	1.82	0.40	0.70
Corn meal,	3	14.0	1.92	0.34	0.71
Corn and cob meal,	29	11.0	1.38	0.46	0.56
Common millet seed,	2	12.0	2.00	0.45	0.95
Japanese millet seed,	1	12.0	1.58	0.35	0.63
Oat kernels,	1	11.0	2.05	–	–
Buckwheat hulls,	1	12.0	0.49	0.52	0.07
Cocoa dust,	1	7.0	2.30	0.63	1.34
Corn cobs,	8	8.0	0.52	0.63	0.06
Cotton hulls,	3	11.0	0.75	1.08	0.18
Oat feed,	1	7.0	1.46	0.72	0.60
Peanut feed,	2	10.0	1.46	0.79	0.23

B. Fertilizer Ingredients of Fodder Articles — Concluded.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — CONCENTRATED FEEDS — *Con.*					
(*b*) *Starchy* — Con.					
Peanut husks,	1	13.0	0.80	0.48	0.13
Louisiana rice bran,	1	11.0	1.42	0.83	1.70
Rye feed,	1	11.0	1.92	0.97	1.54
Rye middlings,	1	11.0	1.87	0.82	1.28
Schumacher's stock feed,	1	8.0	1.80	0.63	0.83
Victor corn and oat feed,	2	10.0	1.38	0.61	0.59
Damaged wheat,	1	13.0	2.26	0.51	0.83
Wheat flour,	2	12.0	2.02	0.36	0.35
(*c*) *Poultry.*					
American poultry food,	1	8.0	2.22	0.52	0.98
Wheat meal,	1	8.0	11.21	0.30	0.73
VI. — DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19*	0.16*
Human milk,	3	88.1	0.24	-	-
Skim-milk,	22	90.3	0.59	0.18†	0.20†
Buttermilk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	-	-

* From Farrington and Woll. † From Woll's handbook.

C. Analyses of Dairy Products.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Solids.			Fat.			Curd (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	3,281	19.55	10.02	13.57	10.70	1.50	4.32	3.54*	-	0.73†
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	-	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84‡	-	1.00
Skim-milk (largely from Cooley process),	358	10.48	7.68	9.20	1.80	0.05	0.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	-	-	-
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	-	-	-
Butter (salted),	117	94.84	83.41	87.56	89.33	77.95	83.31	1.17§	3.17§	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	-	-
Whole-milk cheese,	2	-	-	63.51	-	-	35.83	24.41	-	3.27
Cheese from partially skimmed milk,	2	-	-	60.23	-	-	25.62	31.18	-	3.44
Skim-milk cheese,	2	-	-	55.32	-	-	16.72	34.09	-	4.51
Cheese from skim-milk, with addition of buttermilk,	1	-	-	51.62	-	-	18.35	28.63	-	4.65
Genuine oleomargarine cheese,	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* Average of 297 analyses. † Average of 253 analyses. ‡ Nitrogen. § Average of 115 analyses.

D. Coefficients of Digestibility of American Feed Stuffs. — Experiments made in the United States.

COMPILED BY J. B. LINDSEY, ASSISTED BY NATHAN J. HUNTING.

Experiments with Ruminants.
Experiments with Swine.
Experiments with Horses.
Experiments with Poultry.

Dec. 31, 1901.

Experiments with Ruminants.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.—Green Fodders.									
(*a*) *Meadow Grasses and Millets.*									
Barnyard millet in blossom (Mass.),	3	6	67—76 70	– –	45—67 56	58—70 65	71—77 73	65—77 71	54—67 58
Japanese millet, bloom, to early seed (Storrs),	2	3	– –	62—66 64	52—58 55	45—57 50	59—63 62	64—68 67	60—72 68
Hungarian grass, early to late bloom,	3	8	61—71 66	61—74 68	– –	59—72 63	65—76 70	64—71 67	48—85 62
Grass, meadow, young,	1	1	69	–	–	65	74	72	55
Grass, meadow, young, and dried,	1	1	71	–	–	71	77	73	60
Grass, timothy,	1	3	63—65 64	– –	31—33 32	48—48 48	54—58 56	65—67 66	52—54 52
Grass, timothy rowen,	1	2	– –	65—67 66	– –	72—72 72	60—68 64	67—68 68	51—55 52
(*b*) *Cereal Fodders.*									
Corn fodder, dent, immature,	4	11	64—74 68	– –	– –	56—80 66	60—76 67	64—79 71	37—83 68
Corn fodder, dent, milk,	3	9	70	–	–	61	64	76	78
Corn fodder, dent, mature,	7	13	66	–	–	53	52	74	76
Corn fodder, dent, mature, B. & W., coarse,	1	2	51—54 52	– –	– –	20—28 24	46—47 46	57—61 59	74—82 78

Corn fodder, sweet, milk stage,	1	2	77—78 77	- -	- -	77—78 77	74—76 75	80—81 81	73—74 74
Corn fodder, sweet, roasting stage,	9	12	- -	67—79 72	22—61 48	52—69 62	54—72 60	73—82 77	62—82 74
Sorghum, blossom,	1	2	73—73 73	- -	- -	51—56 53	74—75 75	78—78 78	81—82 81
Sorghum, Early Amber, past blossom,	1	2	61—62 61	- -	- -	38—42 40	42—45 42	70—71 71	- 67
Sorghum, average both samples,	2	4	67	-	-	46	59	74	74
Barley fodder, bloom,	2	4	- -	62—71 67	- -	69—73 72	49—66 61	69—76 71	56—63 60
Barley fodder, seeds forming,	2	2	- -	66—71 68	40—44 42	67—71 69	47—65 56	- 74	48—50 49
Oat fodder, bloom (?),	1	2	- -	63—65 64	- -	75—76 75	58—63 60	63—63 63	68—71 70
Oat fodder, early seed,	2	3	- -	56—63 60	49—68 60	68—73 71	43—56 51	60—67 62	67—72 69
Rye fodder, heading,	1	2	73—74 74	- -	- -	79—80 79	80—80 80	70—71 71	74—74 74
(c) Legumes.									
Clover, red, late blossom,	1	2	65—67 66	- -	- -	66—68 67	52—53 53	76—79 78	63—66 65
Clover, rowen, late blossom,	1	2	- -	60—62 61	- -	61—62 62	51—54 52	64—68 65	60—61 61
Clover, crimson, late blossom,	1	3	- -	68—70 69	- -	77—77 77	54—58 56	74—75 74	63—69 66
Clover, average three samples,	3	7	-	-	-	70	54	72	64
Cow-peas, ready for soiling,	2	4	66—77 68	72—76 74	19—28 23	73—77 76	57—62 60	76—84 81	56—62 59

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.—Green Fodders—*Con.*									
(*c*) *Legumes*—Con.									
Canada field peas, before bloom,	1	2	68	71—72 71	– –	81—83 82	62—62 62	71—71 71	50—55 52
Canada field peas, bloom to seed,	1	3	60—65 63	– –	40—45 43	79—80 80	40—52 46	72—75 74	45—53 49
Soy beans, variety uncertain, before bloom,	1	2	– –	64—67 66	– –	77—80 79	45—55 50	71—73 72	50—58 54
Soy beans, variety uncertain, seeding,	1	2	– –	61—63 62	– –	68—71 69	38—43 41	72—75 73	49—59 54
Soy beans, medium green, full bloom,	1	2	– –	62—63 63	22—28 25	76—78 77	45—49 47	69—73 71	46—54 50
Soy beans, medium green, seeding,	1	2	– –	67—67 67	16—29 23	74—76 75	49—50 50	75—77 76	54—61 58
Soy beans, medium green, seeding,	1	4	– –	65—69 67	– –	74—78 76	39—44 44	76—81 79	31—46 36
Soy beans, average all trials,	5	12	–	65	?	75	46	75	48
Spring vetch (*Vicia sativa*),	1	2	62—62 62	– –	– 17	71—72 71	42—46 44	75—77 76	57—60 59
Hairy vetch (*Vicia villosa*),	3	12	66—78 71	– –	33—55 44	79—88 83	52—73 63	68—83 76	63—82 72

(d) Mixed and Miscellaneous.								
Oats and spring vetch, bloom,	1	3	65—69 67	- -	49—55 53	73—76 75	65—72 68	66—70 68	42—52 47
Oats and peas, bloom,	2	5	69—72 70	67—69 68	45—52 49	68—82 74	54—70 64	66—77 72	51—74 64
Oats and peas, partly seeded,	3	5	- -	58—70 62	36—63 47	68—83 74	48—67 55	56—67 63	55—74 64
Winter wheat and hairy vetch,	1	3	68—69 68	- -	40—46 44	75—78 77	66—67 67	71—72 72	56—57 57
Barley and peas, bloom,	3	4	- -	55—71 65	52—55 54	73—81 75	38—61 52	56—76 68	54—65 59
Dwarf Essex rape, first growth,	1	2	88—88 88	- -	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2	81	-	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	-	63	89	87	92	48
Skim-milk, with sheep,	1	3	96—102 97	- 100	46—74 62	93—96 94	- -	- 100	- 100
II.—SILAGE.								
Corn silage, dent, immature,	5	13	60—68 64	- -	- -	42—65 54	(?)—78 70	60—70 66	64—85 71
Corn silage, dent, mature,	6	17	60—74 64	- -	- -	45—63 52	45—80 62	63—73 69	78—90 85
Corn silage, dent, stage uncertain,	1	4	53—67 60	- -	- -	19—34 24	43—64 56	61—76 68	55—79 70
Corn silage, dent, Pride of North, mature,	1	2	72—76 74	- -	24—28 26	- 45	72—73 73	81—83 82	72—82 77
Corn silage, flint, mature, small varieties,	4	11	68—78 75	66—80 77	- -	48—73 65	75—79 77	71—83 79	- 82

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II. — Silage — *Con.*									
Corn silage, flint, large white, partly eared,	1	2	69—70 70	72—73 72	31—37 34	56—56 56	72—72 72	75—76 76	72—74 73
Corn silage, fine crushed, steers,	1	2	60—68 64	-	-	32—44 38	72—78 75	60—70 65	75—77 76
Corn silage, fine crushed, sheep,	1	2	51—56 54	-	-	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	-	-	-	45	59	71	86
Corn silage, mature, cooked,	1	1	-	-	-	39	70	75	87
Corn silage, sweet, mature,	1	2	67—70 68	68—72 70	-	53—55 54	68—74 71	71—73 72	82—85 83
Cow-pea silage, steers,	1	4	59—60 60	-	-	57—58 57	50—54 52	72—73 72	62—64 63
Clover silage, late bloom,	1	2	52—52 52	52—54 53	37—51 44	39—40 40	55—55 55	54—58 56	48—60 54
Oat and pea silage,	1	2	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Soy bean silage, goats,	1	2	52—66 59	-	-	71—80 76	47—62 55	46—58 52	66—77 72
Soy bean silage, steers,	1	2	50—50 50	-	-	54—56 55	42—44 43	61—61 61	47—52 49
Soy bean and barnyard millet silage, sheep,	1	4	54—65 59	-	-	55—62 57	61—73 69	54—63 59	69—75 72

Soy bean and corn silage, sheep, ...	1	3	66—72 69	- -	- -	63—67 65	59—73 65	73—78 75	80—84 82
Silage, mixture of corn, sunflower heads and horse beans.*	1	2	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77
Silage, mixture of corn, sunflowers (whole plant) and horse beans.†	1	2	64—67 65	68—71 69	20—31 26	57—59 58	63—68 65	72—75 74	72—76 74
III.—HAY AND DRY COARSE FODDERS.									
(a) Meadow Grasses and Millets.									
Timothy, in bloom, ...	3	5	56—66 60	56—67 60	- -	50—60 56	56—62 58	57—72 63	51—62 57
Timothy, past bloom, ...	5	10	47—61 53	48—62 54	- -	39—50 45	37—57 47	56—70 60	35—61 53
Timothy, average all trials, ...	20	48	56	57	36	48	51	62	51
Timothy, fed with cotton-seed meal, 16 hay, 1 meal,	1	2	52—56 54	- -	17—28 22	24—32 28	46—52 49	61—63 62	36—37 36
Timothy, fed with cotton-seed meal, 12 hay, 1 meal,	1	2	49—55 52	- -	9—30 20	27—38 32	43—51 47	58—62 60	52—54 53
Timothy, fed with cotton-seed meal, 8 hay, 1 meal, .	1	2	44—48 46	- -	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy, fed with cotton-seed meal, 4 hay, 1 meal, .	1	2	45—46 46	- -	- -	4—4 4	42—43 43	56—75 57	44—66 55
Timothy, fed with cotton-seed meal, 2 hay, 1 meal, .	1	2	48—56 52	- -	- 13	- 13	34—44 39	65—71 68	72—74 73
Timothy, fed with cotton-seed meal, 1 hay, 1 meal, .	1	2	47—52 49	- -	19—23 21	- -	24—26 25	68—78 73	79—87 83
Timothy, fed with cotton-seed meal, average all trials,	6	12	50	-	16	20	41	62	57
Timothy and clover, poorly cured, ...	1	2	54—55 55	- -	- -	37—38 38	52—54 53	- 60	- 58

* Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

† Same proportions as above.

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Mixed grasses, rich in protein,	11	46	54—63 60	- -	44—53 48	40—65 59	49—66 60	56—65 61	41—58 50
Mixed grasses, timothy predominating,	2	4	55	-	35	54	58	55	41
Red top,	2	3	58—62 60	59—64 61	- -	60—62 61	61—62 61	59—65 62	44—59 51
Orchard grass, ten days after bloom,	1	1	54	56	-	59	58	54	54
Orchard grass, stage not given,	1	2	57—60 59	- -	- -	60—60 60	60—67 64	55—57 56	55—57 56
Orchard grass, average both samples,	2	3	56	56	-	60	61	55	55
Meadow fescue (*Festuca elatior pratensis*),	1	2	60—61 61	- -	- 46	51—53 52	- 67	58—60 59	53—54 54
Tall oat grass, late blossom (*Arrhenatherum elatius*),	1	2	54—57 55	- -	39—43 41	- 51	53—57 55	56—59 58	54—58 56
Kentucky blue grass (*Poa pratensis*),	1	1	56	-	42	57	63	53	43
Canada blue grass (*Poa compressa*),	1	2	62—63 62	- -	42—42 42	43—44 43	70—71 71	63—63 63	36—39 37
Rowen, mixed grasses,	3	12	- -	63—68 65	- -	- 70	62—72 66	60—69 65	44—51 47
Rowen, chiefly timothy,	1	4	- -	62—67 64	- -	66—69 68	62—73 66	60—65 63	48—51 49

Rowen, average all trials,	4	16	-	65	-	69	66	64	47
Pasture grass,	1	3	73	73	52	73	76	74	67
Meadow, swale or swamp,	1	2	38—40 39	- -	- -	31—37 34	30—36 33	- 46	- 44
Blue-joint, bloom,	1	2	67—70 69	68—71 70	- -	68—72 70	71—73 72	66—71 69	51—53 52
Blue-joint, past bloom,	1	1	40	42	-	57	37	43	37
Buffalo grass (*Bulbilis Dactyloides*),	1	1	55	-	6	54	65	62	62
Prairie grass (*Sporobolus Asper*),	1	1	56	-	25	18	61	61	57
Johnson grass (*Andropogon halepensis*),	2	3	57	-	-	40	68	57	38
Crab grass, ripe (*Eragrostis Neo Mexicana*),	3	8	47—57 53	- -	29—52 43	30—56 38	50—66 60	50—59 53	30—52 43
Chess or cheat (*Bromus secalinus*),	1	1	45	-	23	42	46	49	32
Black grass (*Juncus Gerardi*),	2	5	50—62 56	- -	67—71 69	53—63 58	50—66 59	46—59 52	37—51 44
Fox grass (*Spartina patens*),	3	7	51—56 54	- -	57—59 58	56—63 60	46—60 53	51—55 53	17—51 36
Branch grass (*Distichlis spicata*),	2	5	49—57 52	- -	- 58	- 56	48—57 54	45—55 49	27—42 35
Salt hay mixture, fox and branch grasses, etc.,	1	2	52—56 54	- -	68—70 69	41—43 42	54—61 58	51—54 52	26—30 28
Flat sage (*Spartina stricta maritima var.*),	1	3	55—58 57	- -	61—62 62	50—55 52	60—61 60	54—57 55	33—40 36
Barnyard millet,	1	3	57—58 57	- -	63—64 63	63—64 64	60—64 62	50—52 52	44—50 46
Millet (*Chætochloa italica*),	1	2	52—58 56	- -	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Hungarian,	1	2	64—66 65	66—67 66	- -	- 60	67—68 68	67—67 67	- 64
Golden millet,	1	1	54	-	31	23	56	58	49
Cat-tail millet (*Pennesetum spicatum*),	1	2	61—64 62	- -	- -	61—65 63	65—68 67	58—60 59	45—48 46
(*b*) *Cereal Fodders.*									
Corn stover, average all trials,	6	18	53—62 57	- -	- -	11—55 36	63—74 66	54—64 59	49—77 65
Corn stover,	1	4	53—55 53	56—58 57	- -	11—22 17	63—67 64	54—59 57	69—77 76
Corn stover, without pith,	1	3	54—57 55	55—59 57	- -	16—28 20	60—65 63	55—58 57	70—75 72
New corn product, stover minus pith, ground,	1	3	63—64 63	- -	46—55 49	57—62 60	60—61 61	65—66 66	82—83 83
New corn product, steamed,	1	3	51—59 56	- -	47—55 50	59—60 60	37—54 48	57—62 59	70—85 80
Average three trials, stover minus pith,	3	9	58	-	-	47	57	61	78
Corn stover, tops and blades,	1	2	59—60 60	- -	- -	54—57 55	71—72 71	62—63 62	71—72 71
Corn stover, blades and husks,	1	4	60—68 65	- -	15—35 23	41—55 48	67—76 73	64—71 66	53—64 58

Corn stover, leaves,	1	2	55—56 56	- -	- -	43—69 56	54—67 61	57—61 59	61—65 63
Corn stover, below ear,	1	2	64—69 67	- -	- -	15—27 21	71—75 74	65—73 69	79—80 80
Corn stover, above ear,	1	2	52—58 55	- -	- -	17—27 22	69—72 71	50—57 54	62—65 64
Corn husks,	1	2	71—73 72	- -	- -	24—35 30	78—81 80	- 75	23—42 33
Corn leaves,	1	2	62—67 65	- -	- -	28—41 35	75—80 78	66—70 68	52—59 56
Kafir corn stover, shredded,	1	4	54—58 56	- -	13—26 19	29—34 30	65—69 67	56—60 58	77—81 79
Kafir corn stover,	1	1	63	-	43	50	67	67	60
Kafir corn stover, average all trials,	2	5	57	-	24	34	67	60	75
Flint corn fodder, ears forming,	1	3	69—72 70	71—73 71	- -	69—73 70	72—73 72	71—73 71	63—71 67
Flint corn fodder, mature,	5	11	63—73 70	- -	- -	56—79 64	69—80 76	63—78 71	59—79 71
Dent corn fodder, ears not formed,	4	8	61—70 65	63—71 67	- -	57—67 62	63—77 71	57—70 64	59—72 66
Dent corn fodder, immature, B. & W.,	1	4	51—64 57	- -	- -	20—36 27	45—74 59	57—66 61	66—84 76
Dent corn fodder, in milk,	5	11	59—66 63	- -	- -	44—51 50	50—71 64	61—69 66	67—79 75
Dent corn fodder, mature, ears ground,	2	8	64—70 67	- -	16—30 23	36—47 43	62—73 68	70—77 74	56—77 66
Dent corn fodder, mature,	8	22	57—70 66	- -	- -	30—61 46	43—73 61	61—81 73	56—82 72

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn fodder, flint and dent, mature,	13	33	57—73 67	- -	- -	30—79 52	43—80 66	61—81 72	56—82 72
Corn fodder, sweet, mature,	3	6	60—71 67	62—74 70	- -	54—73 64	70—77 74	57—73 68	63—71 74
Kafir corn fodder,	1	4	59—62 61	- -	5—11 8	34—42 38	56—63 60	64—68 66	57—67 61
Sorghum fodder, leaves,	1	2	60—66 63	- -	- -	59—62 61	65—76 70	62—67 65	46—47 47
Sorghum bagasse,	1	1	61	-	-	14	64	65	46
Oat hay, bloom to milk,	2	6	51—59 55	50—61 55	35—54 45	47—66 57	54—71 58	47—58 53	44—65 53
Oat hay, milk to dough,	4	14	48—60 54	48—61 54	20—54 37	34—60 52	39—62 48	49—62 56	52—72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60
Barley hay,	1	4	59	62	-	65	62	63	41
Oat straw,	1	2	49—52 50	51—53 52	- -	- -	57—58 58	52—55 53	35—41 38

(c) *Legumes.*									
Alfalfa, first crop, budded to full bloom,	3	6	56—63 59	– –	34—50 42	61—70 65	31—44 40	68—76 72	26—40 35
Alfalfa, second crop, budded to full bloom,	3	6	58—62 60	– –	38—54 46	64—74 70	41—49 44	70—74 72	36—45 42
Alfalfa, third crop,	1	2	56—60 58	– –	40—49 44	68—70 69	28—40 34	71—71 71	38—45 42
Alfalfa, average three crops,	7	14	60	–	44	68	41	72	39
Alfalfa, average all trials,	13	22	61	–	46	70	43	72	43
Alsike clover, full to late bloom,	4	9	55—64 59	56—65 60	– 42	64—71 66	40—59 50	59—74 66	21—69 38
Red clover,	6	15	51—67 58	52—66 54	0—41 28	47—69 59	44—70 56	57—72 65	40—70 58
Clover rowen,	2	4	– –	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60
White clover,	1	1	66	67	–	73	61	70	51
Crimson clover,	3	9	57—65 62	52—58 56	– –	64—73 69	32—58 45	52—74 62	29—54 44
Sand or hairy vetch,	1	6	68—71 69	– –	34—46 42	81—83 82	60—63 61	71—75 73	69—74 70
Soy bean,	1	2	62—63 62	– –	– –	70—72 71	59—62 61	66—71 69	19—40 29
Cow-pea,	1	2	– 59	– –	– –	64—65 65	41—45 43	– 71	46—54 50
Peanut vine,	1	2	59-60 60	– –	– –	63—64 63	51—53 52	69—70 70	62—70 66

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*d*) *Mixed and Miscellaneous.*									
Oat and pea,	2	7	56—67 61	56—67 60	54—65 58	69—78 73	50—64 58	54—66 61	51—69 59
Oat and sand vetch,	1	2	55—55 55	56—56 56	43—46 44	64—66 65	48—50 49	58—59 59	58—67 63
Oat and spring vetch,	2	5	57—63 59	- 60	- 60	60—71 65	47—67 57	34—65 59	17—76 52
Oat and vetch, average,	3	7	58	58	56	65	55	59	55
Wheat and sand vetch,	1	3	64—65 64	- -	33—37 35	70—71 71	63—66 65	67—67 67	62—67 64
Cotton-seed hulls,	4	13	35—47 41	- -	- -	0—25 6	.5—58 47	13—46 34	58—89 79
Cotton-seed feed (4 to 1, sheep),*	2	6	54—60 56	- -	23—35 28	36—45 41	51—60 56	57—60 59	86—94 91
Cotton-seed feed (5 to 1, steers),	1	3	42—45. 43	- -	20—24 22	32—41 36	28—33 31	50—59 54	83—86 84
Cotton-seed feed (7 to 1 and 6 to 1, steers),	1	3	45—46 46	- -	- 28	44—46 45	34—40 37	50—51 50	81—82 82
Cotton-seed feed (4 to 1, steers),	1	2	54	-	46	54	45	58	85
Cotton-seed feed (3 to 1 to 2 to 1, steers),	2	9	54	-	32	64	47	54	85
Average both trials (4 to 1),	3	8	56	-	33	44	53	59	90

Average all trials,	7	23	52	-	30	51	46	55	86
Parson's "Six-dollar" feed,	1	2	55—56 56	- -	10—14 12	56—62 59	45—50 47	63—65 64	80—81 81
Wild oat grass (*Danthonia spicata*),	2	3	60—68 64	61—69 65	- -	49—68 58	65—71 68	62—69 65	38—63 50
Witch grass (*Triticum repens*),	2	4	60—63 61	61—64 62	- -	49—64 58	56—68 62	62—70 66	54—60 57
Buttercups (*Ranunculus acris*),	1	2	56	57	-	56	41	67	70
White weed (*Leucanthemum vulgare*),	1	2	58	58	-	58	46	67	62
IV. — ROOTS AND TUBERS.									
Potatoes,	1	3	73—80 77	75—81 78	- -	43—45 44	- -	87—93 91	- 13
Sugar beets,	1	2	94—95 95	98—100 99	- -	90—93 91	88—113 100	100—100 100	40—53 50
Mangolds,	1	2	77—80 79	83—87 85	- -	70—80 75	27—59 43	91—92 91	- -
English flat turnips,	1	2	91—95 93	93—99 96	- -	84—95 90	89—117 100	96—97 97	82—92 88
Ruta-bagas,	1	2	84—90 87	89—93 91	- -	75—86 80	61—87 74	94—95 95	77—92 84
V. — CONCENTRATED FEED STUFFS.									
(*a*) *Protein Feeds.*									
Cotton-seed meal,	2	6	67—82 76	- -	- -	83—96 88	- 32	44—75 64	87—100 93
Cotton-seed, raw,	1	2	63—69 66	- -	- -	66—70 68	65—86 76	49—50 50	- 87
Cotton-seed, roasted,	1	2	53—58 56	- -	- -	44—50 47	62—69 66	50—53 51	68—75 72

* Four hulls to 1 meal.

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V. — Concentrated Feed Stuffs — *Con.*									
(*a*) *Protein Feeds* — Con.									
Cleveland flax meal,	3	9	76—88 83	- 79	- -	- 83	- -	- 79	- 87
New-process linseed meal,	1	3	73—83 78	- -	- -	82—88 85	49—100 74	82—87 84	90—98 93
Average last two,	4	12	81	-	-	84	-	80	89
Old-process linseed meal,	1	3	75—82 79	- -	- -	86—93 89	38—71 57	76—79 78	85—92 89
Chicago gluten meal,	1	2	87—89 88	- -	- -	87—91 89	- -	93—94 93	92—94 93
King gluten meal,	1	2	79—82 81	- -	- -	- 91	- -	78—81 79	91—97 94
Cream gluten meal,	1	2	92—95 93	- -	- -	83—84 84	- -	85—91 88	96—99 98
Average all gluten meals,	4	8	87	-	-	88	-	88	93
Gluten feed,	5	11	85	-	-	85	76	89	83
Germ oil meal,	2	5	72—83 76	- 75	- -	65—77 73	- -	68—82 76	95—98 96
Chicago maize feed,	1	2	83—85 84	- -	- -	83—84 84	68—76 72	84—87 85	90—90 90

Dried distillery grains, brand R,	1	2	56—59 58	- -	- -	56—63 59	- ?	61—73 67	80—88 84
Dried distillery grains, X brands,	4	8	81	-	-	74	?	82	95
Dried distillery grains, Atlas gluten meal,	1	2	80—80 80	- -	- -	73—73 73	- ?	84—85 84	90—92 91
Dried brewers' grains,	1	2	62—62 62	- -	- -	78—81 79	50—55 53	59—59 59	89—93 91
Malt sprouts,	1	1	67	68	-	80	34	69	100
H-O dairy feed,	1	2	64—67 65	- -	- -	76—80 78	39—43 41	67—73 70	83—88 85
Pea meal,	1	2	85—88 87	86—89 88	- -	80—86 83	25—26 26	93—94 94	52—57 55
Soy bean meal,	2	3	75—79 78	- -	- -	89—91 90	0—73 33	68—73 71	81—98 89
Cow-pea meal,	1	2	85—88 87	- -	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Wheat bran, spring,	1	2	62—63 63	- -	- -	78—82 80	22—25 24	70—71 70	76—76 76
Wheat bran, winter,	1	3	57—66 62	- -	- -	75—79 77	- 27	62—76 65	51—80 64
Wheat bran, average all trials,	8	18	62	62	-	77	21	69	66
Wheat middlings, standard,	2	6	-	73	25	77	30	78	88
Wheat middlings, flour,	1	2	79—86 83	- -	- -	82—88 85	33—40 36	84—91 88	82—88 85
Mixed feed, adulterated with corn cobs,	1	3	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92
Rye feed, bran and middlings,	1	3	77—83 82	- -	25—48 35	78—82 80	- -	86—89 88	79—99 90

Experiments with Ruminants — Concluded.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V. — Concentrated Feed Stuffs — *Con.*									
(*b*) *Starchy feeds.*									
Corn meal,	5	14	83—98 89	– 91	– –	40—87 70	– –	85—100 94	71—99 91
Corn and cob meal,	1	3	74—83 79	– –	– –	43—65 52	2—86 45	86—91 88	82—85 84
Kafir corn meal,	2	5	54—76 66	– –	– –	36—62 53	– –	67—84 77	25—62 46
Kafir corn, unground,	2	6	29—58 43	– –	– –	28—54 41	– –	34—62 45	– –
White Kafir heads,	1	4	14—35 24	– –	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Cerealine feed,	1	3	89—92 90	– –	– –	79—81 80	72—92 82	93—97 95	78—83 81
Oats, unground,	2	6	66—74 70	68—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89
Rice meal,	1	2	71—76 74	– –	– –	– 62	– ?	89—95 92	91—92 91
Rye meal,	1	2	85—90 87	– –	– –	83—85 84	– –	89—94 92	63—65 64
Corn bran,	2	4	70—71 70	– –	– –	53—55 54	50—65 59	74—80 77	69—85 77
Rice bran,	1	2	63—66 65	– –	1—4 2	58—68 63	16—42 29	76—81 78	85—92 89

Chop feed, largely corn bran,	2	6	71—92 80	– –	– –	56—77 67	54—70 62	64—92 84	61—86 82
H-O horse feed,	2	3	70—77 74	– 78	–	71—81 75	– –	79—84 82	74—87 81
Corn and oat feed, Victor,	1	3	74—76 75	– –	– –	66—75 71	36—58 48	81—85 83	84—88 87
Oat feed, Quaker,	2	6	62	52	–	72	55	55	72
Oat feed, Royal,	1	3	42—51 47	42—53 48	33—40 37	64—72 69	20—43 33	50—54 51	86—92 88
Oat feed, excessive hulls,	1	3	29—38 34	– –	8—21 13	51—69 62	25—37 32	29—36 33	89—97 92
Oat feed, average last two,	2	6	40	–	25	65	32	42	90
Peanut feed,	1	2	32—32 32	– –	– –	70—71 71	10—13 12	41—58 49	90—90 90
Corn cobs, sheep,	1	2	59—60 59	– –	– –	13—22 17	65—66 65	60—60 60	44—56 50
Experiments with Swine.									
Barley meal,	1	1	80	80	–	81	49	87	57
Maize kernels, whole,	1	1	83	83	–	69	38	89	46
Maize meal,	2	2	89—90 90	91—92 92	– –	86—90 88	29—49 39	94—94 94	78—82 80
Maize meal, with cobs,	1	1	76	77	–	76	29	84	82
Old-process linseed meal,	1	4	76—79 77	– –	8—12 10	83—90 86	10—14 12	82—87 85	78—82 80
Pea meal,	1	1	90	92	–	89	78	95	50

Experiments with Swine — Concluded.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.)	Fat (Per Cent.).
Potatoes,	1	4	97	-	-	84	-	98	-
Wheat, whole,	1	?	72	-	-	70	30	74	60
Wheat, cracked,	1	?	82	-	-	80	60	83	70
Wheat shorts (middlings),	1	2	74—79 77	- -	- -	71—75 73	25—48 37	85—88 87	- -
Wheat bran,	1	2	54—78 66	- -	- -	74—76 75	30—39 34	56—75 66	65—78 72

Experiments with Horses.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.)	Fat (Per Cent.).
Corn, whole,	1	2	71—78 74	- -	20—32 26	40—76 58	- -	85—92 88	43—52 48
Corn meal, same as above,	1	2	84—93 88	- -	- -	74—77 76	- -	93—99 96	70—76 73
New corn product,	1	2	40—59 50	- -	6—37 22	65—70 68	38—71 55	39—54 47	48—72 60
Oats, whole,	1	2	67—77 72	- -	31—36 33	84—87 86	13—49 31	75—83 79	80—85 82
Oats, ground, same as above,	1	2	73—78 76	- -	9—49 29	81—83 82	.6—28 14	85—87 86	79—81 80

Average of both,	2	4	74	-	31	84	22	82	81
Hay, timothy,	1	2	39—48 44	- -	29—39 34	18—24 21	37—48 43	44—50 47	44—51 47

Experiments with Poultry.

Corn, whole-kernel,	1	3	- -	- 86	- -	44—58 50	- -	90—96 92	88—95 92
Corn meal,	1	3	- -	- 85	- -	41—55 48	- -	91—92 91	92—94 93
Kafir corn, kernels,	1	3	- -	- 88	- -	50—55 53	17—22 20	94—98 96	71—76 74
Kafir meal,	1	3	- -	- 87	- -	42—44 43	30—42 35	95—97 96	82—84 83
Cow-peas,	1	3	- -	- 71	- -	32—48 40	2—43 18	86—88 87	87—90 89
Cow-pea meal,	1	3	- -	- 72	- -	40—49 44	8—11 10	84—91 88	75—98 89

Literature. — The following publications have been consulted in compiling the foregoing tables of digestibility: —

Colorado Experiment Station, Bulletin 8.

Connecticut (Storrs) Experiment Station, reports for 1894–96, 1898.

Hatch (Massachusetts) Experiment Station, reports for 1895–99, 1901; Bulletin 50 and in unpublished records.

Illinois Experiment Station, Bulletins 43, 58.

Kansas Experiment Station, Bulletin 103.

Maine Experiment Station, reports for 1886–91, 1893, 1894, 1897, 1898, 1900.

Maryland Experiment Station, Bulletins 20, 41, 43, 51.

Massachusetts State Experiment Station, reports for 1893, 1894.

Minnesota Experiment Station, reports for 1894–96; Bulletins 26, 36, 42, 47.

Mississippi Experiment Station, report for 1895.

New York Experiment Station, reports for 1884, 1888, 1889; Bulletin 141.

North Carolina Experiment Station, Bulletins 80*c*, 81, 87*d*, 97, 118, 148, 160, 172.

Oklahoma Experiment Station, Bulletins 37, 46.

Oregon Experiment Station, Bulletins 6, 47.

Pennsylvania Experiment Station, reports for 1887–94, 1897, 1898.

Texas Experiment Station, Bulletins 13, 15, 19.

Utah Experiment Station, Bulletins 16, 54, 58.

Wisconsin Experiment Station, report for 1889; Bulletin 3.

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THE STATE BOARD OF PUBLICATION.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 8, 1903.

To His Excellency JOHN L. BATES.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the fortieth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1903–1904.

Jan. 7, 1903, Wednesday, fall semester resumed, at 8 A.M.
February 4, Wednesday, fall semester ends.
February 5, Thursday, spring semester begins, at 8 A.M.
March 28, Saturday, to April 2, Thursday, } spring recess.
April 2, Thursday, spring semester resumed, at 8 A.M.
June 13, Saturday, Grinnell prize examination of the senior class in agriculture.
June 14, Sunday, Baccalaureate sermon.
June 15, Monday, { Burnham prize speaking. Flint prize oratorical contest.
June 16, Tuesday, { Class-day exercises. Meeting of the alumni. Reception by the president and trustees.
June 17, Wednesday, commencement exercises.
June 18–19, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Pittsfield; and at Horticultural Hall, Worcester.
September 15–16, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.
September 17, Thursday, fall semester begins, at 8 A.M.
December 23, Wednesday, to Jan. 6, 1904, Wednesday, } winter recess.
January 6, Wednesday, fall semester resumed, at 8 A.M.
February 3, Wednesday, fall semester ends.
February 4, Thursday, spring semester begins, at 8 A.M.
March 30, Wednesday, to April 5, Tuesday, } spring recess.
April 5, Tuesday, spring semester resumed, at 8 A.M.
June 15, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

The past year has been one of prosperity to the college. A larger number of students, with one exception, have taken advantage of its opportunities than in any previous twelve months of its history. Important changes have been made in its faculty, and the academic and graduate courses have been unified and strengthened.

After many years of arduous service, Samuel T. Maynard has retired, and his place has been filled by Frank A. Waugh, a graduate of the Kansas Agricultural College, and for the past fifteen years connected with the agricultural colleges and experiment stations in Kansas, Oklahoma and Vermont. In horticultural work he is well known by his writings in the agricultural press, and his three volumes, "Plums and plum culture," "Landscape gardening," "Fruit harvesting, storing, marketing," have taken their place as standard works. The position made vacant by the resignation of George F. Babb has been filled by the appointment of Louis Rowell Herrick, a graduate of Amherst College. Study abroad and in this country admirably fits him for his work. In addition to his regular classes in French, he has offered an elective to those desiring to take up the study of Spanish.

In the regular academic course elective studies will hereafter commence in junior year instead of senior; the course in horticulture has been greatly modified and strengthened, a course in landscape gardening has been added, as also a two-years general course for young ladies. This last embraces botany, chemistry, horticulture, floriculture, fruit culture, care of bees, poultry, the dairy, etc. Two young ladies have already joined this, and two are successfully pursuing the regular four-years course. In graduate work, horticulture has been added to the studies requisite for the degree of doctor of philosophy.

The money appropriated by the Legislature of 1902 has been carefully expended for the purposes indicated, but we are sorry to report a deficiency both in the dining hall and in the heating and lighting plant. It seems as if it could hardly have been avoided. For various reasons the bill was delayed in being brought before the Legislature; and, during the four months elapsing before its passage, labor, building material, pipes, cement and iron work had steadily advanced in price, while the amount for which we asked was predicated on the January prices. Bids were advertised for the construction of the dining hall, but when the committee opened them, not one was found within the limits prescribed. Changes were then made in the material and plan of the building, finishing the attic was given up, and the three lowest bidders were asked to compete. The lowest bidder was Mr. Hascal Dodge of Springfield, and the contract was awarded to him for $31,538. A few extras required by change of plan has brought the amount up to $31,947.14. Out of the remaining $3,052.86 has been paid a part of the installation of the lighting plant, the grading, and the architect's plans, leaving for the equipment only $168.65, while $3,300 are required. Finishing the attic would require $1,500 to $1,800 more. The whole building, we may say, has been put up in the most thorough, careful manner, and reflects great credit on the builder, who has given it his careful personal attention.

Installation of the heating and lighting plant was placed under the direction of Richard D. Kimball & Sons, whose careful work for the State in the Hospital for Epileptics at Monson had commended itself to the best judgment of your committee. The causes above enumerated made it impossible for them to keep within the limits assigned, and we are compelled to face a deficit of $11,505.

On the second day of July, 1862, the United States Congress passed an act for the establishment and maintenance of a college for the benefit of agriculture and the mechanic arts in every State in the Union. This act assigned a certain portion of the public domain to each State, proportioned to its representation in Congress. It was coupled with certain conditions, three of which demand our special attention.

Section 3 declares: "That all the expenses of management, superintendence and taxes from date of selection of said lands previous to sale, and all expenses incurred in the management and disbursements of the moneys which may be received therefrom, shall be paid by the states to which they may belong, out of the treasury of said states, so that the entire proceeds of the sale of said lands shall be applied without any diminution whatever to the purposes hereinafter mentioned." This section would seem to indicate that premiums necessarily paid in investing funds in the prescribed class of securities must be paid by the State, and not out of the fund itself, or its income. And this has been so decided by the New York Court of Appeals (The People *ex rel.* Cornell University *v.* Davenport). "Section 4. That all moneys derived from the sale of the lands aforesaid by the states to which the lands are apportioned, and from the sale of land scrip hereinbefore provided for, shall be invested in stocks of the United States, or of the states, or some other safe stocks, yielding not less than five per centum upon the par value of said stocks; and that the moneys so invested shall constitute a perpetual fund, the capital of which shall remain forever undiminished (except so far as may be provided in section fifth of this act) and the interest of which shall be inviolably appropriated," etc., "for the maintenance at least of one college. . . ." Section 5, article 1, provides: "That if any portion of the fund invested, as provided by the foregoing section, or any portion of the interest thereon, shall, by any action or contingency, be diminished or lost, it shall be replaced by the state to which it belongs, so that the capital of the fund shall remain forever undiminished, and the annual interest shall be regularly applied without diminution to the purposes mentioned in the fourth section of this act. . . ."

We have here three sections of an act plainly setting forth the intent of Congress with reference to certain sums of money resulting from the sales of public lands granted to each State for the establishment and maintenance of a college. First, that all the expenses incurred in the management and disbursement of the moneys which may be received therefrom shall be paid by the State itself to which they may belong; second, that all moneys derived from the sales of land scrip shall be invested at five per centum, so that the capital may remain forever undiminished; and third, that if through any contingency any portion of the capital or any portion of the interest thereon be diminished or lost, it shall be replaced by the State to which it belongs. The whole intent of this act of Congress, then, is to safeguard its gift for all time, and to fix the interest arising therefrom at five per centum.

The provisions of this act with all the conditions therein contained have been accepted unreservedly by every State in the Union, and every State but one has, up to this time, paid at least five per centum. More than one-half the States have already turned their funds into their respective treasuries, and have issued to their respective beneficiaries their obligations in various forms, in which they agree to pay a fixed rate of interest, varying in amount, but never less than five per centum on the principal of the fund. Georgia and Louisiana each pay seven; New Hampshire, Vermont, Pennsylvania, North Carolina, South Carolina, Ohio, Wisconsin, Michigan and Maine pay six; while the remainder pay five. The fund in Massachusetts has been treated as follows: —

Sale of land scrip (360,000 acres),	$236,307 40
From which a farm was purchased for	29,778 40
Amount of fund then	$206,529 00
In 1871 certain securities were, by advice of the Attorney-General, raised to par,	1,895 65
In the same year, by chapter 89 of the Resolves, the Legislature added enough to the fund to make it amount to $350,000, say	141,575 35
Total fund Dec. 31, 1871,	$350,000 00
Sale of United States bonds, in the fund, at a premium, increased it	10,067 40
Total,	$360,067 40

This remained unchanged until Dec. 31, 1881. But in 1882, owing to the downward tendency of interest on investments, it was deemed advisable to separate the Agricultural College funds into two parts, containing the grant from the United States and the grant from the Commonwealth respectively, in order that five per cent. on the investment should be assured. The one part was called the "Technical education fund, United States grant," and the other the "Technical education fund, Commonwealth grant." And they so remain. The Commonwealth grant amounted in 1882 to $141,575.35, and is still of that amount. The United States grant amounted at that time to $219,000, and was invested in Boston & Albany five per cent. twenty-year railroad bonds. These matured in the early part of 1902, and were at once taken up by the company. The Treasurer of the Commonwealth, having found himself unable to reinvest at the rate of five per cent., asked for an opinion from the Attorney-General. This opinion was adverse to the contention of the college, and the money has since been reinvested in varying amounts for short periods, until such time as relief could be sought from the General Court. It is not our intention to enter into any controversy respecting the interpretation of the section respecting investment at five per centum; but in view of the fact that it has been questioned in only one other State, that it has passed unchallenged in our own Commonwealth for thirty-nine years, and that in 1882 (to use the language of the Treasurer) the full fund was divided "in order that five per cent. on the United States investment should be secured," your petitioners pray that $1,115.36 be appropriated for the college, to pay the difference between five per centum and what was actually realized during the past year; and that $219,000, the full amount of the United States grant, be turned into the treasury of the Commonwealth, and that the Treasurer or other delegated officer be directed to issue to the college the proper form of obligation with agreement to pay five per centum annually on the principal. This would be in effect an investment in "State stocks," and would save the State from the expenses and burdens of management, and also from any responsibilities or liability to restore any portion of the principal or interest which may be lost in consequence of unfortunate or unwise investments or by any other "action or contingency."

Lack of room for use in recitations or lectures has greatly hindered our work. We have all told in our different buildings fourteen rooms that can be used for this purpose, yet we shall be required in the coming semester to provide for sixty or more daily classes, and in the coming year probably at least seventy. Of these rooms, three only can seat forty or more students, yet our entering classes now number over fifty members. To add to our perplexities, the botanical, chemical, zoölogical, entomological, veterinary and horticultural departments each require two hours' consecutive work; and it has become one of our most difficult problems to so arrange the schedule of work that the different recitation rooms can be assigned without conflict. To provide for this exigency, we have seized upon one of the living rooms in south dormitory for the president's office, a second for the recitations of Dr. Walker, and now a third has been set apart for the use of the registrar, while one of the rooms in the chapel building assigned to the Y. M. C. A. has been taken for recitations in German. For use of Professor Waugh, in the horticultural department, we could only find the botanical museum. The specimens have all been removed, thus rendering them entirely unserviceable for purposes of instruction, and are replaced by seats and tables. This arrangement can, however, be only temporary, and it will not be long before suitable accommodations in a special building must be asked for. An administration building, containing offices for president, treasurer and registrar, and a half-dozen general recitation rooms large enough for our growing classes, would greatly relieve this congestion, but it would not answer everything, for we need special buildings for special purposes.

Our library building is full to overflowing, and those books not in active circulation are being withdrawn and piled up on the floor or on top of the cases. The library is essentially scientific. It is especially selected for special purposes, and there are very few books that can be withdrawn without being detrimental to its efficiency. It now numbers

23,681 volumes, and increases 800 to 1,000 volumes a year. A new building properly equipped cannot be long delayed.

A chemical building, with two or three laboratories to suit the growing needs of the classes, has been long waited for. The present structure could hardly be worse. The oldest in point of time, built of wood, used as a laboratory in its lower story and drill hall in its upper, wrenched two or three inches from the perpendicular, with crevices in its sides, through which, until very lately, the inquisitive visitor could look out into the open, — it has descended to us, in modern times, a wreck of the past and monument of all that is bad. At various times it has been fixed over and repaired; but it is altogether inadequate for our necessities, and should be replaced as soon as practicable.

And, last, we dream of an agricultural building, provided with two recitation rooms; a laboratory and small plant house for experimentation; a museum and an amphitheatre, into which can be led a number of cattle for comparison or for judgment of points. At present we have simply one recitation room, specimens for the museum scattered all over the college, no plant house, no laboratory, no amphitheatre. For the present, at an expense of say $1,600, partial provision can be made for laboratory and equipment by fitting up two cellar rooms in south dormitory. All the desks, apparatus, etc., can be so planned as to be serviceable when ready for permanent quarters.

These, in brief, are the buildings that seem to us absolutely necessary for the efficient carrying on of our work, five in number, but they are the five fingers of the hand with which we work, — agriculture, horticulture, chemistry, a library and a building of administration.

This may seem an unnecessary outlay for buildings; but it must be borne in mind that in an institution established for scientific purposes, specific buildings are required for specific purposes. Chemistry, for example, cannot be yoked with physics, since the fumes of the one would affect the value of the other; entomology, botany or any science requiring the careful use of the microscope cannot be placed in an administrative building, where the constant jarring resulting from the going in and out of the classes would necessarily affect the accuracy of the instrument. President Thompson of the University of Ohio, when speaking of the system of education for the masses as that which trains the hand to do, the eye to see and the brain to think, says: "The wide range of studies characteristic of modern education has grown out of the fact that new subjects have proved themselves to have a utility similar to that contained in the older curriculum in realizing the aims and results of education. The conclusion that education should embrace man's relation to all forms of human activity has been accepted. The technical and industrial have as clear a title to a place in a complete system of education as the literary or the professional."

We have here 420 acres of land admirably adapted to our purpose, lying on the slopes of a naturally terraced hill, overlooking the Pelham range on the east and the fertile valley of the Connecticut on the west. It needs but a small outlay to make of these grounds for the western portion of this State what the Arnold Arboretum is for the eastern or what the Worcester parks are to the people of that city. It teaches law, order and civilization to the uninstructed masses. An object lesson and means of instruction for the student; a thing of beauty and yet an education to the people at large. We ask, then, an appropriation of $500 for grading and for laying out walks and drives, to bind into one harmonious whole every portion of this magnificent property.

Briefly summarizing our necessities, we ask for the following appropriations: —

Deficit on dining hall,	$3,300
Finishing of attic in new dining hall,	1,800
Deficit on heating and lighting plant,	11,505
Deficit on income from United States grant,	1,115
Fitting up agricultural rooms,	1,600
Laying out walks, drives, etc.,	500
Maintenance of dining hall (annual),	500
Maintenance of heating and lighting plant (annual),	500

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 1, 1903.

THE CORPORATION.

	TERM EXPIRES
HENRY S. HYDE of Springfield,	1904
MERRITT I. WHEELER of Great Barrington,	1904
WILLIAM R. SESSIONS of Springfield,	1905
CHARLES L. FLINT of Brookline,	1905
WILLIAM H. BOWKER of Boston,	1906
GEORGE H. ELLIS of Boston,	1906
J. HOWE DEMOND of Northampton,	1907
ELMER D. HOWE of Marlborough,	1907
NATHANIEL I. BOWDITCH of Framingham,	1908
WILLIAM WHEELER of Concord,	1908
ELIJAH W. WOOD of West Newton,	1909
CHARLES A. GLEASON of New Braintree,	1909
JAMES DRAPER of Worcester,	1910
SAMUEL C. DAMON of Lancaster,	1910

Members ex Officio.

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President of the Corporation.

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FRANK A. HILL, *Secretary of the Board of Education.*
JAMES W. STOCKWELL, *Secretary of the Board of Agriculture.*

HENRY S. HYDE of Springfield,
Vice-President of the Corporation.

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

WILLIAM R. SESSIONS, J. HOWE DEMOND,
HENRY S. HYDE, SAMUEL C. DAMON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER, ELMER D. HOWE,
CHARLES L. FLINT, GEORGE H. ELLIS,
WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticulture.*

Farm Division.

GEORGE H. ELLIS, N. I. BOWDITCH,
MERRITT I. WHEELER, WILLIAM R. SESSIONS, *Ch'man.*

Horticultural Division.

JAMES DRAPER, ELMER D. HOWE,
E. W. WOOD, *Chairman.*

Committee on Experiment Department.*

JAMES W. STOCKWELL, ELIJAH W. WOOD,
WILLIAM H. BOWKER, WILLIAM WHEELER,
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER, SAMUEL C. DAMON,
CHARLES L. FLINT, N. I. BOWDITCH,
JAMES DRAPER, *Chairman.*

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STATE BOARD OF AGRICULTURE.

Examining Committee of Overseers.

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C. K. BREWSTER, ... of Worthington.
C. H. SHAYLOR, ... of Lee.
ALVAN BARRUS, ... of Goshen.
GEORGE P. SMITH, ... of Sunderland.

* The president of the college is ex officio a member of each of these committees.

The Faculty.

HENRY H. GOODELL, LL.D., *President.*
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

FRANK A. WAUGH, M.S.,
Professor of Horticulture and Landscape Gardening.

HERMAN BABSON, M.A.,
Assistant Professor of English.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

RICHARD S. LULL, M.S.,
Assistant Professor of Zoölogy

RALPH E. SMITH, B.Sc.,
Assistant Professor of Botany.
(Instructor in German.)

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

JOHN ANDERSON, Captain, U. S. A.,
Professor of Military Science and Tactics.

LOUIS R. HERRICK, B.Sc.,
Instructor in French.

GEORGE A. DREW, B.Sc.,
Instructor in Horticulture.

HOWARD L. KNIGHT, B.Sc.,
Instructor in Chemistry.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, M.S.,
Registrar.

ELISHA A. JONES, B.Sc.
Farm Superintendent

Graduates of 1902.*

Doctor of Philosophy.

Hinds, Warren Elmer, ...	Townsend.

Bachelor of Science.

Belden, Joshua Herbert (Boston Univ.), .	Newington, Conn.
Bodfish, Henry Look (Boston Univ.), .	Tisbury.
Carpenter, Thorne Martin (Boston Univ.),	Foxborough.
Church, Frederick Richard (Boston Univ.),	Ashfield.
Claflin, Leander Chapin (Boston Univ.), .	Philadelphia, Pa.
Cook, Lyman Adams (Boston Univ.), .	Millis.
Cooley, Orrin Fulton, ...	South Deerfield.
Dacy, Arthur Lincoln (Boston Univ.), .	Boston.
Dellea, John Martin (Boston Univ.), .	North Egremont.
Dwyer, Chester Edwards (Boston Univ.),	Lynn.
Gates, Victor Adolph (Boston Univ.), .	Memphis, Tenn.
Hall, John Clifford (Boston Univ.), .	Sudbury.
Hodgkiss, Harold Edward (Boston Univ.),	Wilkinsonville.
Kinney, Charles Milton, ...	Northampton.
Knight, Howard Lawton (Boston Univ.),	Gardner.
Lewis, Claude Isaac (Boston Univ.), .	Unionville.
Morse, Ransom Wesley (Boston Univ.), .	Belchertown.
Paul, Herbert Amasa, ...	Lynn.
Plumb, Frederic Henry (Boston Univ.), .	Bridgeport, Conn.
Saunders, Edward Boyle (Boston Univ.),	Southwick.
Smith, Samuel Leroy (Boston Univ.), .	South Hadley.
West, David Nelson (Boston Univ.), .	Northampton.
Total, ...	23

Senior Class.

Allen, William Etherington, . . .	Winthrop.
Bacon, Stephen Carroll, ...	Leominster.
Barrus, George Levi, ...	Goshen.
Bowen, Howard Chandler, . . .	Rutland.
Brooks, Philip Whitney, ...	Cambridge.
Cook, Joseph Gershom, ...	Clayton.
Franklin, Harry James, ...	Bernardston.
Halligan, Charles Parker, . . .	Roslindale.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1902.

Harvey, Lester Ford,	Woodbury, Conn.
Hood, William Lane,	Vandiver, Ala.
Jones, Gerald Denison,	South Framingham.
Lamson, George Herbert,	East Hampton, Conn.
Monahan, Neil Francis,	South Framingham.
Nersessian, Paul Nerses,	Marash, Turkey.
Osmun, Albert Vincent,	Danbury, Conn.
Parsons, Albert,	North Amherst.
Peebles, William Warrington,	Washington, D. C.
Poole, Elmer Myron,	North Dartmouth.
Proulx, Edward George,	Hatfield.
Robertson, Richard Hendrie,	Somerville.
Snell, Edward Benaiah,	Lawrence.
Tinkham, Charles Samuel,	Roxbury.
Tottingham, William Edgar,	Bernardston.
Tower, Winthrop Vose,	Melrose Highlands.
West, Myron Howard,	Belchertown.
Total,	25

Junior Class.

Ahearn, Michael Francis,	Framingham.
Back, Ernest Adna,	Florence.
Barnes, Hugh Lester,	Stockbridge.
Blake, Maurice Adin,	Millis.
Couden, Fayette Dickinson,	Amherst.
Ellsworth, Frank Lawrence,	Holyoke.
Elwood, Clifford Franklin,	Green's Farms, Conn.
Esip, Edward Thomas,	Amherst.
Fahey, John Joseph,	Pittsfield.
Fulton, Erwin Stanley,	Lynn.
Gay, Ralph Preston,	Stoughton.
Gilbert, Arthur Witter,	Brookfield.
Gregg, John William,	South Natick.
Griffin, Clarence Herbert,	Winthrop.
Haskell, Sidney Burritt,	Southbridge.
Henshaw, Fred Forbes,	Templeton.
Hubert, Zachary Taylor,	Pride, Ga.
Lewis, Clarence Waterman,	Melrose Highlands.
Newton, Howard Douglas,	Curtisville.
O'Hearn, George Edmund,	Pittsfield.
Parker, Sumner Rufus,	Brimfield.
Peck, Arthur Lee,	Hartford, Conn.
Pierce, Hervey Cushman,	West Millbury.

Quigley, Raymond Augustine,	Brockton.
Raymoth, Reuben Raymond,	Goshen.
Smith, Walter Abbe,	Springfield.
Staples, Parkman Fisher,	Westborough.
Tinker, Clifford Albion,	West Tremont, Me.
White, Howard Morgan,	Springfield.
Total,	29

Sophomore Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Baker, Perez Raymond,	Amherst.
Bartlett, Francis Alonzo,	Belchertown.
Brett, Clarence Elmer,	Brockton.
Brigham, Fred Washington,	Ashburnham.
Bruce, Ernest Charles,	Westborough.
Carter, Chester Merriam,	Leominster.
Craighead, William Hunlie,	Boston.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Northampton.
Filer, Harry Burton,	Belchertown.
Gardner, John Joseph,	Milford.
Goodenough, Herbert Harold,	Worcester.
Haffenreffer, Adolf Frederick,	Jamaica Plain.
Hall, Jr., Arthur William,	North Amherst.
Hamblin, John Howland,	Falmouth.
Hatch, Walter Bowerman,	Falmouth.
Hill, Louis William Barlow,	Greenfield Hill, Conn.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Amherst.
Huntington, Raymond Edwards,	Newton Centre.
Hutchings, Frank Farley,	South Amherst.
Ingham, Norman Day,	Granby.
Kelton, James Richard,	Orange.
Ladd, Edward Thorndike,	Winchester.
Ladd, Jr., Joseph Hartwell,	Watertown.
Lyman, John Franklin,	Amherst.
Lyman, Richard Rowe,	Montague.
Merrill, Jr., Charles Edward,	Melrose.
Munson, Willard Anson,	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
O'Neil, William James,	Ayer.
Paige, George R.,	Amherst.

Patch, George Willard,	Lexington.
Paul, Augustus Russell,	Framingham.
Peck, Louis Edward,	South Egremont.
Pray, Fry Civille,	Natick.
Ransehousen, Lyman Arthur,	Springfield.
Rhodes, Elmer Elliot,	North Attleborough.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Smith, Robert Edward,	South Hadley Falls.
Swain, Allen Newman,	New Dorchester.
Sykes, Charles Sumner,	Suffield, Conn.
Taylor, Albert Davis,	Westford.
Tinkham, Henry Buffinton,	South Swansea.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth,	Natick.
Walsh, Thomas Frederick,	Ayer.
Whitaker, Chester Leland,	Somerville.
Williams, Franklin Kinne,	Collinsville, Conn.
Williams, Percy Frederic,	Natick.
Willis, Grenville Norcott,	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	57

Freshman Class.

Abbott, Chester Denning,	Andover.
Bacon, Roland Aldrich,	Leominster.
Brydon, Robert Parker,	Lancaster.
Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.
Connelly, Thomas Henry,	Boston.
Cowles, Edward Russell,	Deerfield.
Cutter, Frederick Augustus,	Pelham, N. H.
Farrar, Allan Dana,	Amherst.
Ferren, Frank Augustus,	Peabody.
Foster, Samuel Cutler,	Boston.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Goodale, Ray Coit,	Suffield, Conn.
Hartford, Archie Augustus,	Westford.

Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hersem, Elbert Wood,	Westborough.
Hood, Clarence Ellsworth,	Millis.
Jones, Louis Franklin,	Somerville.
Keith, Earl Wadsworth,	North Easton.
Kennedy, Frank Henry,	South Boston.
Mahoney, Francis Watson,	Boston.
Markham, Joseph Michael,	Ayer.
Martin, James Edward,	Brockton.
Morse, Stanley Fletcher,	Watertown.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
Peakes, Ralph Ware,	Newtonville.
Prenn, Joseph,	Amherst.
Racicot, Jr., Arthur Alphonse,	Lowell.
Rogers, Stanley Sawyer,	Boston.
Russell, Henry Merwin,	Bridgeport, Conn.
Russell, Herbert Osborne,	North Hadley.
Scott, Edwin Hobart,	Cambridge.
Shannon, Alonzo Henry,	Amherst.
Sleeper, George Warren,	Swampscott.
Spurr, Fred Yerxa,	Melrose Highlands.
Stevens, Frederick Oramel,	Amherst.
Strain, Benjamin,	Mt. Carmel, Conn.
Suhlke, Herman Augustus,	Leominster.
Sullivan, Patrick Francis,	Amherst.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tirrell, Charles Almon,	Plainfield.
Watkins, Fred Alexander,	Hinsdale.
Webb, Paul,	Hamden, Conn.
Wellington, Richard,	Waltham.
White, Vernon Ollise,	Attleborough.
Wholley, Michael Francis,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Wood, Herbert Poland,	Hopedale.
Total,	54

Two-years Course.

Hunt, Justine,	Newton.
Hyde, Edith Lucretia,	Cambridge.
Total,	2

Short Winter Courses.

Adams, Walter Stanton,	North Oxford.
Brigham, Walter Edward,	Shrewsbury.
Clark, Horatio Alfred,	Newtonville.
Conant, Walter Aiken,	Boston.
Graves, Richard Warren,	Sunderland.
Hall, Fred Porter,	West Newton.
Hayden, Edward Eliphaz,	Warwick.
Katzenberg, Walter,	New York, N. Y.
Lewis, Horace David,	Westfield.
Litchfield, Leon Charles,	Coventry, Vt.
Openshaw, John,	Amherst.
Richardson, Frederick Wade,	Burlington.
Smith, Samuel Eldredge,	North Amherst.
Spokesfield, William Ferdinand,	Amherst.
Stultz, James Edwin,	Steeves Settlement, N. B.
Weigold, George,	Torrington, Conn.
Total,	16

Graduate Courses.

For Degrees of M.S. and Ph.D.

Babb (A.M., Bates College, '01), George Francis,	Amherst.
Ballou (B.Sc., M. A. C., '95), Henry Arthur,	West Fitchburg.
Billings (B.Sc., M. A. C., '95), George Austin,	Amherst.
Haskins (B.Sc., M. A. C., '90), Henri Darwin,	Amherst.
Hodgkiss (B.Sc., M. A. C., '02), Harold Edward,	Wilkinsonville.
Ikeda (A.B., Univ. of Tokyo, '91), Hidezo,	Tokyo, Japan.
Morrill (B.Sc., M. A. C., 1900), Austin Winfield,	Tewksbury.
Smith (B.A., Smith College, 1900), Elizabeth Hight,	Amherst.
West (B.Sc., M.A.C., '02), David Nelson,	Northampton.
Wiley (B.Sc., M. A. C., '98), Samuel William,	Amherst.
Total,	10

Special Students.

Billings, Minerva Ferrabee,	Amherst.	
Boynton, Myra L.,	Florence.	
Davis, Evelyn H.,	Gardiner, Me.	
Magoun, Alice N.,	Bath, Me.	
Russell, Ida Josephine,	Amherst.	
Total,		5

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	10	
Four-years course: —		
Graduates of 1902,	23	
Senior class,	25	
Junior class,	29	
Sophomore class,	57	
Freshman class,	54	
Two-years course,	2	
Winter courses,	16	
Special students,	5	
Total,		221
Entered twice,		2
Total,		219

OBJECT.

The leading object of the Massachusetts Agricultural College is "to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

GRADUATE COURSES.

In response to the increasing demand for advanced work in various directions, the college has arranged for courses of study leading to the degrees of Master of Science and Doctor of Philosophy.

Honorary degrees are not conferred.

Applicants are not eligible to the degree of Master of Science or Doctor of Philosophy until they have received the degree of Bachelor of Science or its equivalent.

The fee for the degree of Master of Science is ten dollars and for the degree of Doctor of Philosophy twenty-five dollars, to be paid to the treasurer of the college before the degree is conferred.

Courses for the Degree of Master of Science.

A course of study is offered in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary medicine. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

Candidates for the degree of Master of Science must devote not less than one year and a half after graduation to the prosecution of two studies for the degree, one year of which must be in residence at the Massachusetts Agricultural College.

Courses for the Degree of Doctor of Philosophy.

The establishment of courses leading to this degree is the result of many calls for advanced study along certain economic lines neglected in most American universities, and is given only by those departments especially equipped for this grade of study, to graduates of this college or other colleges of good standing. The work required for the degree is intended to be so advanced in its character as to necessitate the greatest industry to complete it, with the belief that such severe requirements will result in the greatest credit to those who are successful. Four courses of study only are therefore open, viz., botany, chemistry, entomology and horticulture as major subjects, though a minor in zoölogy is also available.

At least three years are necessary to complete the work required; twenty hours per week to be devoted to the major subject, while from twelve to sixteen hours per week are required for each of the two minor subjects during one and a half years.

The work in the major and minors will necessarily differ with the previous training and needs of different students, but a general outline of the major in each subject would be about as follows: —

Botany. — No detailed course can be outlined, as the previous training and future aims of the student are kept in mind, and his work is planned accordingly. The main portions of his work, however, will be in vegetable physiology, vegetable pathology, mycology, œcology, taxonomy, phylogeny, the history of botany and the history and theory of evolution. A thesis dealing with some economic problem in plant physiology or pathology, or both, and containing a distinct contribution to knowledge, will also be required.

Chemistry. — The introductory study of a large proportion of the following subjects is included in undergraduate courses; the candidate must, therefore, give proof of a corresponding knowledge of them, as in this graduate course they will be treated only as advanced studies: inorganic analysis, qualitative, of the rarer elements, and quantitative; crystallography; physical chemistry; descriptive and determinative mineralogy; chemical geology; soil formation; soil physics and chemistry; gas analysis; synthetic inorganic work; chemical theory and history; general organic chemistry; special topics in organic chemistry; elementary quantitative organic analysis; proximate qualitative and quantitative organic analysis, including determination of organic radicles; organic synthesis of aliphatic and aromatic compounds; problems in chemical manufacture; recent chemistry of plant nutrition; animal physiological and pathological chemistry, including foods, standards for feeding of all kinds, and among secretions milk and milk industries, and among excretions urine and urinalysis; toxicology, insecticides and fungicides; frequent examinations on current chemical literature.

Early in the course original work on some agricultural chemical topic must be begun. The history and results of this work must be submitted before graduation, in the form of a thesis containing a distinct contribution to knowledge.

Entomology. — General morphology of insects: embryology; life history and transformations; histology; phylogeny and relation to other arthropods; hermaphroditism; hybrids; parthenogenesis; pædogenesis; heterogamy; colors, — their chemistry in insects; luminosity; deformities of insects; variation; duration of life.

Œcology: dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect productions of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects; insects as disseminators of disease; enemies of insects, — vegetable and animal, including parasites.

Economic entomology: general principles; insecticides, apparatus; special cases; photography of insects and their work; methods of drawing for illustrations; field work on insects and study of life histories; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

Journal club: assignments of the literature on the different groups of insects to different students, who report at monthly meetings summaries of all articles of value which have appeared during the month.

Required readings of the best articles on the various topics named above and on the different orders of insects. This reading covers from 15,000 to 20,000 pages, in English, French and German, and the candidate is examined on this together with his other work at the close of his course.

Thesis: a thesis with drawings, which shall consist of the results of original investigation along one or several lines, and which shall constitute a distinct contribution to knowledge, must be completed and accepted before the final examinations are taken.

Horticulture. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, searching original investigation, and the development of individual initiative in dealing with new questions. From the outset each candidate for the degree must select some special field of horticultural study, and afterwards devote himself continuously to it. He will be required to attend frequent lectures, conferences and seminars dealing with horticulture in its broader aspects. The department is prepared to give advanced work in the following subjects: systematic pomology; pomological practice; commercial practice; systematic, practical and commercial olericulture; greenhouse plants and problems; floriculture; landscape gardening; plant breeding and general evolution; and questions of a physiological nature connected with propagation, pruning, etc. The general work mentioned above covers this ground in a fairly thorough manner; but the work specially elected, which would also fall under some one of these heads, must be prosecuted in such a manner as to yield some original and positive contribution to horticultural knowledge.

Other requirements and opportunities are: (1) periodical seminars with special lectures, chiefly by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits to orchards, gardens, greenhouses, estates, libraries, etc., outside the college grounds, always with some definite purpose in view; (4) and, finally, the preparation and publication of a thesis setting forth the results of the candidate's major study.

FOUR-YEARS COURSES.

Degree.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni, provided that the candidate, in addition to the college course, shall have mastered in a preparatory school a three-years preparatory course in studies beyond those commonly presented in the grammar schools of Massachusetts.

Admission.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Certificates. — Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

Examinations. — Candidates for admission to the freshman class will be received on certificate, as explained above, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject-matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1903 and 1904 are: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Tennyson's "The Princess;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1903 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 18 and 19, and on Tuesday and Wednesday, September 15 and 16, as follows: —

First Day.	*Second Day.*
8.30 A.M. — Registration.	9 A.M. — Civil government.
9 A.M. — English.	10 A.M. — Algebra.
11 A.M. — General history.	2 P.M. — Physiology.
2 P.M. — Geometry.	3 P.M. — Physical geography.

Entrance examinations in June will be held on the same days and in the same order as in Amherst, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston, at Horticultural Hall, Worcester, and at Pittsfield, but candidates may be examined and admitted at any other time in the year.

Synopsis of the Courses of Instruction.

[Figures indicate the number of exercises per week; those in parentheses, laboratory hours. Two laboratory hours are equivalent to one exercise hour.]

Freshman Year.

First Semester.

Language,	English,	3	
	French,	4	
Mathematics, algebra,		5	
Science,	Agriculture,	4	
	Botany (4),	3	
Military tactics,		1	
History,		2	
			22

Second Semester.

Language,	English,	4	
	French,	4	
Mathematics, geometry and trigonometry,		4	
Science,	Anatomy and physiology (one-half semester),	5	
	Chemistry (one-half semester),	4	
	Botany (2),	2	
History,		2	
			21 and 20

Sophomore Year.

First Semester.

Language,	English,	3	
	German,	4	
Physics,		4	
Science,	Agriculture,	4	
	Chemistry (6),	3	
	Zoölogy (4),	2	
			20

Second Semester.

Language,	English,	4	
	German,	3	
Physics,		4	
Surveying (4),		2	
Science,	Agriculture,	3	
	Chemistry (5),	2½	
	Horticulture,	3	
			21½

Junior Year.

First Semester.

Course in agriculture,	Agriculture,	4	
	Botany (4),	3	
	Chemistry (6),	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
			20

Course in horticulture,	Horticulture,	4	
	Horticulture (2),	4	
	Botany (4),	3	
	Chemistry (6),	3	
	Geology,	3	
	English,	4	
			21

Course in biology,	Zoölogy (8),	4	
	Botany (4),	3	
	Chemistry (6),	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
			20

Course in chemistry,	Chemistry (8),	4	
	Agriculture,	4	
	Mathematics,	4	
	Geology,	3	
	English,	4	
	Special subject,	2	
			21

Course in mathematics,	Analytical geometry,	4	
	Engineering (2),	4	
	Free-hand drawing,	2	
	Landscape gardening,	4	
	Geology,	3	
	English,	4	
			21

Course in landscape gardening,	Landscape gardening,	4	
	Agriculture,	3	
	Botany (4),	3	
	Free-hand drawing,	2	
	Horticulture,	3	
	Geology,	3	
	English,	4	
			22

Second Semester.

Course in agriculture,	Agriculture,	3	
	Botany (4),	3	
	Chemistry (8),	4	
	Horticulture (4),	2	
	Entomology (8),	4	
	Political economy,	4	
			20

Course in horticulture,	Horticulture,	4	
	Botany (4),	3	
	Chemistry (8),	4	
	Landscape gardening,	2	
	Entomology (8),	4	
	Political economy,	4	
			21
Course in biology,	Entomology (8),	4	
	Zoölogy (6),	3	
	Botany (4),	3	
	Chemistry (8),	4	
	Horticulture (4),	2	
	Political economy,	4	
			20
Course in chemistry,	Chemistry (10),	5	
	Agriculture,	3	
	Mathematics,	4	
	Political economy,	4	
	Special subject,	5	
			21
Course in mathematics,	Engineering,	5	
	Mathematics,	4	
	Mechanical drawing (4),	2	
	Landscape gardening,	4	
	Political economy,	4	
			19
Course in landscape gardening,	Landscape gardening,	4	
	Botany (4),	3	
	Mechanical drawing (4),	2	
	Engineering,	5	
	Entomology (8),	4	
	Political economy,	4	
			22

Senior Year.

First Semester.

The following subjects are required in all courses: —

Bacteriology (one-half semester) (8),	4	
Constitution of the United States (one-half semester),	4	
Military science,	1	
		5

Second Semester.

Constitution of the United States,	4	
Military science,	1	
		5

From the following the student must elect three subjects, closely correlated with his junior year course; only one language can be elected: —

Agriculture,	4	Physics,	4
Horticulture,	4	Engineering,	4
Veterinary,	4	English,	4
Botany,	4	French,	4
Landscape gardening,	4	German,	4
Entomology,	4	Latin,	4
Chemistry,	4		

ENTRANCE EXAMINATION PAPERS USED IN 1902.

The standard required is 65 per cent. on each paper.

Algebra.

1. Factor $\begin{cases} \text{(a)} & x^2+y^2+2xy-4x^2y^2. \\ \text{(b)} & 27x^3-64y^3. \end{cases}$

2. Simplify $1+\frac{2x+1}{2x-2}-\frac{4x+5}{2x+2}$.

3. Solve $\frac{4}{x+3}-\frac{2}{x+1}=\frac{5}{2x+6}-\frac{2\frac{1}{2}}{2x+2}$.

4. Solve $\sqrt{1+\sqrt{3+\sqrt{6x}}}=2$.

5. Simplify $\left[\left\{\frac{1+x}{2}\right\}^{\frac{1}{2}}+\left\{\frac{1-x}{2}\right\}^{\frac{1}{2}}\right]^2$

6. Expand $(a^{\frac{1}{3}}x^{-1}+a^{-\frac{1}{3}}x)^3$.

7. Rationalize denominator of $\frac{2\sqrt{5}}{\sqrt{5}+\sqrt{3}}$.

8. Solve $\begin{aligned} \frac{1}{x}-\frac{1}{y}&=\frac{1}{3}. \\ \frac{1}{x^2}+\frac{1}{y^2}&=\frac{5}{9}. \end{aligned}$

Geometry.

1. A parallel to one side of a triangle divides the other two sides proportionally. Prove when the segments of each side are incommensurable, only.

2. If through a fixed point without a circle a tangent and a secant be drawn, the product of the whole secant and its external segment is equal to the square of the tangent. (Prove.)

3. A circle can be circumscribed about, or inscribed in, any regular polygon. (Prove.)

4. The side of an equilateral triangle is 6. Find the areas of the inscribed and the circumscribed circles.

5. If the radius of a circle is $3\sqrt{3}$, what is the area of a sector whose central angle is 152°?

Physical Geography.

1. What *three* factors influence climate? Have climatic conditions always been the same here in North America? How do the seasons vary in the different climatic zones?

2. Define a volcano. What are the probable causes of an eruption? Name and describe some noted volcanic outbursts.

3. Describe the following: cyclone, typhoon, hurricane, blizzard and waterspout. Where do they occur?

4. What is a tide? What causes tides? Why do tides vary in height at stated intervals, and what is the length of a tidal cycle?

5. How does the coarseness of river deposits vary from source to mouth? Upon what does this depend? Define alluvial plain, river terrace, estuary and delta. Give examples.

Civil Government.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the merit of your paper.

Write upon any *five* of the following topics. You are to develop the topic as fully as you can, choosing your own method and aiming at clearness and accuracy of statement.

1. Town government in Massachusetts.
2. The Massachusetts Legislature.
3. The Congress of the United States.
4. The present way of choosing the President of the United States.
5. The present way of choosing United States Senators.
6. The Supreme Court of the United States.
7. Town or city taxes.
8. The advantages of a republican form of government.

Physiology.

1. Define the terms organ, tissue, cell. Describe the latter in full, drawing a diagram to show the parts.

2. What are the principal elements found in the body? Name and define the three groups of organic compounds which the body contains.

3. What is a joint? Describe, with a diagram, that of the hip. What is a suture? Where are sutures found?

4. Tell what you can of the hygiene of the muscular and digestive systems.

5. What is the pericardium? Describe and locate the mitral, tricuspid and semi-lunar valves. Locate and give the physiology of the papillary muscles. How is the heart nourished?

General History.

1. *Ancient History.*

(*a*) What can you say of the Aryans with respect to their relation to the white race, their religion, their occupations and their migrations?

(*b*) What are the pyramids, and what do they signify with respect to ancient Egypt?

(*c*) State briefly for what the following early Greeks were especially noted: Lycurgus, Draco, Solon, Leonidas.

(*d*) Distinguish between the patricians and the plebians in Roman society. What part did the clients and the slaves play in general Roman society?

2. *Mediæval History.*

(*a*) The dark ages were the years from 476 to 1001. In this period arose the papacy and feudalism. Explain what these great institutions were?

(*b*) What was chivalry, and to what extent did it influence events and enterprises of the middle ages?

(*c*) Give a brief outline of the Norman conquest of England, telling how it came to pass, what the chief battle was, and the effect on the conquered country.

3. *Modern History.*

(*a*) The conquest of Mexico and of Peru: by whom made, why made, and results.

(*b*) What was the French revolution? Show its relation to the political events of modern times.

(*c*) Name five *great* Americans, and state clearly and accurately why you consider them so.

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper. The time allowed is two hours.

1. Choose two of the following topics, and write clearly and interestingly upon them. Let each essay be about two hundred words in length.

(*a*) The boyhood of Shakespeare.
(*b*) Shakespeare's early relations with the London Theatre.
(*c*) An outline of Goldsmith's life.
(*d*) Goldsmith's poverty.
(*e*) Scott's influence on the English novel.
(*f*) Scott's financial troubles.
(*g*) An outline of Cooper's life.
(*h*) Cooper's literary methods.
(*i*) Lowell's early surroundings.
(*j*) Lowell, — the American!

2. Choose one topic from each of the following groups, and write a paragraph or two on each topic. Give title in each case.

Group A, "The Merchant of Venice."

Is Shylock's attitude toward Antonio due to business sagacity or to personal hatred?
The lesson of the caskets.
Whom do we admire most in this play?
Does Shylock ever incite our pity or our sympathy?
Jessica's attitude toward her father.

Group B, "The Vicar of Wakefield."

The style of the story.
An appreciation of Dr. Primrose.
"Mr. Burchell," — the villain.
The Vicar's daughters.
The Primrose family.
The humor of the story.

Group C, "Ivanhoe."

The hostility of the Norman and the Saxon.
A Saxon's home.
The disinherited knight.
Friar Tuck and Robin Hood.
Isaac of York.
The rescue of Cedric, Rowena and others from Front-de-Boeuf's castle.
The death of Front-de-Boeuf.
The trial of Rebecca and its outcome.

Group D, "The Last of the Mohicans."

The historical setting of the story.
David, the singer.
"The Massacre of William Henry."
Uncas.
Magua.

Group E, "The Vision of Sir Launfal."

Nature pictures in the poem.
The great lesson of the poem.
The leper.
Sir Launfal: before and after the vision.
The story of the poem.

WINTER COURSES.

For the benefit of those who are unable to take the regular four-years course, the college offers short courses in dairying and horticulture, and for these, examinations are not required. These courses are offered during the ten weeks succeeding the first Wednesday in January. They are open to persons of both sexes, and are all optional. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

A tabulated outline of the courses, all of which are optional, follows: —

1. Short Winter Course in Dairy Farming.

	Hours per Week.
Soils, tillage and methods of soil improvement; manures and fertilizers, and their use; crops and rotations,	4
Breeds and breeding of dairy stock; judging to scale of points,	2
Fodders and feeding farm live stock,	1
Stable construction and sanitation,	1
Common diseases of stock, — prevention and treatment,	1
Dairy products, — their general characteristics, testing, etc.,	2
Chemical composition of milk and of special milk products,	1
Botany,	2
Horticulture,	3
Entomology,	3
Dairy practice, including testing, use of separators, butter making, preparation of certified and modified milk, and pasteurization (exercises per week),	4
Exercise in horticulture (per week),	1

Begins first Wednesday in January; continues ten weeks.

2. Short Winter Course in Horticulture.

	Hours per Week.
Soils, tillage, manures, etc.,	4
Plant propagation and pruning,	3
General fruit growing,	3
Market gardening,	3
Botany,	4
Entomology,	3

Practice work in seed testing, seeding, grafting, budding, transplanting, judging fruit, etc.

Begins first Wednesday in January; continues ten weeks. This course will not be given unless at least eight men register for it.

3. Outline of Course in Poultry Culture.

	Total Hours.
Plans of poultry plants and poultry houses, including incubator cellars, brooder houses, heating, ventilation, drainage, etc.,	20
Zoölogy, anatomy, physiology and embryology of fowls,	10
Breeds and principles of breeding,	20
Crops for poultry,	5
Incubators and brooders; hatching and raising chickens,	5
Chemistry of foods and the compounding of food rations,	5
Diseases of poultry; caponizing,	10
General management, for eggs, in fattening, etc.,	5

In addition, a few special lectures on the following subjects: turkeys and pheasants; preparing birds for exhibition; practice in scoring; object lessons in killing and dressing fowls; marketing; water fowls, — ducks and geese; broiler raising; pigeons.

Practical exercises; scoring, running incubators and brooders, testing eggs, caponization, etc., 5 hours per week.

Begins fourth Wednesday in March; continues four weeks.

4. Bee Culture.

	Total Hours.
The structure of bees, with special reference to their work,	5
Flowers and fruits in their relations to bees,	10
Honey crops, and how to grow them,	5
Bees and bee keepers' supplies,	10
Work in the apiary,	20
Specialists,	4

Begins fourth Wednesday in May; continues two weeks.

TWO-YEARS COURSE FOR WOMEN.

First Year.

First Semester.

	Hours per Week.
Soils, fertilizers and cultivation,	4
Elementary botany,	5
French,	4
Free-hand drawing (optional),	4

Second Semester.

Propagation and pruning (horticulture, 1),	3
Botany; morphology, plant analysis,	5
Chemistry, descriptive,	5
Vegetable gardening,	4
French,	4

Second Year.

First Semester.	Hours per Week.
Pomology,	3
Greenhouse construction and management,	3
Botany; structure and physiology of plants,	5
Zoölogy,	2
Chemistry,	5
German,	4

Second Semester.	
Landscape gardening,	3
Floriculture,	4
Vegetable pathology,	5
Entomology,	3
Chemistry,	5
German,	3

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables are stocked with the best breeds of horses, cattle, sheep and swine. Attached to the barn is a dairy building equipped with the latest machinery, driven by an electric motor. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution and the theory and practice of agriculture. Three large lecture rooms, one in south college and two in the dairy building, have been assigned to this department.

Horticulture.

For illustration of the science and the practice of horticulture the department possesses about one hundred acres devoted to orchards planted with all the leading old and all new varieties of apples, pears, peaches, plums, Japanese and American cherries, quinces, chestnuts, hickory nuts and walnuts; vineyards containing nearly two hundred named varieties of grapes, for sale, beside several hundred seedlings, and about an acre devoted to a commercial crop of a few market varieties; nurseries containing all kinds of fruit and ornamental trees, shrubs and plants, in all stages of growth, from the seed and cuttings to those ready for planting in the orchard or field; small fruit plantations containing valuable varieties, and showing the modern methods of training, pruning and cultivation; extensive greenhouses that contain not only valuable collections of specimen plants, representing types of the flora of the world, but also the most valuable economic plants, such as the orange, banana, lemon, guava, pomegranate, sago palm, arrowroot, tapioca, ginger, pepper, tea, coffee, camphor, India rubber, Manila hemp, banyan tree, etc. All the common greenhouse and outdoor decorative plants are found, and small quantities of roses, carnations, chrysanthemums and other commercial flowering plants are grown, to illustrate the business of horticulture. All vegetable crops, now so largely grown under glass, are grown in limited quantities for purposes of instruction and for market.

For illustration in the work of landscape gardening, the grounds about the greenhouses, as well as that part of the grounds known as the Clark Park, are planted with a very large and complete collection of ornamental trees, shrubs and plants.

For forestry there are two large groves of trees of varying ages, from those of almost primeval growth to the youngest seedlings, besides several plantations of younger growth either natural or planted; and in the Botanical Museum there is a very complete collection of woods of Massachusetts.

All kinds of pumps and other appliances for distributing insecticides and fungicides, as well as various modern tools and implements, are in constant use.

A small cold-storage room makes possible the keeping of the products beyond their natural season, and illustrates one of the most important adjuncts to the business of modern horticulture.

Chemistry.

This department has fourteen rooms, well adapted to their special uses. They are supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor has a seating capacity for seventy students. Immediately adjoining it are four smaller rooms, used for storing apparatus and preparing materials for the lecture table. The laboratory for beginners is a large room on the first floor, furnished with forty working tables. Each table is provided with reagents and apparatus for independent work. A well-filled laboratory for advanced work is also provided on the first floor. A weighing room has six balances, and improved apparatus for determining densities of solids, liquids and gases. The apparatus includes, besides balances, a microscope, a spectroscope, a polariscope, a photometer, a barometer, and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milking products, fibres and other vegetable and animal products, and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished product.

Geology.

Geological teaching is illustrated by a very complete series of minerals, the State collection of rocks of Massachusetts, a series of Ward's fossils and casts of fossils, models and charts.

Zoölogy.

Zoölogical Laboratory. — A large, well-lighted room, situated in the old chapel building, is fitted with necessary tables, trays and general apparatus, microscopes, dissecting instruments, hand lenses and the like. There have lately been added aquaria, in which, as far as possible, the various types studied may be seen in their natural environment. A reference library is kept in the laboratory.

Zoölogical Lecture Room. — An ample lecture room is situated in south college, adjacent to the museum. It is supplied with a set of Leuckart charts and many special ones as well, and with a complete set of Auzoux models, illustrative both of human and comparative anatomy. A special set of typical specimens is being set apart for class illustration, although the more extensive museum collection is drawn upon for the same purpose.

Museum of Zoölogy. — The museum is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth, and those types which show the evolution and the relationship of the members of the animal kingdom. The total number of specimens contained in the museum now exceeds eleven thousand. The museum is open to the public from 3.30 to 5.30 P.M. each week day.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glass ware. One portion of the building is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over forty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject. This is supplemented by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. As the laboratory is directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room, fitted up for the analysis of insecticides and other chemico-entomological work; and a greenhouse, where plants infested by injurious insects are under continual observation and experimental treatment, — all these are available to the student. In addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large greenhouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for study of the attacks of injurious insects under natural conditions.

Veterinary Science.

The department has for its sole use a commodious and modern laboratory and hospital stable, erected in 1899. Both buildings are constructed according to the latest ideas as regards sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The laboratory building contains a large working laboratory for student use, and several small private laboratories for special work. In addition, there is a lecture hall, museum, demonstration room, photographing room and work shop. The hospital stable contains a pharmacy, operating hall, post-mortem and disinfecting room, besides a section for poultry, one for cats and dogs, and six sections, separated from each other, for the accommodation of horses, cattle, sheep, swine and other domestic animals.

The laboratory equipment consists of a dissecting Auzoux model of the horse, Auzoux models of the foot and the legs, showing the anatomy and the diseases of every part. There are skeletons of the horse, cow, sheep, dog and pig, and, in addition, a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams, which are made use of in connection with lectures and demonstrations.

The laboratories are supplied with the most modern high-power microscopes, microtomes, incubators and sterilizers, for the use of students taking the work in bacteriology and parasitology.

Botany.

The botanical department possesses a general laboratory, furnished with tables and benches for microscopical and physiological work, and with a dark closet for photographic purposes. There are forty compound microscopes, twenty-three dissecting microscopes, a micro-photographic and landscape camera and various accessories; also microtomes, paraffine baths, etc., for histological work; a large and useful collection of physiological apparatus for the study of photo-synthesis, respiration, metabolism, transpiration, heliotropism, geotropism, hydrotropism, galvanotropism, chemotropism, and other irritable phenomena connected with plants; a set of apparatus for the study of the mechanical constituents of the soil, and for experimental work in soil physics; a large and unique outfit of electrical appliances for the study of all phenomena related to electricity and plant growing; various devices for the study of mechanics of plant structure; numerous contrivances to determine the power exerted by living plant organisms; several types of self-registering auxanometers, used to measure the rate of growth of plants; self-registering thermometers, and hygrometers for recording constant changes in conditions.

A small special laboratory for graduate students is equipped with microscopes and other apparatus and reagents for advanced work.

Botanical Lecture Room. — The botanical lecture room adjoining the laboratory is adapted for general work in morphology and flower analysis, with opportunity to use dissecting microscopes. It contains a movable chart system, arranged to display over three thousand figures relating to the structure and function of plants.

Library.

The library now contains 23,681 volumes, having increased by gift and purchase 1,059 volumes. There are on file 185 unbound periodicals, mostly scientific. About 60 agricultural and horticultural newspapers and periodicals have been presented to the reading room connected with the library; these are not kept on file.

The circulation for the past year has been about 4,000 volumes, not including books drawn by the several departments of the college. These books are in most cases drawn at the beginning of the college year and retained until its close in June. Nearly 500 books are drawn by the departments and kept there for use of the students as reference books.

Although the shelves have been open to the students for reference work, not more than three books have been missing.

As a library for reference, the library has been used more in the past year than in former years, not only by the students but by people outside of the college interested in scientific studies.

The shelving of books has for the past year become a very serious problem. The library, having outgrown its present quarters, has crowded on shelves barely accommodating 20,000 volumes the 23,681 volumes above mentioned. As a result, a part of the cases are dangerously overloaded. Books are injured in taking down from or returning to the crowded shelves, and also by frequent moving of shelves to different parts of library.

EXPENSES.

Tuition. — Tuition is free to citizens of the United States. Citizens of Massachusetts, however, in accordance with an act of the Legislature, must make application to the Senator of the district in which they live for a free scholarship that covers the charge for tuition. Blank forms for such application may be obtained from the president of the college.

Rooms. — It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere. For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. All rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

Board. — Board at the new dining hall has been $3.25 per week; in private families, $4 to $5.

Incidental Expenses. — The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $15 per semester used; zoölogical, $4 per semester used; botanical, $2 per semester used by sophomore class, $3 per semester used by senior class; entomological, $3 per semester used. Some expense will also be incurred for text books.

Room rent, in advance, $12 to $24 per semester,	$24 00	$48 00
Board, $3.25 to $5 per week,	123 50	190 00
Heat, $13,	13 00	13 00
Light, $12,	12 00	12 00
Washing, 30 to 60 cents per week,	11 40	22 80
Military suit,	15 00	15 00
Expenses per year,	$198 90	$300 80

In addition to the above expenses, $80 tuition is charged to foreigners.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the

Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator from his district for a scholarship. Blank forms of application will be furnished by the president.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Frank A. Waugh, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

For the best herbarium collected by a member of the class of 1903 a prize of twenty dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of native woods.

The prizes in 1902 were awarded as follows: —

Burnham Rhetorical Prizes: George E. O'Hearn (1904), first; Arthur L. Peck (1904), second; Herbert H. Goodenough (1905), first; George H. Allen (1905), second.

Flint Oratorical Prizes: Harry J. Franklin (1903), first; Myron H. West (1903), second; William H. Peebles (1903), honorable mention.

Grinnell Agricultural Prizes: J. Herbert Belden (1902), first; Edward B. Saunders (1902), second.

Hills Botanical Prizes: Arthur L. Dacy (1902), first; John M. Dellea (1902), second.

Dairy Prizes, given by the Massachusetts Society for Promoting Agriculture: for best butter, — first, Fred P. Hall; second, George Weigold; third, Frederick W. Richardson. For general excellence, — first, George Weigold; second, James E. Stultz; third, Walter

A. Conant. Special prize given by Mr. W. H. Bowker for best knowledge of the use of fertilizers on the dairy farm, — George Weigold. Special prize given by Mr. B. von Herff for best knowledge of use of fertilizers on grass land, — Walter E. Brigham.

RELIGIOUS SERVICES.

Chapel services are held every week day at 8 A.M. and public worship in the chapel every Sunday at 9.25 A.M. Further opportunities for moral and religious culture are afforded by Bible classes taught by one of the professors and other teachers for an hour every Sunday afternoon, and by a religious meeting Thursday evening under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of four hundred acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, Jan. 1, 1902, to Jan. 1, 1903.*

	Received.	Paid.
Cash on hand Jan. 1, 1902,	$10,996 43	–
State Treasurer, Morrill fund,	16,666 66	–
State Treasurer, endowment fund,	10,142 04	–
State Treasurer, maintenance appropriation,	5,000 00	–
State Treasurer, maintenance appropriation, special,	8,000 00	–
State Treasurer, scholarship appropriation,	10,000 00	–
State Treasurer, labor appropriation,	5,000 00	$5,492 82
Gassett scholarship fund, income,	40 00	42 91
Mary Robinson scholarship fund, income,	34 07	50 23
Whiting Street scholarship fund, income,	50 40	59 80
Grinnell prize fund, income,	96 24	60 00
Hills fund, income,	355 93	386 62
Library fund, income,	421 84	421 84
Burnham emergency fund, income,	159 64	164 64
Salary,	60 27	30,520 36
Extra instruction,	–	401 00
Botanical laboratory,	132 60	117 43
Chemical laboratory,	656 92	528 30
Entomological laboratory,	82 50	51 24
Veterinary laboratory,	1,000 00	613 52
Zoölogical laboratory,	103 66	119 95
Term bill,	2,848 98	1,186 26
Advertising,	–	908 18
Electric plant,	653 49	3,403 12
Agricultural department,	663 49	1,925 56
Farm,	8,295 83	12,549 08
Horticultural department,	3,795 31	6,553 57
Expense,	2,081 43	14,702 83
Insurance,	–	554 00
Investment,	9 63	–
Labor fund,	17 50	–
Individual labor fund,	81 11	–
Cash on hand Jan. 1, 1903,	–	6,632 71
	$87,445 97	$87,445 97

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1902, to Jan. 1, 1903, and find the same correct and properly kept. All disbursements are vouched for, the balance being six thousand six hundred and thirty-two dollars and seventy-one cents ($6,632.71), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Jan. 1, 1903.

CASH ON HAND, AS SHOWN BY THE TREASURER'S STATEMENT, BELONGS TO THE FOLLOWING ACCOUNTS.

Gassett scholarship fund,	$36 91
Whiting Street scholarship fund,	35 86
Grinnell prize fund,	76 24
Hills fund,	70 43
Burnham emergency fund,	105 56
Botanical laboratory,	15 17
Entomological laboratory,	37 34
Veterinary laboratory,	530 54
College,	5,724 66
	$6,632 71

BILLS RECEIVABLE JAN. 1, 1903.

Horticultural department,	$549 30
Term bill,	1,500 00
	$2,049 30

BILLS PAYABLE JAN. 1, 1903.

Horticultural department,	$20 03
Electric plant,	209 00
	$229 03

INVENTORY — REAL ESTATE.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 00	
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding house,	2,000 00	
Amounts carried forward,	$174,575 00	$44,350 00

Amounts brought forward,	$174,575 00	$44,350 00
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		248,775 00
		$293,125 00

EQUIPMENT.

Botanical department,	$4,210 00
Horticultural department,	13,146 39
Farm,	17,924 70
Chemical laboratory,	2,723 00
Botanical laboratory,	2,831 53
Entomological laboratory,	15,425 00
Zoölogical laboratory,	2,200 00
Zoölogical museum,	6,000 00
Veterinary laboratory,	5,250 00
Physics and mathematics,	5,500 00
Agricultural department,	3,500 00
Library,	23,473 00
Fire apparatus,	600 00
Band instruments,	350 00
Furniture,	1,200 00
Text books,	300 00
Tools, lumber and supplies,	360 00
Heating and lighting plant,	45,000 00
	$149,993 62

SUMMARY.

Assets.

Total value of real estate, per inventory,	$293,125 00
Total value of equipment, per inventory,	149,993 62
Bills receivable,	2,049 30
Investments, New York Central & Hudson River Railroad stock,	100 00
Cash on hand,	5,724 66
	$450,992 58

Liabilities.

Bills payable,	$229 03	
Burnham emergency fund,	2,502 27	
		2,731 30
		$448,261 28

	Fund.	Income in 1902.
Maintenance Funds.		
Technical educational fund, United States grant,*	$219,000 00	$6,184 64
Technical educational fund, State grant,* .	141,575 35	3,957 40
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890, ...	–	16,666 66
Hills fund, ...	8,542 00	355 93
Maintenance Appropriations.		
State appropriation made by Legislature of 1900 for four years, ...	–	5,000 00
Labor appropriation made by Legislature of 1900 for four years, ...	–	5,000 00
State appropriation made by Legislature of 1900 for four years ($8,000), ...	–	8,000 00
Scholarship Funds.		
Whiting Street fund, ...	$1,260 00	50 40
Gassett fund, ...	1,000 00	40 00
Mary Robinson fund, ...	858 00	34 07
Scholarship Appropriation.		
State appropriation by the Legislature of 1886, ...	–	10,000 00
Prize Fund.		
Grinnell prize fund, ...	$1,000 00	96 24
Miscellaneous Funds.		
Library fund, ...	$10,546 12	421 84
Burnham emergency fund, ...	5,000 00	159 64
		$55,966 82

* The above is two-thirds of the income from these funds.

GIFTS.

From German Kali Works, New York, four tons high-grade sulfate of potash; two and three-fourths tons muriate of potash; one-half ton sulfate of potash; one ton kainite.

Chilian Nitrate Works, New York, seven and one-half tons nitrate of soda.

Massachusetts Society for Promoting Agriculture, Boston, one hundred and fifty dollars in prizes for dairy school; fifty dollars for other purposes for dairy school.

W. H. Bowker (M. A. C., '71), Concord, one ton Stockbridge fertilizer (value $40) for prize in dairy school.

B. von Herff, New York, one ton kainite (value $15) for prize in dairy school.

E. F. Hodgson, Dover, Peep-of-day brooder.

Fuller Manufacturing Company, Danvers, one wheel hoe.

Wm. S. Myers, New York, thirty-two volumes on the agriculture and industries of Chili.

Edward Powers, Amherst, samples tobacco leaf.

The National Milk Sugar Company, New York, six hundred and fifty pounds milk albumin.

R. C. Buckley, Peoria, Ill., vine cutter.

The Farmer Seed Company, Faribault, Minn., one quart Early Fortune millet seed.

Ezra F. Parker, Peoria, Ill., two varieties of seed corn.

Dunham, Fletcher & Coleman, Wayne, Ill., seven portraits of horses.

James S. Bent Company, Boston, one can "Fly Away."

Joseph Dixon Crucible Company, Jersey City, N. J., two cans Dixon's silica graphite paint.

Wm. S. Myers, New York, framed photographs illustrating results of European experiments with fertilizers; two exhibition stands for framed photographs.

E. M. Curtiss, Bristol, Conn., specimens for the museum.

Dr. F. B. Loomis, Amherst, specimens for the museum.

O. B. Gilman, Boston, specimens for the museum.

C. L. Fisher, South Deerfield, specimens for the museum.

From Dr. R. P. Lyman (M. A. C., '92), Boston, collection of histological specimens.

Y. H. Canto (M. A. C., 1900), New York, collection of histological specimens.

Loans to the College and Experiment Station.

From De Laval Separator Company, New York, six separators, one milk heater.

Vermont Farm Machine Company, Bellows Falls, Vt., five separators, one thirty-two-bottle Babcock tester.

U. S. Butter Extractor Company, Bloomfield, N. Y., one separator.

J. S. Biesecker, New York, one Child's bottle filler, one strainer.

Rice & Adams, Buffalo, N. Y., one bottler.

A. H. Reid, Philadelphia, Pa., one hand separator.

P. M. Sharples, West Chester, Pa., two separators.

Cyphers Incubator Company, Buffalo, N. Y., two incubators, one brooder.

Cornell Incubator Company, Ithaca, N. Y., one incubator, one brooder.

Star Incubator and Brooder Company, Lincoln, N. Y., one incubator.

Moseley & Stoddard Manufacturing Company, Rutland, Vt., model of silo.

FARM REPORT.

The operations on the college farm during the past year have been attended with a fair measure of success, although the unseasonable weather of the summer is to be charged with some comparative failures. The most important of these was with the corn crop, which is hardly one-half a normal average. The shortage in the crop was doubtless more serious with us than with many, because of the fact that most of our land is comparatively low, and has a heavy and naturally moist soil. On account of the light corn yield, we have hardly one-half the usual amount of silage, and must use hay more largely than usual in feeding our cattle. This will inevitably reduce the surplus of this crop available for sale. The onion crop also was an unsatisfactory one, chiefly because of the very slow growth during the early part of the season, while the weather was so abnormally cold and wet. The crop in the end made fair growth, but too late to permit its ripening. The proportion of scallions was very large.

The nature of the farm operations and the financial results with the several crops are shown in the following table : —

College Farm Crops, 1902.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.*	Labor and Seed.			
Carrots,	½	–	11	$15 57	$25 30	$77 00	$36 13	–
Celery,	1	300 doz bunches.	–	30 15	68 90	270 00	177 58	–
Corn,	40	700 bu. on ear.	180 silage. 16 dry fodder.	442 75	535 32	920 00	–	$58 07
Japanese millet,	5	150	10 straw.	44 62	114 60	357 50	198 28	–
Onions,	4	530 large. 80 small.	–	143 10	36 05	–†	–†	–
Parsnips,	½	200	–	–	20 07	100 00	79 93	–
Potatoes,	10	1,566 large. 358 small.	–	118 41	338 27	1,029 10	572 42	–
Hay,	–	–	109	–	–	1,962 00	–	–
Rowen,	–	–	27	–	–	432 00	–	–
Soy beans,	6	120	3	37 63	70 30	282 00	174 07	–
Turnips,	½	175 small. 275 large.	–	–	20 00	110 00	90 00	–
Mangles,	½	–	17	19 56	18 18	68 00	30 26	–
Total,	68	–	–	$932 22	$1,216 92	$5,607 60	$1,358 67	$58 07

* One-half value of manure and three-fourths the value of the fertilizers.

† Raised on shares.

System of Manuring.

The manures and fertilizers used for the several crops of the year are shown by the following table. The manure which is used for our crops is for the most part hauled from the pits connected with the stables every few weeks. It is usually spread on the fields when hauled, and much of it accordingly lies upon the surface for several months. Our practice is, in the case of manure applied to old fields, to work the land in the spring with a disc harrow for the lighter soils, to replough on the heavier. Sod land used for hoed crops is usually ploughed in the fall, manured during the winter, and the fitting of the land for seed in the spring is completed by the use of disc and other harrows. The fertilizers used, with the exception of nitrate of soda, the acid phosphate and about half the potash, are usually spread broadcast on the rough furrow, and harrowed in for most of our crops. For the potatoes we use a somewhat larger proportion of the fertilizers in the drill.

Manures and Fertilizers for the Several Crops, per Acre, 1902.

	Corn, Twenty Acres.	Corn, Twenty Acres.	Carrots, One-half Acre.	Mangles, One-half Acre.	Celery, One Acre.	Onions, Four Acres.	Soy Beans, Six Acres.	Millet, Five Acres.	Potatoes, Ten Acres.	Old Mowings, Thirty Acres.
Manure (cords),	5	5	8	8	10	6	–	–	–	–
Nitrate of soda (pounds),	–	–	75	150	125	150	125	125	125	130
Acid phosphate (pounds),	–	–	150	300	300	800	300	400	400	–
Sulfate of potash, high grade (pounds),	100	–	75	–	150	200	175	150	175	–
Kainite (pounds),	–	100	–	–	–	–	–	–	–	–
Muriate of potash (pounds),	–	–	–	250	–	–	–	–	–	80
Dried blood (pounds),	–	–	–	–	150	250	–	200	175	–
Tankage (pounds),	–	–	–	–	200	–	–	–	250	–

Experiments in the Use of Manures and Fertilizers.

A. Method of Application of Barnyard Manure.

Experiments carried out in the agricultural department of the experiment station having indicated a decisive advantage in favor of putting manures hauled from the stables during the winter into large heaps, to be spread and ploughed in in the spring, as compared with spreading in the winter and leaving upon the surface until spring upon fields having a moderate slope, it has been thought best to try a similar experiment upon one of the very level fields of the farm. Two plots of one acre each have accordingly been laid off in one of these fields. The manure was applied to one during the winter, while the ground was frozen, at the rate of 6 cords per acre. On the other plot the same quantity of manure was put into a large heap and spread in the spring just before ploughing. The yields were as follows: first acre, winter-spread manure, 3,850 pounds corn on the ear; second acre, manure piled and spread in the spring, 3,510 pounds corn on the ear.

The difference is comparatively small, and the advantage happens to be with the manure spread in the winter; which appears to indicate that the loss in the case of the plots in the experiment station grounds may have been due to wash over the surface. These farm plots being level, there could have been no wash.

B. Experiments with Nitrate of Soda and Muriate of Potash on Grass Lands.

Plots of considerable size, usually about one-half acre each, were laid out in some of the farm mowings in 1899 for experiments in the use of nitrate of soda and muriate of potash in different combinations. To one plot in each mowing nitrate of soda alone is applied each year, at the rate of 150 pounds per acre; to another plot nitrate of soda and muriate of potash are applied at the rates respectively of 150 and 100 pounds per acre; to the third plot muriate of potash is applied at the rate of 100 pounds per acre. In the field in which the experiments have continued longest the results are of much interest. This field, so far as is known, has not been ploughed for something like twenty years. At the beginning of the experiment the sod of all plots consisted chiefly of Kentucky blue-grass, although there was a moderate mixture of orchard grass, and here and there a clover plant. The application of fertilizers to each of the three plots has yearly been the same; and, as a result of the different use of fertilizers, the character of the hay produced and of the sod is now markedly different. Where the nitrate of soda is used alone, the product is made up wholly of grasses, and examination of the turf fails to disclose even a single clover plant. The product of the plot to which nitrate of soda and muriate of potash are annually applied is the largest of the three, and is a good mixture of grasses and clover. The product of the third plot is now very rich in clover, but the character of the turf appears to be improving from year to year in a marked degree. The grasses, which at first did not appear to be much benefited by the application of potash, at the present time appear to be more vigorous than on either of the other plots. It would seem that these are now making use of some of the nitrogen taken from the air by the clovers which are so abundant in this plot. Red clover, which is the prevailing species, is not a long-lived plant. It maintains itself in mowings by seeding, and as the older clover plants die, the grasses growing in the same plot feed upon the products of the decay of the clover roots and stubble; so that in the end we appear to benefit grasses as well as clovers to a marked degree by the continuous use of a fertilizer whose benefits in the first instance are confined almost exclusively to clovers. The product of the plots in this field for the several years is shown in the following table: —

Experiments with Nitrate of Soda and Muriate of Potash on Grass Lands.

FERTILIZERS.	Pounds per Acre.	Yield per Acre (Pounds). 1899. First Crop.	1900. First Crop.	1901. First Crop.	1902. First Crop.	1902. Second Crop.
Nitrate of soda, . .	150	1,960	1,480	2,430	2,230	1,404
Nitrate of soda, . .	150	1,990	1,760	1,730	2,740	2,080
Muriate of potash, .	100					
Muriate of potash, .	100	2,020	1,340	1,930	1,700	1,630

It is a matter of regret that the weights of the rowen were not taken in the earlier years of the experiment.

Live Stock.

During the past year we have had but little disease among our live stock. We lost, however, six lambs, as a result of an attack of an intestinal parasite. It is not definitely known how this parasite gained access to our flock, as no stock was purchased. It is the belief of the writer, however, that it was brought to us by an Angora goat suffering with the disease, which was for a time kept in the veterinary department. The lambs, it is true, never came into direct contact with the goat, but the land from the yard where the goat was for a time allowed to run slopes towards the field, at a distance of about one-eighth of a mile, in which the lambs were pastured. These lambs, however, did not come into contact with the other animals of our flock, and it is believed that we are now entirely free from the disease.

The tuberculin test made last winter indicated the possible presence of incipient disease in three cows, which will be slaughtered if another test shows disease.

An attack by dogs caused the loss of two sheep, but fortunately the flock was neither seriously frightened nor injured.

The kinds and numbers of the several classes of live stock are as follows: —

Horses. — French Coach, 2 stallions, 1 two-year-old stallion, 1 yearling fillie, 1 weanling, 1 brood mare; Percheron, 1 stallion, 1 mare; French Coach, half-blood, 2 colts; four-year-old grade colts, 3; work horses, 4.

Neat Cattle. — Jersey, 1 bull, 2 cows, 4 heifers, 1 heifer calf; Shorthorn, 1 heifer, 1 bull calf; Holstein-Friesian, 1 bull, 3 cows, 2 yearling heifers; Ayrshire, 2 cows, 1 two-year-old heifer, 1 heifer calf, 1 bull calf; grade, 29 cows, 21 heifers, 4 heifer calves; total, 71 head.

Sheep. — Southdown, 1 ram, 28 breeding ewes, 9 lambs; total, 39 head.

Swine. — Middle Yorkshire, 2 breeding sows; Belted, 1 sow; Poland-China, 1 boar; Berkshire, 4 boars, 5 sows, 5 pigs, 12 shoats, 17 pigs; total, 47.

The Milk Record.

During the past year we have disposed of a considerable number of the less satisfactory milkers in our herd. The high prices of beef have enabled us to do this to unusually good advantage. The record of the cows and heifers now in our herd only can be reported. This record includes that of 32 individuals. Of these, 5 are heifers with their first calf. In obtaining the average, one of these heifers which has milked only five months is not included. The total yield of milk has been 167,845 pounds. The average yield per cow for the 31 individuals included is 5,349.7 pounds. The milk product of our herd averages about 4.2 per cent. butter fat. We have in our herd at the present time 10 individuals, giving a product of more than 6,000 pounds of milk per year. The herd includes, besides the heifers with first calf, a considerable number of very young cows.

The Southdown Flock.

The flock of Southdown sheep at the farm includes many individuals of splendid quality. It has averaged about 35 breeding ewes per year for the past six years. Most of our lambs have been sold as breeding stock before they were one year of age. The inferior individuals have been sold as mutton, also before they were one year of age. A portion of our bucks are wintered and sold as yearlings for breeding purposes, and we have sold a few yearling ewes. It is impossible to state the exact number of lambs wintered from year to year, but it cannot have exceeded 8, making the number of individuals wintered annually, therefore, about 44. The cash received for sales of stock and wool during the past six years has amounted to $1,331.23, which is an average of $221.87 per year. The number of individuals annually wintered being taken as 44, we have a yearly return for each animal wintered of $5.04. There can be no doubt that our sheep are proving the most profitable among the different classes of live stock kept.

Improvements.

The chief improvements of the year are the following: —

Two of our pastures have been improved by getting out and burning the very numerous stumps. This improvement is now complete in the north pasture, and has covered about six acres in the south pasture in the Durfee lot. It is believed that the latter will be greatly improved further if it is once ploughed, cultivated for at least a year, and reseeded.

A considerable portion of the wood fence surrounding the hog pasture has been replaced by Page woven-wire fence.

The plank floor in the cow stable has been removed and replaced by a solid concrete floor. Most of the expense of this change was covered by a special appropriation; but $100 from the regular farm funds has been expended in painting the overhead plaster, oiling the wood work, putting in ties, building an approach, and in repiping other parts of the barn.

Farm roads have been improved by the application of about 100 loads of gravel. The underdrains on the farm have required considerable attention. About 1,000 feet of 8-inch tile and 300 feet of 2-inch tile have been dug up and relaid. These lines of drains had become obstructed with roots and silt which had washed in at the joints. The main outlet of our system of underdrains has been extensively improved.

The fittings of the interior of the quarantine barn, which will probably not be needed for quarantining cattle in the near future, have been removed, and the barn has been fitted for horses and colts. A paddock for horses has been substantially built south of the main barn.

Other minor improvements about the buildings have occupied a considerable share of the time of a carpenter who is regularly employed.

The Financial Outcome.

The cash receipts for the year are $9,013.59. As there are no outstanding bills due, this sum is to be compared with $8,864 for last year, which included both cash receipts and bills receivable. The increase for the year, therefore, is a little more than $100. The total expenses this year amount to $11,160.62. The inventory at the present time amounts to $17,924.70, which is $200 less than the inventory of a year ago. The cash received during the year has come from the following sources: milk and cream, $2,672.29; cattle, including calves for veal, $158.13; horses, including fees for use of stallions, $441.25; swine, $306.12; sheep, $220.42; hay, $66.89; potatoes, $1,073.85; celery, $130.16; team labor, $1,653.04; manual labor, $176.01; soy beans, $327.55; hardware, $9.96; ice, $12.21; wood, $14; millet seed, $90.50; stover, $25.60; straw, $15; sundries, $193.61.

The increased expenses of the past year are almost exactly accounted for by the higher prices paid for grain. We have not been able to offset this by increased returns for milk and cream, as our situation has rendered it impossible to increase the prices charged for these products. The labor bills of the year are also somewhat greater than for last year, the frequent rains having rendered the care of crops and the making of hay considerably more difficult and expensive than in more normal seasons.

In conclusion, I desire to express sincere appreciation of the hearty interest and support of the farm committee of the board of trustees, and of the faithful interest and untiring efforts of the farm superintendent.

WM. P. BROOKS,
Professor of Agriculture.

Amherst, Dec. 23, 1902.

MILITARY DEPARTMENT.

AMHERST, MASS., Dec. 31, 1902.

To President H. H. GOODELL, *Massachusetts Agricultural College.*

SIR: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1902.

At the beginning of the present college year I received General Order 94, dated Headquarters of the Army, Washington, D. C., Aug. 9, 1902, which added very materially to the duties heretofore required in this department.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.: —

Monday of each week, recitation of freshmen at 10.15 A.M., first section. Drill and instruction in the ceremony of guard mounting and duties of sentinels, 3.30 to 4.30 P.M.

Tuesday of each week, same as Monday; freshman recitation at 2.15 P.M., second section.

Thursday of each week, same as Monday and Tuesday, omitting recitation.

Friday of each week, senior recitation at 1.15 P.M., and from 3.30 to 4.30 a detail taken pro rata from each class is instructed in the ceremony of guard mounting and duties of sentinels.

Saturday of each week, inspection of dormitories and students' rooms, 8.30 A.M.; instruction in the ceremony of guard mounting and duties of sentinels, 8.15 to 10.15 A.M. The latter exercise is only required of such students as have previously incurred demerits in the military department.

A squad of about eight men is sent to the target range for practice one hour each regular drill day. This practice and the ceremony of guard mounting are omitted during the inclement weather prevailing from about December 1 to March 31.

It has been my purpose to vary the drill exercises as much as consistent with official regulations, in order to avoid monotony, and to impart a more general system of instruction; hence drills have been frequently changed to battalion parades, inspections and reviews. Squads have also been instructed in field artillery drill, manual of the piece only. The exercises prescribed in "Butts' Manual of Physical Drill" were used to advantage in the drill hall in the past winter.

During the spring and early summer practical exercises are mostly company and battalion drills, and the ceremonies of reviews, inspections, parades and guard mountings. It is my aim to have a well-drilled infantry battalion, to make the exercises both interesting and profitable to the students, and to fulfill the purpose for which military instruction in this college is intended.

By vote of the student body, the old, unsightly uniform cap has been exchanged for one of a later pattern, which is more comfortable and better looking. The cadet officers have also been permitted to wear shoulder straps of the army pattern, indicating their rank, as distinguished from that of a non-commissioned officer, in place of the chevrons heretofore worn on the sleeve of the blouse. The present cost of a private's uniform is fifteen dollars. This includes blouse, trousers and cap, and, by proper care, can be made to last through the entire four-years course.

One hundred and ten students have had target practice with the Springfield cadet rifle. Fair progress has been made, but much more could be accomplished if more time could be devoted to it. It is a subject of the greatest importance, which calls for more time and attention than the schedule permits me to give. Only one hour of practice each regular drill day, during favorable weather, fails to arouse much enthusiasm. If some reward could be offered for the best scores, sufficient to induce students to interest themselves at other times when not otherwise employed, much better results would be obtained.

June 16 last a team of ten men from this college engaged in an intercollegiate target practice (competitive) with teams from the following-named colleges: Iowa State University, University of California, Oregon Agricultural College and Northern Georgia Agricultural College. The team from this college stood third on the list, with a percentage of 72.6.

Gallery practice is held in the gun shed, using the service rifle, round balls with only two grains of powder fired at an iron target of reduced size.

The band has been doing excellent work, under the leadership of a member of the senior class, Myron H. West. The instruments are new, most of them owned by the college, and the band is placed upon a secure footing, the organization of which can be permanently maintained provided it is given proper support and encouragement. The appropriation of $200 generously made by the last General Court for the support of the band and purchase of a State flag has nearly all been expended for the purpose for which it was intended. One or two new instruments will be required for the coming year, to replace those that are still the private property of students; also music from time to time, and the contingency of occasional repairs. To meet these necessary contingencies, I recommend an appropriation of $75.

During the past year the two dormitories have received some attention in the way of repairs, and the north dormitory provided with steam heat from the central heating plant, in place of the stoves heretofore in use. This will no doubt prove a matter of economy, and also render the building more secure against the liability of fire. Some inexpensive repairs are still needed, and which I recommend, to window casings, painting, etc.; also new seats in the water-closets of north dormitory. Two cast-iron sinks, one in each dormitory, should be replaced by porcelain-lined ones that do not gather rust.

The drill hall has been improved by a toilet room and shower bath for the exclusive use of students. The whole building is greatly in need of reshingling.

The central heating plant erected during the year promises to give satisfaction, and the new dining hall appears well adapted to fill all the requirements for which it was designed.

The following-named cadets of the last graduating class were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown "special aptitude" for the military service, viz., Arthur L. Dacy, Howard L. Knight and Edward B. Saunders.

The following is a list of ordnance and ordnance stores, property of the United States, in possession of the college: —

2	3.2-inch breech-loading steel guns, with implements complete.
2	8-inch mortars, with implements.
2	mortar beds.
2	carriages and limbers for 3.2 B.L. steel rifles.
147	Springfield cadet rifles, model 1884.
147	sets of infantry accoutrements.
51	headless shell extractors.
1	set reloading tools.
6	non-commissioned officers' swords, steel scabbards.
14	non-commissioned officers' waist belts and plates.
14	sliding frogs for waist belts.
118	blank cartridges for field guns.
4,000	metallic blank cartridges, calibre .45.
3,700	metallic rifle ball cartridges, calibre .45.
300	friction primers, radial, for field guns.
20,000	cartridge primers, small arms.
10,500	round balls.
40	pounds of powder for small arms, reloading
8,000	pasters, white and black.
200	paper targets, "A" and "B."

There is no signal property on hand.

One hundred and eighty-one students have received practical instruction in the military department during the year, some for only a short period, on account of not remaining in college.

The organization at present is as follows, one battalion of two infantry companies, which, for the purpose of battalion drill and ceremonies, are equalized into four companies, and the band: —

Commandant.

Capt. JOHN ANDERSON, ... U. S. Army.

Staff.

Cadet Adjutant, ... NEIL F. MONAHAN.
Cadet Quartermaster, ... RICHARD H. ROBERTSON.

Company A.

Cadet Captain, ... GEORGE L. BARRUS.
Cadet First Lieutenant, ... WINTHROP V. TOWER.
Cadet Second Lieutenant, ... ELMER M. POOLE.
Cadet First Sergeant, ... STEPHEN C. BACON.
Cadet Sergeant, ... HARRY J. FRANKLIN.
Cadet Sergeant, ... CHARLES S. TINKHAM.
Cadet Sergeant, ... CHARLES P. HALLIGAN.
Cadet Corporal, ... WILLIAM L. HOOD.
Cadet Corporal, ... REUBEN R. RAYMOTH.
Cadet Corporal, ... CLARENCE H. GRIFFIN.
Cadet Corporal, ... CLIFFORD F. ELWOOD.
Cadet Corporal, ... MICHAEL F. AHEARN.
Forty-seven privates; aggregate, 59.

Company B.

Cadet Captain, ... WILLIAM E. ALLEN.
Cadet First Lieutenant, ... ALBERT PARSONS.
Cadet Second Lieutenant, ... EDWARD B. SNELL.
Cadet First Sergeant, ... EDWARD G. PROULX.
Cadet Sergeant, ... FAYETTE D. COUDEN.
Cadet Sergeant, ... JOSEPH G. COOK.
Cadet Sergeant, ... PHILIP W. BROOKS.
Cadet Sergeant, ... GERALD D. JONES.
Cadet Corporal, ... HOWARD D. NEWTON.
Cadet Corporal, ... HOWARD M. WHITE.
Cadet Corporal, ... GEORGE H. ALLEN.
Cadet Corporal, ... JOHN J. GARDNER.
Forty-seven privates; aggregate, 59.

Band.

Cadet First Lieutenant, ...	MYRON H. WEST, *Chief Musician.*
Cadet First Sergeant, ...	WILLIAM E TOTTINGHAM, *Principal Musician.*
Cadet Sergeant, ...	ARTHUR L. PECK.
Cadet Corporal, ...	ERNEST A. BACK.
Cadet Drum Major, ...	RALPH P. GAY.

Fourteen privates; aggregate, 18.

Total in military department: 2 captains, 5 first lieutenants, 2 second lieutenants, 11 sergeants, 10 corporals, 1 drum major, 108 privates; aggregate, 139.

Respectfully submitted,

JOHN ANDERSON,
Captain, U. S. Army, Commandant.

FIFTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1903.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

HENRY H. GOODELL, LL.D.,	*Director.*
WILLIAM P. BROOKS, Ph.D.,	*Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Chemist* (fertilizers).
JOSEPH B. LINDSEY, Ph.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
HENRY M. THOMSON, B.Sc.,	*Assistant Agriculturist.*
RALPH E. SMITH, B.Sc.,	*Assistant Botanist.*
HENRI D. HASKINS, B.Sc.,	*Assistant Chemist* (fertilizers).
DANIEL L. CLEAVES, B.Sc.,	*Assistant Chemist* (fertilizers).
JAMES E. HALLIGAN, B.Sc.,	*Assistant Chemist* (fertilizers).
EDWARD B. HOLLAND, M.Sc.,	*First Chemist* (foods and feeding).
PHILIP H. SMITH, B.Sc.,	*Assistant Chemist* (foods and feeding).
——— ———	*Assistant Chemist* (foods and feeding).
GEORGE A. DREW, B.Sc.,	*Assistant Horticulturist.*
——— ———	*Assistant Horticulturist.*
STEPHEN C. BACON,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 73. Orchard experiments; fertilizers for fruits; thinning fruits; spraying fruits.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 80. Fungicides; insecticides; spraying calendar.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

An outline of the more important work undertaken and the results secured is all the limits of our space will allow. There have been no serious outbreaks of insects during the year. The gypsy moth and brown-tail moth have continued their ravages, while the elm-leaf beetle has been found more particularly in the north-eastern part of the State. Extensive experiments on the best methods of treatment of the San José scale under New England conditions have been carried on. Six hundred trees have been under observation, and the results of different treatment have been verified by repeated investigations. A bibliographical catalogue of all the scale insects of the world is about completed and will soon be in press.

It has been found that to prevent the mildew on cucumbers grown under glass they should be started as late as possible in the season, and that a dry atmosphere in the house would largely prevent the spread of mildew. Apple-leaf spots were found not to be due to a fungus, as at first supposed, but to exposure to a freezing temperature and to subsequent cold, wet weather. The effect of spraying for leaf spot on linden and elm has been very marked, the foliage being more abundant and remaining green longer. So far as production of fruit is concerned, the experiment of planting cucumbers, watermelons and tomatoes on the edge of fields under tent cloth has proved a failure, because no provision was made for fertilizing the flowers. For sterilizing soil, two-inch pipe with three-sixteenths or one-fourth perforations gives better results than one-inch pipe. Sterilization of soil has marked beneficial results on germination of seeds and subsequent growth of plants; but tomato seeds seem to be an exception to this rule.

In addition to the regular work of the dairy division, with its 3,240 substances analyzed, 2,344 pieces of glass were tested for accuracy. Investigations have been on the following lines: (*a*) examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) the improvement of methods for determination of the pentosans and starch in feed stuffs; (*c*) determination of the availability of organic nitrogen in fertilizing materials; (*d*) to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk. The pentosans were found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt grasses and wheat bran. A mixture of winter wheat and sand or hairy vetch was found to be an early and desirable spring green fodder, but for the cost of vetch seed.

In the agricultural division, besides a carefully planned series of experiments to throw light on some of the numerous conditions determining productiveness, — chiefly as affected by different manures and fertilizers, either alone or in a wide variety of combinations, — variety tests with potatoes have been undertaken, with the result that in productiveness the following varieties stood first in the order given: Beauty of Hebron, I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley, Early Rose, Gem of Aroostook, and Daughter of Early Rose.

The details of the experiments thus briefly outlined may be found in the reports of the several divisions herewith submitted.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1902.

Cash received from United States Treasurer,			$15,000 00
Cash paid	for salaries,	$7,366 88	
	for labor,	2,224 12	
	for publications,	1,205 64	
	for postage and stationery,	359 37	
	for freight and express,	60 57	
	for heat, light, water and power,	765 27	
	for seeds, plants and sundry supplies,	530 60	
	for fertilizers,	444 25	
	for feed stuffs,	210 83	
	for library,	140 53	
	for tools, implements and machinery,	538 16	
	for furniture and fixtures,	28 95	
	for scientific apparatus,	59 24	
	for live stock,	410 93	
	for traveling expenses,	150 57	
	for contingent expenses,	131 15	
	for building and repairs,	372 94	
			$15,000 00

Cash received	from State Treasurer,	$11,200 00	
	from fertilizer fees,	3,405 00	
	from farm products,	2,274 66	
	from miscellaneous sources,	2,319 66	
			$19,199 32
Cash paid	for salaries,	$11,966 73	
	for labor,	2,012 21	
	for publications,	406 36	
	for postage and stationery,	321 22	
	for freight and express,	132 93	
	for heat, light, water and power,	639 40	
Amount carried forward,		$15,478 85	

Amount brought forward,		$15,478 85	
Cash paid	for chemical supplies,	354 53	
	for seeds, plants and sundry supplies,	141 69	
	for fertilizers,	428 05	
	for feed stuffs,	784 50	
	for library,	143 87	
	for tools, implements and machinery,	87 05	
	for furniture and fixtures,	16 40	
	for scientific apparatus,	443 97	
	for live stock,	253 09	
	for traveling expenses,	437 45	
	for contingent expenses,	114 05	
	for building and repairs,	515 82	
			$19,199 32

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1902; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $34,199.32, and the corresponding disbursements $34,199.32. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1902.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 26, 1902.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, DANIEL L. CLEAVES.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1902.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 37 have offices for the general distribution of their goods in Massachusetts, 9 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 1 in Ohio and 1 in Illinois.

Two hundred and eighty-three brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Four hundred and fifty-one samples were analyzed at the close of November, 1902, representing two hundred and seventy-three distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 83, July; and No. 84, November, 1902.

From the above statement it will be noticed that there is a marked increase in the amount of work which is involved in the official inspection of commercial fertilizers from year to year. Four more manufacturers were recorded as having secured licenses for the sale of their goods in Massachusetts in 1902 than in the preceding year. Seventeen more brands of fertilizers were licensed and fifty-five more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1901 and 1902: —

	1901.	1902.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee,	15	20
Number with one element above the highest guarantee,	51	83
Number with three elements between the lowest and highest guarantee,	142	183
Number with two elements between the lowest and highest guarantee,	91	87
Number with one element between the lowest and highest guarantee,	39	54
Number with three elements below the lowest guarantee,	–	3
Number with two elements below the lowest guarantee,	8	18
Number with one element below the lowest guarantee,	86	67
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	7	10
Number with one element above the highest guarantee,	12	22
Number with two elements between the lowest and highest guarantee,	24	16
Number with one element between the lowest and highest guarantee,	14	13
Number with two elements below the lowest guarantee,	2	4
Number with one element below the lowest guarantee,	14	19
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	7	9
Number between lowest and highest guarantee,	18	14
Number below lowest guarantee,	9	20

The quality of our commercial fertilizers for the past year has been fully as good as in the preceding years, and, with few exceptions, the commercial value of the fertilizer has not suffered where a discrepancy has occurred between the results of analysis and the manufacturer's guarantee. This would indicate that it was the manufacturer's aim to furnish an article fully equal to his guarantee of composition, and, where a difference has occurred between the analysis and guarantee, that poor mixing is responsible for the discrepancy. It is self-evident that those fertilizers should be selected for general use which furnish the greatest amount of nitrogen, potash and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1901 and 1902 (Cents per Pound).

	1901.	1902.
Nitrogen in ammonia salts,	16.50	16.50
Nitrogen in nitrates,	14.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.00	16.50
Organic nitrogen in fine bone and tankage,	16.00	16.00
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	5.00
Phosphoric acid soluble in ammonium citrate,	4.50	4.50
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values for 1901 and 1902 shows that the market cost of the different essential elements of plant food remains the same as in 1901, with the exception of nitrogen in form of nitrates and the higher grades of organic nitrogenous fertilizing materials, which show a somewhat higher cost, as compared with the previous year.

The trade values of fertilizing ingredients in raw materials and chemicals are based on the market cost, during the six months preceding March, 1902, of standard raw materials which enter largely into the manufacture of commercial fertilizers found in our markets. The following is a partial list of such materials: —

Sulfate of ammonia.	Dissolved bones.
Nitrate of soda.	Acid phosphate.
Azotine.	Refuse bone-black.
Dried blood.	Ground phosphate rock.
Cotton-seed meal.	High-grade sulfate of potash.
Linseed meal.	Sulfate of potash and magnesia.
Bone and tankage.	Muriate of potash.
Castor pomace.	Kainit.
Dry ground fish.	Sylvinite.
Dry ground meat.	Crude saltpetre.

As definite instructions have been given from time to time regarding the calculation of the approximate commercial value of fertilizers, no attempt is here made for the discussion of that matter.

Table A, following, gives the average analysis of officially collected fertilizers for 1902; Table B gives a compilation of analyses of commercial fertilizers for the year 1902, showing the maximum, minimum and average percentages of the different essential elements of plant food in special crop fertilizers, so called.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1902.*

Nature of Material.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.14	2.29	2.10	4.57	3.57	2.66	10.64	9.29	8.03	7.37	4.96	4.69
Ground bones,	6.92	3.16	2.85	-	9.44	15.12	25.04	22.99	9.44	-	-	-
Tankage,	10.66	3.82	3.56	-	9.01	8.78	17.79	18.00	9.01	-	-	-
Dissolved bone-black,	11.06	-	-	10.16	5.24	1.97	17.68	16.00	15.71	15.00	-	-
Acid phosphate,	10.92	-	-	9.89	4.82	2.40	17.32	15.33	14.72	13.50	-	-
Wood ashes,	13.19	-	-	-	-	-	1.48	1.30	-	-	6.14	4.70
Cotton-seed meal,	7.11	6.48	6.75	-	-	-	-	-	-	-	-	-
Flax meal,	10.43	6.17	6.08	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.97	15.17	15.40	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.82	22.02	19.00	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	.81	-	-	-	-	-	-	-	-	-	49.02	48.00
Low-grade sulfate of potash,	.23	-	-	-	-	-	-	-	-	-	25.85	26.00
Muriate of potash,	2.27	-	-	-	-	-	-	-	-	-	50.32	50.00
Kainit,	4.37	-	-	-	-	-	-	-	-	-	12.08	12.00

Table B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1902.*

Name of Fertilizer.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	12.27	3.48	1.04	2.35	14.20	9.52	11.22	10.65	6.32	8.55	8.88	1.80	4.49
Fruit and vine fertilizer,	9.75	3.44	2.07	2.55	11.82	9.60	10.92	8.70	7.96	8.23	6.78	5.04	5.88
Grain fertilizer,	10.60	6.64	1.82	3.01	17.28	8.88	11.29	10.50	5.22	7.86	12.08	2.20	6.49
Grass fertilizer,	8.56	7.72	2.48	4.08	17.28	5.02	9.24	9.84	2.90	5.87	12.08	2.06	5.86
Market-garden fertilizer,	12.60	3.61	2.02	2.69	12.12	7.70	10.47	9.72	6.30	8.34	10.40	2.18	5.89
Potato fertilizer,	10.87	4.88	1.05	2.54	12.84	7.18	10.58	10.94	4.24	8.39	10.48	2.90	5.30
Tobacco fertilizer,	8.32	6.68	1.76	3.91	13.71	5.38	10.36	11.50	2.84	7.66	14.15	1.54	7.74

The writer wishes to call special attention to Table B, on the preceding page. A comparison of the results in this compilation of analyses of so-called special crop fertilizers reveals a wide difference between the maximum and minimum amount of nitrogen, phosphoric acid and potassium oxide claimed and found in the different brands of commercial fertilizers. In the different brands of tobacco fertilizers, for instance, there is a difference of 4.92 between the highest and lowest percentage of nitrogen, a difference of 8.75 between the maximum and minimum percentage of available phosphoric acid, and a difference of 12.61 between the mean and extreme percentage of potassium oxide which was found. A correspondingly great difference will be observed between the maximum and minimum percentages of plant food found in the several special crop fertilizers which have been compiled in the table. The average farmer is apt to lay too much stress upon the trade name of a fertilizer, and oftentimes buys an inferior article when guided wholly by the name under which it is sold.

There are many things to be taken into consideration in the judicious selection of a fertilizer for growing special crops. The physical and chemical character of the soil and sub-soil, the previous management of the soil and the system of crop rotation employed should all enter into consideration when selecting a fertilizer. A study of the soil should be made by simple local experiments with the different kinds and forms of plant food, to find what elements have become depleted; when these facts have become established, then supply the wants of the soil in the most suitable and economical manner. When the character of a soil is not known and its wants are not manifested, it is advisable to use a fertilizer more nearly corresponding to what a chemical analysis of the crop shows is required for its proper development. For the purpose of illustrating how the chemical composition of a crop may serve as a guide in the compounding of a commercial fertilizer, an example is here inserted. We find the average analysis of potatoes (see compilation of analyses of fruits, garden crops, etc., in annual report of this department for the year 1901) is as follows: —

	Parts per Thousand.
Phosphoric acid,	.70
Potassium oxide,	2.90
Nitrogen,	2.10

The relative proportion of phosphoric acid, potassium oxide and nitrogen present, according to this analysis, is: —

	Parts per Thousand.
Phosphoric acid,	1.00
Potassium oxide,	4.10
Nitrogen,	3.00

In other words, for every pound of phosphoric acid removed from the soil by a crop of potatoes there are 4.1 pounds of potassium oxide and 3 pounds of nitrogen removed. A fertilizer supplying the essential elements of plant food in this proportion would, therefore, under the above-stated conditions, be more suitable to use, as far as potassium oxide and phosphoric acid are concerned, as these elements are supplied only by the soil, while nitrogen is supplied in part by atmospheric sources.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1902, to May 1, 1903), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Nitrate of Soda.
- Muriate of Potash.
- High-grade Sulfate of Potash.
- Double Manure Salt.
- Dry Ground Fish.
- Fine-ground Bone.
- Dissolved Bone-black.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- High-grade Fertilizer with Ten Per Cent. Potash.
- Tobacco Starter and Grower.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.

The American Agricultural Chemical Co. — *Con.*
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's Grass and Lawn Top-dressing.
- Breck's Lawn and Garden Dressing.
- Brightman's Fish and Potash.
- Church's Fish and Potash.
- Bradley's Seeding-down Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's New Rival Phosphate.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Blood, Bone and Potash.
- Potato and Root Crop Manure.
- Complete Ten Per Cent. Manure.
- Potato Manure.
- Farm Favorite.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's Complete Potato Manure.
- Baker's A. A. Ammoniated Phosphate.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Grass and Oats Fertilizer.
- General Fertilizer.
- Garden Special.
- Vegetable Vine and Tobacco.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Soluble Pacific Guano.
- Pacific Potato Special.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Gardener's Complete Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Dissolved Bone.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's Practical Potato Special.
- Read's Vegetable and Vine.
- Read's High-grade Farmers' Friend.
- Read's Standard.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.

The American Agricultural Chemical Co. — *Con.*
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Havana Tobacco Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Animal Fertilizer.
- Eagle Brand.
- Tobacco Fertilizer.

The Abbott & Martin Rendering Co., Columbus, Ohio: —
- Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- Grain Grower.
- All Soluble.
- High-grade Potato.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

Bartlett & Holmes, Springfield, Mass.: —
- Animal Fertilizer.
- Pure Ground Bone.
- Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash "Square Brand."
- Bowker's Potato Phosphate.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Superphosphate.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.
- Fine Dry Ground Fish.
- Bone, Blood and Potash.
- Fish and Potash D Brand.
- Bristol Fish and Potash.
- Corn Phosphate.
- Tobacco Ash Elements.
- Early Potato Manure.
- Sulfate of Ammonia.

Butchers' Rendering Co., Fall River, Mass.: —
- Tankage.

Chas. M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.

E. Frank Coe Co. — *Con.*
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's F. P. Fish and Potash.
- American Farmers' Market Garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.
- Excelsior Potato Fertilizer.
- Columbian Corn Fertilizer.
- Columbian Potato Fertilizer.
- New Englander Corn Fertilizer.
- New Englander Potato Fertilizer.
- Columbian Bone Superphosphate.
- X. X. X. Ground Bone.
- Red Brand Excelsior Guano.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Unleached Hard-wood Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Bone Meal.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.
- Hardy's Complete Manure.

C. W. Hastings, Cambridgeport, Mass.: —
- Ferti Flora.

John Joynt, Lucknow, Can.: —
- Pure Canada Unleached Hardwood Ashes.

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
- Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn and Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Animal Bone and Potash.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Market Garden.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Potato Manure.
- Swift's Lowell Animal Brand.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.
- Swift's Lowell Lawn Dressing.
- Acid Phosphate.

McQuade Bros., West Auburn, Mass.: —
- Ground Bone.

Geo. L. Munroe, Oswego, N. Y.: —
- Pure Canada Unleached Hardwood Ashes.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Potato Manure.
- Tobacco Starter improved.
- Tobacco Manure Wrapper Brand.
- Fruit and Vine Manure.
- Economical Potato Manure.
- Average Soil Complete Manure.
- Vegetable Manure or Complete Manure for Light Soils.
- Corn Manure.
- Complete Manure "A" Brand.
- Cereal Brand.
- Complete Manure Ten Per Cent. Potash.
- Complete Manure for General Use.

Mapes Formula and Peruvian Guano Co. — *Con.*
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.
- Grass and Grain Spring Top-dressing.
- Top-dressing improved, One-half Strength.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Tankage.

New England Fertilizer Co., Boston, Mass.: —
- Corn Phosphate.
- Potato Fertilizer.
- Seeding-down Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Rogers & Hubbard Co. — *Con.*
- Hubbard's Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Corn and General Crops.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Potato Phosphate.
- Hubbard's Corn Phosphate.
- Hubbard's '02 Top-dressing Phosphate.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Soluble Tobacco.
- Pure Fine Ground Bone.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market Garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X. X. X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Fine Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sulfate of Potash.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

J. Stroup Son & Co., Boston, Mass.: —
- Canada Hard-wood Unleached Wood Ashes.

Jas. P. Trainor, Jamesville, Mass.: —
- Pure Ground Bone.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- Whitman & Pratt's Potato Plowman.
- Whitman & Pratt's Corn Success.
- Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Complete Bone Superphosphate.
- Potato Manure.
- Fish and Potash.
- High-grade Tobacco Fertilizer.
- Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. Analysis of Materials sent on for Examination.

During the season of 1902, 217 samples of fertilizing materials, soils, etc., have been received from farmers within our State. The results of analysis of these substances have been published, when deemed of importance to the general public, in three bulletins: No. 81, March; No. 83, July; and No. 84, November, 1902, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Nearly every manufacturing industry has its by-products, which have often a distinct value for manurial purposes. The use of this class of materials has been encouraged whenever the chemical analysis of the same proves them to be of sufficient value to merit their use. The investigation of general fertilizing material of this nature is carried on free of charge to farmers in the State; the material is taken up for analysis in the order of arrival of samples at this office. We have advised farmers to send material for free analysis as early in the season as possible, as work of this nature has to be suspended during the rush of official inspection work during the spring and summer months. Following is a list of materials received during the past season: —

Wood ashes,	52	Dry ground fish,	10
Miscellaneous material,	25	Ground bones,	6
Soils,	35	Onions,	8
Complete fertilizers,	22	Natural phosphates,	6

Cotton-seed meal,	4	Castor pomace,	1
Horn dust,	3	Sulfate of potash,	1
Mill waste,	2	Hemp ashes,	1
Wool waste,	3	Air-slaked lime,	1
Sheep manure,	2	Nitre lime,	1
Tankage,	2	Nitrate of soda,	1
Barnyard manure,	2	Low-grade sulfate of potash,	1
Acid phosphate,	2	Dissolved bone-black,	1
Carbonate of potash,	2	Muriate of potash,	1
Lime ashes,	2	Sulfate of ammonia,	1
Paris green,	1	Mold from compost pile,	1
Basic slag,	1	Waste ashes,	1
Pulverized rock weed,	1	Burned bone,	1
Coral formation,	1	Turf,	1
Leaf mold,	1	Tan-bark ashes,	1
Peat,	1	Brick-yard ashes,	1
Vegetable potash,	1	Sizing paste,	1
Tobacco stalks,	1	Sewage,	1
Cotton-hull ashes,	1	Acetylene tank refuse,	1
Celery plant,	1		

As in the past, we have collected and analyzed samples of Paris green and other insecticides found in our general markets. The analysis of these materials will be found in our March bulletin, No. 81, for 1902.

We have been engaged in work for the Association of Official Agricultural Chemists, to assist in the selection of the best methods of analysis of insecticides, etc., and have taken up co-operation work for the association on new methods of potash determination. The results of this work do not appear in our publications, the work being of technical nature, and of value only to the Association of Official Agricultural Chemists in the establishment of new methods of analysis.

We are constantly occupied with investigations of new methods for the determination of the available plant food in soils, and new and improved methods for the ash analysis of plants, and have been to considerable expense in procuring the equipment for the latter work, being obliged to import most of the apparatus from Germany. The equipment consists of a power mill (*Kugelmuhle*) to be used in the preparation of the plant for analysis, and which eliminates all danger of the contamination of the sample with iron or other metallic substances, the grinding being accomplished by means of porcelain balls revolving within a tightly sealed porcelain vessel. In this connection we have imported suitable platinum apparatus, recommended by Wislicenus, Tollens and others, for the purpose of securing the ashes of plants at a low temperature; its structure being such as to eliminate all danger of the volatilization of potash, soda, phosphoric acid and other mineral constituents of plants. Attention has also been directed to the investigation of the available phosphoric acid in natural phosphates. The results of investigations above mentioned will be published from time to time, whenever the results prove of general interest and value to the public.

2. Notes on Wood Ashes.

During the season of 1902, 24 per cent. of the materials forwarded for analysis consisted of wood ashes. The following table shows their general chemical character: —

Analysis of Wood Ashes.

	Number of Samples.
Moisture below 1 per cent.,	2
Moisture from 1 to 10 per cent.,	18
Moisture from 10 to 20 per cent.,	22
Moisture from 20 to 30 per cent.,	6
Potassium oxide from 7 to 8 per cent.,	4
Potassium oxide from 6 to 7 per cent.,	8
Potassium oxide from 5 to 6 per cent.,	21
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	2
Potassium oxide below 3 per cent.,	1
Phosphoric acid from 1 to 2 per cent.,	46
Phosphoric acid below 1 per cent.,	2
Average per cent. of calcium oxide (lime),	32.18
Insoluble matter below 10 per cent.,	15
Insoluble matter between 10 and 15 per cent.,	17
Insoluble matter between 15 and 20 per cent.,	13
Insoluble matter above 20 per cent.,	3

The average standard of this class of materials remains about the same as in previous years.

Farmers have been advised to patronize dealers and importers of wood ashes who are on record at our institution as having complied with our State laws and secured licenses for the sale of their article in Massachusetts, for only in such cases is a protection by our State laws possible. We have also urged them to state in every case the particular source from which the materials forwarded for free analysis have been derived.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

During the year the work of the division of horticulture has been extensively reorganized. These changes have been necessitated partly by new conditions and partly by a change in the administration of the division. The principal innovations are three, as follows: —

1. The abandonment of miscellaneous variety tests, and the substitution, in their place, of systematic studies of varieties from all sources and under all conditions.

2. The establishment of definite lines of experiment designed to develop the principles underlying the practice of fruit and vegetable culture.

3. The opening of an extensive system of permanent records, which are expected to hold together the work of successive years, to assist in the interpretation of current observations by offering a comparison with previous results, to make possible the accumulation of comparable data through a period of years, to make the results of experiments at all times available, and, in general, to secure definiteness of aim, clearness of interpretation and consectivity of work in all the experimental operations of the division.

There is no need of publishing at this time a full programme of the experimental work already determined on. It may be proper to say, however, that the work is planned to cover certain important practical problems in the propagation and cultivation of orchard fruits, particularly apples, peaches and plums, and similar investigations in the culture of small fruits and vegetables.

As has been the practice hitherto, every effort will be made to furnish prompt and reliable information in response to the many inquiries which are sent in from day to day.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Plant Diseases in 1902.

Diseases affecting cultivated plants have, as usual, caused more or less damage during the past season. The following pages describe briefly the occurrence of the most important.

Peach-leaf Curl (*Exoascus deformans*).

This fungus was rather more prevalent than usual early in the season. Its effects were most noticeable upon young trees, particularly upon Elberta and Crosby, these varieties being attacked to the exclusion of others in the same orchards. Though very destructive in many portions of the country, it is not commonly a serious one in Massachusetts.

Apple-leaf Spot.

One of the most noticeable troubles of the season has been the injury to apple foliage caused by frost, which is described elsewhere in this report. Many trees, after the spotting and yellowing of the leaves early in the season, were quite denuded by midsummer. Well-cared-for trees were not often affected, so that the actual damage from this source was probably very slight.

Sycamore Blight (*Glœosporium nervisequum*).

This disease was, as usual, very severe, causing the fall of almost all the leaves on sycamore trees during June and July.

Strawberry Root Rot.

This apparently new trouble of the strawberry plant (see p. 108) was much complained of in new beds set out this season.

Apple Scab (Fusicladium dendriticum).

Both early and late apples were badly affected by scab during the year, except on high ground.

Cucumber Wilt.

This bacterial disease was more prevalent than ever before in large cucumber fields, and is evidently on the increase, though no great damage resulted this year.

Sweet Pea Troubles.

The cool, moist summer proved very favorable to the growth of this plant, and much less trouble than for several years was experienced by large growers. The "shelling" of the buds and blossoms, brought on by close, muggy weather, occurred somewhat; but the blight of the vines, so common and destructive of late, appeared very little this season.

Aster Diseases.

The "yellow" disease of this plant was noticeably less abundant than usual this year, its prevalence being evidently influenced by the character of the season. The wilt or stem rot proved very destructive in many plants started in the greenhouse, while those grown entirely out of doors were comparatively free from its attack.

Potato Blight (Phytophthora infestans).

This disease came on somewhat later than usual, being retarded by cool weather early in August. It soon became prevalent, however, and rotting of the tubers was unusually severe, the crop being greatly diminished.

Cucumber and Melon Diseases.

These plants suffered greatly during the season from a variety of causes, chief among which was the downy mildew (*Plasmopara cubensis*), the unusual prevalence of which is described more fully elsewhere in this report. The *Alternaria* disease and anthracnose were also common. Muskmelons were a total failure everywhere, and cucumbers were considerably injured. The cold, wet season proved very unfavorable to the melon crop, so that the vines readily succumbed to disease.

Asparagus Rust (Puccinia Asparagi).

Asparagus plants were affected by rust much less than in previous years, demonstrating the influence of conditions of weather upon this disease.

Chrysanthemum Rust (Puccinia Hieracii).

The destructiveness of this disease, which has seriously threatened the chrysanthemum, is evidently declining. Cases of its occurrence have been very few this season, and no serious damage has been evident.

The Cucumber Mildew in Massachusetts (Plasmopara Cubensis (B. & C.) Humph.).

The general occurrence of this disease during the past season upon cucumbers and melons calls attention to its peculiar history in this State. The fungus was described from Cuba many years ago, but was discovered in this country in 1889, when it appeared in Massachusetts, New Jersey and other States at about the same time. In the report of the Massachusetts Experiment Station for 1889, Dr. Humphrey, then of this division, noted the occurrence of the disease, calling attention to the serious damage which its general distribution might cause. In subsequent years this mildew became very prevalent throughout the southern and middle States, causing great damage each year to cucumbers and melons as far north as Long Island, but not in New England. From this limited distribution it appeared that the fungus required a somewhat warmer climate than ours for its normal development.

In the autumn of 1900 the downy mildew appeared again in this State, being found upon greenhouse cucumbers in two different localities, as noted in the report of this division for that year. These were the only cases known at that time. The next season the muskmelon crop all over the State was quite generally affected and destroyed by this fungus, which also occurred abundantly upon greenhouse cucumbers, but was not observed upon the latter plant when grown out of doors. During the past season (1902) muskmelons have been almost a total failure from this cause; and cucumbers, both in and out of doors, have been generally affected, the fungus being abundant everywhere upon these two plants.

Thus it appears that for the past three years this fungus has been steadily increasing in its distribution. Its most serious effects in this State have been upon the muskmelon. Scarcely a single melon was obtained this year by most of the growers, the vines being killed completely within a few days' time. Experiments in spraying, made in co-operation with this division in several different places, have shown but little gain. It seems quite evident, in fact, that so long as this disease continues to prevail the muskmelon cannot be grown in Massachusetts. The plant is not naturally adapted to our climate, and succeeds at best only in favored localities. When attacked by disease it succumbs very easily, especially in such an unfavorable season as the past one has been.

Upon the cucumber, the disease, while general, is as yet by no means as serious. Out-of-door fields showed the fungus everywhere this year, but the vines remained alive for some time, and the yield did not appear to be seriously diminished. This, however, is but one year's experience.

The effect of this disease upon greenhouse cucumbers is perhaps the most important consideration of the whole subject. Here is an industry of considerable and very rapidly increasing importance in this State, involving, relative to most other agricultural industries, a large amount of capital. It is one in which success means good profits and failure large losses. No serious obstacle which cannot be overcome has as yet been met with, but considerable alarm has been caused by the general appearance of the downy mildew. It may be said, however, that thus far no great damage has been evident. It is noticeable that the disease is most serious in the greenhouse upon plants started in August, which is the time of its occurrence out of doors. Those started later in the season or in spring do not seem to suffer. Even when present in the house, the disease does not kill the vines outright, and by picking off the affected leaves growers have succeeded in keeping it considerably in check. It is therefore recommended that greenhouse cucumbers be started as late as possible, to avoid the mildew. Plants started in October have not shown the disease, where those planted in August were badly affected. This is the safest and easiest preventive. In case this is impracticable, on account of an early crop being desired, a dry atmosphere in the house will largely prevent the spread of the mildew, the development of which is favored by atmospheric moisture. By removing affected leaves, and keeping the house dry, the disease can be effectually kept down. A third remedy lies in spraying, which must be resorted to with an early crop in moist atmosphere. This has been practised very successfully with out-of-door cucumbers upon Long Island, using the Bordeaux mixture. Spraying can be done thoroughly in the greenhouse, and both sides of the leaves should be well covered.

The Muskmelon Blight.

On account of the general prevalence and general destructiveness of this disease, melon growing has become practically impossible in Massachusetts. This plant, as described in our last report, has become affected worse and worse each year with several different fungous diseases, the attacks of which its delicate nature has little power to resist. The chief trouble this year and last has been the downy mildew, in connection with which the anthracnose and *Alternaria* disease have also developed. The cold weather of the last season was very unfavorable for muskmelons, making it almost impossible to get vigorous plants started. Those started in-doors and transplanted made practically no growth for weeks after being set out, and fell an easy prey to disease. The *Alternaria* disease appeared about July 15, but appeared to cause no immediate damage; but the mildew, coming on in the latter part of August, killed the vines completely all over the State, and no returns whatever were received from many large fields. After these two years of complete failure since the mildew appeared, it is probable that but few attempts will be made in the near future to grow this crop.

The subject of spraying as a preventive for this trouble has received considerable attention from this division for several years. During the past season experiments were made in co-operation with a local grower along the lines which previous experience had suggested. The details of this work will be reserved for a bulletin; but it may be said here that, even where plants were thoroughly sprayed with Bordeaux mixture, commencing early in July when the first leaves developed, no effect could be seen upon the development of the mildew. Sprayed and unsprayed plots and fields were alike a complete failure. It therefore seems quite evident that, so long as this disease continues to prevail, the muskmelon cannot be grown here under ordinary treatment. In seasons favorable to the plant, persistent spraying with good culture may give some returns; but in a poor year the crop is almost sure to be a failure, in spite of anything which can be done to save it. The plant is too poorly adapted to our climate to withstand a serious disease.

An Apple-leaf Spot.

One of the most frequent subjects of inquiry of this division during the past summer was a spotting and dying of apple leaves, which occurred very generally in this and other States. The trouble was first noted in May or early June, when trees affected showed a spotting of the leaves resembling a fungous leaf spot. This occurred quite generally, but usually on trees in pastures and by roadsides, rather than in well-kept orchards. The spotting was also more evident on low, frosty ground. With the advance of the season the spotting became much more marked, the foliage gradually turning yellow and dropping from the trees. This became very noticeable and caused considerable alarm, being in striking contrast to the usual healthy condition of apple foliage. Good orchard trees were in few cases seriously affected, though in some the spotting came on rather late in the season. The trouble prevailed mostly in neglected trees growing under unfavorable conditions; most of these lost their leaves during the summer.

Investigation of affected leaves failed at all times to show any fungus or other organism which could be regarded as the cause of the spotting, but revealed peculiarities which point to a cause of quite a different nature; namely, the occurrence of freezing temperature and frost at the time the leaves were unfolding, and subsequent cold, wet weather to an unusual extent throughout the season. At the time when apple trees were leaving out, a period of very low temperature came on, with frost and ice. Immediately following this the first spotting of the leaves appeared, being most noticeable in the most frosty places. Affected leaves showed numerous dead spots, especially near the veins, where would be the largest amount of water. In these spots the tissue was dead and ruptured. No organism was to be found as the cause of the injury, and from the sequence of events there could be no reasonable doubt that the frost was the destructive agency. As the season progressed, these leaves gradually dropped off, as might be expected. Further than this, however, the spotting of the leaves gradually increased through the summer, so that in the latter part of the season trees were affected which had not shown the trouble at first, while those originally affected lost almost all their leaves. This at first sight seemed to render it impossible that the trouble was due to the spring frost, since much of the spotting did not appear until August, particularly in well-cared-for orchards. In all these cases, however, the injurious effects were undoubtedly due to the same original cause. Careful microscopic examination of leaves when first affected showed not only the actual dead spots, but also many other portions affected in a peculiar manner. Here and there on the leaf could be found minute, blister-like spots, retaining at first the natural green color. In these places freezing had evidently occurred, causing more or less mechanical injury to the tissues, but not sufficient to cause immediate death. The epidermis became separated from the underlying cells, and more or less ruptured. In such spots, apparently, originated the trouble manifested later in the summer. The weather, being abnormally wet and cold, produced a low state of vitality, so that the tissue gradually died away in these injured places, and visible dead spots appeared. Orchard trees in good condition were perhaps less affected in the first place, and subsequently were better able to withstand the injury, owing to their better condition. This trouble is an unusual one, of more interest on account of its peculiar nature than from any economic importance.

A Strawberry Disease.

Many complaints were made during the past summer of the dying of strawberry plants set out in new beds. The same also occurred to a much less extent in old beds at the time of fruiting. In the latter case the trouble appeared as a withering and dying of the fruit stalks, followed by the same effect in the leaves. Much more pronounced was the case of the new beds, where in numerous instances many of the young plants withered away in July, showing symptoms of a very definite nature. The first indications of the disease appeared in the leaf stalks, which showed a dark discoloration and withering. Following this the leaves slowly faded away, the whole plant finally becoming dead. The trouble at first sight appeared to be located in the petioles, where the black spots first appeared. Examination of these parts, however, showed no fungus present, nor anything which would account for the effect. The roots of affected plants were found in all cases to be in very poor condition, the older ones being decayed and little new growth present, as should be the case where the plants had been set out some time. Further examination showed that a fungous growth was present in almost all the roots of affected plants, apparently causing them to rot away at the ends. Even in the sound parts this fungus could be detected, growing in from the outside toward the centre. In affected plants from many different localities the same condition was found, so that there can be little doubt that the withering of the petioles and leaves was due to the rotting of the roots. Attempts were made to obtain cultures of the fungus, in order to determine its identity more definitely and test its effect upon healthy plants. As this was not accomplished, no definite conclusions can be drawn as to the actual cause of the disease. The cold, wet weather of the past season would naturally tend to aggravate a trouble of this nature, but its general and characteristic occurrence indicates the presence of a more definite cause than this. Should the disease continue to prevail, care should be taken in starting new beds to propagate only from healthy, vigorous plants.

Plum "Yellows."

A disease apparently similar to the "yellows" of the peach has been noticed for several years upon the college grounds. It occurs only upon the Japanese varieties, particularly the Abundance, and is as yet of no serious consequence. The trouble is characterized by the production of wiry yellow shoots, just as in the peach yellows.

Spraying of Linden and Elm Trees for Leaf Spot.

Both of these shade trees are frequently affected with leaf-spot fungi, which sometimes becomes quite abundant, causing the leaves to fall prematurely. Some lindens on the college grounds become badly affected each year with leaf spot (*Cercospora microsora*), while other much younger trees show little or no trace of it. The older, infected trees are also more or less injured by borers, and many of the younger trees show the effects of sun scald on their trunks. The presence of the leaf spots on the older trees in such abundance is probably secondary, *i.e.*, the trees are in such poor condition they induce leaf spot to thrive. Elms are not so badly affected with the leaf spot (*Dothidella ulmea*) as lindens with the *Cercospora*. Some lindens and elms were sprayed twice this summer, viz., July 12 and August 13. The result of this spraying was very marked. The sprayed linden trees could be easily identified by any one during September and October, on account of the more abundant foliage and greener color of the leaves. The foliage remained on the sprayed trees some days longer than on the unsprayed ones. While the sprayed trees were affected to some extent with the spot fungus, there was a decided difference in the amount of infection between the treated and untreated. Better results would undoubtedly have been obtained if the lindens had been sprayed earlier, or about July 1, as at the time of the first spraying the spot was beginning to appear.

None of the elm trees, either the sprayed or unsprayed, developed much of the leaf spot. All that can be said in favor of the sprayed trees is that their foliage remained green longer than the other trees, and the trees retained their leaves the latest of any. We estimate that linden trees affected as these were, if sprayed twice during the season, would result in a gain of from two to five per cent. in their growth and development. The cost of spraying was insignificant, as the trees were not large. The question involved in all such instances is, whether the tree is worth the expense. This depends on the owner's interest in such matters, and in the means and facilities to have such work done.

Crops under Tent Cloth.

Much interest has been manifested in Massachusetts and Connecticut in the last two or three years in growing Sumatra tobacco under tent cloth. That the environmental conditions of plants are greatly modified under tent cloth is well known. Besides exerting a characteristic influence on the texture of the plants, we might expect, from our knowledge of the conditions which favor fungous infection, that the conditions prevailing under tent-cloth culture would result in producing in certain cases beneficial results. In some instances tobacco growers have planted cucumbers, watermelons, tomatoes, etc., on the border of tobacco beds planted under tent cloth, largely as a matter of curiosity, to see how they would develop under these conditions. So far as the production of fruit is concerned, it may be stated that these experiments have been a failure, because no adequate provision was made to fertilize the flowers. As a result of this, plenty of fruit set but did not mature. The foliage of watermelons which was observed under tent cloth was in excellent condition. We noticed, however, on a few vines about a dozen leaves affected with *Alternaria*, which, however, showed no tendency to spread. Muskmelons developed good vines and foliage, but towards the latter part of the season they showed some of the usual blights. The foliage of tomato plants which we observed was absolutely perfect, there being no trace of the flea beetle or *Macrosporium*. None of the crops developed any fruit of any consequence. The melons, etc., should have been provided with bees to fertilize the flowers, and the tomatoes should have been shaken frequently, to accomplish the same purpose. Cucumbers did well, but failed on account of bees to set fruit. It is generally agreed by growers that the foliage produced under tent cloth was of superior quality, though, on account of the inability of the crops to set fruit, they were considered a failure. The foliage of geraniums and other decorative plants was excellent, and the geraniums showed no tendency to a leaf spot which had been rather abundant during the past summer. Our experiments in growing muskmelons under glass during the summer were more favorable than those conducted under tent cloth, both in respect to fungi and setting fruit. Our melon crop ran into October, and there was not to be seen the slightest trace of any form of blight during the whole season. The house was ventilated freely during the day time, hence allowing insects free opportunity to fertilize the flowers, as a result of which we had a superabundance of fruit. Since it was our purpose to observe what effect the absence of moisture would have upon infection, the foliage of the vines was kept entirely free from water throughout. Notwithstanding that the various blights which affect the cucumber were present everywhere out of doors, no infection took place in this crop. We are convinced that *Plasmopara* or the downy mildew (see p. 105) can be held in check in greenhouses, if the moisture conditions are controlled; and the same may hold good to some extent in the *Alternaria* and the anthracnose. At any rate, none of these fungi made their appearance on the foliage under glass. There is considerable difference in the conditions prevailing under glass from those under tent cloth. Tent cloth may succeed in keeping off dews and mists from the plants. It will, however, allow rain to pour through without much difficulty, whereas the greenhouse can be kept practically tight. In conclusion, it may be stated that it is not generally conceded by tobacco growers who experimented with cucumbers, etc., under tent cloth, that this method of culture will be of any practical importance in the cultivation of garden crops. It is quite evident, however, that it succeeds in producing plants of better foliage, and, on the whole, it has a value in certain cases of preventing infection.

Experiments in Heating Soils.

The rather unusual interest taken in the problem of soil sterilization within the last few years has been the means of inducing growers to improvise various devices for heating soil. Some of these appliances have been constructed for personal use only, while others have been patented and placed on the market. The diameter of the tubing and method of perforating, together with the size and number of the perforations, differ much in the various appliances. The amount and pressure of steam and distance between pipes in the soil also vary with different appliances, as does the relative efficiency and cost of heating. Our experiments, which were rather limited in extent, consisted in testing the relative heating capacity of pipes one foot long and of various diameters, which contained the same number and area of perforations; also of pipes of the same diameter, containing various sizes and numbers of perforations. We made use of iron pipe, galvanized iron and tin tubing, and porous tile. In order to test their relative efficiency, we placed them in the centre of a keg that had a hole bored in the side for a thermometer, which in each case was placed about six inches from the tubes. The keg was filled with soil, and steam entered into the tube. All of the tubes except the tile were plugged at the lower end, and the steam had to penetrate the soil through the perforations. The table shows the result of these experiments: —

Table showing the Relative Heating Efficiency of Tubes of Various Diameters, Sizes, and Numbers of Perforations.

Kind of Tube.	Number of Perforations.	Area of Perforations (Square Inches).	Size of Perforations (Inches).	Time required to heat Soil 200 Degrees F. (Minutes).
(*a*) Two-inch iron pipe, . .	44	1.21	3/16	5
(*b*) One-inch iron pipe, . .	44	1.21	3/16	11
(*c*) Two-inch colander tin, .	4,646	14.26	1/16	2½
(*d*) Two-inch galvanized iron,	29	1.42	¼	2
(*e*) Two-inch galvanized iron,	116	1.42	⅛	3¼
(*f*) Two-inch tile, . . .	-	-	-	7½

A comparison of one-inch and two-inch iron pipes, each containing four rows, giving a total of forty-four perforations, three sixteenths of an inch in diameter, gave as a heating capacity for two-inch pipe five minutes, and for one-inch pipe eleven minutes; or, in other words, it requires six minutes longer for the one-inch pipe to heat the same mass of soil than the two-inch pipe. An average of four experiments gave for the two-inch pipe nine minutes and for the one-inch pipe seventeen minutes, or nearly the same ratio.

Two tests were made with one and one-half inch pipe, similar in every way to those just described. Since this pipe was mislaid, further experiments with it were discarded. It may be stated, however, that the results obtained by the use of this pipe were better than those with the one-inch, although not so good as those obtained by the use of the two-inch.

A comparison of the three perforated tin and galvanized iron tubes (*c*, *d* and *e*) showed little variation in heating capacity. The colander tin tubes, however, had a great many perforations, representing a much larger area for steam to escape. Notwithstanding this, it was not superior to tube *d*, which was a section of Cartter's sterilizing apparatus. The experiment with tile (*f*) was, as might have been expected, less satisfactory as a heater than any of the others except the one-inch pipe. The lower end of the tile was not closed, hence practically all the heat which escaped did so through both ends of the tile, and only a little through the pores.

In these experiments it appears that a two-inch pipe is far superior to a one-inch pipe as a heater, where the number and size of the perforations are the same; also that for all practical purposes one-fourth-inch perforations are better than smaller ones, even where the total area is the same or even greater. It is therefore not so desirable, if efficiency is to be considered, to construct sterilizers out of one-inch iron pipe, as some have done, inasmuch as a two-inch tubing with three-sixteenths or one-fourth inch perforations will give better results. The best results were obtained with a section of Cartter's tube, which contained four rows of perforations one-fourth inch in diameter.

In heating soils there are many factors which have to be taken into consideration, such as the pressure and the amount of steam supplied, the size of the apparatus, and the amount of earth that is to be heated. These factors are so variable that probably no two men have sterilized soil at the same cost. Sterilizers that will do rapid and cheap work at a certain pressure and supply of steam will do less work at a greater cost with the same pressure and less volume of steam. It is not only essential that the sterilizer should be constructed on the best principles, but the volume of steam and pressure maintained should be adapted to the requirements.

Influence of Sterilized Soil on Seed Germination.

In previous reports and bulletins from this station there have been given results of some experiments relating to the influence of various agencies upon the germination of seeds. For some years much use has been made of sterilized soils by this division in studying the various diseases of greenhouse crops. In numerous experiments, made upon a considerably large variety of plants, we have always noticed the marked effect which sterilization had upon the germination of seeds and the subsequent growth of the plant. Many photographs have been made from time to time of those crops which display very important differences, and in some instances the weight of the plants has been recorded, which show the marked effects that soil sterilization has upon germination and growth. We had made no experiments, however, to ascertain to what extent acceleration took place in seed germination, until the following were made, the results of which are shown in the table: —

Germination of Seeds in Sterilized and Unsterilized Soil.

Number of Experiment.	Kind of Seed.	Total Number of Seed tested.	Number germinated in — Sterilized Soil.	Number germinated in — Unsterilized Soil.	Per Cent. Gain or Loss.
Experiment 2,	Radish,	600	159	81	41
Experiment 3,	Tomato,	600	93	110	—13
Experiment 5,	Cucumber,	600	281	187	33
Experiment 10,	Lettuce,	600	26	10	61
Experiment 11,	Tomato,	600	37	33	10
Experiment 13,	Onion,	400	48	31	35
Experiment 14,	Mustard,	400	84	32	61
Experiment 15,	Turnip,	400	105	37	64
Experiment 16,	Red clover,	400	68	45	33
Experiment 17,	Onion,	200	57	32	43
Experiment 18,	Red clover,	200	83	73	12
Experiment 21,	Lettuce,	200	87	26	70

In these experiments we purposely made use of seeds representing considerable variations in age and of low germinating capacity, and where certain numbers are omitted in column 1, it should be understood that in such cases the seeds were so old that little or no germination took place. The seeds in each experiment were taken from uniform lots, *i.e.*, they were supposed to be of the same age and from the same source; and where the same kind of seed appears twice in the table, it indicates that they are of different age and origin. Two hundred seeds were used in each experiment, one hundred being sown in sterilized soil and one hundred from the same lot in unsterilized soil. In some instances the experiment is repeated three times, in which case we have the average germination of six hundred seeds. The soil used was the same, except that one lot was sterilized, the other not. The lower the per cent. of germination which seeds exhibit, the more important it is that a larger number should be employed in order to obtain true averages. Where seed showed 95 per cent. germinating capacity, a test including one hundred seeds is of some value. On the other hand, where there is only a germination equal to 10 per cent., a truer average can be obtained by employing eight hundred or a thousand or more, or, what is better, to repeat the experiment at least half a dozen times with a smaller number of seeds. The high percentages given are somewhat misleading, as the number of seeds used was not sufficient to obtain reliable averages. All of the experiments could be repeated to advantage. Since in many instances the seeds were used up, it was not possible to continue the experiments further. These experiments, nevertheless, possess a certain value, and the results coincide in a general way with what we have continually observed in the greenhouse. In germinating thousands of lettuce seeds in boxes we have noticed many instances similar to that shown on No. 21, although the percentage of gain is too high for average results. The average acceleration given in all of the experiments shown in the table, or the percentage of germination noted on the fourth day after planting, was 25 per cent. in favor of the sterilized soil. It will be noticed that the tomato seeds do not respond to sterilized soil, and in four out of seven tests those growing on unsterilized soil gave the best results. Since these experiments are preliminary ones, and are being continued, further comments at this time are not necessary, except to relate that from an economic point of view we consider it worth while to start such plants as lettuce, cucumbers, melons, tobacco, etc., in sterilized soil, provided steam is available. In such cases the expense would be very insignificant. Besides returns from acceleration and increase in germinating capacity, the important factor of immunity from diseases such as those arising from the damping fungus, etc., is important.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division of this station during the past year has been much the same as outlined in previous reports. The abnormal temperature conditions prevailing during much of the growing season caused more than the usual interest in the monthly bulletins issued, and in abstracts from them published by a considerable number of the papers of the State.

At the end of June, Miss S. C. Snell, the voluntary observer for the United States Weather Bureau, resigned after a service of more than twenty-five years. At the request of Mr. J. W. Smith, section director, the station has arranged to furnish the temperature and precipitation records on the voluntary observer blanks, in addition to the records published in the monthly bulletin. All records for Amherst now published in the monthly report of the New England section of the climate and service of the Weather Bureau are now credited to the Hatch Experiment Station, instead of only the barometer and wind records, as formerly. Arrangements have been made to furnish the weekly snow reports to the Boston office the present winter, as heretofore.

The local forecasts for the weather of the following day have been furnished daily, except Sunday, as in former years. Their transmission to the college by telegraph has been less satisfactory than formerly, owing to the interference of the electric currents of the local electric railways. If our telegraph line from the Western Union office to the tower could be relocated, so as to avoid this interference, the forecasts could be received more certainly and promptly.

The monthly observations of the declination of the magnetic needle have been made, as indicated in last year's report. The laying of steam pipe to the several buildings during the summer has probably affected the results of the last few months. Pending a more complete report of these results, it may be stated that the mean declination for 1900 was 11° 10′ west; for 1901, 11° 10′ west; and for the present year, 11° 14′ west.

The equipment has remained practically the same during the year. In the near future a number of new clocks for some of the self-recording instruments will be required.

At the close of the college year, in June, Mr. H. L. Bodfish, the observer, retired from the division, and was succeeded by the assistant observer, Mr. S. C. Bacon.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

During the year 1902 the work of the entomological division has been concentrated along a few but important lines. The correspondence has, as usual, occupied much time, and a large portion has been of a routine nature. This part of the work is of great importance, and it has been the intention to give the most careful attention to every letter received, however common the insect concerned may be, as the greatest amount of assistance is often needed in order to effectively combat the most common forms.

Extensive experiments on the best methods of treatment for the San José scale under New England conditions have been carried on in the college orchard during the year. Over six hundred trees have been treated in different ways, and the results studied by means of repeated inspections during the summer and fall. A discussion of this work and its results thus far is now being prepared for publication as a station bulletin.

Much attention has also been given to the preparation of the early stages of insects for the insectary collection. As in most cases the injuries caused by insects are while the latter are immature, the importance of representing all stages in a collection at once becomes evident. In connection with the additions thus made, an extensive rearrangement of the collection has been begun, the result of which will be to make it more instructive and available for direct study and comparison than ever before. Many records and life histories have also been added to the insectary files.

Work on the card catalogue, referred to in previous reports, has been continued, and the value of the catalogue as a whole is demonstrated by its frequent use each day. From it a bibliographical catalogue of the scale insects of the world has been prepared, and is ready for the printer.

The nursery inspection law, passed by the Legislature of 1902, has removed the work of nursery inspections from the list of duties of the entomological division of the station; but the appointment of the associate entomologist of the station as inspector has enabled him to make the service of the station available to many who were not previously aware of the opportunities it offers for assistance in difficulties they meet, and it has also enabled him to learn more of the entomological problems which need investigation in the State than could possibly have otherwise been the case.

Insects of the Year.

No serious insect outbreaks have been observed during the year, though many kinds have made their presence felt.

The brown-tail moth has continued to spread, and in the more central portion of its distribution has become extremely abundant. So serious is it in some places that city and town authorities have taken up the work of gathering and destroying the tents during the winter months, as a partial method of relief from the sufferings which would otherwise be caused from the irritation on the human skin produced by the hairs of this insect during the following summer months. A bulletin has been prepared on this insect, and published by the State Board of Agriculture.

The gypsy moth has increased in numbers, until in some places it is nearly as abundant as it has ever been. In general, however, it has not as yet made its presence seriously felt, though a year or two more is all that will be necessary for it to fully re-establish itself throughout its original territory.

The San José scale is now present in over one hundred cities and towns, and is rapidly spreading, though fortunately the number of food plants on which it thrives so as to endanger the life of the plant appears to be small. During the fall it was found on California privet, arbor-vitæ and spruce,— food plants not heretofore reported, though whether it can live for any length of time on these remains to be seen.

The elm-leaf beetle has attracted but little attention this year, except in the north-eastern part of the State, where it has appeared in abundance for the first time. Elsewhere it was about as plenty as usual, and was generally treated by the tree wardens and city foresters with considerable success. It has now been established that in the Connecticut valley this insect has but a partial second brood, — so small, in fact, that the injury it causes is almost infinitesimal.

The resplendent shield-bearer (*Aspidisca splendoriferella*) has been abundant, attacking the apple leaves, but appears to have caused but a small loss. The apple-leaf miner (*Tischeria malifoliella*) appeared in abundance in apple leaves in the fall of 1901, and was present in large numbers last spring. Careful studies on this insect show that in Massachusetts it is two-brooded, the adults appearing in early spring and also in July.

Two species of *Aleyrodes* have been doing a great deal of damage in some parts of this State, — one in greenhouses, the other out of doors on strawberries and other plants. These species have long been considered identical with *Aleyrodes vaporariorum* Westw., a common European insect, but the one on strawberries proves to be a new species. Both have been very carefully studied here, and the new one described and published with illustrations in the Canadian "Entomologist," under the name of *Aleyrodes packardi.* The studies on the other species will be published with illustrations as soon as completed.

The life histories of several bugs have also been worked out, and are now in the printer's hands for publication.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, J. W. KELLOGG,[1] T. M. CARPENTER.[1]
Inspector of Babcock Machines and Dairy Tester: N. J. HUNTING.
In Charge of Feeding Experiments: ABEL GILBERT.
Stenographer: MABEL SMITH.

PART I. — OUTLINE OF YEAR'S WORK.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Execution of the dairy law.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

- A. Tests of pure-bred cows.
- B. Tests of fly preventives.
- C. Summer forage crops.
- D. The pentosans.
- E. Digestion experiments with sheep, 1894–1902.

[1] During the year Messrs. Kellogg and Carpenter severed their connection with this division, to accept more lucrative positions elsewhere, the former going to the Rhode Island and the latter to the Pennsylvania Experiment Station. The loss of these two efficient workers has been seriously felt, and naturally impeded the work of the division.

Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The correspondence of this division was about the same in character and amount as in preceding years. Information is asked on a great variety of subjects. Some questions can be easily answered by reference to bulletins already published, while others require considerable thought and study. The total number of letters sent out during the year has been 1,950.

B. Extent of Chemical Work.

The work in the chemical laboratory has been similar to that of previous years. The large amount of routine work in connection with the examination of water, milk, cream, butter, feed stuffs and miscellaneous substances leaves little time available for strictly chemical investigation. The amount of chemical work may be better understood by noting the variety and number of substances recorded below.

There have been sent in for examination 181 samples of water, 120 of milk, 1,482 of cream, 118 of pure and process butter, 9 of oleomargarine, 130 of feed stuffs and 9 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 187 samples of milk and cream, 42 of butter fat and 642 of fodders and feed stuffs. There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 320 samples of concentrated feed stuffs. This makes a total of 3,240 substances analyzed during the year, as against 3,622 last year and 3,036 in the previous year. Work on pentosans, fiber, starch, sugar and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 13 candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 2,344 pieces of glassware have been tested for accuracy.

C. Character of Chemical Work.

(*a*) *Water.*

This division during the past year has endeavored to make sanitary analyses of drinking water, so far as time and means would permit. Samples were received not only from farmers, but from persons following various trades and professions. They were practically all from wells, springs and ponds, in towns not provided with a public water supply. A few were of excellent quality, many of fair quality only, others quite suspicious, while some were entirely unfit for use. A number of samples were found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.*

It has been the custom, ever since the establishment of the Massachusetts Experiment Station, in 1882, to make sanitary analyses of drinking water free of cost to citizens of Massachusetts. Because of the increase of other lines of work, and the limited funds available, it has become necessary to make a small charge for each sample of water examined. Acting under instructions from the Experiment Station committee, the following regulations have been adopted: —

After Jan. 1, 1903, there will be a charge of three dollars for each sample of water tested at this station. This charge is intended to simply cover the cost of the chemist's time and the gas and chemicals employed in the examination. Heretofore, to aid in promoting the public health, sanitary analyses of drinking water have been made free of cost to citizens of Massachusetts, although the station has in no way been required by law to do so. The increase of other important lines of work now severely taxes the limited resources of this division, and renders such a step necessary.

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. Lindsey,
Hatch Experiment Station.

(*b*) *Dairy Products and Feed Stuffs.*

Slightly less than the usual number of samples of milk and cream were received during the past year. They were sent largely for the purpose of ascertaining their butter fat content. Some farmers wish to ascertain the quality of milk produced by their animals, while others who sell cream wish to check the work of the local creamery. Oftentimes samples are received from milk dealers whose product has been found below the legal standard; in such cases, both total solid matter and fat are determined. Printed circulars are sent to all inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instruction relative to the best methods to be employed in determining the butter-producing capacity of dairy herds.

This division also examines milk, cream, butter and oleomargarine collected by the agent of the Dairy Bureau in western Massachusetts. The past year the work has been confined almost wholly to the examination of renovated butter. The number of feed stuffs received was somewhat in excess of those received a year ago. In some cases a physical inspection only was necessary, while in other cases both a chemical and microscopic examination are required. Numerous samples are received from wholesale dealers, who avail themselves of the station facilities to make sure that the materials they are offering are as represented. It is the intention to give such samples immediate attention, and to return the results promptly.

(*c*) *Chemical Investigation.*

It is the aim of this division to devote as much attention as possible to chemical investigation, in connection with the many dairy and feeding problems. The very limited time at our disposal the past year has been given: (*a*) to the examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) to the improvement of methods for the determination of the pentosans and starch in feed stuffs; and (*c*) to the determination of the availability of organic nitrogen in fertilizing materials. An inquiry was also conducted to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk.

A great deal of time has also been given to chemical work in connection with the various feeding and dairy experiments. Some of the experiments, being completed, are reported in Part II., while others are still in progress.

D. Cattle Feed Inspection.

During the past year only one complete canvass of the State has been made for the purpose of collecting samples of concentrated feeds; heretofore, at least two inspections were made yearly. More work had been done, however, along this line in the past than the small amount of money available under the law would admit; hence the necessary curtailment. The results of the samples collected and examined for 1901 were published in Bulletin No. 78, of which 9,000 copies were issued. A quite thorough inspection was made in October and November, 1902, and the feeds are now undergoing a chemical and microscopic examination. It may be said that, owing to the unusually open autumn, and because of the expectation that with the advent of new corn the prices of feeds would generally reach a lower level, dealers were carrying light stocks. Little new cotton-seed meal had arrived, and the various gluten products were in light supply. West of the Connecticut River very little material, excepting wheat feeds, was found. As soon as the weather becomes colder, and especially after the new crop of corn becomes available, the quantity and variety of feed stuffs must be greatly increased.

In general, it may be said that the better grades of concentrated feeds, such as cotton-seed meal, linseed meal, the gluten and unmixed wheat products, are practically free from adulteration. Exceptions to this statement are to be found in the frequent admixture of wheat screenings with wheat bran, and in an entire car of so-called "Fancy Canada Bran," containing a very large admixture of coffee hulls, — a worthless feeding material.

Mixed feed, a trade name for a mixture of 1,200 to 1,800 pounds of wheat bran and 200 to 800 pounds of fine middlings and "red dog," is often seriously adulterated by substituting ground corn cobs or broom-corn waste for the middlings. This falsification is not practised by reputable millers, but by unscrupulous outside parties, or possibly by small millers in remote localities. It is hardly necessary to remark that this material is sold at the same price as the genuine. A considerable variety of oat offal is always in the market, and in some cases it is guaranteed to contain a noticeably higher percentage of protein than is shown by analysis. The manufacturers' attention has been called to this misrepresentation, but they do not choose to rectify it. A large amount of so-called provender consists of mixtures of oat offal and cracked corn in place of ground oats and corn. It is believed that this deception is increasing. The larger part of the oat offal in the market is sold at prices much in advance of its value.

Among the new feeds in the market the past year may be mentioned dried distillers' grains, — the residue in the manufacture of alcohol, spirits and whiskey, from the several cereals; and nutrene dairy feed. This latter product is made in Louisiana, and consists of cheap molasses soaked up in oat clippings or similar material, with the addition of a little cotton-seed meal, hulls, etc. Its exact value is at present uncertain.

Attention was called in the last report to the need of a new feed law, and the reasons therefor made as explicit as possible. This need cannot be too strongly emphasized at the present time. A bill has been prepared for presentation at the coming session of the Legislature, and it is hoped it will receive the cordial support of all consumers, as well as reputable manufacturers and dealers.

E. Execution of the Dairy Law.

The text of the law (chapter 202, Acts of 1901) may be found in the report of this station for 1901, page 156. The law naturally resolves itself into three sections: (1) the testing of Babcock glassware for accuracy of graduation; (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast. During the first year it was necessary to inspect the ware in use by all creameries and milk depots employing the test; now practically all is received from supply houses that keep tested ware in stock. The total number of pieces examined the present year has been 2,344, of which 56 pieces, or 2.4 per cent., were found incorrect. A year ago 5 per cent. were found improperly graduated. Manufacturers are now very careful concerning the accuracy of their product.

In testing glassware, the following limits of error are allowed: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30-35-40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	.25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.01
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	-	.10
Pipettes, milk,	17.60	-	.10
Acid measures,	17.50	-	.20

Examination of Candidates. — Mr. E. B. Holland has taken charge of this work. Last year 45 candidates were examined, being principally the operators in the employ of Massachusetts creameries and milk depots. The present year 13 were examined and given certificates of competency. It is believed that practically all now using the Babcock test as a basis for payment have a good understanding of the process, and are capable of doing satisfactory work.

Inspection of Babcock Machines. — The examination of Babcock machines has been in charge of Mr. N. J. Hunting, who visited each creamery or milk depot, and made a personal inspection of all machines in use. At the time of presenting the last report it was not possible to state the results of the first inspection (1901), which showed 20 machines to be in good condition, 11 to be in need of repairs and 9 to be entirely unfit for satisfactory work. A number of machines needed levelling, and several were without a steam gauge or speed indicator. The condition of a machine frequently depends upon the operator. If he is careful and painstaking in his work, the tester is likely to be found in good repair. The total cost of the first inspection was $182.42, — $4.56 each. It was impossible to exactly apportion the cost of examining each machine, so that it seemed wiser to divide the total cost of inspection by the number of machines examined, the quotient being the cost to each creamery. It became necessary, because of the number of machines out of condition or condemned, to make a second inspection, the cost of which was apportioned as equally as possible among those directly interested. A few managers considered the cost excessive, but it was not possible to do the work for less. Simply because one-half or one hour was occupied in making the actual examination, it must not be understood that the charge should be only for the time thus employed. The entire cost covers the time actually spent en route, including occasional delays, as well as travelling and hotel expense. The proper enforcement of this law has required the expenditure of a great deal of time on the part of the employees of this division without any financial return. The extra labor has been cheerfully given, however, with a belief that it has resulted in positive good to both creameries and patrons.

The inspection for 1902 is in progress at this writing (December 10). The inspector states that he finds nearly all machines now in good working condition, the improvement over last year being quite marked.

It is evident that the creamery law has been of direct benefit to the creameries of the State. It has decidedly improved the accuracy of Babcock glassware, taught many operators to be more careful in making the test, given the majority a better understanding of the principles involved, caused many Babcock machines to be put in proper condition to do accurate work, and replaced worn and antiquated machines with those of modern construction. The total expense to each creamery and indirectly to each patron has been merely nominal.

Part II. — Dairy and Feeding Experiments.

J. B. LINDSEY.

A. Tests of Pure-bred Cows.

During the past year this division has made the following milk, butter fat and butter tests for the several cattle associations, in accordance with their prescribed rules: —

Five cows were tested for the Holstein-Friesian Association, to ascertain the amount of milk and butter fat produced during seven consecutive days.

Nine cows are now being tested for the American Guernsey Cattle Club. The amount of milk and butter fat produced in one day of each month is ascertained, and upon this is based the monthly yield.

Two cows are now undergoing a yearly milk and butter fat test for the American Jersey Cattle Club. The amount of milk and fat produced during two consecutive days of each month is ascertained, and upon this product is based the monthly yield.

The tests are all made at the farms of the several owners, by or under the supervision of a representative of this station.

The results of the following confirmed tests, made at the request of the American Jersey Cattle Club, for Mr. C. I. Hood of Lowell, Mass., are sufficiently instructive to warrant their presentation in this report: —

Confirmed Butter Tests at Hood Farm.

Milk produced (Pounds).	Per Cent. Fat in Milk.	Butter Fat produced (Pounds).	Equal to 85 Per Cent. Butter. Pounds.	Equal to 85 Per Cent. Butter. Ounces.	Butter churned. Pounds.	Butter churned. Ounces.	Fat lost in Skim Milk and Buttermilk, etc. (Pounds).	Fat available for Butter (Pounds).	Fat recovered in Butter (Pounds).
Elsie Wolcott.									
258.12	4.96	12.81	15	1	14	10	.207	12.60	12.31
Betsona Khedive La Gros.									
282.00	5.49	15.50	18	4	17	10½	.227	15.27	14.92
Figgis.									
293.44	5.48	16.08	18	15	19	½	.160	15.92	15.85
Sophie Tenth.									
278.06	4.59	12.77	15	-	15	5½	.160	12.61	12.72
Oonan Eighth.									
211.70	5.94	12.58	14	13	14	10½	.109[1]	12.47	12.10
Brown Bessie Forty-Sixth.									
210.38	5.42	11.41	13	7	13	8½	.171	11.24	11.16
Nora of Argyle.									
276.44	5.30	14.65	17	4	16	13	.216	14.43	14.25
Oonan Fourteenth.									
287.56	4.42	12.71	15	-	15	3	.308	12.40	12.41
Hood Farm Belle.									
260.31	4.66	12.13	14	-	14	2	.221	11.91	11.41
Oonan Seventh.									
289.20	4.41	12.74	15	-	14	2½	.820[2]	11.92	11.46

[1] Fat in buttermilk not included. [2] Buttermilk contained 1.4 per cent. of fat.

The first three columns show the total milk produced in seven days, the average per cent. of fat it contained, and the pounds of butter fat actually produced by each animal.

The fourth column indicates the equivalent of this butter fat in 85 per cent. butter, and the fifth column shows the amount of butter actually churned. There are no wide variations between estimated and actual butter,[1] which means that the butter was of normal composition.

The sixth column, entitled "Fat lost," etc., means the entire amount of fat contained in the skim milk and buttermilk, and in the milk used in Babcocking. The average per cent. of fat in the skim milk was .031 per cent., and in the buttermilk (excepting Oonan Seventh), .061 per cent. In only two cases did the buttermilk show .15 or more per cent. of fat.

The seventh column shows the fat available for butter, and is obtained by deducting the fat lost in the manufacturing process from the entire quantity of fat produced.

The eighth column contains the quantity of fat actually recovered in the butter, as ascertained by chemical analysis. Theoretically, the seventh and eighth columns should agree. In five out of the ten results this is practically the case; the other five show discrepancies, which must be charged to errors in manipulation. The differences in case of Hood Farm Belle and Oonan Seventh are excessive. Of the 133.38 pounds of fat produced by the ten animals, 128.59 pounds, or 96.41 per cent., were recovered in the butter, showing a loss of 3.59 per cent. in the entire manufacturing process.

The butter was made by the regular Hood farm butter maker. Samples of each lot were taken at once by the tester, and sent to the Experiment Station for analysis. In six cases two lots of butter were made from the cream produced in seven days, and in four cases the entire cream produced during the period was churned at one time. The following table gives the analysis of the butter made from the fat produced by each animal: —

[1] There is one exception in case of Oonan Seventh, due to the loss of considerable fat in the buttermilk.

Analyses of Butter.

CONSTITUENTS.	Elsie Wolcott.	Betsona.	Figgis.	Sophie Tenth.	Oonan Eighth.	Brown Bessie Forty-sixth.	Nora of Argyle.	Oonan Fourth.	Hood Farm Belle.	Oonan Seventh.
Water,	11.45	11.74	14.36	13.98	15.37	13.56	12.37	13.28	16.23	14.45
	14.27	14.24	13.30		14.35	14.63		16.91		
Fat,	86.37	85.34	82.87	82.98	82.23	83.27	84.82	83.81	80.75	81.00
	81.80	83.40	83.96		82.55	82.00		78.98		
Salt,	1.38	2.01	1.98	2.28	2.00	2.49	1.91	2.24	2.76	3.39
	3.13	1.70	1.87		4.00	2.60		3.39		
Curd,	.80	.91	.79	.76	.40	.68	.90	.67	.26	1.16
	.80	.66	.87		.70	.77		.72		

The extremes in the percentage of butter fat were 78.98 and 86.37 per cent., and in the percentage of water, salt and curd, 13.63 and 21.02. The average composition of the 16 samples was: water, 14.03 per cent.; fat, 82.88; salt, 2.45; and curd, .74.

The Babcock machine in the hands of the tester has shown how much butter fat the cow has actually produced, and how much has been lost in the process of manufacturing the same into butter. The chemist has demonstrated the amount of butter fat actually recovered in the form of butter, and his results in eight out of the ten cows closely agree with those obtained by the Babcock machine (total butter fat produced minus fat lost). The chemist further gives evidence that the butter produced, while it varied somewhat in composition, was of normal character.

It is clear from the above data that the amount of butter fat produced by the cow furnishes, to say the least, accurate and consequently satisfactory evidence of her butter-producing capacity.

The results, taken as a whole, reflect much credit upon the work done by the testers and butter maker.[1]

[1] These confirmed tests were made by Messrs. F. R. Church, W. A. Conant, E. S. Fulton and B. Tupper. In each case the work was very carefully done.

B. Tests of Fly Preventives.

For the past two years this division has made a trial of a number of so-called fly removers. These materials are generally sold at retail for from one to one and one-half dollars a gallon. No effort was made to ascertain the exact composition of each. They appeared to consist largely of some oil such as crude petroleum, to which more or less pine tar had been added. In one case fish oil was noticed, and in another light coal tar oil. When not too thick, they were applied with a Woodason or Aspinwall sprayer; otherwise, a four-inch varnish brush, dipped in the liquid, was very lightly drawn over the animals. The latter method is less satisfactory, for the reason that it is hardly possible to avoid putting on an excess; in which case it forms a sticky mass with the hair, to which the dust adheres, giving the animals a very untidy appearance.

Brands and Manufacturers.

Brand.	Manufacturer.	Location.
1. Sure Thing,	Empire State Shaft Coupling Company.	Utica, N. Y.
2. Cattle Comfort,	Hammond Slug Shot Works,	Fishkill, N. Y.
3. Stop Fly,	Standard Oil Company,	New York, N. Y.
4. Norwood Sanitary Fluid,	Smith, Kleine & French Company,	Philadelphia, Pa.
5. Flylene,	American Glucose Works,	Camden, N. Y.
6. Shoo Fly,	Shoo Fly Manufacturing Company,	Philadelphia, Pa.
7. Eli Fly Chaser,	Vail Seed Company,	Indianapolis, Ind.
8. Eureka,	J. H. Ames Company,	Bowdoinham, Me.
9. Rippley's Fly Remover,	Rippley Hardware Company,	Grafton, Ill.
10. Cyphers Anti-fly Pest,	Cyphers Incubator Company,	Boston, Mass.

Results with Cows.

The cows were treated in the morning before being turned out in the yard, and again at night before milking. They were observed at frequent intervals during the day, in order to note the effect of each particular brand.

1. *Sure Thing.* — Applied as spray. Keeps off flies for a short time, but not lasting in its effects.

2. *Cattle Comfort.* — Applied as spray. Not very satisfactory.

3. *Stop Fly.* — Applied as spray. Favorable effect disappeared in one-half hour.

4. *Norwood Sanitary Fluid.* — Applied as spray. This material is unquestionably crude creolin ; it is very valuable as a disinfectant, but not satisfactory as a fly remover.

5. *Flylene.* — Very effective, keeping the flies off for a long time.

6. *Shoo Fly.* — Applied with brush. It was fairly effective in keeping off small flies, but not the large house fly.

7. *Eli Fly Chaser.* — Applied with brush. Same as No. 6.

8. *Eureka.* — Fairly satisfactory. Weather cool, and trial consequently not as thorough as others.

9. *Rippley's Fly Remover.* — Keeps small flies off for a short time. One year's trial.

10. *Cyphers.* — Keeps flies off for a short time. Only one year's trial.

Tests with Other Substances.

11. *Light Coal Tar Oil.* — This is the lighter of the two oils derived from tar. It was obtained through the courtesy of the Pocahontas Collieries Company, Pocahontas, Va. It appears as a dark, thin oil, with a strong creosote odor. It was applied as a spray, and gave quite satisfactory results.

12. *Recommended by J. M. W. Kitchen, M.D.* — One pound resin, one-half pound caustic potash, two pounds whale oil soap (chipped), two quarts water. Boil these until all united into a smooth liquid, then add one pound pine tar and one pint kerosene. Thin down if necessary with water and kerosene. This mixture was quite thick and heavy. It was applied lightly with a brush, but was not effective.

13. *Recommended.* — One-half tea cup bi-sulphide carbon, in which dissolve one tablespoonful pine tar, stirring thoroughly until tar is dissolved, and then add one quart kerosene or crude petroleum, and apply as a spray. This mixture was quite effective for a few hours, until the carbon bi-sulphide had evaporated. It must be kept in glass-stoppered bottles.

Results with Horses.

The agricultural division of this station gave a number of these articles a test with work horses, applying the same with an Aspinwall sprayer.

1. *Sure Thing.* — Keeps flies off well for about five hours; the large green fly does not mind it. Gums horse some.

2. *Cattle Comfort.* — Lasts about three-fourths of a day. Gums horses.

3. *Stop Fly.* — Ineffective.

4. *Norwood Sanitary Fluid.* — Ineffective.

5. *Flylene.* — Keeps flies off well, and gums horses but little. Very satisfactory.

6. *Eli Fly Chaser.* — Quite satisfactory, and equal to No. 5. Does not gum badly.

7. *Eureka.* — Same as No. 6.

8. *Cyphers.* — Protects for short time only and gums badly.

General Conclusions.

(*a*) Quite satisfactory: 1. Flylene; 2. Eureka; 3. Eli Fly Chaser; 4. Shoo Fly; 5. Light coal tar oil.

(*b*) Less satisfactory: 1. Sure Thing; 2. Cattle Comfort; 3. Rippley's Fly Remover; 4. Cyphers Anti-fly pest; 5. Recommended mixture No. 13.

(*c*) Unsatisfactory: 1. Norwood Sanitary Fluid; 2. Stop Fly; 3. Recommended mixture No. 12.

The only objection to those marked "quite satisfactory" is their cost. It is hoped that we shall be able to find some cheaper and equally effective substance or mixture. The most promising substance is the light coal tar oil. Even at the present cost of the commercial articles, it is believed their use is warranted, because cows remain much quieter, and horses work better and require less attention from the driver.

C. Summer Forage Crops.

(*a*) *Winter Wheat and Sand or Hairy Vetch.*

This mixture of a non-legume and legume has been tried for a number of years at the station, and has proved to be an early and desirable spring green fodder. The only objection is to be found in the present cost of the vetch seed, — $5 or more a bushel. This excessive cost is due to the fact that the vetch is a poor seeder, and frequently sheds its seeds before they can be harvested.

History of the Several Trials. — The first planting of this mixture, Aug. 1, 1898, winter-killed, in all probability, owing to the fact that the seed was sown too early.

The second planting, made Aug. 25, 1899, in the proportion of 2 bushels of wheat to 1½ bushels of vetch, wintered well, and made a fine spring growth. Cutting began May 31, and the yield was at the rate of 10 tons to the acre.

The third planting was made Aug. 24, 1900, with equal quantities of wheat and vetch seed. The autumn of that year was extremely dry, and the wheat killed out to some extent, so that the vetch predominated. The following spring was wet and cold, — a condition which appeared to favor the growth of the vetch at the expense of the wheat. At the time of cutting, May 30, the vetch had completely covered the wheat in spots, and had lodged badly. The vetch roots were full of the characteristic nodules. The weight of the entire yield was not obtained, but a conservative estimate places it at 6 to 7 tons to the acre.

The fourth planting (⅓ acre), made Sept. 3, 1901, at the rate of 1½ bushels of Rural New Yorker No. 6 wheat and 1 bushel of vetch to the acre, wintered well, and cutting began May 28, at which time the mixture was from 2½ to 3 feet high. At that time the wheat was about ready to show the head, and scattered vetch blossoms were noticed. When in full bloom the mixture stood from 3½ to 4 feet high. The total yield was 6,545 pounds, equivalent to 9.5 tons to the acre.

Further Use of the Land. — Immediately after the removal of this crop the land was ploughed, a light dressing of manure applied, and seeded with Longfellow corn. A yield (the past season) of 35,362 pounds (17.68 tons) of fairly well-eared green fodder to the acre was secured. The land was light and the rainfall excessive, which conditions were favorable, excepting lack of heat, for fodder production. The total product of this piece of land for one year (first sown to wheat and vetch, and followed by corn) was at the rate of 8,622 pounds of dry matter to the acre, being equivalent to fully 5 tons of well-cured hay. It is not to be expected that such quantities could be obtained yearly under average conditions, for the land could not be as fully utilized. It is interesting to note, however, the quantity of fodder that may be secured from an acre of land in an average state of fertility, when climatic conditions are favorable and the land is occupied the entire season.

Best Method of growing Wheat and Vetch. — The land should be ploughed, harrowed if necessary, manure spread at the rate of 4 to 6 cords to the acre,[1] harrowed in; a mixture of 1½ bushels of wheat and 1 bushel of vetch sown broadcast about September 1, and covered, not too deeply with a wheel or other harrow. Cutting should begin just before the wheat heads appear, which in this locality is the last of May. The green crop will remain in feeding condition for twelve to fourteen days. If more of the fodder mixture has been produced than can be fed green, the balance may be made into hay. The vetch seed may be procured of New York seedsmen.

Composition of Wheat and Vetch.

CONSTITUENTS.	GREEN FODDER.		DRIED FODDER.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Water,	83.40	79.60	11.90	13.70
Ash,	1.50	1.76	7.97	5.22
Protein,	3.25	3.14	17.07	10.93
Fibre,	5.13	5.98	28.38	29.51
Extract matter,	6.24	8.92	32.52	38.70
Fat,	.48	.60	2.16	1.94
	100.00	100.00	100.00	100.00

The percentage of protein in the mixture is dependent to an extent upon the quantity of vetch present. In case of

[1] Fertilizer may be used in place of manure, at the rate of 50 pounds of nitrate of soda, 300 pounds of acid phosphate and 200 pounds of muriate of potash to the acre. In the spring a top-dressing of 50 to 100 pounds of nitrate of soda will prove beneficial.

sample No. 1 of both the green and dry fodder, the vetch predominated. In case of sample No. 2 of the dry fodder, the wheat was probably in excess. In fodder combinations it is difficult to secure an even distribution of the several plants. The mixture of 1½ bushels of wheat and 1 bushel of vetch per acre is satisfactory, does not lodge, and will show from 12 to 15 per cent. of protein in a thoroughly air-dry condition.

Digestibility of Winter Wheat and Sand Vetch. — Five digestion trials have been made with two different samples of green fodder, and six trials with two samples of the dried material: —

Series.	Fodders.	Number of Trials.	Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
VI.	Wheat and vetch (green),	3	67.54	42.47	76.27	66.05	71.13	55.65
VII.	Wheat and vetch (green),	2	70.13	43.59	70.92	70.50	75.05	57.92
	Average,	5	68.58	42.92	74.13	67.83	72.70	56.56
VII.	Wheat and vetch (dry), same as Series VI. (green).	3	68.33	59.41	76.86	64.47	69.71	63.46
VII.	Wheat and vetch (dry),	3	64.50	35.20	70.77	64.59	66.75	63.75
	Average,	6	66.42	47.31	73.82	64.53	68.23	63.61
	Dent fodder corn (milk), for comparison.	9	70.00	-	61.00	64.00	76.00	78.00
	Oats and peas (bloom), for comparison.	5	70.00	49.00	74.00	64.00	72.00	64.00

The several digestion trials make it clear that the wheat and vetch mixture is as digestible as either fodder corn or oat and pea fodder. They also show this fodder when dried under normal conditions to be as digestible as when fed green.

General Conclusions.

1. Wheat and sand vetch is a hardy fodder mixture.

2. When sown the previous autumn, it will be ready to cut the last of May, and is considered preferable to rye.

3. It will yield about 10 tons of green material to the acre under average conditions, and in composition, digestibility and feeding value it fully equals peas and oats and similar crops.

4. Because of the present cost of vetch seed, it is doubtful if the ordinary dairyman can afford to grow it; but the milk producer in the vicinity of profitable markets, who cultivates intensively, may find it a satisfactory source of early green feed.

5. Wheat seeded by itself in early September makes a fairly satisfactory early soiling crop, and is to be preferred to rye.

6. The dried wheat and vetch fodder if cut when in bloom is preferable to ordinary hay for milk, but, on account of the increased cost of production, it would hardly be considered profitable as a hay substitute.

(*b*) *Corn and Soy Beans.*

Attention has already been called (in Bulletin No. 72) to the value of this fodder combination for August and September soiling. The present season about one-third of an acre was grown. In early September the beans were podding and the corn was fairly well eared, but the ears were only partially developed. The mixture was cut and bound successfully October 4, with the Deering corn harvester, at which time the bean stalks were quite tough, the bean pods filled and the corn kernels glazed. This is the first attempt made to cut the corn and bean mixture with a harvester. A larger area will be planted another season, in order to see if the mixture can be economically handled for silage.

Corn and soy bean silage was grown and used at this station during 1895 and 1896. At that time the corn and beans were grown in separate fields. The silo was filled in the proportion of two-thirds corn and one-third beans. The silage was satisfactory, eaten clean, and furnished 30 per cent. more protein than did corn silage. It was believed at the time, however, that the increased cost of handling the two crops when grown separately more than counterbalanced the value of the additional protein secured. If it proves economical to grow and handle the two together, it will in a measure aid in increasing the supply of home-grown protein.

(c) *Soy Beans v. Cow Peas.*

Much is being said in the agricultural press concerning the home production of protein, and this division receives frequent inquiries concerning the relative merits of soy beans and cow peas for this purpose.[1]

During the past season the following varieties of cow peas were tested: Whippoorwill, Black, Extra Early Black and Warren. Although seeded the first of June, they grew but little until late in July, the unusually cool season being decidedly unfavorable to their development. The Whippoorwill and Black produced a few blossoms early in September. The former yielded about 5 and the latter 7 tons of green fodder to the acre. The seed of the Whippoorwill did not come up as well as did the Black.

The Extra Early Black seeded fully in September, but the growth was not sufficient to warrant its use for green feed.

The Warren blossomed some, but did not grow to sufficient size to be suitable for forage purposes.

The Whippoorwill and the Black are probably the best suited to northern conditions.

In comparing the relative merits of the two legumes, it may be said that the stem of the cow pea is softer than that of the soy bean, and that the crop does its best in very warm weather, and is likely to succeed better than the soy bean upon light, sandy soils, naturally deficient in moisture.

The medium green soy bean, on the other hand, prefers a medium moist loam, and will yield more dry food material, and especially more seed to the acre at moderate temperatures, than the cow pea. The cow pea is better suited to southern, and the soy bean to northern conditions, and the latter is regarded as decidedly preferable in New England.

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[1] This division is giving what is termed the "protein problem" considerable attention. While the growing of soy beans, cow peas and clover will in many cases prove economical, it is believed that the majority of Massachusetts dairymen will be obliged to purchase at least a portion of their protein in the form of cotton-seed meal, gluten or other nitrogenous meals, and depend upon the farm for the production of the carbohydrates in the form of hay and corn.

D. The Pentosans.

J. B. LINDSEY.

(a) *Character of Plant Tissue.*

Various investigations have shown that the larger part of the cellular structure of vegetables and coarse fodders consists:[1] (1) of substances insoluble in water, but soluble in dilute mineral acids, and which are classified as hemi-celluloses; (2) of substances insoluble to any extent in dilute mineral acids, alkali, or F. Schulze's reagent, and which are turned blue by sulphuric acid and iodine, namely, the true celluloses; (3) of lignin acids, which compose one-third to one-half of the true woods, but exist only in small quantities, if at all, in the soft new cells of young plants and vegetables.

Under the hemi-celluloses[2] belong the mother substances dextran, lævulan, mannan, galactan and pentosans (araban and xylan), which on inversion yield dextrose, lævulose, mannose, glactose, arabinose and xylose. These hemi-celluloses are intermixed and perhaps chemically united to the true celluloses and ligno-celluloses in the cell walls of plants and seeds. In some cases they have been recognized as reserve material, and are used as food in the sprouting of the seed.

The true celluloses, upon being dissolved in strong sulphuric acid, and the resulting product hydrolyzed with dilute acid, yield dextrose as a rule, hence the name dextroso cellulose. Schulze has also recognized mannose and xylose, consequently there exist dextroso, mannoso and pentoso celluloses.

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[1] This classification does not include amyloid, a substance soluble in water, and yielding various sugars by hydrolysis. See Winterstein, Zeitsch. f. physiol. Chem., 15, 1892; also Agricultural Science, 1893, p. 162.

[2] See various publications of E. Schulze in Zeitsch. f. physiol. Chem.

The lignin acids are probably strongly united to the dextroso cellulose, and it seems reasonable to suppose also to the pentoso cellulose.

(b) *Recognition of the Pentosans.*

By treating wood with dilute alkali, and precipitating the extracted material with alcohol and hydrochloric acid, Th. Thomson[1] obtained a substance termed wood gum (Holzgummi); and by inversion Koch[2] secured wood sugar or xylose, which was carefully examined by Wheeler,[3] Allen[4] and Tollens, and declared to be a pentose ($C^5H^{10}O^5$). The mother substances in wood gum and also in cherry gum[5] contain less water than the pentoses, and are termed pentosans ($C^5H^8O^4$). The substance yielding xylose was termed xylan, and that yielding arabinose, araban.

(c) *Methods for Determination of Pentosans.*

After wood gum and the resulting sugar had been carefully studied, it became necessary to obtain a method for their quantitative determination, in order to note to what extent they occurred, especially in agricultural products. The first experiments were made by Stone, Wheeler, Allen and Tollens,[6] by dissolving the substance in hydrochloric acid, precipitating the furfural with ammonia, and weighing the resulting furfuramid.

Gunther[7] and Tollens distilled with hydrochloric acid of 1.06 specific gravity, and titrated the distillate with acetate of phenylhydrazine, using analine acetate as indicator.

Stone[8] proposed a method in which he titrated the distilled furfural with a dilute solution of phenylhydrazine of known strength, using Fehling solution as indicator.

De Chalmot[9] and Tollens precipitated the furfural distillate

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[1] Journal for Pract. Chem., 19, (2) p. 146.
[2] Pharm. Zeitsch. für Russland, 25, p. 619, 635, 651.
[3] Liebig's Ann. Chem., 254, p. 304.
[4] Liebig's Ann. Chem., 260, pp. 289–306.
[5] From cherry gum, Scheibler first obtained the arabinose ($C^5H^{10}O^5$).
[6] Loco citato.
[7] Berichte, 23, p. 1751; 24, p. 3575.
[8] Journal of Analyt. and Applied Chem., Vol. V, No. 8, p. 421.
[9] Berichte, 24, p. 3579.

with acetate of phenylhydrazine, dried and weighed the precipitate in glass tubes. This method was further studied and improved by Flint,[1] Mann[2] and Tollens, and was designated the phenylhydrazine method. The Association of Official Agricultural Chemists adopted this method at its meeting in 1895, and later it was slightly modified by Krug.[3]

Hotter[4] recommended that, in place of phenylhydrazine, a portion of the furfural distillate be heated in closed glass tubes with pyrogallol, and that from the weight of the resulting precipitate be calculated the percentage of furfural.

Counciler[5] suggested that phloroglucol be employed instead of the pyrogallol, for the reason that the union of the furfural with the phloroglucol would take place at ordinary temperature. Krüger,[6] Rimbach[7] and Tollens studied and perfected the method, and recommended it as reliable for the determination of pentosans in coarse fodders, grains and vegetables. The Association of Official Agricultural Chemists adopted the phloroglucol method as recommended by Krüger and Tollens in 1897, as a provisional method with slight modifications, the most important of which was the use of the Gooch crucible in place of filter paper for collecting the precipitate. Kröber[8] and Tollens have recently published the results of a very exhaustive investigation of the phloroglucol method, together with a complete table for converting any weight of phloroglucid between .030 and .300 gram into furfural, arabinose, araban, xylose, xylan, pentose and pentosans. The principal conclusions were as follows: —

1. That the results are not influenced by the length of time (over fifteen hours) the precipitate stands.

2. That the phloroglucid is best collected in a Gooch crucible.

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[1] Berichte, 25, p. 2912; Landw. Vers. Stat., 42, p. 381.
[2] Zeitsch. f. Angw. Chem. 1896, p. 33, 194.
[3] Bulletin 49, Division of Chemistry, U. S. Department of Agriculture.
[4] Chemiker Zeitung, 1893, p. 1743.
[5] Chemiker Zeitung, 1894, No. 51.
[6] Zeitsch. für Angw. Chem., 1896, Heft 2.
[7] Inaug. Diss. Göttingen, 1898.
[8] Journal f. Landw., 1900, p. 357; 1901, p. 7.

3. That the precipitate should be washed with small quantities of water, and should not be allowed to become dry during the washing.

4. That the presence of diresorcol in the phloroglucol does not affect the results.[1]

5. That the precipitate be dried four hours in a water bath, and that the Gooch crucible be kept in a glass bottle during the drying, and be weighed in the glass-stoppered bottle after cooling, in order to prevent the hydroscopic phloroglucol from taking on water.

The Association of Official Chemists at its 1902 meeting adopted Kröber's formulæ and tables for calculating the results.

While the phloroglucol method has been perfected, it can still be regarded only as a conventional method. Furthermore, the fact must not be overlooked that other substances besides pentosans yield furfural. Thus Tollens[2] and his earlier pupils have shown that glycuronic, euxanthic and urochloralic acids yield furfural on distillation with hydrochloric acid, and Cross and Bevan[3] have obtained furfural from oxycellulose. Widstoe[4] and others[5] have also shown that methyl pentosans $C^5H^7(CH)^3O^4$ frequently accompany the true pentosans, and upon distillation yield methyl furfural $C^5H^3(CH)^3O^2 + 2H^2O$ and is likewise precipitated by phloroglucol. Fraps[6] finds that the hydrochloric acid distillate from hay yields on standing, besides furfural, a black precipitate and other substances which are precipitated by phloroglucol. These latter he termed furaloids.

Cross and Bevan[7] have applied the term furfuroids in place of pentosans to all furfural-yielding substances. Tollens, on the other hand, as well as Stone,[8] believe it preferable to retain the old name.

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[1] This statement has been disputed by American chemists (see especially Fraps, Bulletin No. 172, North Carolina Experiment Station).

[2] Loco citato.

[3] Berichte, 27, p. 1061.

[4] Berichte, 33, p. 143.

[5] Zeitsch. für Angw. Chem., 1902, Heft 20, p. 481.

[6] Am. Chem. Jour., 25, p. 501.

[7] Chemical News, 1894; Am. Chem. Jour., 22, p. 634.

[8] Chemical News, 1895, p. 40.

(*d*) *Perfected Methods*[1] *for the Determination of the Pentosans.* — *Present Phloroglucol Method.*

Reagents.

Twelve per cent. hydrochloric acid (specific gravity 1.06): 275 c.c. conc. acid (specific gravity 1.20) to 725 c.c. water; test with a hydrometer as 15° C.

Phloroglucol solution (purified): 11 grams are dissolved in 300 c.c. hot 12 per cent. acid by constant stirring, made up to 1,500 c.c. with cold acid, allowed to stand several days for the diresorcinol to crystallize out, and filtered immediately before use.

Pumice stone: the stone is prepared by dropping it at white heat into distilled water, and leaving it there until required.

Aniline acetate (test solution): equal parts of aniline and 50 per cent. acetic acid.

Apparatus.

Erlenmeyer flask, 300 c.c.; Liebig condenser and Aubrey connecting tube; separatory funnel (open); graduated cylinders; beaker, 25 ounce; Gooch crucible.

Method.

A weight[2] of material[3] that will not yield over .300 gram of phloroglucid is brought into a 10-ounce Erlenmeyer flask, together with 100 c.c. of 12 per cent. hydrochloric acid and several pieces of pumice stone. The flask, placed on a wire gauze, is connected with a Liebig condenser, and heat applied, gently at first, and regulated so as to distil over 30 c.c. into a graduated cylinder in ten minutes. The 30 c.c.

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[1] The phenylhydrazine method will be found described in the twelfth report of the Massachusetts State Experiment Station, p. 177, and in Bulletin No. 51, Division of Chemistry, U. S. Department of Agriculture. The phloroglucol method, as used in this laboratory for a number of years, is described in Bulletin No. 51, just referred to, and in the ninth report of the Hatch Experiment Station, p. 97.

[2] With material containing pentosans: 30 per cent., take 1 gram of material; 25 per cent., take 1.25 grams of material; 20 per cent., take 1.50 grams of material; 15 per cent., take 2 grams of material; 10 per cent., take 3.25 grams of material; 5 per cent., take 5 grams of material.

[3] Previous extraction with ether is not warranted, except with materials of a high fat content.

driven over are replaced by a like quantity of dilute acid by means of an "open-top" separatory funnel, the flask agitated to wash down the particles adhering to the sides, and the process continued until the distillate amounts to 360 c.c.[1]

The completed distillate is filtered to remove insoluble fats into a 25-ounce lipped beaker, graduated at 500 c.c., and 50 c.c. of phloroglucol solution gradually added, precipitating the furfural as phloroglucid, and the mixture thoroughly stirred. The solution is made up to 500[2] c.c. with 12 per cent. acid, and allowed to stand at least fifteen hours.

The amorphous black precipitate is filtered under pressure into a tared Gooch through an asbestos felt, washed carefully, never allowing it to become dry, with 150 c.c. of water, dried at 100° C. to a constant figure, weighed in a glass-stoppered bottle, and the increase reckoned as phloroglucid, from which furfural, pentosans, etc., can be calculated by the following formulæ: —

1. Less than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5170
2. Pentosans = (weight of the phloroglucid + .0052) × .8935
3. Pentose = (weight of the phloroglucid + .0052) × 1.0156

2. More than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5180
2. Pentosans = (weight of the phloroglucid + .0052) × .8822
3. Pentose = (weight of the phloroglucid + .0052) × 1.0025

Kröber has published very complete tables for calculating the results, which will soon be reproduced by the Association of Official Agricultural Chemists.

(e) *Digestibility of the Pentosans.*

The investigations of Günther, De Chalmot, Flint, Mann, Krüger, Glaubitz, Kröber and Tollens, Cross and Bevan,[3]

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[1] Theoretically, the process should be continued as long as the distillate gives a reaction with aniline acetate on filter paper, but 12 distillates are usually considered sufficient.

[2] Tollens advises 400 c.c., but in this laboratory 500 c.c are preferred.

[3] Loco citato.

Winterstein,[1] Stift,[2] Stone,[3] Lindsey and Holland,[4] Wittmann[5] and others, have shown the pentosans to be very widely distributed in plants and seeds, and this general distribution naturally leads to an inquiry as to their nutritive value in the animal economy. Several investigations have been published relative to the ability of both men and animals to assimilate the sugars, xylose and arabinose. Ebsten[6] fed 25 grams of these sugars to men, and found this amount in the urine in a short time. Cremer,[7] on the other hand, found only 10 grams of arabinose in the urine after feeding 25 grams to a healthy man. Salskowski[8] concluded that rabbits were able to assimilate a portion of this sugar, and that as a result the per cent. of glycogen in the body is materially increased. Frentzel's[9] investigations indicated that glycogen could not be formed from xylose in the animal organism, that the xylose prevented the destruction of substances that naturally produced glycogen, thus causing an increase in the amount of this animal sugar in the body. Salskowski[10] found that a rabbit and hen excreted only a fifth of the arabinose fed.

Cross, Bevan and Remington[11] digested brewers' grains with 1 per cent. sulphuric acid in an autoclave at 130° C., neutralized, with carbonate of lime, filtered, evaporated the solution, and obtained 39.5 per cent. of furfural in the dry matter. The evaporated product, when mixed with gelatine and bread and fed with vegetables to rabbits, proved to be 94.5 to 98.4 per cent. digestible, no furfural or pentoses being recognized in the urine. The investigators claim that,

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[1] Zürcher Diss., 1892, p. 31.

[2] Osterr. Unger. Zeitsch. für Zücherindustrie, 1894, p. 925.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth Report of Massachusetts Experiment Station, 1894, p. 175; Agricultural Science, 8, p. 162; Proceedings of the sixteenth meeting of the Society for the Promotion of Agricultural Science, 1895.

[5] Zeitsch. Landw. Versuchst. Osterr., 4, pp. 131–139. Abs. Exp. Sta. Rec., 13, p. 420.

[6] Centralblatt f. die medicin. Wissenschaften, 1892, p. 577.

[7] Zeitsch. f. Biologie, 24, p. 484.

[8] Centralblatt f. die medicin. Wissenschaften, 1893, p. 193.

[9] Archw. f. d. ges. Physiologie, 56, p. 273.

[10] Zeitsch. Physio. Chem., 1895, p. 491.

[11] Journal of the Am. Chem., Sec. 22, p. 633.

when fully hydrolized, these substances are as digestible as starch and its hydrolized product; and in this respect they differ from the pentoses and their anhydrides. J. König and F. Reinhardt[1] report experiments with a man in which canned peas, dried peas and other foods rich in pentosans were added to a mixed diet. The results indicated that the pentosans were very thoroughly digested and assimilated.

A number of experiments have been made with farm animals, to study the digestibility of the pentosans. In 1892, Stone[2] fed corn meal and wheat bran to rabbits, and found that about 60 per cent. of the pentosans did not reappear in the fæces. A like conclusion was drawn a year later by Stone and Jones[3] from hay and different grasses fed to sheep. Lindsey and Holland[4] fed hay and different grains to sheep, and found from 55 to 90 per cent. of the pentosans digested, traces only being recognized in the urine. Weiske and Wicke reported similar results.[5] Sherman[6] found the pentosans in wheat bran to be 66.2 per cent. digested. Fraps[7] determined the digestibility of pentosans in a number of cattle feeds. The pentosans in the crude fibre he termed pseudo-pentosans, which proved less digestible than what he termed the true pentosans, as found in the nitrogen-free extract.

In addition to the experiments already reported,[8] the writer[9] has made a number of others with different varieties of hays and grains.

The table which follows contains the percentage and digestion coefficient of the pentosans, and, for the sake of comparison, the percentages and digestion coefficients of each of the other groups of substances in the several feed stuffs.

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[1] Zeitsch. Untersuch. Nahr. u. Genussmtl., 1902, No. 3, pp. 111–116.

[2] Am. Chem. Journal, 14, p. 9.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth report of Massachusetts State Experiment Station, p. 175; report of the Society for Promotion of Agricultural Science, 1895, p. 54.

[5] Zeitsch. f. physiol. Chem., 20, p. 489.

[6] Journal of the Am. Chem., Sec. 19, p. 308.

[7] North Carolina Experiment Station, Bulletin No. 172.

[8] Loco citato.

[9] Together with E. B. Holland.

It includes all experiments made at this station to determine the digestibility of the pentosans.

Description of Feed Stuffs.

English Hay. — Largely Kentucky blue-grass, with a sprinkling of timothy, red-top, meadow fescue and sweet vernal grass, together with some clover.

Millet Hay. — *Panicum crus-galli.* The cultivated species of barnyard grass from Japan, now known as barnyard millet.

Black Grass. — *Juncus Gerardi.*

Fox Grass. — *Spartina patens.*

Branch Grass. — *Distichlis spicata.*

Cove Mixture. — A mixture of black grass and red-top.

Salt Mixture. — A mixture of fox grass and branch grass.

Flat Sage. — *Spartina stricta maritima* var. A variety of creek sedge or thatch. It rarely blossoms, and is easily recognized by its pale-green color.

Buffalo Gluten Feed. — The residue in the manufacture of starch from corn. It contains the gluten, bran and some broken germs. This is an old-process meal. In the new process the oil is largely removed.

New and Old Process Linseed Meals. — Crushed flax seed, after the oil has been expressed. The former is treated by the naphtha process, and the latter by warm pressure.

Atlas Meal. — The dried residue in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

Peanut Feed. — Ground peanut husks.

Composition and Digestibility of Feed Stuffs, with Especial Reference to the Pentosans (Per Cent.).

Series.	Feed Stuff.	Composition (Dry Matter).						Digestibility.					
		Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.	Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.
00,	English hay (a),	6.58	11.10	30.33	48.51	3.48	**19.80**[1]	-	63.49	64.46	63.32	51.43	**63.25**
0,	English hay (a),	7.09	11.17	32.09	46.42	3.23	**20.84**[1]	-	59.77	63.69	60.60	51.49	**64.79**
III.,	English hay (a),	5.53	9.49	32.23	49.53	3.22	**22.15**	-	58.48	58.64	60.73	50.78	-
00,	English hay (b),	7.83	10.79	32.74	45.56	3.08	**21.87**[1]	-	57.32	57.14	57.85	46.90	**62.54**
IV.,	English hay (b),	6.34	10.04	32.67	48.53	2.42	**22.25**	46.25	61.22	64.96	63.17	49.51	**63.95**
0,	English hay (d),	7.63	9.74	32.96	47.26	2.41	**20.76**[1]	-	58.10	57.29	56.69	46.82	**57.36**
I.,	Meadow or swale hay,	6.20	7.97	31.06	52.90	1.87	**18.25**	-	33.88	32.97	46.03	43.60	**28.62**
IV.,	Barnyard millet hay,	10.18	10.73	34.48	43.05	1.56	**23.35**	63.15	63.67	61.59	51.58	46.34	**60.66**
III.,	Black grass,	7.87	8.71	28.71	52.23	2.48	**24.95**	68 97	54.29	57.35	49.04	45.71	**47.69**
I.,	Black grass,	11.67	9.51	26.80	49.54	2.48	**25.22**	-	62.88	60.50	56.34	41.45	**63.13**
I.,	Fox grass,	8.14	7.48	26.41	55.46	2.51	**25.75**	-	62.70	50.37	53.26	46.64	**45.40**
I.,	Fox grass,	5.84	7.13	26.57	57.89	2.57	**28.20**	-	57.00	51.30	52.00	23.80	**48.96**
III.,	Fox grass,	7.51	8.76	26.96	54.31	2.46	**26.37**	58.24	59.30	57.40	53.12	36.39	**50.31**
I.,	Branch grass,	10.29	8.27	26.47	52.76	2.21	**26.42**	-	62.26	52.25	53.78	31.48	**53.50**
III.,	Branch grass,	7.85	7.87	26.46	55.00	2.82	**26.15**	58.13	51.69	56.41	45.74	36.65	**44.81**
III.,	Cove mixture,	7.19	8.82	27.57	54.32	2.10	**22.24**	57.50	47.92	59.68	53.19	40.33	**53.18**
III.,	Salt mixture,	9.98	6.48	26.77	54.26	2.51	**24.09**	68.77	41.72	57.51	52.28	27.90	**48.52**

IV.,	Flat sage,	9.79	7.82	29.71	49.77	2.91	23.82	61.96	51.77	60.42	55.05	36.14	58.05
00,	Buffalo gluten feed,	.78	26.35	8.38	50.20	14.29	16.64[1]	-	84.95	43.10	81.40	81.41	79.32
0,	Buffalo gluten feed,	.40	22.93	8.46	54.89	13.32	17.22[1]	-	87.13	88.94	86.92	93.17	85.08
00,	New-process linseed meal,	5.84	40.40	8.59	41.56	4.01	13.21[1]	-	87.24	61.23	85.51	91.01	88.34
00,	Old-process linseed meal,	6.97	36.75	8.21	39.80	8.27	13.24[1]	-	88.79	57.02	77.55	88.59	83.99
00,	Corn cobs,	1.92	3.86	27.17	65.77	1.28	30.35[1]	-	17.38	65.33	60.04	50.11	63.12
00,	Dried brewers' grains,	3.59	22.99	14.52	51.09	7.81	23.77[1]	-	79.26	52.57	57.83	91.11	56.48
00,	Spring wheat bran,	6.13	17.60	11.48	59.39	5.40	28.22[1]	-	79.63	23.59	70.38	75.60	62.41
00,	Winter wheat bran,	6.24	17.04	9.32	62.83	4.57	23.95[1]	-	78.54	56.28	70.43	60.54	64.24
0,	Atlas meal,	1.03	42.63	9.73	30.84	15.77	12.76[1]	-	72.80	105.70	84.45	91.24	90.03
0,	Peanut feed,	5.06	12.06	54.40	22.94	5.54	20.69[1]	-	70.56	11.68	49.05	89.68	40.51
0,	Soy bean meal,	6.20	38.47	4.50	31.94	18.89	5.18[1]	-	90.05	50.42	72.17	85.02	64.43

[1] These results were obtained by the phenylhydrazine method; the others, by the Krüger and Tollens phloroglucol method.

The results show that the pentosans comprise from one-tenth to nearly one-third of the entire feed stuff, the grains and by-products naturally containing the smaller and the coarse feeds the larger amounts.

The pentosans are found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt grasses and wheat bran. An explanation of this is to be found in the fact that association affects the digestibility of the pentosans. Late-cut hays, straws and bran contain considerable lignified matter, and it is this lignified or incrusting substance which exerts a negative influence upon the digestibility of all of the several fodder groups, the pentosans proving no exception. Most grains contain relatively small amounts of lignin and pentosans. Concentrated by-products, the residues of the several grains from which the starch, fat or both have been removed, contain higher pentosans percentages than the grains, for the reason that the pentosans are found largely in the external coverings, which are always more or less lignified. The pentosans, being closely associated with the lignified tissue, are in such cases less digestible than the protein, fat or total extract matter. In other cases (gluten feed), the incrusting substances being less developed, the pentosans have a digestibility nearly equal to the other groups.

Lehmann,[1] and later Kellner and Köhler,[2] have clearly shown that lignin interferes with the digestibility of the pentosans. The former subjected oat and wheat straws to the action of dilute sodium hydrate, under low pressure, for several hours, neutralizing with hydrochloric acid. After this treatment the pentosans in oat straw showed an increased digestibility of 69 per cent. and those in wheat straws of 115. Kellner, by a similar process, found the fibre and pentosans in extracted rye straw to be respectively 84.5 and 84.8 per cent. digested.

The experiments herein reported show that sheep were able to digest from 40 to 90 per cent. of the pentosans in grains and by-products. It has been held, however, that,

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[1] Landw. Jahrbücher 24. Jahrg., 1895; I Erganzungsband, p. 118.

[2] Landw. Versuchsstationen 53, p. 278.

although these quantities are removed from the digestive tract, it is by no means certain that they have a food value equal to starch and similar substances. Considerable quantities have been recognized in the urine of human beings. Weiske and Wicke,[1] as well as ourselves, have recognized only traces in the urine of sheep. It has been assumed that they may be destroyed in the digestive track by various micro-organisms. Tollens[2] very pertinently suggested that they were no less susceptible to such destructive influences than is starch.

It remained, however, for Kellner,[3] as a result of very exhaustive experiments with the aid of the respiration calorimeter, to furnish definite information. Oxen were fed a basal ration, to which were added at different times 2.5 kilograms of starch and 3 kilograms of rye straw, the latter previously extracted with dilute sodium hydrate under pressure. He found 2.32 per cent. of the carbon from the digested starch to be in the form of marsh gas (equivalent to a loss of 10.1 per cent. potential energy) ; and, from the extracted straw[4] digested, 3.34 per cent. of the carbon to be in the form of marsh gas (equal to a loss of 14 per cent. of potential energy). The differences were not marked. In general, the poorer the mechanical condition of the feed and the larger the amount of incrusting substance present, the longer it remains in the intestines and the greater the opportunity for micro-organisms to attack it; and, *vice versa*, the more easily digested starchy matters, free from lignin, are more quickly resorbed and are less likely to undergo bacterial destruction. Kellner concluded that the furfural-yielding substances (pentosans) of the extracted straw took part in the formation of fat, and indirectly in the formation of flesh, to as great an extent as did either starch or cellulose.[5]

It may be safely concluded, therefore, that the pentosans are as digestible as any of the other fodder groups (except in the presence of excessive incrusting substance), and that the digested material is practically utilized in the animal organism to the same degree as the other carbohydrates.

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[1] Loco citato. [2] Journal f. Landw., 1897, p. 110. [3] Loco citato, pp. 426–428.

[4] This treated straw contained 82 per cent. of crude fibre, and over 30 per cent. of pentosans. [5] Loco citato, p. 457.

E. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

Digestion experiments were begun with sheep at this station in 1893. Two series were published in full in the eleventh and twelfth reports of the Massachusetts State Experiment Station, together with a description of the method employed (see eleventh report). Since 1894 the coefficients only of several series have been published in different reports of the Hatch Experiment Station. In the table which follows will be found the results of 185 single trials with 73 feed stuffs, being the entire number of experiments made between 1894 and 1902, excepting a few which gave results of uncertain value, and hence were discarded. The complete data for each experiment is on file at this station.

It is believed that the brief description of the various feeds found in the table will suffice in most instances to give a clear understanding as to their character. The following additional information may prove of value: —

Mixed grasses in the table includes Kentucky blue-grass, red-top, timothy, meadow fescue, sweet vernal grass, and alsike and red clover. Kentucky blue-grass and clover predominated.

English hay is a term commonly used in many localities for good upland hay, as distinct from salt and swale hays.

Gluten meal consists of the glutinous part of the corn, mixed with the starchy portion, that cannot be recovered by mechanical methods.

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[1] These experiments were made with the co-operation of a number of assistants. The results in the following table were compiled from the completed data by P. H. Smith.

Gluten feed includes the glutinous part of the corn (gluten meal), together with the corn bran and broken germs.

Germ oil meal consists of the ground corn germs, from which the oil has been partially pressed.

Distillers' grains are the dried residues in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

H-O feeds consist of oat offals and light oats as a basis, together with some corn, and fortified with wheat bran and cotton-seed or gluten meal.

Quaker dairy feed — formerly Quaker oat feed — consists principally of oat offal, fortified with some material rich in protein.

Data of Digestion Experiments with Sheep, 1894–1902.

[The teachings from these experiments are presented from time to time in popular bulletins treating of feeds and feeding. — J. B. L.]

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	English hay, "D," mixed grasses in bloom (taken from twelfth annual report, State Experiment Station).	–	7.63	9.74	32.97	47.25	2.41	–	55.00	–	58.00	57.00	57.00	47.00
II.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	7.15	5.83	7.47	36.41	47.90	2.39	1	54.90	–	53.52	56.34	55.73	41.54
								2	55.68	–	47.02	59.68	56.26	38.67
								3	57.83	–	56.25	59.60	58.85	44.42
								4	58.19	–	54.77	60.72	58.73	46.12
								Av.,	56.65	–	52.89	59.09	57.39	42.69
II.,	English hay, "B," mostly *poa pratensis* in bloom, 850 gm.	8.22	5.94	11.07	32.00	47.92	3.07	2	62.37	–	62.17	64.28	62.72	56.18
								4	65.30	–	62.86	69.76	65.38	51.27
								Av.,	63.84	–	62.52	67.02	64.05	53.72
III.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.,	7.41	5.53	9.49	32.23	49.53	3.22	1	60.33	45.63	56.33	63.09	61.31	54.79
								2	58.43	49.45	59.78	57.11	60.52	50.57
								3	56.36	44.73	52.58	56.26	59.21	44.44
								4	59.26	46.34	57.18	60.17	60.95	50.99
								Av.,	58.60	46.54	56.47	59.16	60.50	50.20

III.,	English hay, "B," the same as III., "A," . . .	-	-	-	-	-	-	1	59.60	52.19	57.53	60.68	60.20	53.85
								5	63.18	48.45	62.47	65.90	63.54	57.63
								6	59.95	49.50	59.46	59.28	61.86	56.24
								Av.,	60.91	50.05	59.82	61.95	61.87	55.91
IV.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	11.54	6.34	10.04	32.67	48.53	2.42	1	61.52	43.80	59.48	66.00	61.90	48.11
								2	59.55	45.13	59.83	61.05	60.96	47.40
								3	62.61	47.94	63.09	64.77	63.69	48.27
								4	63.40	47.35	61.50	66.56	64.37	51.31
								5	63.13	45.92	61.69	66.05	64.36	50.03
								6	62.68	47.36	61.74	65.32	63.71	50.34
								Av.,	62.15	46.25	61.22	64.96	63.17	49.51
V.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	13.36	6.84	9.32	34.52	47.02	2.30	1	57.16	47.96	60.01	53.47	61.30	43.64
								2	60.15	47.95	62.22	59.00	62.85	48.51
								3	56.30	43.80	57.56	54.87	59.66	40.94
								4	57.33	52.59	61.39	53.69	60.22	49.33
								5	60.26	47.78	60.79	60.20	62.56	49.31
								6	60.11	49.45	62.16	59.60	62.08	50.94
								Av.,	58.63	48.26	60.76	56.81	61.45	47.11

Data of Digestion Experiments with Sheep, 1894-1902 — **Continued.**

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per (Cent.).	Fibre (Per (Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	14.46	6.01	10.49	33.43	47.10	2.97	1	63.30	48.78	65.16	62.75	65.54	56.75
								2	61.73	48.87	64.87	58.79	65.11	56.17
								3	63.85	47.73	64.57	63.67	66.29	58.01
								4	63.28	48.25	65.45	64.58	64.19	56.88
								5	62.47	47.23	64.69	63.67	63.22	60.04
								Av.,	62.93	48.11	64.95	62.69	64.87	57.57
VII.,	English hay, "A," the same as VI., "A," sampled a year later.	10.13	4.44	9.78	32.71	50.45	2.62	-	63.00	48.00	65.00	63.00	65.00	57.50
II.,	Timothy hay, 850 gm., ...	7.60	6.16	9.64	33.98	47.22	3.00	1	55.09	-	57.15	55.52	54.72	56.76
								2	55.87	-	50.65	59.16	55.85	58.24
								Av.,	55.48	-	53.91	57.34	55.29	57.50
IV.,	English hay, mixed grasses, late cut, 900 gm., . .	11.94	5.64	9.39	34.73	48.32	1.92	2	52.39	22.39	51.18	55.26	54.44	36.53
								3	53.54	29.57	56.66	56.71	53.97	40.73
								Av.,	52.96	25.98	53.92	55.98	54.20	38.63

IV.,	English hay, mixed grasses, late cut, 900 gm.,	9.95	5.40	9.57	33.98	48.98	2.07	1	56.92	38.53	54.29	61.17	56.89	46.73
								2	56.57	45.65	56.27	57.07	58.08	42.10
								Av.,	56.74	42.09	55.28	59.12	57.49	44.42
I.,	Black grass, *Juncus Gerardi* (fed with 450 gm. English hay, I., "D"), 450 gm.	22.66	11.67	9.51	26.80	49.54	2.48	3	56.69	-	62.47	56.80	53.40	37.31
								4	62.35	-	63.29	64.20	59.29	45.77
								Av.,	59.52	-	62.88	60.50	56.34	41.45
III.,	Black grass, *Juncus Gerardi*, rather damp and mouldy (fed with 400 gm. English hay, III., "A"), 500 gm.	16.44	7.87	8.71	28.71	52.23	2.48	2	50.06	70.95	52.62	50.43	46.64	41.40
								3	51.37	66.96	52.57	56.06	46.44	44.39
								4	58.82	69.00	57.68	65.55	54.04	51.35
								Av.,	53.42	68.97	54.29	57.35	49.04	45.71
I.,	Branch grass, *Distichlis spicata* (fed with 400 gm. English hay, I., "D"), 600 gm.	18.13	10.29	8.27	26.47	52.76	2.21	3	56.68	-	63.19	56.06	55.20	35.57
								4	54.52	-	61.34	48.45	52.37	27.39
								Av.,	55.60	-	62.26	52.25	53.78	31.48
III.,	Branch grass, *Distichlis spicata*, in poor condition (fed with 400 gm. English hay, III., "A"), 500 gm.	22.98	7.85	7.87	26.46	55.00	2.82	2	49.43	58.19	52.16	56.63	45.25	34.53
								3	50.08	60.30	50.97	56.33	46.54	33.24
								4	49.54	55.90	51.93	56.27	45.42	42.17
								Av.,	49.68	58.13	51.69	56.41	45.74	36.65
I.,	Fox grass, *Spartina patens* (fed with 450 gm. English hay, I., "D"), 450 gm.	14.30	8.14	7.48	26.41	55.46	2.51	3	50.63	-	62.83	45.55	51.85	42.25
								4	54.82	-	62.48	55.19	54.68	51.03
								Av.,	52.70	-	62.70	50.37	53.26	46.64

Data of Digestion Experiments with Sheep, 1894-1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, I., "D"), 550 gm.	15.37	5.84	7.13	26.57	57.89	2.57	3	51.54	-	56.99	49.25	52.30	17.30
								4	54.11	-	57.41	53.39	51.20	30.26
								Av.,	52.80	-	57.00	51.30	51.50	23.80
III.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, III., "A"), 500 gm.	17.56	7.51	8.76	26.96	54.31	2.46	1	55.82	58.11	55.69	58.67	54.65	41.91
								2	52.94	59.31	61.19	53.64	51.28	31.26
								4	55.74	57.30	61.03	59.89	53.43	36.00
								Av.,	54.83	58.24	59.30	57.40	53.12	36.39
	Fox grass, *Spartina patens*, ...	-	-	-	-	-	-	-[1]	53.44	58.24	59.67	53.02	52.63	35.61
III.,	Salt hay, "cove mixture," black grass and red top (fed with 400 gm. English hay, III., "A"), 500 gm.	18.00	7.19	8.82	27.57	54.32	2.10	2	54.40	58.77	52.04	59.53	52.49	31.20
								3	52.57	57.17	46.49	56.92	51.16	48.03
								4	56.61	56.56	45.22	62.59	55.91	41.75
								Av.,	54.59	57.50	47.92	59.68	53.19	40.33

III.,	Salt hay mixture, fox and branch grasses, etc. (fed with 400 gm. English hay, III., "A"), 500 gm.	16.00	9.98	6.48	26.77	54.26	2.51	2	52.18	67.83	42.32	53.91	50.57	30.18
								4	55.97	69.71	41.12	61.11	53.99	25.70
								Av.,	54.07	68.77	41.72	57.51	52.28	27.90
III.,	Red top hay, *Agrostis vulgaris*, bordering salt marsh, mixed with some sedge, over ripe (fed with 400 gm. English hay, III., "A"), 500 gm.	13.00	6.46	7.80	32.38	51.54	1.82	2	45.74	14.57	36.61	54.54	45.06	55.81
								3	45.94	9.19	36.75	54.62	46.37	47.13
								4	46.47	6.46	38.29	58.16	45.39	44.03
								Av.,	46.05	10.07	37.22	55.71	45.61	48.99
IV.,	Flat sage hay, *Spartina stricta maritima* var. (fed with 400 gm. English hay, IV., "A"), 500 gm.	17.00	9.79	7.82	29.71	49.77	2.91	2	55.39	61.41	50.70	59.75	53.67	32.67
								3	57.62	62.32	49.75	61.36	56.74	39.70
								4	56.55	62.15	54.86	60.16	54.75	36.06
								Av.,	56.52	61.96	51.77	60.42	55.05	36.14
I.,	Swale hay, fresh water grasses, sedges, brakes and wild flowers, 1,000 gm.	12.33	6.20	7.97	31.06	52.90	1.87	3	37.88	-	31.11	30.27	46.03	43.60
								4	39.89	-	36.66	35.66	45.99	43.61
								Av.,	38.88	-	33.88	32.97	46.01	43.60
V.,	Meadow fescue hay, *Festuca elatior pratensis*, early blossom, 900 gm.	12.73	6.60	7.33	37.89	45.96	2.22	2	60.29	46.49	53.29	66.79	58.49	53.05
								6	61.29	46.37	51.35	67.34	60.05	54.47
								Av.,	60.79	46.43	52.32	67.07	59.27	53.76

[1] Average of 7 sheep.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter. (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Tall oat grass hay, *Arrhenatherum elatius*, early blossom, 800 gm.	13.23	5.78	6.51	36.32	49.30	2.09	1	54.01	38.87	51.31	53.04	56.39	57.96
								6	56.56	43.40	50.53	56.67	59.00	53.62
								Av.,	55.27	41.14	50.92	54.86	57.69	55.79
VI.,	Tall oat grass hay, *Arrhenatherum elatius*, late blossom, 900 gm.	10.25	5.34	6.53	40.57	46.16	1.40	4	46.47	13.80	33.27	55.38	44.63	33.16
								5	50.02	25.15	38.08	59.58	46.54	37.29
								Av.,	48.25	19.48	35.69	57.48	45.59	35.23
VI.,	Canada blue grass hay, *Poa compressa*, in blossom, 900 gm.	10.75	5.65	6.86	36.40	48.87	2.22	1	61.97	40.91	42.96	69.94	62.22	38.13
								2	62.51	42.01	43.27	70.69	62.70	35.78
								Av.,	62.24	41.46	43.12	70.32	62.46	36.96
V.,	Kentucky blue grass hay, *Poa pratensis*, in blossom, 900 gm.	10.50	5.75	9.29	37.62	45.59	1.75	2	56.37	42.40	56.67	63.14	53.03	42.52
IV.,	Millet hay, *Panicum Italicum*, 800 gm., ...	12.52	6.34	4.66	35.98	51.38	1.64	3	51.81	15.73	32.08	60.17	52.42	47.72
								4	58.08	31.54	30.06	66.24	58.57	52.31
								Av.,	56.47	23.64	31.07	63.21	55.50	50.02

III.,	Barnyard millet, *Panicum crus-galli*, late blossom, fed green, 3,000 gm.	81.83	8.59	11.00	35.03	43.65	1.73	4	67.17	61.23	72.30	70.64	64.51	61.08
IV.,	Barnyard millet hay, late blossom, the same lot as preceding sample, (fed with 400 gm. English hay, IV., "A"), 500 gm.	12.67	10.18	10.73	34.48	43.05	1.56	1	57.10	62.99	63.69	59.82	52.26	44.18
								5	58.43	62.58	62.92	63.60	52.41	49.62
								6	56.88	63.89	64.39	61.36	50.07	45.21
								Av.,	57.50	63.15	63.67	61.59	51.58	46.34
VI.,	Barnyard millet, just heading out, fed green, 3,000 gm.,	83.36	8.77	10.18	33.60	45.48	1.97	1	67.08	50.94	61.22	71.57	68.71	54.83
								2	70.49	47.83	61.65	77.12	72.61	54.73
								3	67.44	45.09	58.11	73.18	70.19	53.91
								Av.,	68.34	47.95	60.33	73.96	70.50	54.49
VII.,	Barnyard millet hay, just heading out, the same lot as preceding sample, 900 gm.	12.33	9.04	10.24	36.38	42.88	1.46	1	58.75	50.58	56.37	66.42	54.84	49.39
								2	62.39	52.07	59.27	70.84	58.64	47.48
								Av.,	60.57	51.33	57.82	68.63	56.74	48.44
III.,	Barnyard millet, early blossom, fed green, 3,000 gm.,	81.12	7.84	8.44	32.06	49.92	1.74	2	71.51	64.79	66.59	70.94	74.10	61.39
								3	75.51	67.49	69.65	76.79	77.39	67.39
								Av.,	73.51	66.14	68.12	73.86	75.74	64.39
VI.,	Winter wheat and hairy or sand vetch hay (1½—1), 900 gm.	13.72	6.05	12.67	34.20	44.83	2.25	1	64.64	37.36	70.87	64.48	66.85	61.65
								2	64.18	35.70	71.89	63.09	66.71	63.07
								3	64.81	32.53	69.56	66.19	66.69	66.52
								Av.,	64.50	35.20	70.77	64.59	66.75	63.75

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	Winter wheat and hairy or sand vetch (1 — 1) vetch predominating, in blossom, fed green, 3,000 gm.	83.52	9.04	19.58	30.88	37.59	2.91	1	68.51	46.46	77.21	66.85	71.59	56.37
								2	65.71	36.81	73.89	65.51	69.44	54.41
								3	68.40	44.15	77.71	65.80	72.37	57.47
								Av.,	67.54	42.47	76.27	66.05	71.13	55.65
VII.,	Winter wheat and hairy or sand vetch hay, the same lot as preceding sample, 900 gm.	11.90	9.05	19.38	32.21	36.91	2.45	1	67.90	59.63	76.04	64.21	69.24	61.61
								2	69.20	60.42	77.43	65.25	70.74	65.21
								3	67.89	58.19	77.12	63.94	69.15	63.56
								Av.,	68.33	59.41	76.86	64.47	69.71	63.46
VII.,	Winter wheat and hairy or sand vetch (1½ — 1), fed green (with 300 gm. English hay, VII., "A"), 2,000 gm.	79.57	8.63	15.38	29.34	43.73	2.92	3	68.78	42.23	68.86	69.72	73.71	54.48
								4	71.47	44.95	72.98	71.28	76.38	61.36
								Av.,	70.13	43.59	70.92	70.50	75.05	57.92
VI.,	Canada field peas, full blossom, fed green (with 300 gm. English hay, VI., "A"), 2,000 gm.	83.17	8.83	19.72	31.60	37.20	2.65	1	63.49	43.81	80.40	45.76	75.15	48.10
								2	64.88	40.24	79.26	52.44	74.31	53.36
								3	60.15	44.79	79.14	40.12	71.63	44.95
								Av.,	62.84	42.95	79.60	46.11	73.70	48.80

VII.,	Canada field peas, full blossom, fed green, 3,000 gm., .	86.19	8.81	21.31	28.09	38.48	3.31	1	63.59	32.63	81 49	44.58	75.08	58.42
								2	67.18	33.40	83.49	48.48	79.80	64.11
								3	61.14	26.38	79.75	39.69	74.83	56.89
								Av.,	63.97	30.80	81.58	44.25	76.57	59.81
VII.,	Hairy or sand vetch in blossom, fed green (with 300 gm. English hay, VI., "A"), 2,000 gm.	82.37	12.82	25.52	26.21	32.12	3.33	1	68.99	30.33	82.12	61.19	79.87	64.48
								2	72.51	28.65	81.40	70.37	84.13	68.99
								Av.,	70.75	29.49	81.76	65.78	82.00	66.74
III.,	Spring vetch and oats (1—1) in blossom, fed green, 3,000 gm.	83.10	8.70	12.78	35.48	40.34	2.70	2	67.17	54.81	75.96	67.85	67.76	47.63
								3	69.26	53.71	75.00	71.53	69.97	52.09
								4	64.70	49.45	73.33	65.47	65.98	41.93
								Av.,	67.04	52.66	74.76	68.28	67.90	47.22
III.,	Canada peas and oats (1—1), in blossom, fed green, 3,000 gm.	82.80	7.99	11.24	31.05	46.67	3.05	2	69.63	51.62	69.43	66.50	75.56	58.59
								3	72.01	51.20	73.21	70.32	77.12	61.19
								4	69.03	45.26	67.72	68.07	75.21	51.46
								Av.,	70.22	49.36	70.12	68.29	75.96	57.08
IV.,	Corn silage, Pride of the North corn, mature (fed with 400 gm. English hay, IV., "A"), 1,500 gm.	72.00	4.62	6.67	20.77	65.13	2.81	1	72.07	24.04	13.40[1]	73.44	80.90	72.05
								5	75.62	27.78	45.34	72.44	82.78	81.78
								Av.,	73.84	25.91	45.34	72.94	81.84	76.91

[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance. Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).	Sheep Number.	Digestion Coefficients. Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II.,	Barnyard millet and medium green soy bean silage (fed with 400 gm. English hay, II., "A"), Sheep 1-2, 1,600 gm., Sheep 3-4, 1,800 gm.	81.67	10.55	12.01	36.07	37.12	4.25	1	54.40	-	58.13	57.47[1]	51.49[1]	75.93
								2	58.11	-	52.20	64.32	55.78	72.04
								3	57.95	-	41.79[1]	70.11	58.66	68.59
								4	64.75	-	61.94	73.89	63.29	80.00[1]
								Av.,	58.80	-	57.42	69.44	59.24	72.19
II.,	Corn and soy bean silage (2—1), Pride of the North corn and medium green soy bean (fed with 400 gm. English hay, II., "B"), 1,600 gm.	74.83	7.18	9.42	28.22	52.78	2.40	1	66.42	-	64.84	58.95	72.71	82.83
								2	68.62	-	63.07	64.74	74.31	79.81
								4	71.84	-	67.21	70.63	77.79	83.74
								Av.,	68.96	-	65.04	64.77	74.94	82.13
II.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 350 gm.,	11.88	3.15	11.67	42.45	38.92	3.81	3	56.55	-	36.37	60.37	57.29	85.52
								4	57.57	-	41.86	57.33	59.75	92.65
								Av.,	57.06	-	39.12	58.85	58.52	89.09

III.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 900 gm., .	11.79	3.73	12.21	37.83	42.16	4.07	1	54.74	34.68	42.17	50.89	59.84	93.78
								4	54.03	30.22	44.51	52.16	56.82	92.89
								Av.,	54.38	32.45	43.34	51.52	58.33	93.33
III.,	Cotton-seed feed, 4 parts hulls, 1 part meal (fed with 400 gm. English hay, III., "A"), the same lot as preceding sample, 500 gm.	12.24	-	-	-	-	-	2	57.74	23.52	41.23	59.99	59.84	98.38
								3	57.12	22.54	40.03	57.52	60.43	-
								Av.,	57.52	23.03	40.63	58.76	60.14	98.38
	Cotton-seed feed, average of six preceding tests, . .	-	-	-	-	-	-	-	56.29	27.74	41.03	56.38	58.99	92.64
V.,	Cleveland flax meal (fed with 700 gm. English hay, V., "A"), 150 gm.	10.46	5.82	40.37	9.88	41.32	2.61	1	85.21	23.28	84.05	-	93.98	53.25
								6	88.24	19.05	82.36	-	-	97.15
								Av.,	86.73	21.17	83.21	-	93.98	75.90
II.,	Pope cream gluten meal (fed with 700 gm. English hay, II., "A"), 150 gm.	8.20	.75	39.06	1.71	50.03	8.45	3	91.61	-	83.50	-	90.97	99.14
								4	94.89	-	84.00	-	95.35	-
								Av.,	93.25	-	83.75	-	93.16	99.14
II.,	Pope white gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	9.24	1.36	27.92	6.72	55.79	8.21	3	85.90	-	84.52	75.61	90.36	82.02
								4	87.18	-	88.46	78.30	89.97	79.12
								Av.,	86.54	-	86.49	76.95	90.16	80.57
II.,	Buffalo gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	8.42	.90	25.10	7.61	52.75	13.64	3	66.51	-	72.73	6.42	71.67	83.03
								4	69.25	-	74.80	11.65	72.56	85.62
								Av.,[2]	67.88	-	73.76	9.03	73.46	84.32

[1] Omitted from average.

[2] Digestibility apparently much too low.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance. Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).	Sheep Number.	Digestion Coefficients. Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III.,	Peoria gluten feed (fed with 600 gm. English hay, III., "B"), 200 gm.	8.53	1.02	22.72	7.15	63.03	6.08	1	93.61	-	84.59	99.77	97.81	89.00
								5	92.76	-	86.39	-	95.71	88.01
								6	87.64	-	82.79	84.94	92.93	83.77
								Av.,	91.34	-	84.59	92.35	95.48	87.59
VI.,	Germ oil meal (fed with 700 gm. English hay, V , "A"), 250 gm.	8.69	3.50	24.72	10.53	49.07	12.18	2	77.05	-	65.33	94.90	89.73	97.66
								3	82.59	-	72.89	-	83.58	95.46
								Av.,	79.82	-	69.11	94.90	86.66	96.66
V.,	Biles distiller's grain, brand R (fed with 600 gm. English hay, V., "A"), 250 gm.	8.80	2.18	17.93	13.69	60.11	6.09	5	55.61	-	56.29	-	61.09	80.06
								6	58.57	-	62.57	-	73.46	88.46
								Av.,	57.59	-	59.43	-[1]	67.28	84.26
V.,	Biles distiller's grain, brand X. (fed with 650 gm. English hay, V., "A"), 200 gm.	8.91	1.84	32.00	10.52	43.95	11.69	1	86.50	-	65.51	-	93.12	93.94
								3	87.07	-	80.05	-	85.15	97.60
								Av.,	86.78	-	72.78	-[1]	89.14	95.77

V.,	Biles distiller's grain, brand XX. (fed with 600 gm. English hay, V., "A"), 250 gm.	9.53	2.70	28.17	12.40	46.21	10.52	1	88.53	-	79.94	-	88.22	94.45
								6	79.77	-	76.50	-	79.77	94.87
								Av.,	84.15	-	77.22	-[1]	84.00	94.66
V.,	Biles distiller's grain, brand XXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	7.46	2.22	32.27	11.11	41.62	12.78	2	79.88	-	73.41	-	78.03	91.78
								6	71.41	-	74.01	-	72.69	93.95
								Av.,	75.65	-	73.71	-[1]	75.36	92.87
V.,	Biles distiller's grain, brand XXXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	8.83	1.86	38.13	12.50	36.74	10.77	1	79.82	-	72.08	-	81.12	96.99
								6	73.47	-	69.22	-	76.73	98.45
								Av.,	76.65	-	70.65	-[1]	78.93	97.70
IV.,	H-O dairy feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	8.20	4.01	19.62	13.84	57.66	4.87	2	63.70	-	75.99	42.98	67.16	88.10
								3	66.84	-	79.64	38.69	72.61	82.83
								Av.,	65.27	-	77.82	40.84	69.89	85.47
VII.,	H-O dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.71	4.09	20.37	14.02	56.37	5.15	1	64.65	-	77.50	16.62	75.19	84.43
								2	64.82	-	67.93	41.75	73.99	83.23
								Av.,	64.74	-	72.72	29.19	74.59	83.83
IV.,	H-O horse feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	9.79	3.42	14.33	10.92	67.16	4.17	2	63.46	-	61.20	8.32	76.17	81.17
								3	70.10	-	74.38	35.16	78.70	84.04
								Av.,[2]	-	-	-	-	-	-

[1] The digestibility of fibre varied so much that coefficients are omitted.

[2] The results taken of Sheep 3 only.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance. Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).	Sheep Number.	Digestion Coefficients. Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VII.,	H-O horse feed (fed with 600 gm. English hay, VII., "A"), 300 gm.	11.20	3.57	13.39	10.32	68.53	4.19	2	74.40	-	64.90	52.34	84.88	78.49
								3	74.74	-	61.99	58.97	84.16	77.06
								Av.,	74.57	-	63.45	55.66	84.52	77.78
IV.,	Quaker oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	7.41	5.39	11.97	19.02	59.67	3.95	1	63.30	-	82.35	44.05	68.14	91.52
								5	63.51	-	84.18	43.00	69.85	88.15
								6	59.04	-	76.87	40.66	64.27	87.24
								Av.,	61.95	-	81.10	42.57	67.42	88.97
VII.,	Quaker dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.62	5.06	15.07	17.27	58.84	3.76	1	64.08	-	69.07	56.45	70.50	75.67
								2	57.99	-	61.72	53.69	71.23	80.09
								Av.,	61.04	-	65.40	55.07	70.87	77.88
IV.,	Victor corn and oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	9.56	3.75	10.21	12.42	69.44	4.18	1	73.75	-	65.70	35.90	84.89	84.39
								5	74.01	-	71.40	51.72	81.19	88.36
								6	76.45	-	75.41	57.75	82.76	87.74
								Av.,	74.74	-	70.84	48.46	82.95	86.83

V.,	Rye feed, bran and fine middlings (fed with 650 gm. English hay, V., "A"), 250 gm.	12.88	3.17	13.83	3.67	76.33	3.00	4	78.56	30.68	80.71	-	85.68	79.33
								5	84.91	48.19	82.14	-	89.27	90.81
								6	82.73	24.74	77.98	-	88.68	99.08
								Av.,	82.07	34.54	80.28	-	87.88	89.74
II.,	Rice meal (fed with 600 gm. English hay, II., "A"), 200 gm.	10.39	8.57	13.53	5.62	57.81	14.47	1	71.47	-	61.85	-	89.23	90.66
								2	76.19	-	37.36[1]	-	95.28	91.56
								Av.,	73.83	-	61.85	-	92.25	91.11
V.,	Chop feed, hulls bran and broken germs of maize (fed with 650 gm. English hay, V., "A"), 250 gm.	11.08	.93	12.10	14.06	66.75	6.16	1	71.30	-	64.02	58.83	75.56	86.41
								2	92.29	27.54	76.77	-	92.07	85.46
								3	77.47	-	62.64	70.12	82.96	75.60
								Av.,	80.35	27.54	67.81	64.48	83.53	82.49
III.,	Cerealine feed (fed with 600 gm. English hay, III., "A," and 100 gm. Chicago gluten meal), 150 gm.	12.10	2.53	10.85	5.00	74.03	7.59	1	89.59	-	69.69	-	92.62	77.54
								5	92.24	-	79.41	92.41	96.36	83.23
								6	89.39	-	80.59	72.08	96.88	80.94
								Av.,	90.39	-	80.00	82.24	95.29	80.57
VI.,	Corn bran (fed with 500 gm. English hay, VI., "A"), 400 gm.	16.56	1.52	10.27	14.80	68.60	4.81	4	69.87	-	55.22	64.68	74.06	80.25
								5	71.44	-	55.48	64.64	75.82	85.17
								Av.,	70.66	-	55.35	64.66	74.94	82.71

[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Concluded.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Parson's $6 feed, grain hulls and mill sweepings (fed with 600 gm. English hay, V., "A"), 300 gm.	11.22	8.88	11.23	20.10	57.41	2.38	1	56.37	13.88	61.96	49.55	62.54	81.07
								3	55.12	10.49	56.23	44.66	64.88	80.00
								Av.,	55.75	12.19	59.09	47.11	63.71	80.54
V.,	Oat feed, inferior (fed with 600 gm. English hay, V., "A"), 250 gm.	9.89	6.23	5.60	30.27	56.30	1.60	1	29.32	9.75	65.29	24.67	29.16	96.94
								2	38.22	20.72	69.26	37.47	35.81	88.89
								3	34.78	8.12	50.95	34.50	35.24	89.17
								Av.,	34.11	12.86	61.83	32.21	33.40	91.67

Influence of Drying and Curing on Digestibility.

Jordan[1] summarized the results of six experiments made to throw light on this point, and states that in only two cases (clover and corn fodder) was there any decrease in digestibility due to drying. Experiments were made at this station with wheat and vetch and barnyard millet, and the results are found in the above tables. It will be seen that in case of the wheat and sand vetch no important difference was noted as a result of the curing process, while in both experiments drying noticeably decreased the digestibility of barnyard millet. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be especially true with young and tender plants and with the finer grasses. In the case of plants with coarse, tough stems, the reverse is likely to be true. The hardening of the woody stems in the curing process and the less perfect mastication resulting, as well as possible chemical and physiological changes, are all factors which may cause lessened digestibility.

Digestion experiments enable the investigator to form a reasonably correct opinion concerning the nutritive and economic value of the different coarse and concentrated feeds. The results of these experiments are presented from time to time in popular bulletins treating of feed and feeding.

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[1] Bulletin No. 77, U. S. Department of Agriculture: The Digestibility of American Feeding Stuffs.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the Experiment Station has followed the general lines of earlier years. It has for its chief object to obtain light on some of the numerous conditions determining productiveness, chiefly as affected by different manures and fertilizers used alone and in a wide variety of combinations. The questions connected with the use of manures and fertilizers are self-evidently of vital importance in our agriculture, which cannot, as in some of the newer States of the Union, depend upon the accumulated fertility of ages. Equally self-evident to every intelligent mind must be the fact that the solution of even the simplest problem connected with the use of manures is a matter of much inherent difficulty, so numerous are the conditions which determine production, — conditions, too, many of which are beyond control. It is clearly perceived that much caution should be exercised in drawing conclusions from the results of experiments; that field results especially should be tested again and again, under varying conditions of soil and season; that such results obtained on plots inevitably varying somewhat in natural fertility should be checked by results obtained on equal quantities of thoroughly mixed soils from the same plots under conditions made as nearly normal as possible; as well as by vegetation experiments in plots, where all the conditions of moisture, — exposure, etc., are most perfectly under control. Our work, therefore along these lines includes three distinct methods of experiment: first, plot experiments in the open field; second, closed plot experiments (plunged cylinders) with mixed soil; and third, vegetation experiments in pots.

In connection with lines of inquiry pertaining to the use of manures and fertilizers and in the other lines of work mentioned below we have cared for 251 plots upon our own grounds and have supervised work upon 20 plots in different parts of the State. In our experiments with mixed soil in enclosed plots (plunged cylinders) we have employed 153 cylinders. In our vegetation experiments we have cared for 278 pots.

Variety tests also have received considerable attention. The test with corn, which has included 31 varieties, will not be reported, as the grain is not yet dry enough to shell. We have had under careful observation some 70 species of grasses and forage crops, in addition to 18 varieties of millets. In connection with the grasses we are endeavoring to gain some light as to the relative value of the different kinds for pastures as well as for mowings by lawn-mowing one-half of each plot. We have obtained some striking results, but these will not be reported until we have carried the test further. The work with poultry has been for the most part along the lines which have engaged our attention in previous years, viz., a study of the best methods of feeding for eggs. In connection with our poultry work we are making comparative trials of various types of incubators and brooders, which are being used in raising the fowls we use in our feeding experiments. We are also making careful records touching the food cost of raising chickens.

In this report we shall discuss briefly the results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers, selecting for this purpose the results which are confirmed by the greatest number of years' work, as well as in many cases by the closed plot and pot experiments. We shall report also the results of the variety test with potatoes, and shall make a brief statement touching the results obtained in experiments with poultry. The nature of the subjects of inquiry and the more important features of our results will be made clear by the following statement: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood as sources of nitrogen. The crop of this year, potatoes, gives yields on the basis of which the materials rank in the following order: dried blood, sulfate of ammonia, barnyard manure, nitrate of soda. The yield on the last two is, however, below the yield on the plots receiving no nitrogen, and the results are complicated by the fact that the crop suffered from blight and rot. The average to date ranks the materials in the following order: nitrate of soda, barnyard manure, sulfate of ammonia, and dried blood.

II. — To determine to what extent, if any, the introduction of a crop of the clover family will make the application of nitrogen to the following crop unnecessary. Potatoes this year followed soy beans, and gave a yield on the no-nitrogen plots equivalent to 99.3 per cent. of that obtained on the plots to which nitrogen has been yearly applied.

III. — To determine the relative value of muriate and high-grade sulfate of potash for field crops. The results of the year indicate sulfate to be superior to the muriate for cabbages, mixed timothy and clover, and potatoes as indicated by the yield of merchantable tubers. The results with onions were indecisive as the crop failed to mature, largely, it is believed, on account of the cold summer.

IV. — *A.* To determine the relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank in the following order: nitrate of soda, dried blood, sulfate of ammonia. *B.* To determine the relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for onions, tomatoes and celery; while the muriate has given slightly superior results with strawberries and squashes.

V. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate, and silicate. The crop of this year was clover. The potash salts giving the best yields are the silicate, high-grade sulfate, and nitrate. The most striking result brought out is the injury to young clover in a cold, wet spring, due to potash salts containing chlorine, especially to the kainite.

VI. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was onions; and the phosphates giving the best results, and the only ones which can be considered even fairly satisfactory, in the order of their rank, are: dissolved bone meal, fine-ground raw bone, phosphatic slag, and the steamed bone meal. Two gave results very much inferior to all others, viz., Tennessee phosphate and Florida soft phosphate.

VII. — *A.* Soil test with corn. The results of this year indicate that potash to a far greater extent than any other plant-food element controls the yield of corn. Muriate of potash alone at the rate of 160 pounds per acre annually for fourteen years gives this year a yield at the rate of 47.7 bushels of shelled grain per acre. The combination of dissolved bone-black with the same amount of muriate of potash gives a crop of 55.9 bushels of shelled grain per acre. *B.* Soil test with potatoes. The results of the year indicate that the muriate of potash on the limed portion of the field increased the crop more than either of the other fertilizer elements; but the potato crop is increased to a considerably greater extent by the use of materials furnishing phosphoric acid and nitrogen than was the corn in the other soil test.

VIII. — To determine the relative value for the production of corn and mixed grass and clover in rotation of a large application of manure, as compared with a smaller application of manure in connection with a potash salt. The crop of this year was mixed grass and clover. The manure alone gave crops somewhat larger than the combined manure and potash, but, owing to the lesser cost of the combination, the financial result is in its favor.

IX. — To determine the relative value for crop production of two fertilizer mixtures, one furnishing the important elements of plant food in the same proportion in which they are found in the average of corn fertilizers offered in our markets, the other containing less phosphoric acid and more potash, the crops being corn and mixed grass and clover in rotation. The crop of this year was mixed grass and clover. The result is a yield at the rate of 1,520 pounds per acre more on the fertilizer mixture containing the greater amount of potash; and this superior crop is produced at a cost per acre for fertilizers of about $4 less than the combination of materials used on the other plots. The nutritive value of the hay from the plots receiving the greater amount of potash is superior to that from the other plots, on account of the greater relative abundance of clover.

X. — To determine the economic result of using in rotation on grass lands: the first year, wood ashes and nitrate of soda; the second year, ground bone, muriate of potash, and nitrate of soda; and the third year, barnyard manure. The yields amount on the average to about 2 tons per acre, produced at a cost for manure and fertilizers making their application decidedly profitable.

XI. — To determine which is the better practice, — to spread fresh manure directly on the field during late autumn or winter, or to put into large piles in the field at the same time, these piles to be spread and immediately ploughed in in the spring. The field where this experiment is tried has a moderate slope. The crop of this year was corn, and the results were on the whole quite favorable to the spring application, although the difference in the yield this year was not sufficient to repay the cost of the extra handling.

XII. — To determine whether the use of nitrate of soda for rowen is profitable. The application of nitrate to a timothy sod at rates varying from 150 to 250 pounds per acre gives a marked increase in every case, — an increase more than sufficient to cover the cost of nitrate and its application.

XIII. — Variety test with potatoes. The varieties giving yields exceeding 250 bushels of merchantable tubers per acre, mentioned in the order of productiveness, are: Beauty of Hebron (first generation from Maine seed), Beauty of Hebron (second generation from Maine seed), I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley, Early Rose, Gem of Aroostook, and Daughter of Early Rose. It is significant that the old variety — the Beauty of Hebron — outranks all other varieties; while the still older Early Rose is exceeded by only 6 out of the 31 varieties.

XIV. — To determine the best nutritive ration in feeding hens for eggs. The results of the year appear to indicate that if materials carrying considerable fat are used in combination with rations in which wheat and corn respectively are most prominent, the wheat slightly surpasses the corn; but that if fat be not freely supplied in connection with such rations, the corn is superior to wheat. Corn and buckwheat compared, without materials furnishing any considerable amount of fat, give results markedly favorable to corn.

I. — The Relative Value of Manures furnishing Nitrogen. (Field A.)

A full description of the plan of the experiment in this field will be found in the twelfth annual report. The object is to determine the relative value for various crops of a few of the standard materials which may be used on the farm as a source of nitrogen. The materials under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. These wherever used are applied in such quantity as to furnish equal amounts of nitrogen. To three plots in the field no nitrogen in any form has been applied. All the plots in the field receive the same amounts of materials furnishing phosphoric acid and potash and in liberal quantities. Barnyard manure is the source of nitrogen on one plot, nitrate of soda on two plots, sulfate of ammonia on three plots, and dried blood on two. This experiment was begun in 1890, and the crops which have been grown previous to this year in the order of succession are: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, and soy beans. As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.0
Barnyard manure,	91.8
Sulfate of ammonia,	90.0
Dried blood,	87.7
The plots receiving no nitrogen,	71.0

The crop for this year was potatoes, which therefore follow a leguminous crop, — the soy bean. After the beans were harvested rye was sown as a cover crop, but the season of sowing was so late that it had made but little growth when the land was ploughed for potatoes this spring. The variety of potatoes grown was Beauty of Hebron. The seed stock used was grown in northern Maine. On April 10 it was treated in the customary way in solution of corrosive sublimate for prevention of scab. The seed was then spread in a single layer in a sunny room, where it remained until May 5. The seed stock was of excellent quality, the tubers in general smooth and of good size. Before planting they were cut to pieces of two good eyes each. They were planted in rows 3 feet apart and 1 foot apart in the rows. It is a matter of regret that the stock of seed reserved for this field proved not quite sufficient. Plots 0 to 2 and a part of 3 were planted with seed also grown in Maine, of the White Maine variety. This also was treated with corrosive sublimate solution, and before planting cut to pieces of two eyes. It was not, however, budded before planting. Growth throughout the early part of the season was normal and good. The crop was sprayed four times with Bowker's Boxal, which, as in other experiments, proved effective in destroying bugs, but did not entirely prevent blight. The dates of spraying were June 19 and 28, and July 11 and 26. Much care was taken in spraying, and it is believed that the fact that blight was not entirely prevented was due to the use of nozzles which threw the spray only on the upper surfaces of the leaves. Blight was quite general, although only just beginning, on August 12. By August 27 the tops were nearly all dead, except that a few scattering plants were still green at the tips on plots 0, 1, 2 and 3, and that the top leaves of the plants were generally green on plots 5, 6 and 8. The last three plots are those, as will be seen by the table below, to which sulfate of ammonia was applied; and it seems likely that this longer persistence of life in the tops was connected with the retarded growth due to the fact that the nitrogen of the sulfate of ammonia probably became available relatively late in the season. Digging the crop was commenced on August 29 and finished September 6. Those plots were dug first on which it was believed there was most decay. Some rotten tubers were found on all plots, those affected being generally of large size. The amount of rot, so far as can be judged, does not appear to have been affected by the nature of the fertilizers used, for we find very wide variations between plots all of which were similarly manured. The fertilizer treatment and the yields on the several plots are shown in the following table: —

Yield of Potatoes per Acre (Bushels).

Plots.	Nitrogen Fertilizer.	Merchantable.	Small.	Rotten.
0	Barnyard manure,	132.00	19.50	16.33
1	Nitrate of soda,	119.67	15.50	8.33
2	Nitrate of soda,	104.17	18.67	21.67
3	Dried blood,	136.17	24.50	27.17
4	No nitrogen,	93.33	42.50	32.67
5	Sulfate of ammonia,	129.83	35.67	1.50
6	Sulfate of ammonia,	153.83	34.67	14.50
7	No nitrogen,	116.33	50.17	19.17
8	Sulfate of ammonia,	102.00	34.00	27.00
9	No nitrogen,	119.67	40.00	9.17
10	Dried blood,	157.67	32.83	37.67

The average results are as follows: —

Fertilizer.	Merchantable (Bushels).	Small (Bushels).	Rotten (Bushels).
Average of the no-nitrogen plots (3),	109.78	44.22	20.34
Nitrate of soda plots (2),	111.92	17.09	15.00
Dried blood plots (2),	146.92	28.67	32.42
Sulfate of ammonia plots (3),	128.55	34.78	17.89

The relative standing of the different materials furnishing nitrogen, calling the one giving the largest yield 100, is as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	87.10
Barnyard manure,	80.68
Nitrate of soda,	69.22
No nitrogen,	83.80

The nitrate of soda stands relatively much lower than in previous experiments on this field. The past season was exceptionally rainy, and there may have been some loss of the nitrate, all of which was applied just before planting. Such loss would not, however, account for the fact that the yield on the nitrate is below that on the no-nitrogen plots; and we are compelled to conclude that the fact that normal development and ripening were interfered with by the prevalence of blight and rot has prevented the several fertilizers from exerting a full normal effect. In estimating the significance of the results, we must not, however, lose sight of the fact that the crop of last year was a legume (the soy bean), and that the great abundance of nodules upon its roots indicated that it developed under conditions making possible a very large assimilation of atmospheric nitrogen.

II. — Crops of the Clover Family (Legumes) as Nitrogen Gatherers.

This experiment is carried out in connection with experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and clover have been used previous to the present season, the former during three years and the latter for one year. The crop of both is harvested. Our object is to test, not the effect of ploughing under these crops, but simply the improvement following the introduction of each derived from their roots and stubble. Previous to the present year the results have indicated little or no improvement in the condition of the soil following the culture of the soy bean, and a very great improvement followed the turning under of the clover sod, as shown by the fact that the potato crop of 1900 grown upon the clover sod was almost as good where no nitrogen fertilizers have been used for eleven years as it was where such fertilizer has been annually used in fairly liberal amounts. The crop in 1901 was soy beans. For the present season it was potatoes. The average yields for this year as well as for the previous years during which the experiment has continued are shown by the table: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

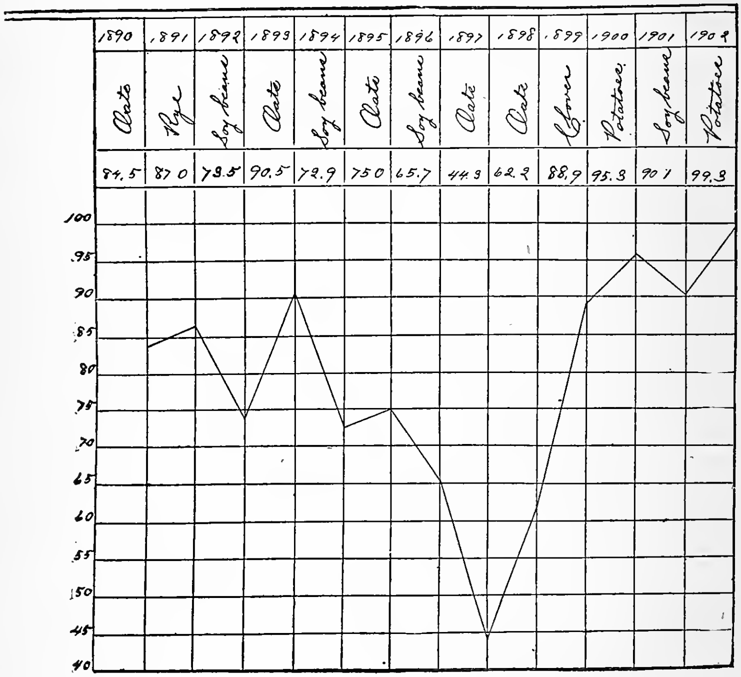
Plots (Each One-tenth).	1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean.
Nitrogen plots,	343	484	1,965	598	620	494	1,740
No-nitrogen plots,	290	421	1,443	540	452	370	1,143

Effect of Leguminous Crops upon the Following Crop (Pounds) — Concluded.

Plots (Each One-tenth).	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.	1901. Soy Bean.	1902. Potatoes.
Nitrogen plots,	445	254	413	1,316	442.2[1]	1,053.6
No-nitrogen plots,	197	158	367	1,254	398.3[1]	1,046.0

[1] Dry beans and straw.

There are three plots in the field which have received neither manure nor fertilizer supplying nitrogen since 1884, and the figures showing yields are the averages for these plots. The figures for the nitrogen plots show the average products of the eight plots in the field which have yearly received an application of materials furnishing nitrogen in fairly liberal amounts. These materials are as follows: barnyard manure, one plot; nitrate of soda, two plots; sulfate of ammonia, three plots; and dried blood, two plots. At the rates at which they are used, these materials furnish 45 pounds of nitrogen per acre, and they are so used that each plot receiving a nitrogen fertilizer receives annually the same number of pounds of nitrogen. The past season is the eighteenth since the no-nitrogen plots have been manured with anything containing nitrogen. The curve below shows the per cent. which the yield on these plots constitutes of the yield on the plots manured with nitrogen.



That the crop of potatoes on the no-nitrogen plots this year amounts to 99.3 per cent. of the crop on the plots receiving nitrogen is a fact of much significance. In the earlier years of this experiment, as has been stated, the crops following soy beans have not appeared to derive any considerable benefit from the roots and stubble of this crop. For this year it is believed that we must conclude the benefit is considerable. This difference in the after-effect of the soy beans is possibly explained in part by the fact that the bacteria, whose presence is essential to the acquisition of atmospheric nitrogen, are now more abundant in this soil than during the earlier years when soy beans were grown;

but it may be that the relative standing of the no-nitrogen plots is higher than it would have been had the crop of potatoes grown to normal maturity. It will be remembered that blight and rot prevailed to a considerable extent, and these would naturally injure the potatoes with the ranker growth more than those where the growth was less luxuriant. It does not seem, therefore, that we are justified in concluding that the after-effect of the soy beans is as useful as the relation between the figures appears to indicate.

III. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The object of this experiment, which has been in progress since 1892, is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans, and cabbages. Most of these crops have been grown during several different years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages, and soy beans have usually done much the best on the sulfate of potash; the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash.

The crops of the past year have been mixed timothy and clover, cabbages, potatoes, and onions.

1. Timothy and Clover (Sulfate v. Muriate of Potash).

Mixed timothy and clover occupied two plots which were seeded in July, 1901. The proportion of clover on the sulfate of potash plot was distinctly greater than on the other. The variety of clover was the alsike. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Timothy and Clover Hay per Acre (Pounds).

	Muriate of Potash.	High-grade Sulfate of Potash.
Hay,	4,710	4,725
Rowen,	1,745	1,997
Totals,	6,455	6,722

It will be seen that there is no considerable difference in the amount of hay yielded by the two potash salts. The first crop, indeed, in which of course timothy was relatively abundant, was practically equal upon the two. There is more difference in the rowen crops, which is without doubt a consequence of the better growth of the clover (which furnishes most of the rowen) on the sulfate of potash. Our results, then, are confirmatory of those in previous years, which have tended to show that, especially in cool and wet seasons, clover does better upon sulfate than upon muriate of potash. The experiment of the present season upon another of our fields (Field G), to be reported later, is also strikingly confirmatory of this general principle.

2. Cabbages.

Cabbages occupied two plots (17 and 18) on which clover was grown last year; and a considerable growth of mixed white and alsike clover, with some sorrel and weeds, was ploughed in a few days before planting the cabbages. The variety of cabbage grown was the All Seasons, from Gregory & Son, Marblehead. The seed was planted in hills 3 by 2½ feet apart on June 16. A very heavy shower interrupted the work, and so packed the soil on the muriate of potash plot, where the planting had been completed, that germination was imperfect; while on the other plot, where the seed was put in after the shower, the stand of plants was good. When the plants were finally thinned and vacancies filled, it was found necessary to use some plants from the sulfate of potash plot to fill vacancies on the other plot. The summer proved so cool that the crop did not fully mature on either plot, as growth was unusually slow. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Cabbages, Yields per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Hard heads (number),	2,648	3,420
Hard heads (pounds),	26,063	35,550
Soft heads (pounds),	22,650	18,263

It will be noticed that the total yield of hard heads on the sulfate of potash was materially greater than on the other plot. The merchantable value of the hard heads on the two plots, at ½ cent per pound was, respectively, for the muriate of potash $130.32, for the sulfate $177.75; the sulfate, therefore, gave a crop worth $47.43 per acre more than the muriate. The sulfate in the quantity used cost less than 70 cents per acre more than the muriate. The result of this year is in exact agreement with the result obtained in 1899, when, as this year, the season was rather cold and rainy. When the seasons are hot and relatively dry, the difference between the two salts is comparatively small, and sometimes the muriate gives a slightly better crop than the sulfate. It seems evident, however, that on all except the lightest soils the sulfate is the safer of the two potash salts to employ for the cabbage crop.

3. *Potatoes* (*Sulfate v. Muriate of Potash*).

The potatoes grown in this experiment occupied two plots, 15 and 16. For the two preceding years these plots had been in clover, the clover sod being turned on April 15.

The variety of potatoes was Beauty of Hebron, and the seed stock was purchased in northern Maine. It was prepared for planting by treating with corrosive sublimate on April 10, exposed in a light room in a single layer until April 22, and then cut into pieces of two eyes each. The pieces were planted 1 foot apart in rows 3 feet apart the same day the tubers were cut. The crop was thoroughly cared for throughout the season. It was sprayed with Bowker's prepared insecticide and fungicide four times, June 19 and 28, and July 11 and 26. As in our other experiments, the spraying proved thoroughly effective in destroying bugs, but not entirely so in preventing blight and rot. The growth on both plots was vigorous, and from a very early period there was a marked difference in the shade of green on the two; the vines on the sulfate of potash plot were of a dark-green color, those on the muriate of potash plot were of a light-yellowish — or pea-green color. This difference persisted until the crops began to ripen. On August 5 the tops were generally beginning to show signs of ripeness. On the 12th, blight was general, though not apparently severe. The tops were entirely dead on August 29, on which date the potatoes were dug. They were divided into two grades as to size, the potatoes classed as small including those estimated to be below 2 ounces in weight. There was considerable rot, as a rule of the larger tubers only. The total weight of the decayed potatoes on the muriate of potash plot was 50 pounds, on the sulfate of potash plot 314 pounds. In the estimate of total product these tubers are included with the merchantable. The yields were at the rates per acre shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

	Muriate of Potash.	High-grade Sulfate of Potash.
Potatoes, merchantable,	208	215
Potatoes, small,	53	39
Totals,	261	254

The total yield on the two plots is nearly the same. The crop on the sulfate of potash averaged of larger size than that on the muriate, but there was most decay on the sulfate. Whether this fact has any special significance it is impossible to say, without repeating the experiment.

4. Onions (Sulfate v. Muriate of Potash).

The onions grown in this experiment occupied two plots, 19 and 20. The crop of last year on these plots was cabbages, with winter rye as a cover crop, sown before the cabbages were harvested. The variety of onions was Danvers Yellow Globe. The seed was obtained from Gregory & Son, Marblehead, 1901; it was therefore one year old. It was sown in the thoroughly prepared soil in rows 14 inches apart on April 24. Growth throughout the earlier part of the season was very slow, and the final crop was poor. The fertilizers usually employed on this series of plots were supplemented by the application of a combined form of quick-lime and nitrate of soda, known as "niter-lime,"[1] at the rate of 175 pounds per acre. This was applied on July 12 and cultivated in. Soon after its application growth became much more rapid; but whether this was due chiefly to the somewhat more seasonable weather which then prevailed, or to the application of niterlime, we cannot feel certain. The onions were pulled on September 23, those on the sulfate of potash being more nearly mature than those on the other plot. The yield per acre, in bushels of sound onions and pounds of scallions, is shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Onions, Yield per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Onions (bushels),	110	75
Scallions (pounds),	10,811	8,828

[1] Niterlime contains: nitrogen, about 10.5 per cent.; and lime, about 20 per cent.

It will be seen that the muriate of potash has given the larger yield; but, since the onions on the sulfate were riper than those on the muriate, the figures probably have no special significance.

IV. — Fertilizers for Garden Crops. (Field C.)

The conclusions now presented are based upon the results of experiments which have been in progress since 1891. From that date to 1898 chemical fertilizers alone were used. During the past five years stable manure has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. The crops grown during this series of years have included all important out-door crops: spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn, celery, and one small fruit, — strawberries. Two of the perennial garden crops, asparagus and rhubarb, have now been planted, but these will not be discussed in the present report. Experiments have been planned with reference to throwing light especially upon two points: —

A. The relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen.

B. The relative value of sulfate of potash and muriate of potash.

These two points will be separately discussed.

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers used as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot, and each fertilizer is always applied to the same plot. Each of the nitrogen fertilizers is used on two plots, — on one with sulfate of potash, on the other with muriate. Dissolved bone-black as a source of phosphoric acid is applied in equal quantities to all plots. The results previous to this year may be thus summarized: —

For the early crops, *i.e.*, the crops making most of their growth before midsummer, including onions, lettuce, table beets, garden peas, and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers is as follows:—

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	92.7
Sulfate of ammonia,	54.8

For late crops, including cabbages, turnips, and celery, the relative standing is:—

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	98.7
Sulphate of ammonia,	77.5

The average rate of yield per plot for each of the nitrogen fertilizers for the present season is shown in the following table:—

Nitrogen Fertilizers compared for Garden Crops. — Yield per Plot (Pounds).

Average of Two Plots.	Onions.		Tomatoes.		Straw-berries.	Celery.	Squashes.
	Ripe.	Scallions.	Ripe.	Green.			
Nitrate of soda,	367.5	29	235.9	264	125.8	360	841.3
Sulfate of ammonia,	209.5	94	242.1	345	128.4	180	819.6
Dried blood,	357.0	34	403.7	269	146.4	295	807.4

It will be seen that for most of the crops the results are similar to the average results of preceding years. Nitrate of soda, however, stands relatively somewhat lower. Combining the results of this year with those of previous years, the relative standing of the different fertilizers used as sources of nitrogen is as follows:—

For the early crops, including onions and strawberries:—

	Per Cent
Nitrate of soda,	100.0
Dried blood,	93.7
Sulfate of ammonia,	57.3

For the late crops, including tomatoes, celery, and squashes : —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	99.0
Sulfate of ammonia,	78.4

Since nitrate of soda furnishes a pound of nitrogen at lower cost than any other of the fairly concentrated fertilizers, it becomes very evident, in view of our results, that it should be used as the source of this element as largely as the nature of the conditions permits. It should be remembered, as has been stated in previous reports, that the soil of Field C is a moderately retentive loam. Upon a lighter soil the superiority of the nitrate would probably be less marked. It must again be pointed out that experiments here, as elsewhere, make it very probable that the relative standing of the sulfate of ammonia would be bettered by making a heavy application of lime to the plots where it is used. Since, however, the pound of nitrogen costs more in the sulfate of ammonia than in either the nitrate or the dried blood, it would seem that there can be little probability that the selection of this nitrogen fertilizer is usually wise. Its physical properties, it is true, are such that it is more readily and conveniently used in mixtures with other materials than the nitrate, since the latter attracts moisture, while the sulfate of ammonia does not do this to any considerable extent. If, however, nitrate of soda which has been recently reground and which has been stored in a dry place be used, and if the mixture can be applied soon after it is made, there is little difficulty in employing nitrate.

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The history of the plots where these two potash salts are under comparison has been outlined under section *A*. The crops are the same as those which have been named under that section. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results of the past year are shown in the following table : —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

AVERAGE OF THREE PLOTS.	Onions.	Tomatoes.	Strawberries.	Celery.	Squashes.
Muriate of potash,	360	579.8	135.7	270	879.7
High-grade sulfate of potash,	367	593.0	131.4	287	766.2

In the discussion of the relative standing of these two potash salts, the same crops are included respectively under the headings early and late as those specified in section *A*. The relative standing of these two salts at the beginning of the present year is shown in the following table: —

FERTILIZERS.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	92.6	103.0

Including the crops of the past year, the relative standing of the two potash salts is as follows: —

FERTILIZERS.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	93.2	102.9

Attention is called to the fact that the results of this year are in exact accord with those of earlier years. The sulfate of potash proves considerably superior to the muriate for the crops making most of their growth early in the season, while for those making their growth in the latter part of the season the muriate is slightly superior.

V. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

Since 1898 the following potash salts have been under comparison for various field crops: kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate, and silicate. Each is applied annually to the same plot, and all are used in such quantities as to furnish equal potash to each plot. All plots are equally manured with materials furnishing nitrogen and phosphoric acid. There are forty plots, in five series of eight plots each, each series including a no-potash plot and one for each potash salt used. The area per plot is about one-fortieth of an acre. The crops on this land last year were winter wheat on one series and ensilage corn on the other four series. On the series occupied by the winter wheat, clover was sown after reploughing, the last of July. On the four series occupied by corn last year clover was sown in the corn early in August. The clover on the series following wheat got an excellent start, and went through the winter well. The clover on the other series, owing to the dense shade of the corn, which was very heavy, made much less growth, and was to a considerable extent winter-killed. On these plots, Nos. 9 to 40, it was necessary to sow additional seed this spring. This was done on March 26, when the soil and weather conditions were favorable. The seed sown at this time started well. The usual fertilizers were applied this spring on April 25. The crop on all the plots was cut on June 11. That on the series which followed wheat was well grown, and the product of each plot was separately weighed. The product of the other plots was much mixed with weeds, which, on account of the winter-killing, were able to make considerable growth; and it was not considered that the weights would have much value, as indicating the relative yield of clover. Before the clover was cut, however, the plots were carefully examined. It was found that on each of the plots to which kainite had been applied the condition of the young clover was much inferior to that of the clover on the other plots. The color was poor, while many of the plants appeared to be dying. This difference was not apparent between the clover plants which had survived the winter on the different plots. Examination disclosed the further fact that there was a somewhat similar degree of inferiority in the condition of the young clover on all of the plots which had received an application either of the low-grade sulfate of potash or of muriate of potash, as compared with that on the other plots.

Indeed, at this time the young clover on all the kainite, low-grade sulfate and muriate of potash plots appeared to be inferior to that on the plots which had received no potash. By the middle of the season there were many places in all these plots on which there was no clover. Before the end of the season, however, such clover plants on these plots as survived became perfectly healthy, and were characterized by a marked degree of vigor. It cannot be doubted, in view of the unfavorable results which have been previously obtained in our experiments where muriate of potash has been used for clover, that it is the chlorides in the three fertilizers which cause the injury. Chlorides may produce this effect either because of the increased loss of lime which their use leads to, or possibly because of the fact that their continued use brings the soil into an acid condition. Either deficiency of lime or presence of free acid is known to be decidedly unfavorable to the growth of clover.

All the plots in the field were cut twice subsequent to June 11, viz., on August 4 and October 10. On the first date there was a moderate growth of small weeds and a few large ones on the plots on which the clover was poor, *i.e.*, on the kainite, muriate of potash, and low-grade sulfate of potash plots. These, as far as practicable, were thrown out. In estimating the significance of the differences in yield, however, it should be remembered that the real difference in the condition and growth of the clover was undoubtedly greater than the figures indicate, as where the clover is weakest the weeds are most numerous, and it is impossible to separate them all. The crops cut were carefully cured in cocks without loss of leaf, and the hay was well dried when weighed. The tables show the rates of yield per acre and the averages for the last two cuttings of the several potash salts : —

Clover. — Yield per Acre (Pounds).

Plots.	Potash Salt.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
1	No potash,	2,458	2,078	1,273	5,809
2	Kainite,	2,681	2,491	1,475	6,647
3	High-grade sulfate,	2,681	2,301	1,564	6,546

Clover. — Yield per Acre (Pounds) — Concluded.

Plots.	Potash Salt.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
4	Low-grade sulfate,	2,904	2,324	1,430	6,658
5	Muriate,	2,904	2,188	1,609	6,701
6	Nitrate,	3,128	2,156	1,475	6,759
7	Carbonate,	3,128	2,391	1,430	6,949
8	Silicate,	3,128	2,480	1,541	7,149
9	No potash,	–	2,100	1,273	3,373
10	Kainite,	–	1,966	849	2,815
11	High-grade sulfate,	–	2,569	1,296	3,865
12	Low-grade sulfate,	–	2,458	1,229	3,687
13	Muriate,	–	2,414	1,162	3,576
14	Nitrate,	–	2,670	1,162	3,832
15	Carbonate,	–	2,458	1,385	3,843
16	Silicate,	–	2,793	1,206	3,999
17	No potash,	–	2,435	670	3,105
18	Kainite,	–	2,145	581	2,726
19	High-grade sulfate,	–	2,636	983	3,619
20	Low-grade sulfate,	–	2,726	961	3,687
21	Muriate,	–	2,547	1,340	3,887
22	Nitrate,	–	2,815	1,251	4,066
23	Carbonate,	–	2,591	1,117	3,708
24	Silicate,	–	2,726	1,251	3,977
25	No potash,	–	2,234	626	2,860
26	Kainite,	–	2,324	849	3,173
27	High-grade sulfate,	–	2,815	1,206	4,021
28	Low-grade sulfate,	–	2,525	983	3,508
29	Muriate,	–	2,681	938	3,619
30	Nitrate,	–	2,748	1,117	3,865
31	Carbonate,	–	2,591	1,162	3,753
32	Silicate,	–	2,860	1,340	4,200
33	No potash,	–	2,435	849	3,284
34	Kainite,	–	2,100	760	2,860
35	High-grade sulfate,	–	2,703	1,251	3,954
36	Low-grade sulfate,	–	2,636	1,162	3,798
37	Muriate,	–	2,949	1,072	4,021
38	Nitrate,	–	2,681	1,117	3,798
39	Carbonate,	–	2,681	983	3,664
40	Silicate,	–	2,502	849	3,351

Clover Rowen. — Average Yield per Acre (Pounds).

Potash Salt.	First Cut, Rowen.	Second Cut, Rowen.
No potash (1, 9, 17, 25, 33),	2,256	938
Kainite (2, 10, 18, 26, 34),	2,205	903
High-grade sulfate (3, 11, 19, 27, 35),	2,605	1,260
Low-grade sulfate (4, 12, 20, 28, 36),	2,534	1,153
Muriate (5, 13, 21, 29, 37),	2,556	1,224
Nitrate (6, 14, 22, 30, 38),	2,614	1 224
Carbonate (7, 15, 23, 31, 39),	2,542	1,215
Silicate (8, 16, 24, 32, 40),	2,672	1,237

The figures call for little comment. They strikingly show the marked inferiority of the product on the plot receiving kainite. Not only is the average product on this plot lower than the yield on any of the other potash salts, — but it is lower in every series except one than the yield on the plot receiving no potash. The potash salt giving the highest average total yield is the silicate, — almost as good is the high-grade sulfate, — while the yield on the nitrate muriate and carbonate is not far behind.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

In this experiment, which has been in progress six years, we have under comparison the following phosphates: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone, and acid phosphate. The phosphates are all applied in the finely ground form, being carefully spread broadcast after ploughing in the spring, and harrowed in. Three plots in the field have received no phosphoric acid in any form since the beginning of the experiment. The plots are one-eighth of an acre each in area. The phosphates yearly applied are used in quantities sufficient to furnish actual phosphoric acid at the rate of 96 pounds to the acre. All plots are manured alike, with materials furnishing nitrogen and potash in available forms and in equal amounts to each. The materials regularly used furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. During the past year every plot in the field has received an extra application furnishing nitrogen during the growth of the crop. The material used was niterlime, a combination of nitrate of soda and quicklime, containing 10.44 per cent. nitrogen and 20.41 per cent. lime. This was applied broadcast on July 2, at the rate of 176 pounds per acre, and cultivated in.

The preceding crops have been: corn, cabbages, corn, and in 1900 oats for hay, and Hungarian grass also cut for hay, and onions. With the exception of the onions, all these crops have given large yields, even on the three plots in the field which have received no application of phosphoric acid. Attention is once more called to the fact that the soil of plot 1 seems to have been naturally in a much higher condition of fertility than that of any other plot in the field. In estimating the significance of the results, therefore, the yield of this plot should be disregarded. A more correct indication of the effect of each of the phosphates on plots 2 to 6 is afforded by comparing the yields of those plots with the yield on plot 7. It is, however, without doubt true that the soil from plot 7 towards plot 1 improves gradually in physical condition and natural fertility. The crop the present year has been onions. These throughout this part of the State have generally been a poor crop this year. Our yields are comparatively small even on the best plots. The results are given in the table: —

Onions on Plots with Equal Amounts of Phosphoric Acid.

Plots.	Fertilizer.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
1	No phosphate, ...	195.7	8,560
2	Apatite, ...	101.7	8,480
3	South Carolina rock phosphate, ...	121.8	9,360
4	Florida soft phosphate, ...	52.3	6,880
5	Phosphatic slag, ...	252.0	5,600
6	Tennessee phosphate, ...	44.6	6,960
7	No phosphate, ...	50.5	5,360
8	Dissolved bone-black, ...	173.8	5,640
9	Raw bone, ...	301.4	4,144
10	Dissolved bone meal, ...	388.9	5,400
11	Steamed bone meal, ...	243.8	5,840
12	Acid phosphate, ...	159.4	6,560
13	No phosphate, ...	26.2	6,600

Up to the time when onions were introduced as a crop on this field, the leading conclusions drawn from the experiments were the following : —

1. The phosphatic slag has apparently furnished phosphoric acid in an exceedingly available form, the yield on the plot receiving the slag being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate has given the lowest yields of any plot receiving phosphoric acid.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

For last year the phosphates giving the largest yields of sound onions, mentioned in the order of their rank, were: raw bone, phosphatic slag, South Carolina rock phosphate, apatite, dissolved bone meal, and dissolved bone-black. All others gave yields under 200 bushels to the acre.

Examination of the table shows that the results are in general similar to those of last year; the differences, however, are much greater and the apatite and South Carolina rock phosphate take a relatively much lower rank. The dissolved bone meal gives the largest crop; raw bone ranks next; while the phosphatic slag stands next in order, with steamed bone meal not far behind.

The proper ripening of the onion crop, as shown by this as well as other of our experiments, appears to be dependent in very large measure upon the presence of a liberal supply of highly available phosphoric acid. It appears very doubtful, therefore, whether it is likely ever to prove expedient to depend upon natural rock phosphates or untreated bone as a source of phosphoric acid for this crop.

VII. — Soil Tests.

During the past season we have conducted three soil tests, — two upon our own grounds, both in continuation of previous work upon the same fields, and one on the farm of A. M. Lyman of Montague. In these experiments the fertilizers are used in accordance with the co-operative plan for soil tests adopted in Washington in 1889. Each plot receives annually the same kinds of fertilizers, and usually in the same amounts. These experiments are not calculated to secure the production of heavy crops, but are designed rather to throw light upon the general question as to how the different crops should be manured for the most profitable results. The fertilizers are so applied that it becomes possible to determine with much accuracy the effects of each of the leading elements of plant food. Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Fertilizers and manures are always applied broadcast after ploughing, and harrowed in. The following table shows the kinds and usual amounts per acre: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre), Amherst.

This acre has been used in soil tests for fourteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, and this year corn once more. Since 1889 this field has therefore borne six corn crops, and during this time it has been four years in grass.

It will be noticed that the crop last year was grass. The sod was turned on April 12. The land was thoroughly harrowed, twice before sowing the fertilizer and once after. The variety of corn was Sibley's Pride of the North. It was planted in drills, 3½ feet apart, on May 22. The season was cold and unfavorable to corn, but in spite of this fact the crop made very good growth upon the four plots to which potash has been yearly applied and upon the plot which has been yearly manured. Four of the plots in this field have received no manure nor fertilizer throughout the entire fourteen years, and these show a high degree of exhaustion, — indeed, these produced scarcely any sound grain this year. The crop, however, is not yet sufficiently dried to shell; and calculation, allowing 90 pounds of ears, as weighed November 22, to a bushel, shows that the average apparent yield is at the rate of 9.7 bushels per acre. The actual yield of grain is believed to be under 4 bushels per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1902.

Plots.	Fertilizer used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels, 90 Pounds).	Stover (Pounds).
1	Nitrate of soda,	7.3	1,180	—3.1	—300
2	Dissolved bone-black,	11.4	1,780	1.0	300
3	Nothing,	10.4	1,480	-	-
4	Muriate of potash,	47.7	4,760	37.3	3,507
5	Lime,	4.9	860	—5.5	—167
6	Nothing,	10.4	800	-	-
7	Manure,	68.7	6,220	58.3	5,420
8	Nitrate of soda and dissolved bone-black.	11.2	1,380	2.0	20
9	Nothing,	9.2	1,360	-	-
10	Nitrate of soda and muriate of potash.	53.4	3,540	44.3	2,200
11	Dissolved bone-black and muriate of potash.	55.9	4,640	47.0	3,320
12	Nothing,	8.8	1,300	-	-
13	Plaster,	14.6	1,880	5.8	580
14	Nitrate of soda, dissolved bone-black and muriate of potash.	56.2	4,540	47.4	3,240

The effect of each of the three elements of plant food — nitrogen, phosphoric acid and potash — is more clearly brought out in the tables which follow: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	—3.1	1.0	7.0	.4	1.3
Stover (pounds),	—300	—280	—1,307	—80	—492

Value of decrease,	$0 45
Financial result (loss),	3 65

	Results of the Addition of Phosphoric Acid to—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels), . .	1.0	5.1	9.7	3.1	4.7
Stover (pounds), . .	300	320	—187	1,040	368

Value of increase, ... $3 74
Financial result (gain), ... 54

	Results of the Addition of Potash to—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels), . .	37.3	47.4	46.0	45.4	44.0
Stover (pounds), . .	3,507	2,500	3,020	3,220	3,062

Value of increase, ... $34 06
Financial result (gain), ... 30 86

	Results of the Addition to Nothing of—			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels), ...	—5.5	58.3	5.8	47.4
Stover (pounds), ...	—167	5,420	580	3,240
Value of increment, ...	-	$48 53	$4 93	$36 54
Value decrease, ...	$3 72	-	-	-
Financial result, ...	$6 12 loss.	$23 53 gain.	$1 33 gain.	$26 94 gain.

The Effect of the Nitrogen. — It will be noticed that the employment of nitrate of soda alone (nitrogen) gives a crop which is actually less than that produced where no fertilizers are used. This variation is very likely accidental, as it can hardly be supposed that the nitrate is actually injurious. When used with potash alone, the nitrate gives a moderate increase in the crop. The average result is an increase of a little more than a bushel of grain, but a decrease of nearly 500 pounds in stover. The nitrate does not pay for itself, on either of the four plots to which it was applied; for the cost of the 160 pounds is $3.60, and on the only plot where the increase in grain is sufficient to be worth this sum there is a decrease in the amount of stover, which brings the net increased value below the cost of the nitrate.

The Effect of the Phosphoric Acid. — Dissolved bone-black (phosphoric acid) used alone produced an insignificant increase. In the different combinations the results of its use indicate it to be moderately beneficial. The best result is secured where it is employed in connection with potash. The cost of the dissolved bone-black wherever employed was at the rate of about $3.20 per acre. The average increase in crop is sufficient to barely cover this amount. Particular attention is called to the splendid crop produced where dissolved bone-black and muriate of potash are used together. The combination of these two fertilizers without nitrogen apparently suffices, under the system of rotation which has been followed, to fully maintain the productiveness of this plot. Last year its yield was at the rate of 1,900 pounds of hay to the acre in the first crop and 1,500 pounds of rowen in the second crop. As was pointed out last year, this splendid product is undoubtedly due to the capacity which clover grown in mixture with the grasses possesses to draw the needed nitrogen from the air. The advantage obtained by this system of manuring is, however, not exhausted when we have taken the hay crops; for, as shown by the yield of corn this year of almost 56 bushels of sound grain to the acre, the corn crop which requires a large amount of nitrogen (which, so far as we know, must be taken from the soil), is able to derive the needed quantity of this element from the products of the decay of the clover roots and stubble. The expenditure for fertilizers applied to this plot has been at the rate of about $6.40 per acre, and for this sum we have this year nearly 56 bushels of corn and more than 2½ tons of stover. Moreover, the beneficial effects of this system of manuring appear to be cumulative. The productivity of this plot shows not the slightest signs of decrease after fourteen years, during which time neither manure nor fertilizer furnishing a single ounce of nitrogen has been applied. In view of the results upon other plots, it cannot be doubted that the increased yield on this plot is due in very large measure to the potash employed, but the dissolved bone-black is also evidently useful.

The Effect of the Potash. — It will be noticed that wherever potash is applied, whether alone or in combination with either one or both of the other fertilizers, the result is a large yield. Potash is evidently the dominant plant food element on this soil for corn. The increase where this element is used alone is at the rate of more than 37 bushels to the acre; the average increase, at the rate of 44 bushels to the acre. The potash used costs at the rate of $3.20 per acre. This amount is covered many times over by the increase in the crop.

The Effect of the Manure. — The manure alone gives a large crop, — considerably larger than on any other plot. That this should be true is natural, in view of the fact that the manure at the rate at which it is applied furnishes a larger amount of plant food than is furnished in the fertilizers. It also tends to keep up the supply of humus in the soil, and this, as is well understood, is highly beneficial in many ways. The yearly cost of the manure applied is, however, at the rate of about $25 per acre, while the complete fertilizer used on plot 14 costs only $10.

The results with corn this year are entirely similar in kind to those which have been obtained in the earlier years in which corn has been grown on this piece of land. They show very conclusively that on such land corn can be cheaply grown by the use of fertilizers alone, and they demonstrate conclusively that potash should be a very prominent constituent. In view of the fact that the fertilizers generally used by the farmers of the State for corn usually contain far more phosphoric acid than potash, these results appear to be well worth attention. The important question naturally at once arises, "How far are the requirements of the corn crop on the farms in other parts of the State similar to those shown by these experiments?" In answer to this question, attention is called to the results of similar experiments in various parts of the State, which have been published in Bulletins Nos. 9 and 14 of this station. These results indicate that in most localities the potash in fertilizers appears to have a greater effect in increasing the corn crop than either of the other prominent elements. Especially has this been found to be the case on the better soils of the State. The results upon light and poor soils in Yarmouth, Freetown and Marblehead have shown but small increase for any of the fertilizers used. On such soils farmyard manures prove much the most effective. On the soils with good physical characteristics, *i.e.*, soils on which crops are not likely to suffer excessively in hot, dry weather, and especially if the soil is one which is in a fair state of fertility, the increase due to potash has always been found to be striking, and it is believed that farmers should see to it that this element is more largely supplied to this crop.

B. — Soil Test with Potatoes (North Acre).

The field on which this test was carried out has been used in similar tests with various crops for thirteen years, beginning in 1890. The crops grown in order of succession include potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, potatoes, and onions, for four years (1898 to 1901 inclusive).

Rye was sown a short time before the onion crop of last year was pulled, in the hope of producing a crop which would serve as winter cover, and to prevent washing, to which this field is liable. This object was only in part accomplished, as the rye sown on the surface did not make a perfect start. There was considerable washing, as a result of heavy storms in March. It is not believed, however, that this was of such a character as seriously to interfere with the accuracy of our fertilizer tests, for it was for the most part with and not across plots. The several plots in this field have been manured in accordance with the usual soil test plan, with the exception that double quantities of all fertilizer materials were used during the years when onions have been grown, as well as this year. In one other respect the treatment of this field has been peculiar. The lower half of all plots received an application of lime in the spring of 1898 at the rate of 1 ton to the acre. The nitrate used during the present season was put on in two applications, — one-half applied broadcast just before planting the seed, the other half scattered about the plants and cultivated in on June 30, at which time the crop was about half grown. The field was ploughed on May 7, at which time the rye had made considerable growth. There were marked differences on the different plots, but no clearly defined difference beween the limed and unlimed portions of the several plots. The fertilizers in double the usual amounts were spread broadcast on May 12 and immediately harrowed in. The variety of potatoes planted was the Delaware, the seed being grown in the adjoining town of Hadley. In preparation for planting the seed was soaked in a solution of corrosive sublimate, for the prevention of scab. It was then dried, and the tubers were cut into pieces with two good eyes each, and planted at once. The date of planting was May 13. The potatoes started well, the crop was thoroughly cared for, and there were no accidental conditions recognized as interfering with the normal development of any of the plots. The potatoes were sprayed twice, — on July 11 with Bowker's Boxal, and on July 26 with Bowker's Bodo, to which a suitable quantity of Paris green for destruction of bugs was added. Both sprayings were effective in destroying bugs but not fully effective in preventing blight, which, however, was not serious on this field, where the growth of the tops was comparatively light. There was no rot whatever, although this disease was prevalent on similar soils in the immediate neighborhood. The crop was dug on September 8 and 9. All tubers were smooth, but of rather small average size; they were, however, of excellent quality. The following tables show the fertilizers applied to the several plots, the yields per acre, and the gain or loss compared with the nothing plots: —

Potatoes. — North Acre Soil Test (Unlimed), 1902.

Plots.	Fertilizers used.	Yield per Acre (Bushels). Merchantable.	Yield per Acre (Bushels). Small.	Gain or Loss per Acre compared with Nothing Plots (Bushels). Merchantable.	Gain or Loss per Acre compared with Nothing Plots (Bushels). Small.
1	Nothing, ...	27.7	24.0	-	-
2	Nitrate of soda, ...	30.0	20.7	1.1	—2.9
3	Dissolved bone-black, . .	39.3	20.0	9.2	—3.1
4	Nothing, ...	31.3	22.7	-	-
5	Muriate of potash, . . .	58.0	15.3	25.7	—9.1
6	Nitrate of soda and dissolved bone-black.	69.3	28.7	36.0	2.7
7	Nitrate of soda and muriate of potash.	51.3	26.0	17.0	—1.7
8	Nothing, ...	35.3	29.3	-	-
9	Dissolved bone-black and muriate of potash.	73.7	18.0	41.1	—9.4
10	Nitrate of soda, dissolved bone-black and muriate of potash.	110.3	17.0	80.4	—8.5
11	Plaster, ...	24.7	16 0	—2.5	—7.6
12	Nothing, ...	24.5	21.7	-	-

Potatoes. — North Acre Soil Test (Limed), 1902.

Plots.	Fertilizers used.	Yield per Acre (Bushels). Merchantable.	Yield per Acre (Bushels). Small.	Gain or Loss per Acre compared with Nothing Plots (Bushels). Merchantable.	Gain or Loss per Acre compared with Nothing Plots (Bushels). Small.
1	Nothing, ...	21.3	27.7	-	-
2	Nitrate of soda, ...	27.3	20.3	5.5	—5.3
3	Dissolved bone-black, . .	26.0	22.0	2.2	—1.4
4	Nothing, ...	22.7	21.3	-	-
5	Muriate of potash, . . .	69.0	12.7	43.8	—8.6
6	Nitrate of soda and dissolved bone-black.	71.3	29.0	43.6	7.7
7	Nitrate of soda and muriate of potash.	58.3	17.3	28.1	—4.0
8	Nothing, ...	32.7	21.3	-	-
9	Dissolved bone-black and muriate of potash.	93.7	20.0	61.6	—.3
10	Nitrate of soda, dissolved bone-black and muriate of potash.	115.3	17.3	83.8	2.0
11	Plaster, ...	24.3	13.7	—6.6	—4.6
12	Nothing, ...	30.3	17.3	-	-

Potatoes (Bushels per Acre).	Results of the Addition of Nitrogen to—				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	1.1	26.8	—8.7	39.3	14.6
Small, ...	—2.9	5.8	7.4	.9	2.8
Limed:—					
Merchantable, . .	5.5	39.8	—15.7	22.2	13.0
Small, ...	—5.3	9.1	4.6	2.3	2.7

Value of increase, unlimed, ...	$9 32
Financial result, unlimed (gain), ...	2 92
Value of increase, limed, ...	8 34
Financial result, limed (gain), ...	1 94

Potatoes (Bushels per Acre).	Results of the Addition of Phosphoric Acid to—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	9.2	34.9	15.4	63.4	30.7
Small, ...	—3.1	5.6	—.3	—6.8	—1.2
Limed:—					
Merchantable, . .	3.8	38.1	17.8	55.7	28.9
Small, ...	—1.4	13.0	8.3	6.0	6.5

Value of increase, unlimed, ...	$18 18
Financial result, unlimed (gain), ...	11 78
Value of increase, limed, ...	18 64
Financial result, limed (gain), ...	12 24

Potatoes (Bushels per Acre).	Results of the Addition of Potash to—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Unlimed:—					
Merchantable, . .	25.7	15.9	31.9	44.4	29.5
Small, ...	—9.1	1.2	—6.3	—11.2	—6.4
Limed:—					
Merchantable, . .	43.8	22.6	57.8	40.2	41.1
Small, ...	—8.6	1.3	1.1	—5.7	—3.0

Value of increase, unlimed, ...	$16 42
Financial result, unlimed (gain), ...	10 02
Value of increase, limed, ...	24 06
Financial result, limed (gain), ...	17 66

Potatoes (Bushels per Acre).	Results of the Addition to Nothing of —	
	Complete Fertilizer.	Plaster.
Unlimed: —		
Merchantable,	80.4	—2.5
Small,	—8.5	—7.6
Limed: —		
Merchantable,	83.8	—6.6
Small,	2.0	—4.6
Value of increase, unlimed,	$46.64	-
Value of decrease, unlimed,	-	$3.02
Financial result, unlimed,	27.44 gain	6.62 loss
Value of increase, limed,	50.68	-
Value of decrease, limed,	-	4.88
Financial result, limed,	31.48 gain	8.48 loss

It will be noticed that no plot in the field has produced what is regarded as a good crop. This field has now been tilled for several years without the introduction of a grass crop, and the stock of humus in the soil must be exceedingly small. It is believed that this deficiency in humus, on the presence of which, in moderate quantity, potatoes are known to be quite dependent, accounts in a measure for the relatively low yield on the plot to which a complete fertilizer was applied. It will be noticed, further, that there is not a very wide difference between the yields of the unlimed and limed portions of the several plots. With onions as a crop the difference is very large on all plots to which muriate of potash, nitrate of soda, or both of these fertilizers without dissolved bone-black are applied. The fact that potatoes show a far smaller difference may be due to either of two causes: first, that this crop is less sensitive to a deficiency of lime than onions; or, second, that the effects of the lime applied in 1898 are now largely exhausted. We have some evidence that this effect is so exhausted. The soil on the limed portion of the plots manured with muriate of potash or nitrate of soda, as shown by chemical tests, appears to be once more acid.

The Effect of the Nitrogen. — It will be remembered that nitrate of soda was applied to the four plots receiving this fertilizer in double the usual quantities, viz., at the rate of 320 pounds per acre. It increases the crop to a considerable extent only where it is used in connection with dissolved bone-black. Used in connection with this fertilizer, it gives an increase sufficient, with potatoes at 60 cents per bushel, to much more than cover the cost. The fact that it does not give an increase when used in connection with potash (which as will be seen later was the most useful of the fertilizer elements) is strongly indicative of the fact that the soil on the plot receiving nitrate and muriate of potash is once more acid, even on the part limed in 1898. A study of the results leads to the conviction that the experiment furnishes but an imperfect test as regards the necessity of an application of nitrogen on account of the poor physical and chemical condition of the soil, due to deficiency both of humus and lime.

The Effect of the Phosphoric Acid. — The dissolved bone-black (furnishing phosphoric acid), when used in connection with either or with both of the other fertilizers, gives an increase more than sufficient to cover its cost. It gives the largest increase in connection with both of the other fertilizers, which indicates a high degree of general exhaustion. It gives the smallest increase when used in connection with muriate of potash, which is still further evidence of the probable deficiency of lime, for such deficiency is known to be most marked where muriate of potash is largely employed as a fertilizer.

The Effect of the Potash. — The increase in crop produced by the application of muriate of potash where it is used alone or with either or both of the other fertilizers is in all cases much more than sufficient to cover the cost of the fertilizer. The increase on the limed half of the plots is without exception, if small and large tubers both be included, considerably greater than on the unlimed portion of the plots; indicating that, although there may be a present deficiency in the amount of lime necessary for the best results, the effects are not yet wholly exhausted. In practically all soil tests which have been carried out by this station, whether on this farm or on farms in other parts of the State, the potato crop has always shown a marked dependence upon a liberal supply of potash, which we may safely say, therefore, should be more prominent than it usually is in the special fertilizers made for this crop. It seems worth while to call attention here to the fact that, for the sake of uniformity in soil test-work, the potash salt here employed was the muriate. It will be remembered that it has been shown as a result of numerous experiments here that the sulfate is preferable, giving better results, as indicated both by yield and quality.

VIII. — Manure Alone *v.* Manure and Potash.

This experiment was begun in 1890, and is intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure in connection with a potash salt. Full accounts will be found in the preceding annual reports, and summaries in the reports for 1895 and 1900. The field is level, and the soil of apparently even quality. It is divided into four quarter-acre plots. The crop for the years 1890 to 1896 was corn; for the years 1897 and 1898, mixed grass and clover; for the years 1899 and 1900, corn; for the past two years, mixed grass and clover. The present is therefore the second year that the land has been continuously in grass. Plots 1 and 3 received an application of manure at the rate of 6 cords per acre; plots 2 and 4, manure at the rate of 4 cords per acre, and high-grade sulfate of potash at the rate of 160 pounds per acre. The annual cost of the manure as applied to plots 1 and 3 is estimated to be at the rate of $30 per acre. The annual cost of the manure and the potash salt applied to plots 2 and 4 at the same price per cord for the manure is at the rate of $23.60 per acre. The yields for the present season are shown in the table: —

Yields of Hay and Rowen (Pounds).

Plots.	Hay.	Rowen.
Plot 1,	955	740
Plot 2,	915	690
Plot 3,	1,010	780
Plot 4,	900	680

The rates of yield per acre are shown below: —

Yield of Hay and Rowen per Acre (Pounds).

Plots.	Hay.	Rowen.	Total.
Plot 1,	3,820	2,860	6,680
Plot 2,	3,660	2,760	6,420
Plot 3,	4,040	3,120	7,160
Plot 4,	3,600	2,720	6,320

Averaging the yields for plots 1 and 3, we find the total to be at the rate of 6,920 pounds per acre. A similar average for plots 2 and 4 gives a yield at the rate of 6,370 pounds per acre. The larger application of manure therefore gives a yield at the rate of 450 pounds per acre more than the smaller application of manure and the potash. The difference in cost of the two applications, as shown above, is at the rate of $6.40 per acre. The 450 pounds of hay costs, therefore, this amount standing in the field. Grass standing in the field cannot be considered to be worth in an average season more than about $7 or $8 per ton of well-made hay. Although, therefore, we have a small difference in favor of the larger application of manure in total crop, the financial outcome is clearly in favor of the combination of the lesser amount of manure and the potash salt.

We have now grown on this field under substantially the present system of manuring nine corn crops and four hay crops, and the results may be briefly stated as follows: —

1. The corn crops under the two systems of manuring have been practically equal in value.

2. The hay crops have been slightly larger on the plots receiving the more liberal application of manure alone; but these increases have been produced at a cost, where manure is estimated at $5 per cord in the field, which is greater than their value.

IX. — Special Corn Fertilizer *v.* Fertilizer Richer in Potash.

This field has been used continuously in experiments designed to throw light upon the question of the proper use of fertilizers for the corn crop since 1891. From that year to 1896 inclusive the crop was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900, it was corn; and for the past two years, it has been grass and clover. A full account of results to date will be found in preceding annual reports. The especial object in view is to test the question as to whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production of corn in rotation with mixed mowing. The field is divided into four quarter-acre plots, and throughout the entire period during which the experiment has continued two of these plots (1 and 3) have yearly received an application of mixed fertilizers, furnishing the same amounts of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average in 1899, since which date there has been no change in the kinds and amounts of fertilizers used, was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The other two plots (2 and 4) have annually received an application of materials substantially the same in kind and quantity as those recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference between the applications on the two pairs of plots is that 2 and 4 receive materials furnishing a much larger quantity of potash and much less phosphoric acid than the other pair of plots. The fertilizers applied to the several plots are shown below: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Sulfate of potash,	37.5	62.5

The present is the second season that this field has now been in grass. The past season has been favorable to the hay crop, the field was cut twice, and the hay was weighed and housed in excellent condition. The tables show the yields: —

Yields of Hay and Rowen, 1902 (Pounds).

Plots.	Hay.	Rowen.	Total.
Plot 1 (lesser potash),	3,712	1,540	5,252
Plot 2 (richer in potash),	5,072	1,900	6,972
Plot 3 (lesser potash),	3,992	1,260	5,252
Plot 4 (richer in potash),	5,012	1,560	6,572

Averaging the two pairs of plots, we have the rates of yield per acre for hay, rowen and total shown below: —

Average Yield per Acre (Pounds).

PLOTS.	Hay.	Rowen.	Total.
Plots 1 and 3, ...	3,852	1,400	5,252
Plots 2 and 4, ...	5,042	1,730	6,772

It will be noticed that the yields both of hay and rowen were considerably heavier on plots 2 and 4 (*i.e.*, the plots which received fertilizers richer in potash) than on the other pair of plots. The proportion of clover was much the larger on plots 2 and 4; and, as clover is superior in nutritive value to grass, it is evident that the superiority of the crop was even greater than the weight difference in yield in itself indicates. The cost of the fertilizers applied to plots 1 and 3 exceeds that of the fertilizers applied to plots 2 and 4 at the rate of about $4 per acre. We have, then, as a result of this experiment for this year, 6,772 pounds of hay of superior nutritive value, produced at a cost of $4 less than the 5,252 pounds produced by the other pair of plots. This result is in exact accordance with the teachings of the soil test on the south acre. There can be no doubt that potash should be more abundant in fertilizers for corn than is usually the case. It is important to point out the further fact that the difference between the two pairs of plots, as indicated by the greater productivity of the plots receiving the heavier application of potash, seems to be increasing from year to year. The results of this experiment to date may be briefly stated as follows: —

1. The crops of corn thus far have been substantially equal under the two systems of manuring.

2. The crops of hay have always been larger on the plots where more potash has been used, and the nutritive value pound for pound has been greater on account of the larger proportion of clover.

In conclusion, I may quote from my report for last year: —

In view of the fact that the clover sod when turned is exceedingly favorable for succeeding crops, it is confidently anticipated that the differences in yields under the two systems of manuring will increase from year to year, and that the superiority of the mixture of fertilizers containing more potash will therefore become increasingly evident.

X. — Experiment in manuring Grass Lands.

In this experiment, which has continued since 1893 upon one uniform system, our object is to test the value for production of grass of the system of using wood ashes, ground bone and muriate of potash, and manure, in rotation. Owing, however, to the fact that the land has been for many years in grass, and that it has never been cultivated consecutively for a sufficiently great length of time to free it from weeds, the sod had become considerably infested with daisies, ragged robin, buttercups, and a number of other species. It has accordingly been decided to break up and reseed a part of the land. A portion has been cultivated for two years, and is now reseeded. This portion constitutes a part of plot 3. This year, after the harvest of the first crop, which was cut early to avoid ripe weed seeds, a portion each of plots 1 and 2 was broken up. This was frequently harrowed between the date of ploughing, which was about the middle of July, and the date of seeding, which was August 15. The portion of plot 3 not previously broken up has been similarly treated. The area reported upon this year, therefore, comprises only a portion of the plots included in this field, the total area of which is about nine acres.

The rates at which the several manures are employed are as follows: wood ashes, 1 ton per acre; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre; manure, 8 tons per acre.

The plot which receives wood ashes one year is the next year manured with bone and potash, and the third year with manure.

The manuring of the several plots is so planned that each year we have one plot under each of the systems of manuring. For the last three years the plots receiving respectively wood ashes and bone and potash have also received nitrate of soda at the rate of 150 pounds per acre. The manure is always applied in the fall; the ashes, and the bone and potash and the nitrate of soda, in early spring.

The past season has been in general favorable to the hay crop, but our yields on this field are lower than usual, chiefly, it is believed, on account of the fact that both the first and second cuttings were made earlier than usual, which, as has been stated, was for the purpose of avoiding ripe weed seeds. The yields of hay, and of rowen, where any was cut, and the totals for each system of manuring, were as follows: —

Fertilizers used.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
On barnyard manure,	2,396	1,805	4,201
On bone and potash and nitrate of soda,	2,661	1,242	3,903
On wood ashes and nitrate of soda,	3,723	–	3,723

The average yield of the entire area for this year is 3,942 pounds; the average for the period 1893 to the beginning of the present year was 6,619 pounds; the average to date, 6,413 pounds. The plots when dressed with manure have averaged 6,655 pounds; when dressed with bone and potash, 6,420 pounds; and when dressed with wood ashes, 6,094 pounds. The average yields for this year, as will be seen, are materially below the general averages. As has been stated, this is undoubtedly accounted for chiefly by the difference in the time of cutting. The average even for this year constitutes a very satisfactory crop, and for the entire period is such as to render the hay crop, at the prices which the manures used cost, a decidedly profitable one.

XI. — Experiment in the Application of Manure.

The experiment now to be reported is in continuation of work begun in 1899. It has for its object to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large heaps, to be spread just before ploughing the land in the spring. A full account of the plan of the experiment will be found in the last annual report. The field contains five plots, one-half of each having the manure spread in winter, the other half put into a large heap and spread in spring. We have, in reality, then, five parallel experiments yearly. In 1901 this field produced a crop of Japanese barnyard millet. After the millet was harvested, the field was ploughed and sown to winter rye, which served as a cover crop. During the past season the field has been in corn for the silo. The soil is naturally cold, and with the cool summer it produced but a small yield. The actual and relative yields of the several plots of rather more than one-fourth acre each are shown in the following table: —

Actual and Relative Yields of Ensilage Corn.

Plots.	Manuring Previous to 1899.	Actual Yields (Pounds).		Relative Yields (Per Cent.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1	Barnyard manure,	5,275	5,480	100	103.9
2	Wood ashes,	4,780	4,650	100	97.3
3	No manure,	2,600	3,900	100	150.0
4	Fine-ground bone and muriate of potash.	4,480	4,105	100	91.6
5	Fine-ground bone and sulfate of potash.	4,905	5,325	100	108.6

In previous years the south half (spring manured) of each plot has without exception given a much superior yield to the north half. This year there are two exceptions: plot 2, where the difference, however, is very small; and plot 4, where there is a difference of 375 pounds in favor of the north or winter-manured half. It must be stated, however, that, owing to unavoidable conditions, one load of the corn on the south half of plot 4 lay upon the ground as it was cut from Saturday night until Monday. There can be no doubt that there was a considerable loss of weight, due to drying. We must not, therefore, attach any special significance to the results upon this plot. The results upon the others are practically confirmatory of the results of previous years. The differences, however, are considerably less. In 1900, the yield of the winter-manured portion of each plot being considered as 100, the yields of the spring-manured portion of the plots varied from 103 to 125. In 1901 the relative yields of the spring-manured plots, on the same basis, varied from 118 to 177. The smaller differences this year are believed to be in part at least a consequence of the fact that the conditions prevailing during the winter of 1901 and 1902 were such that there was much less washing over the surface of the plots, which, it will be remembered, slope lengthwise, than during the two preceding winters. The smaller differences may also be in part due to the unfavorable effects of the season, which prevented entirely normal development on any part of the field. It is believed that our experiments indicate decisively the necessity of greater care than is always taken to avoid spreading manures on slopes during late fall and winter. Our differences in yield this year are not, it is true, sufficiently great to pay for the extra cost of rehandling the manure, which is first piled in the field. During the two past years the differences in crops have been much more than sufficient to pay this extra cost. The experiment will be continued.

XII. — Nitrate of Soda for Rowen.

The present is the third year during which we have conducted experiments for the purpose of determining whether an application of nitrate of soda after the harvest of the first crop of hay will give a profitable increase in the rowen crop. The results for the two preceding years have with one exception on a timothy sod shown an increase more than sufficient to cover the cost of the nitrate and its application. The experiments of this year were carried out upon a timothy sod which was seeded in 1899. This mowing was top-dressed this spring as follows: —

	Pounds per Acre.
Nitrate of soda,	150
Fine-ground bone,	400
Muriate of potash,	200

The product at the first cutting was at the rate of 5,640 pounds of hay per acre.

Eight equal plots were laid out, and on the alternate plots nitrate of soda was applied, — to two at the rate of 150 pounds to the acre, to one at the rate of 200 pounds, and to another at the rate of 250 pounds. The first crop of timothy was cut on July 11 and 14. The nitrate was applied on July 22. The rowen was cut on September 22 and weighed on October 3, in good condition. The rates of yield per acre are shown in the following table: —

Plots.	Fertilizers used.	Pounds.
Plot 1,	No nitrate,	459
Plot 2,	Nitrate of soda, 150 pounds,	826
Plot 3,	No nitrate,	367
Plot 4,	Nitrate of soda, 150 pounds,	789
Plot 5,	No nitrate,	257
Plot 6,	Nitrate of soda, 200 pounds,	1,320
Plot 7,	No nitrate,	587
Plot 8,	Nitrate of soda, 250 pounds,	1,542

The average results were as follows: —

	Pounds.
Average no-nitrate plots,	417.5
Average increase due to application of 150 pounds of nitrate,	390.0
Increase due to application of 200 pounds of nitrate,	902.5
Increase due to application of 250 pounds of nitrate,	1,124.5

The moisture conditions on the different plots of this field, which is of considerable length, are not exactly uniform, being somewhat more favorable toward that end of the field on which the larger applications of nitrate of soda were made. It is believed that this difference in moisture conditions in part accounts for the better apparent effect of the nitrate where applied in the larger quantities. If we determine the increases apparently due to the nitrate by comparison of the yields on plots to which such application was made with the nearest nothing plots only, the apparent effect is as follows: —

	Pounds.
Average increase due to application of 150 pounds of nitrate,	446.5
Increase due to application of 200 pounds of nitrate, . .	898.0
Increase due to application of 250 pounds of nitrate, . .	955.0

All these increases are more than sufficient to cover the cost of the application of nitrate made.

XIII. — Variety Test, Potatoes.

During the past year we have grown, under conditions allowing a fair opportunity for comparison, thirty-three varieties of potatoes. The seed of all varieties was the first generation of our own growing. We included for purposes of comparison an equal area of one of the standard varieties, — Beauty of Hebron, — with seed of the second generation, from northern Maine. We raise our own seed, because it is recognized that the locality in which seed stock is produced and the way in which it is stored and handled has much to do with its productive capacity. We cultivate all varieties of potatoes that we test, therefore, two years, the first year being the preliminary test, made with small quantities of seed gathered from the many different sources from which a list of varieties must be made up. It is the product of this first crop that we use a second year in a final test, the seed of all varieties being stored and handled in precisely the same way. It is the results of this second year's test which are here reported.

The seed tubers planted this year were selected to as nearly as possible an average size of 60 grams in weight for each variety. The tubers were treated with corrosive sublimate in the ordinary way on April 9, and were spread in a light and sunny room in a single layer until May 14, when they were planted, being first cut to pieces of two good eyes each. The pieces were planted 1 foot apart in rows 3 feet apart. The field is one which has been used for a number of years in experiments with corn, in growing which a moderate application of fertilizers alone has been made.

The soil is a medium loam underlaid by gravel, and with perfect natural drainage, — a good potato soil. It received this year an application of manure from milch cows at the rate of 4 cords per acre. A fertilizer mixture was made, containing: —

	Pounds
Nitrate of soda,	80
Dried blood,	100
Dry ground fish,	180
Acid phosphate,	280
High-grade sulfate of potash,	160

This mixture was used in the drill, being scattered widely the full length of the open furrow at the rate of 1,600 pounds per acre. The crop was thoroughly cared for, and sprayed three times with a combined insecticide and fungicide. This application did not prove altogether effective, although there was no rot. Growth was normal, and no signs of blight appeared until early in August. The varieties on which it showed itself previous to August 10 were: All the Year Round, Daughter of Early Rose, Early Carmen, Early Trumbull, Early Eureka, Early Rose, Early Pioneer, Ensign Bagley, Ford 1902, Harvest King, Honoeye Rose Seedling, Northern Beauty, New England Thoroughbred, Sunlight, and Smith's Six Weeks. Those on which it showed itself later than August 20, and which therefore may fairly be considered unusually disease-resistant, were: Livingston, Million Dollar, Mark Hanna, and Smith's '99.

The table shows the dates at which the vines of the several varieties were completely dead, and the rates of yield per acre for each: —

Variety.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
All the Rear Round,	Aug. 5,	165.9	41.5
Arcadia,	Aug. 30,	235.4	12.5
Beauty of Hebron (first generation from Maine seed).	Aug. 30,	315.3	16.6
Beauty of Hebron (second generation from Maine seed).	Aug. 30,	298.7	24.9
Daughter of Early Rose,	Aug. 30,	256.2	35.3
Early Carmen,	Aug. 16,	170.0	23.9

Variety.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
Early Trumbull,	Aug. 20,	242.7	28.0
Early Eureka,	Aug. 20,	232.3	27.0
Early Rose,	Aug. 25,	258.2	36.3
Early Pioneer,	Aug. 20,	185.7	27.0
Early Nancy,	Aug. 30,	273.8	35.3
Ensign Bagley,	Aug. 25,	262.4	50.8
Ford 1902,	Aug. 25,	73.5	13.0
Gem of Aroostook,	–	258.2	51.8
Harvest King,	Aug. 30,	248.9	20.8
Hammond's Wonderful,	Aug. 5,	224.0	22.8
Honoeye Rose Seedling,	Aug. 25,	177.4	31.1
I. X. L.,	Aug. 30,	298.7	53.9
Livingston,	Aug. 30,	161.8	37.3
Million Dollar,	Aug. 30,	265.5	9.3
Mark Hanna,	Aug. 30,	210.5	10.4
Northern Beauty,	Aug. 30,	245.8	47.7
New England Thoroughbred,	Aug. 30,	232.3	60.2
Rough Rider,	Aug. 30,	214.5	43.6
Rose of the North,	Aug. 30,	239.5	41.5
Stevens,	Aug. 25,	148.3	38.4
Steuben,	Aug. 30,	297.7	35.3
Sunlight,	Aug. 25,	224.0	49.8
Smith's Six Weeks,	Aug. 30,	65.3	36.3
Smith's '99,	–	203.3	31.1
The June,	–	77.8	19.7
Twentieth Century,	Aug. 20,	214.7	42.5
White Giant,	Aug. 20,	230.3	8.3

Among these varieties it will be seen that ten give a yield at the rate of over 250 bushels of merchantable tubers per acre. These, mentioned in the order of productiveness, are as follows: Beauty of Hebron (first generation from Maine seed), 315.3 bushels; Beauty of Hebron (second generation from Maine seed), 298.7 bushels; I. X. L., 298.7 bushels; Steuben, 297.7 bushels; Early Nancy, 273.8 bushels; Million Dollar, 265.5 bushels; Ensign Bagley, 262.4 bushels; Early Rose, 258.2 bushels; Gem of Aroostook, 258.2 bushels; Daughter of Early Rose, 256.2 bushels.

Six varieties, as will be seen, gave yields at the rate of between 100 and 200 bushels per acre. These, mentioned in the order of least productiveness, are the following: Stevens, 148.3 bushels; Livingston, 161.8 bushels; All the Year Round, 165.9 bushels; Early Carmen, 170 bushels; Honoeye Rose Seedling, 177.4 bushels; Early Pioneer, 185.7 bushels. Three varieties have given yields at the rate of under 100 bushels merchantable tubers per acre, viz.: Smith's Six Weeks, 65.3 bushels; Ford, 73.5 bushels; The June, 77.8 bushels. The last three varieties would seem beyond a doubt to be very inferior in productive capacity, and probably not worth cultivation. The varieties giving yields at the rate of between 100 and 200 bushels to the acre are, with one exception, well above 150 bushels; and, although giving much below the average yield for this season, they cannot be unreservedly condemned for lack of productiveness.

It may be remembered that in every test of varieties which has been made by this department of the Hatch Experiment Station the Beauty of Hebron and the Early Rose have been included. They have always ranked high in productiveness. This year it will be noticed that the Beauty of Hebron (first generation from Maine-grown seed) stands at the head, that the second generation from Maine-grown seed is next (although equalled by one other variety), and that the Early Rose is only seventh in the list. These facts constitute a striking commentary upon the claims which are usually made for new varieties. It is firmly believed that it is much wiser that potato growers shall secure seed of standard varieties grown and stored under the best conditions, than to pay high prices for new varieties, which in so many instances when carefully tested under the fairest possible conditions are found not to equal the older sorts either in productiveness or in quality. In our experience seed grown in northern Maine has invariably been found to be superior to that of our own production, even in the first generation. The Maine seed gives the larger yield, and the crop is somewhat earlier. It usually costs somewhat more than home-grown seed, but it is richly worth the greater price.

XIV. — Poultry Experiments.

In our experiments with poultry during the past year we have confined our attention almost exclusively to questions connected with the feeding of fowls for eggs. The principal question upon which we are striving to obtain light relates to the proper relation between the different nutrients in the ration fed; or, in other words, it is a question of the best nutritive ratio. During the past year our work has been as follows: —

1. We have compared two rations in one of which corn is prominent, in the other wheat, using beef scraps as the source of animal food, the nutritive ratios being: for the ration including corn, from 1 : 4.25 — 4.74; and in the ration in which wheat is prominent, 1 : 6.25 — 6.45.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food. The nutritive ratio of the ration including wheat has been varied from 1 : 4 — 4.48; for the ration including corn, from 1 : 4.95 — 6.05.

3. We have compared two rations in one of which buckwheat is prominent, in the other corn, with milk albumin as the source of animal food. The nutritive ratio of both these rations has been rather wide, — from about 1 : 5.5 — 6.08.

The most important points to be noted in connection with the results are as follows: —

1. In the comparison of wheat with corn, where beef scraps are the source of animal food, the egg production has been good and nearly equal on the two rations, although the hens receiving the wheat ration have been somewhat the most productive.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food, the egg production has been less satisfactory, and the hens which have received the corn ration have been the more productive.

3. In the comparison of buckwheat and corn, with milk albumin as the source of animal food, the egg yield has been rather small, with the advantage decidedly in favor of the corn.

It may be remembered that, in experiments carried out in 1899 and reported in our annual report for 1900, the comparisons between corn and wheat gave results decidedly in favor of the corn. A similar line of inquiry was continued during the years 1900 and 1901. A number of comparisons were made during these years between rations respectively rich in wheat and in corn, in connection with which in all cases beef scraps were used as the source of animal food. In the experiments of these two years, as in the experiment for this year, where beef scraps are used as the source of animal food the yields are slightly in favor of the wheat. It is not believed that we are yet in position to account for the difference in results made evident by the statements just given; but it is thought that a possible explanation is offered by the fact that in the tests comparing wheat and corn in 1899 animal meal was used as the source of animal food. The principal differences between such animal meal as we have employed and beef scraps are, that the animal meal contains the more mineral matter (undoubtedly derived from bone) and less fat than the scraps. It is the latter point especially which is believed to be significant. Corn is rich in fat; wheat is relatively poor in that constituent. With animal meal as a source of animal food, corn gave the best results. It has given the best results this year where milk albumin (which is still lower in fat than animal meal) is used as the source of animal food. And again, although this is less significant because buckwheat and corn differ from each other in marked degree in the amount of fibre they contain, we find the corn when compared with buckwheat, which is relatively low in fat, with milk albumin as the source of animal food, gives much superior results. It is fully recognized that the conditions determining the egg yield from a flock are numerous, and that the relation between the different nutrients in the rations fed is only one, and possibly by no means the most important, of these conditions. It is, however, believed that the question of the proper combination of nutrients has its importance. It is recognized that the problems arising are difficult; but the investigations will be continued, in the full belief that the results of faithful work will prove of ultimate value.

PUBLIC DOCUMENT . . . . No. 31.

FORTY-FIRST ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

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APPROVED BY
THE STATE BOARD OF PUBLICATION.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 8, 1904.

To His Excellency JOHN L. BATES.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the forty-first annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

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CALENDAR FOR 1904–1905.

Jan. 6, 1904, Wednesday, fall semester resumed, at 8 A.M.
February 3, Wednesday, fall semester ends.
February 4, Thursday, spring semester begins, at 8 A.M.
March 30, Wednesday, to April 5, Tuesday, spring recess.
April 5, Tuesday, spring semester resumed, at 8 A.M.
June 11, Saturday, Grinnell prize examination of the senior class in agriculture.
June 12, Sunday, Baccalaureate sermon.
June 13, Monday, Burnham prize speaking. Flint prize oratorical contest.
June 14, Tuesday, Class-day exercises. Meeting of the alumni. Reception by the president and trustees.
June 15, Wednesday, commencement exercises.
June 16, 17, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Pittsfield; and at Horticultural Hall, Worcester.
September 20, 21, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.
September 22, Thursday, fall semester begins, at 8 A.M.
December 21, Wednesday, to Jan. 4, 1905, Wednesday, winter recess.
January 4, Wednesday, fall semester resumed, at 8 A.M.
February 8, Wednesday, fall semester ends.
February 9, Thursday, spring semester begins, at 8 A.M.
March 29, Wednesday, to April 4, Tuesday, spring recess.
April 4, Tuesday, spring semester resumed, at 8 A.M.
June 21, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

In the history of every institution of learning there comes a time when there must be either advance or retreat. There can be no halting place. Halting is decay, and decay is followed by slipping backward. If the growth has been healthy and normal, a movement forward must necessarily result; classes must increase in size and be divided into sections, in order to teach to the best advantage; new men must be added to the faculty, to provide for additional work; and an increased equipment, with larger and more numerous recitation rooms, must follow. Such a moment has apparently come to the college. For the last ten years the college has been slowly but steadily increasing in numbers, as the accompanying table of freshmen and whole number in college indicates: —

Year.	Number in Freshman Class.	Number in College.
1895,	16	190
1896,	20	133
1897,	27	122
1898,	35	151
1899,	34	161
1900,	42	176
1901,	31	185
1902,	62	224
1903,	54	212
1904,	62	249

From entering classes of 16 we have, then, in ten years nearly quadrupled our numbers, rising to 62, and the increase has been for the most part slow but steady. For the accommodation of our students we have only 12 recitation rooms and 7 laboratories. During this semester we are holding on an average 46 to 52 recitations daily. To add to our perplexities, in the chemical, botanical and entomological laboratories it is very difficult to hold exercises on consecutive hours, because necessarily uncompleted work must be left over. Chemical analyses or investigations by microscope may take three hours or as many days, and during that period to disturb the instrument would be the ruin of the problem. Every class containing over forty requires division, and four or five extra hours must be added to the work of men already overloaded. Even if it were not detrimental to the best interests of a class to have more than 40, we have only two recitation rooms which would accommodate more than that number, and both of these belong to the class above described. They are in effect laboratories.

The $10,000 granted under Resolves of 1883, chapter 46, and Resolves of 1886, chapter 34, is no longer adequate to provide for tuition. With the number of students now attending the college we ought to have $15,000 each year in order to fully compensate us for making tuition free. Technical institutions like our own, and requiring large expenditures in laboratories, charge an annual tuition fee of from $200 to $250; ours is only $120, — a mere pittance when compared with that charged by others. We ask, therefore, that for the purpose of providing the necessary scholarships to make tuition free in this State college, the sum of $15,000 be yearly appropriated, instead of $10,000. We ask this for the following specific reasons: —

1. The departments of physics, chemistry, botany, agriculture, horticulture, meteorology and entomology require a yearly outlay for material and apparatus that we are now unable to grant, from lack of funds; $200 apiece, or $1,600, is a small estimate per year.

2. The increasing number of students and the division of our classes require a number of assistants — three or four

— to enable us to furnish the best instruction and to relieve our present corps of teachers.

3. The growing demand for courses in the care of poultry, instruction in bee culture and the study of vegetable and animal tissue calls for opening short elective courses in those branches of farm life. The enormous extent of the poultry industry is scarcely appreciated, and yet from good authority we learn that during last year there was paid out by the people of Massachusetts more than twenty million dollars for eggs and poultry from outside the State. A petition has come to us, "urging that our plans include a practical, working poultry plant, somewhat after the manner of the one at the Maine station, — something that would be substantial and valuable." In the statistics of 1895 we find the following startling figures for our whole country: —

Total value of dairy products, ...	$454,900,000
Total value of poultry and products, . .	343,000,000

To provide for this inadequacy of revenue to furnish the theoretical and practical education required by its charter, the college asks that 40 additional scholarships, under Resolves of 1886, chapter 34, be established, at an increased annual expenditure of $5,000; and that $5,000 additional be appropriated annually to its income. To supply the lack of room the college asks that a horticultural building be erected and equipped, at a cost not to exceed $40,000, and $1,000 annual maintenance fund. This will provide for the classes in market gardening, horticulture, floriculture, greenhouse management and landscape gardening, and relieve the congested condition of the botanical department. A fine building, 50 by 70 feet, one story and a half on its front and three on its rear, containing laboratory, photographing rooms, landscape gardening and recitation rooms, can be put up for the sum indicated. The building is a necessity. The only room the department now can call its own is the botanical museum, where all specimens have been made useless by being pushed back to the wall to allow room for tables.

The year has in many respects been a hard one. The installation of our heating plant and the delay in completing it prevented our securing coal in the early part of the season, and we were at one time driven almost to the point of closing the college. Reduced to our last two or three tons, and not a ton to be purchased in town at any price, the faculty met to consider the question of closing the college until such time as a supply of coal could be procured. Through the courtesy of Amherst College we were enabled to borrow sufficient to keep our doors open until we could replenish our bins. But our loss was very heavy, the deficit in that one item footing up to $3,500.

The library has entirely outgrown its building. Twenty-eight hundred volumes have been withdrawn from circulation, and by the close of the present college year another thousand volumes of reference or books not frequently called for will have to be added. Another building, fireproof, with stackroom and all the adjuncts that add so much to the serviceableness of a modern library, is imperatively demanded. The present structure, erected in 1885, was built in connection with the chapel, and does not admit of enlargement. It can be utilized by turning it into one large recitation room in the centre, and using the one end for the president's office and records and the other as a practice room for the cadet band. The library should be kept up to the very highest state of efficiency. It is really the pivot on which the whole college turns, and should be the very centre of college life.

On this year expire two appropriations, one of $10,000 first granted by the Legislature of 1889 for four years and continued since by the Legislatures of 1892, 1896 and 1900 for the same period of time. Five thousand dollars of this appropriation was for the establishment of a labor fund, out of which needy students could be paid for labor performed. It would seem as if there could hardly be any question respecting the continuance of this fund. This college was founded, as the words of its charter proclaim, "in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." In this respect it stands unique. It is to promote an education both liberal and practical for the vast industrial class that fills our towns and cities. No command could have been stated more explicitly, nor could any command have been allowed a greater latitude in its interpretation, for it was left to the Legislature of each State to build up its own college in the way that best answered its own special needs. Bearing in mind this central idea of benefiting the industrial classes, we find, as we should naturally expect to find, nearly two-thirds of each class dependent either wholly or in part on the aid received from this fund. We find young men boarding themselves at a total expense of one dollar fifty cents per week, and others who during the same time have not enjoyed the comfort of a single warm meal. A large proportion of our students cannot complete their course without aid of this kind. They are willing to work, if work can only be given them. Our only regret is that the appropriation is not larger.

The other five thousand dollars was to provide the theoretical and practical education required by the charter of the college and the laws of the United States relating thereto. The chairs of English and veterinary science were at once created, and have continued ever since. It would be hard to find two chairs that would be more missed if the appropriation should be withheld.

Second, the appropriation of $8,000 was made in 1900, by chapter 50, and was to cover the general depreciation in stocks and consequent lowering of the college income, and for providing such instruction as was demanded by college charter. It was also made for four years, and the same urgent demand exists for its continuance as there did for its creation. The college cannot exist without it.

It is the policy of the State not to insure its property. For thirty-six years the college has borne that burden, insuring all its buildings, twenty-seven in number. With the establishment of a central heating and lighting plant, the danger from fire in buildings on the west side of the grounds is practically eliminated, and it would therefore seem wise to discontinue the insurance of buildings on the west side of the grounds, but to furnish a night watchman to care for property that has cost the State over a quarter million dollars. On the east and north of the heating and lighting plant are eight buildings that could be easily brought into the same system. In two of these buildings new furnaces are required now, and the third is a new building as yet without heat. Would it not be the part of economy and wisdom to complete the circuit, and heat and light all from the same plant?

Summing up briefly the necessities of the college, we ask for the following sums:—

Horticultural building and equipment,		$38,000
Maintenance fund of same (annual),		1,000
Scholarship fund (annual),		5,000
Insurance,		400
Special maintenance appropriation,		5,000
Deficit on coal,		3,500
Renewal of appropriations of 1900,	Labor,	5,000
	Endowment of two chairs,	5,000
	Maintenance,	8,000

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 8, 1904.

THE CORPORATION.

	TERM EXPIRES
WILLIAM R. SESSIONS of SPRINGFIELD,	1905
CHARLES L. FLINT of BROOKLINE,	1905
WILLIAM H. BOWKER of BOSTON,	1906
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J. HOWE DEMOND of NORTHAMPTON,	1907
ELMER D. HOWE of MARLBOROUGH,	1907
NATHANIEL I. BOWDITCH of FRAMINGHAM,	1908
WILLIAM WHEELER of CONCORD,	1908
ELIJAH W. WOOD of WEST NEWTON,	1909
CHARLES A. GLEASON of NEW BRAINTREE,	1909
JAMES DRAPER of WORCESTER,	1910
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MERRITT I. WHEELER of GREAT BARRINGTON,	1911
CHARLES H. PRESTON of DANVERS,	1911

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STATE BOARD OF AGRICULTURE.

* The president of the college is ex officio a member of each of these committees.

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JOHN BURSLEY (*Chairman*), . .	of West Barnstable.
C. K. BREWSTER, ...	of Worthington.
W. C. JEWETT, ...	of Worcester.
ARTHUR A. SMITH, . . .	of Colrain.
CHARLES H. SHAYLOR, . .	of Lee.

The Faculty.

HENRY H. GOODELL, LL.D., *President,*
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

JOHN ANDERSON, Captain, U. S. A.,
Professor of Military Science and Tactics.

FRANK A. WAUGH, M.S.,
Professor of Horticulture and Landscape Gardening.

RICHARD S. LULL, Ph.D.,
Associate Professor of Zoölogy.

PHILIP B. HASBROUCK, B.S.,
Associate Professor of Mathematics.
Adjunct Professor of Physics.

HERMAN BABSON,* M.A.,
Assistant Professor of English.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

LOUIS R. HERRICK, B.Sc.,
Instructor in Modern Languages.

HOWARD L. KNIGHT, B.Sc.,
Instructor in English.

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* Absent on leave.

GEORGE F. FREEMAN, B.Sc.,
Instructor in Botany.

GEORGE O. GREENE, M.S.,
Instructor in Horticulture.

FRANCIS CANNING,
Instructor in Floriculture.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law.

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, Ph.D.,
Registrar.

ELISHA A. JONES, B.Sc.,
Farm Superintendent.

Graduates of 1903.*

Doctor of Philosophy.

Morrill, Austin Winfield, . . .	Tewksbury.

Bachelor of Science.

Allen, William Etherington, . . .	Winthrop.
Bacon, Stephen Carroll, . . .	Leominster.
Barrus, George Levi, ...	Goshen.
Bowen, Howard Chandler (Boston Univ.),	Rutland.
Brooks, Philip Whitney (Boston Univ.),	Cambridge.
Cook, Joseph Gershom, . . .	Clayton.
Franklin, Henry James (Boston Univ.), .	Bernardston.
Halligan, Charles Parker, . . .	Roslindale.
Harvey, Lester Ford, ...	Woodbury, Conn.
Hood, William Lane (Boston Univ.), .	Vandiver, Ala.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1903.

Jones, Gerald Denison (Boston Univ.), .	South Framingham.
Lamson, George Herbert (Boston Univ.),	East Hampton, Conn.
Monahan, Neil Francis, ...	South Framingham.
Nersessian, Paul Nerses (Boston Univ.),	Marash, Turkey.
Osmun, Albert Vincent (Boston Univ.), .	Danbury, Conn.
Parsons, Albert, ...	North Amherst.
Peebles, William Warrington, . .	Washington, D. C.
Poole, Elmer Myron (Boston Univ.), .	North Dartmouth.
Proulx, Edward George, . . .	Hatfield.
Robertson, Richard Hendrie, . . .	Somerville.
Snell, Edward Benaiah, ...	Lawrence.
Tinkham, Charles Samuel, . . .	Roxbury.
Tottingham, William Edgar, . . .	Bernardston.
Tower, Winthrop Vose, ...	Melrose Highlands.
West, Myron Howard (Boston Univ.), .	Belchertown.
Total, ...	26

Senior Class.

Ahearn, Michael Francis, . . .	Framingham.
Back, Ernest Adna, ...	Florence.
Blake, Maurice Adin, ...	Millis.
Couden, Fayette Dickinson, . . .	Amherst.
Elwood, Clifford Franklin, . . .	Green's Farms, Conn.
Fahey, John Joseph, ...	Pittsfield.
Fulton, Erwin Stanley, ...	Lynn.
Gay, Ralph Preston, ...	Stoughton.
Gilbert, Arthur Witter, ...	Brookfield.
Gregg, John William, ...	South Natick.
Griffin, Clarence Herbert, . . .	Winthrop.
Haskell, Sidney Burritt, ...	Southbridge.
Henshaw, Fred Forbes, ...	Templeton.
Hubert, Zachary Taylor, . . .	Pride, Ga.
Newton, Howard Douglas, . . .	Curtisville.
O'Hearn, George Edmund, . . .	Pittsfield.
Parker, Sumner Rufus, ...	Brimfield.
Peck, Arthur Lee, ...	Hartford, Conn.
Quigley, Raymond Augustine, . .	Brockton.
Raymoth, Reuben Raymond, . . .	Goshen.
Staples, Parkman Fisher, . . .	Westborough.
White, Howard Morgan, . . .	Springfield.
Total, ...	22

Junior Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Barnes, Hugh Lester,	Stockbridge.
Bartlett, Francis Alonzo,	Belchertown.
Carter, Chester Merriam,	Leominster.
Craighead, William Hunlie,	Boston.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Amherst.
Gardner, John Joseph,	Milford.
Goodenough, Herbert Harold,	Worcester.
Hall, Jr., Arthur William,	North Amherst.
Hatch, Walter Bowerman,	Falmouth.
Hill, Louis William Barlow,	Greenfield Hill, Conn.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Amherst.
Hutchings, Frank Farley,	South Amherst.
Ingham, Norman Day,	Granby.
Kelton, James Richard,	Orange.
Ladd, Edward Thorndike,	Winchester.
Lewis, Clarence Waterman,	Melrose Highlands.
Lyman, John Franklin,	Amherst.
Merrill, Jr., Charles Edward,	Melrose.
Munson, Willard Anson,	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
Patch, George Willard,	Lexington.
Paul, Augustus Russell,	Framingham.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Swain, Allen Newman,	New Dorchester.
Taylor, Albert Davis,	Westford.
Tinkham, Henry Buffinton,	South Swansea.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth,	Natick.
Whitaker, Chester Leland,	Somerville.
Williams, Percy Frederic,	Natick.
Willis, Grenville Norcott,	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	39

Sophomore Class.

Abbott, Chester Denning,	Andover.
Bacon, Roland Aldrich,	Leominster.
Baird, Clarence Henry,	Holyoke.
Brett, Clarence Elmer,	Brockton.
Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.
Cutter, Frederick Augustus,	Pelham, N. H.
Farrar, Allan Dana,	Amherst.
Ferren, Frank Augustus,	Peabody.
Filer, Harry Burton,	Belchertown.
Foster, Samuel Cutler,	Boston.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Goodale, Ray Coit,	Suffield, Conn.
Hartford, Archie Augustus,	Westford.
Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hersem, Elbert Wood,	Westborough.
Hood, Clarence Ellsworth,	Millis.
Jones, Louis Franklin,	Somerville.
Kennedy, Frank Henry,	South Boston.
Mahoney, Francis Watson,	Boston.
Martin, James Edward,	Brockton.
Morse, Stanley Fletcher,	Watertown.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
O'Neil, William James,	Ayer.
Paige, George R.,	Amherst.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civille,	Natick.
Prenn, Joseph,	Amherst.
Racicot, Jr., Arthur Alphonse,	Lowell.
Rogers, Stanley Sawyer,	Boston.
Russell, Henry Merwin,	Bridgeport, Conn.
Scott, Edwin Hobart,	Cambridge.
Shannon, Alonzo Henry,	Amherst.
Sleeper, George Warren,	Swampscott.
Spurr, Fred Yerxa,	Melrose Highlands.

Stevens, Frederick Oramel,	Amherst.
Strain, Benjamin,	Mt. Carmel, Conn.
Suhlke, Herman Augustus,	Leominster.
Sullivan, Patrick Francis,	Amherst.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tinker, Clifford Albion,	West Tremont, Me.
Tirrell, Charles Almon,	Plainfield.
Walsh, Thomas Frederick,	Ayer.
Watkins, Fred Alexander,	Hinsdale.
Webb, Paul,	Hamden, Conn.
Wellington, Richard,	Waltham.
White, Vernon Ollise,	Attleborough.
Wholley, Michael Francis,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Wood, Herbert Poland,	Hopedale.
Total,	56

Freshman Class.

Alley, Harold Edward,	Newburyport.
Amsden, Eugene Charles,	West Gardner.
Armstrong, Arthur Huguenin,	Hyde Park.
Barlow, Waldo Darius,	Southbridge.
Bartlett, Earle Goodman,	Chicago, Ill.
Brydon, Robert Parker,	Lancaster.
Caruthers, John Thomas,	Columbia, Tenn.
Chace, Wayland Fairbanks,	Middleborough.
Chadwick, Clifton Harland,	Cochituate.
Chapman, Joseph Otis,	East Brewster.
Chapman, William Spaulding,	Attleborough.
Clark, Jr., Milford Henry,	Sunderland.
Clementson, Lewis Towland,	Millbury.
Cowles, Edward Russell,	Deerfield.
Curtis, Jesse Gerry,	South Framingham.
Curtis, Walter Leon,	Scituate.
Dearth, George Augustus,	Sherborn.
Denham, Edwin Tirrell,	Rockland.
Dickinson, Walter Ebenezer,	North Amherst.
Dudley, Fred Samuel,	Montague.
Eastman, Jasper Fay,	Townsend.
Engstrom, Nils,	Lancaster.

Finkelstein, David Elias,	Philadelphia, Pa.
French, Vida Rachel,	Amherst.
Gould, Harry Wheeler,	Millbury.
Green, Herbert Henry,	Spencer.
Hall, Jr., Walton,	Marshfield.
Hanson, Stuart Waldo,	Boston.
Higgins, Arthur William,	Westfield.
Jones, Arthur Merrick,	Ludlow.
Kalina, Jacob,	New York, N. Y.
King, Clinton,	Easton.
Knox, Harry Cobb,	Roxbury.
Larned, Adelbert Joseph,	Amherst.
Leighton, Carl,	Lowell.
Leominster, William,	Long Plain.
Lincoln, Ernest Avery,	Fall River.
Livers, Susie Dearing,	Boston.
Marran, Bernerd James,	Great Barrington.
Parker, Charles Morton,	Newtonville.
Perkins, Edward Cook,	Springfield.
Peters, Frederick Charles,	Lenox.
Philbrick, Edwin Daniels,	Somerville.
Pierce, Henry Tyler,	West Millbury.
Pray, Rutledge Peyton,	Natick.
Raitt, John Archibald,	New York, N. Y.
Rice, Charles Arthur Allenham,	Springfield.
Russell, Herbert Osborne,	North Hadley.
Searle, George Whitney,	Westfield.
Shaw, Chester Linus,	Brockton.
Shaw, Edward Houghton,	Belmont.
Shaw, Frank Elmer,	Brockton.
Shuttleworth, Edwin Lewis,	Lawrence.
Smith, George Franklin,	Barre.
Stoddard, Calder Sankey,	Canton.
Summers, John Nicholas,	Campello.
Thompson, Clifford Briggs,	Halifax.
Walker, James Hervey,	Greenwich Village.
Watts, Ralph Jerome,	Littleton.
Whitney, John Frank,	Dana.
Total,	60

Two-Years Course.

Hunt, Justine,	Newton.
Total,	1

Short Winter Courses

Bailey, Norman F.,	Pittsfield.
Blessing, John M.,	Albany, N. Y.
Carlson, Axel Robert,	Cambridge.
Clark, Albert Phillips,	Pittsfield.
Colburn, Ned Springer,	Haverhill.
Cooke, Ernest Hubbard,	Austerlitz, N. Y.
Dorling, Samuel William,	Spencer.
Dwight, Daniel Hunt Miller,	Brewster.
Eaton, Hovey Damon,	North Reading.
Folsom, Sara Elizabeth,	Revere.
Gage, William Allen,	Crown Point, N. Y.
Gerber, Nelson,	Webster.
Gilbert, Solon Mowry,	Auburn.
Goold, James,	Albany, N. Y.
Kilbon, Marshall Edwards,	Oberlin, Ohio.
King, George William,	Dudley.
Kohles, Herman,	Fitchburg.
Lord, Jr., Edward Oliver,	Allston.
MacDonald, Raymond Lewis,	Medway.
Macomber, Walter White,	Sturbridge.
Miller, Fred,	East Walpole.
Mower, John Laidlaw,	Litchfield, Conn.
Ramsdell, Elmer Pitts,	West Newton.
Rogers, Harry Fred,	Westborough.
Scott, Richard,	Shrewsbury.
Sonoda, Takeshi,	Boston.
Stygles, Clarence Heaman,	Hyde Park, Vt.
Williamson, Oran Ethan,	Altamont, N. Y.
Total,	28

Graduate Courses.

For Degrees of M.S. and Ph.D.

Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.	
Hodgkiss (B.Sc., M. A. C., '02), Harold Edward,	Wilkinsonville.	
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.	
Knight (B.Sc., M. A. C., '02), Howard Lawton,	Gardner.	
Osmun (B.Sc., M. A. C., '03), Albert Vincent,	Danbury, Conn.	
Tottingham (B.Sc., M. A. C., '03), William Edgar,	Bernardston.	
West (B.Sc., M. A. C., '02), David Nelson,	Northampton.	
Total,		7

Special Students.

Mills, Mabelle Ingalls Lovejoy,	Amherst.	
Russell, Ida Josephine,	Amherst.	
Spaulding, Olive Mary,	Mapleton, Conn.	
Total,		3

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	7	
Four-years course: —		
Graduates of 1903,	26	
Senior class,	22	
Junior class,	39	
Sophomore class,	56	
Freshman class,	60	
Two-years course,	1	
Winter courses,	28	
Special students,	3	
Total,		242
Entered twice,		3
Total,		239

OBJECT.

The leading object of the Massachusetts Agricultural College is "to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

GRADUATE COURSES.

In response to the increasing demand for advanced work in various directions, the college has arranged for courses of study leading to the degrees of Master of Science and Doctor of Philosophy.

Honorary degrees are not conferred.

Applicants are not eligible to the degree of Master of Science or Doctor of Philosophy until they have received the degree of Bachelor of Science or its equivalent.

The fee for the degree of Master of Science is ten dollars and for the degree of Doctor of Philosophy twenty-five dollars, to be paid to the treasurer of the college before the degree is conferred.

Courses for the Degree of Master of Science.

A course of study is offered in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary medicine. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

Candidates for the degree of Master of Science must devote not less than one year and a half after graduation to the prosecution of two studies for the degree, one year of which must be in residence at the Massachusetts Agricultural College.

Courses for the Degree of Doctor of Philosophy.

The establishment of courses leading to this degree is the result of many calls for advanced study along certain economic lines neglected in most American universities, and is given only by those departments especially equipped for this grade of study, to graduates of this college or other colleges of good standing. The work required for the degree is intended to be so advanced in its character as to necessitate the greatest industry to complete it, with the belief that such severe requirements will result in the greatest credit to those who are successful. Four courses of study only are therefore open, viz., botany, chemistry, entomology and horticulture as major subjects, though a minor in zoölogy is also available.

At least three years are necessary to complete the work required; twenty hours per week to be devoted to the major subject, while from twelve to sixteen hours per week are required for each of the two minor subjects during one and a half years.

The work in the major and minors will necessarily differ with the previous training and needs of different students, but a general outline of the major in each subject is as follows: —

Botany. — Vegetable physiology, vegetable pathology, mycology, œcology, taxonomy, phylogeny, the history of botany, and the history and theory of evolution. The above subdivisions of botany will be, to a greater or less extent, pursued as necessitated by the previous training of the student and nature of the original problem undertaken. In this course it is also recommended that the student take, in addition to this prescribed minor work, a brief course in the history of philosophy and psychology, which at present will have to be provided elsewhere. Extensive reading of botanical literature, of both a general and specific nature, will be required in certain subjects, and occasional lectures will be given. A botanical conference is held monthly, wherein various new problems touching upon botanical science are considered by graduate students and those of the senior class electing botany. A thesis dealing with some economic problem in plant physiology or pathology, or both, and containing a distinct contribution to knowledge, will also be required.

Chemistry. — Advanced work in the following subjects: inorganic analysis, qualitative, of the rarer elements, and quantitative; crystallography; physical chemistry; descriptive and determinative mineralogy; chemical geology; soil formation; soil physics and chemistry; gas analysis; synthetic inorganic work; chemical theory and history; general organic chemistry; special topics in organic chemistry; elementary quantitative organic analysis; proximate qualitative and quantitative organic analysis, including determination of organic radicles; organic synthesis of aliphatic and aromatic compounds; problems in chemical manufacture; recent chemistry of plant nutrition; animal physiological and pathological chemistry, including foods, standards for feeding of all kinds, and, among secretions, milk and milk industries, and, among excretions, urine and urinalysis; toxicology; insecticides and fungicides; frequent examinations on current chemical literature.

Early in the course original work on some chemical subject pertaining to agriculture must be begun. The history and results of this work must be submitted before graduation, in the form of a thesis containing a distinct contribution to knowledge.

Entomology. — General morphology of insects: embryology; life history and transformations; histology; phylogeny and relation to other arthropods; hermaphroditism; hybrids; parthenogenesis; pædogenesis; heterogamy; chemistry of colors in insects; luminosity; deformities of insects; variation; duration of life.

Œcology: dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects, insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases; photography of insects and their work; methods of drawing for illustrations; field work on insects, and study of life histories; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

Journal club: assignments of the literature on the different groups of insects to different students, who report at monthly meetings summaries of all articles of value which have appeared during the month.

Required readings of the best articles on the various topics named above, and on the different orders of insects. This reading covers from 15,000 to 20,000 pages in English, French and German, and the candidate is examined on this, together with his other work, at the close of his course.

Thesis: a thesis with drawings, which shall consist of the results of original investigations along one or several lines, and which shall constitute a distinct contribution to knowledge, must be completed and accepted before the final examinations are taken.

Horticulture. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation, and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote himself continuously to it. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects. Advanced work will be required in the following subjects: systematic pomology, pomological practice, commercial pomology; systematic, practical and commercial olericulture; greenhouse plants and problems; floriculture; landscape gardening; plant breeding and general evolution; and questions of a physiological nature connected with propagation and pruning.

Other requirements and opportunities are: (1) periodical seminars with special lectures, by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits to orchards, gardens, greenhouses, estates and libraries outside the college grounds, always with some definite purpose in view; (4) and, finally, the preparation and publication of a thesis setting forth the results of the candidate's major study, which shall be an original and positive contribution to horticultural knowledge.

FOUR-YEARS COURSES.

Degree.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni, provided that the candidate, in addition to the college course, shall have mastered in a preparatory school a three-years preparatory course in studies beyond those commonly presented in the grammar schools of Massachusetts.

Admission.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Certificates. — Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

Examinations. — Candidates for admission to the freshman class will be received on certificate, as explained above, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen —

set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1904 and 1905 are: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Tennyson's "The Princess;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1904 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 16 and 17, and on Tuesday and Wednesday, September 20 and 21, as follows: —

First Day.	*Second Day.*
8.30 A.M. — Registration.	9 A.M. — Civil government.
9 A.M. — English.	10 A.M. — Algebra.
11 A.M. — General history.	2 P.M. — Physiology.
2 P.M. — Geometry.	3 P.M. — Physical geography.

Entrance examinations in June will be held on the same days and in the same order as in Amherst, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston, at Horticultural Hall, Worcester, and at Pittsfield, but candidates may be examined and admitted at any other time in the year.

ENTRANCE EXAMINATION PAPERS USED IN 1903.

The standard required is 65 per cent. on each paper.

Algebra.

1. $\begin{cases} \text{Factor } (7x+3)^2-(5x-4)^2. \\ \text{Factor } 152+11x-x^2. \end{cases}$

2. Simplify $\dfrac{\frac{1}{x}-\frac{2}{x^2}-\frac{3}{x^3}}{\frac{9}{x}-x}$.

3. Find cube root of expression

$$\frac{6b}{a}+\frac{6a}{b}-7+\frac{a^3}{b^3}-\frac{3a^2}{b^2}-\frac{3b^2}{a^2}+\frac{b^3}{a^3}.$$

4. Express with positive exponents and reduce to lowest terms

$$\left\{\frac{a^{-3}}{b^{-2/3}c}\right\}^{-\frac{3}{2}}\div\left\{\frac{(\sqrt{a^{-1/2}})\,(\sqrt[6]{b^3})}{a^2c^{-1}}\right\}^{-2}$$

5. Find the square root of the binomial surd $83+12\sqrt{35}$.

6. $x^{-1/2}+x^{-1/4}=6$. Solve for x.

7. $\left\{\begin{array}{l} x^3+y^3=407. \\ x+y=11. \end{array}\right\}$ Solve for x and y.

8. $\left\{\begin{array}{r} \frac{1}{x^2}+\frac{1}{y^2}=\frac{61}{900} \\ xy=30 \end{array}\right\}$ Solve for x and y.

Geometry.

1. The area of an equilateral triangle is $9\sqrt{3}$. Find its side.

2. The perimeter of a regular hexagon circumscribed about a circle is $12\sqrt{3}$. What is the circumference of the circle?

3. Prove that two triangles having an angle of one equal to an angle of the other, are to each other as the products of the sides including the equal angles.

4. Prove that if two chords be drawn through a fixed point within a circle, the product of the segments of one chord is equal to the product of the segments of the other.

5. A parallel to one side of a triangle divides the other two sides proportionately. Prove only when the segments of each side are incommensurable.

Physical Geography.

1. Give the causes of the wind. What is a tornado? a cyclone? a typhoon?

2. Define a river terrace; a delta; a flood plain; a waterfall.

3. Explain the rain; dew; frost; hail.

4. Give two causes of mountain formation and examples of each. What causes an earthquake? a volcanic eruption?

5. Explain the cause of a spring; a geyser; an artesian well.

Civil Government.

1. Define the following: civil government, municipal government, a franchise, a charter, a veto, the writ of habeas corpus.

2. Name the three kinds of colonial government found in North America before the revolution. Show how they differed, and name the colonies that were under each.

3. Where and in what year was the Constitution of the United States framed? In what year did it go into effect? Name any

of the objects for which the people ordained and established the Constitution.

4. What qualifications must a man have that he may be —

(*a*) A voter in Massachusetts?

(*b*) A United States Senator?

(*c*) A President of the United States?

5. What is a direct tax, and how is the amount of each citizen's tax determined? What is an indirect tax? Give an example. Why should a citizen who has no children be taxed for the support of public schools?

6. Write on the following subjects, developing each in your own way, and aiming at clearness and accuracy of statement: —

(*a*) The Legislature of Massachusetts.

(*b*) The Supreme Court of the United States.

(*c*) Government ownership and control of the coal mines in Pennsylvania.

Physiology.

1. Describe the heart; explain the pulse; describe a red blood corpuscle.

2. Name the bones bounding in any way the mouth. Give the microscopic structure of bone.

3. Locate the kidney; what is its outlet? what its function?

4. Locate the pancreas, and give its function; also the liver and the epidermis.

5. Give the layers of the skin; describe a sweat gland; an oil gland; and the structure of a hair.

General History.

1. *Ancient History.*

(*a*) Distinguish broadly between the three families of the white race, the Hamitic, the Semitic and the Aryan.

(*b*) Write a few words upon the classes of society in ancient Egypt, and upon the Egyptians' worship of animals.

(*c*) Tell the story of the Trojan war.

(*d*) State briefly for what the following Romans are to be remembered: Coriolanus, Regulus, Cataline, Cæsar, Mark Antony, Cicero, Nero.

2. *Mediæval History.*

(*a*) What was the Teutonic influence, as compared with the classical and the Hebrew, which helped to form mediæval and later on modern European civilization?

(*b*) Who were the Anglo Saxons? the Normans? In what way were they connected with the early history of England?

(*c*) One of the mediæval institutions of the church was monasticism. Explain briefly what this was, and what great good it performed.

3. *Modern History.*

(*a*) Give a brief account of some of the early explorers of the new world, and also state what European nations took the lead in early voyages of discovery and colonization.

(*b*) What was Puritanism, in what European country did it find its firmest supporters, and in what way was the movement related to the early history of our country?

(*c*) Name the wars in which the United States has engaged, state the approximate dates and the underlying causes.

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper. The time allowed is two hours.

1. Choose two of the following topics, and write clearly and interestingly upon them. Let each essay be about two hundred words in length.

(*a*) Shakespeare's early days.
(*b*) Shakespeare in London.
(*c*) Goldsmith: the man and the writer.
(*d*) Scott's place in English Literature.
(*e*) An outline of Tennyson's life.
(*f*) Lowell and the Mexican war.
(*g*) Lowell's life in Cambridge.
(*h*) George Eliot's early life.
(*i*) An outline of George Eliot's life.

2. Choose any five from the following list of subjects, and write a paragraph or two on each subject chosen. Give title in each case.

(*a*) Shakespeare's attitude toward the Jew, as shown in "The Merchant of Venice."

(*b*) Some interesting characters in Goldsmith's "The Vicar of Wakefield."

(*c*) Relations of the Norman and the Saxon, as depicted in Scott's "Ivanhoe."

(*d*) The enduring lesson of Tennyson's "The Princess."

(*e*) The relation between the nature pictures and the story in Lowell's "The Vision of Sir Launfal."

(*f*) A comparison of the two brothers, Godfrey Cass and Dunstan Cass, in George Eliot's "Silas Marner."

COURSES OF INSTRUCTION FOR THE DEGREE OF BACHELOR OF SCIENCE.

Agriculture.

Introductory: relations of federal and state governments to agriculture, four lectures, history of agriculture, tenure of land, rents, holdings, etc., six lectures.

Freshman year, first semester, three hours a week required. Animal breeding: Shaw's "Breeding Animals," lectures and discussion of principles of breeding. — Assistant Professor Cooley.

Sophomore year, seven weeks, first semester, four exercises a week in class room required. Breeds of farm live stock, sheep, cattle: lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, nine weeks, first semester, four exercises a week in class room required. Horses and swine: lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, eight weeks, second semester, three hours a week required. Dairying: lectures on dairy farming, milk production, handling and marketing of milk, milk preservation and modification, and products of milk. Text-book, Wing's "Milk and its Products." — Assistant Professor Cooley.

Sophomore year, ten weeks, second semester, required. Soils: formation, classification, composition; physical and chemical characteristics, and their relations to maintenance and increase in productiveness. Brooks's "Agriculture," Vol. I., supplemented by lectures and laboratory work. — Professor Brooks.

Junior year, ten weeks, first semester, elective. Methods of soil improvement, including tillage, drainage and irrigation. Brooks's "Agriculture," Vol. I., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Manures: production, composition, properties, adaptation and use. Brooks's "Agriculture," Vol. II., supplemented by lectures and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Stock judging. — Assistant Professor Cooley.

Junior year, second semester, elective. Fertilizers, including a critical study of their production, composition, properties, adaptation and use; and green manuring. Brooks's "Agriculture," Vol. II., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Senior year, four weeks, first semester, four hours a week, elective. Silos and ensilage: historical development; the merits and methods of construction of the different kinds of silos; the crops suited for ensilage; ensilage machinery; the methods of filling the silo; and the nature and extent of the changes taking place in ensilage as affecting food value. Lectures, books of reference and practical exercises. — Professor Brooks.

Senior year, seven weeks, first semester, four hours a week, elective. Feeding animals: principles of digestion and animal nutrition, a study of feeding stuffs (coarse and concentrated). The relation of food to product; compounding rations. Armsby's "Cattle Feeding," lectures and discussion. — Assistant Professor Cooley.

Senior year, seven weeks, first semester, four hours a week, elective. Dairying: selection and management of the dairy farm, dairy cattle, chemical and physical properties of milk, etc., cream, butter, cheese and by-products. — Assistant Professor Cooley.

Senior year, first and second semester, two exercises a week, for ten weeks. Dairy practice: use of separators, Babcock tester, butter making, etc. — Specialists.

Senior year, second semester, elective. The crops of the farm and crop rotation; including a study of the origin and agricultural botany of all the leading crops of the farm; annual forage crops, grasses and legumes, cereals, root crops, vegetables, tobacco and other special commercial crops; the production and use of each, the varieties and methods of improvement, the adaptation to soil, the special manurial requirements and the methods of raising and harvesting are considered. Lectures, reference books and field work. — Professor Brooks.

Senior year, second semester, elective. Agricultural experimentation: objects, methods, sources of error; interpretation of results. Lectures and study of reports, bulletins, etc. — Professor Brooks.

Senior year, second semester, elective. Farm management: selection of the farm, its subdivisions and equipment, buildings, fences, roads, water supply; farm capital, permanent, perishable and floating; the labor of the farm and its management, farm power and farm machinery. Lectures and practical exercises. — Professor Brooks.

Seminar courses, by arrangement, for advanced students.

Special problems requiring experiment or other research investigation will be assigned to students fitted for and desiring such work.

Training and practice in the use of farm implements and machines by arrangement when desired.

Horticulture.

This department endeavors to give the student a working knowledge of horticulture on its practical and on its scientific side. The attempt is made to inculcate a taste and an enthusiasm for horticultural pursuits, in place of distaste and dislike for the drudgery of farm life. On these things success and further progress chiefly depend.

The courses now offered are as follows, though others will be added as occasion requires: —

1. Sophomore class, second semester. The fundamental operations of horticulture, — propagation, pruning and cultivation, — as related to the physiology of the plant. During the first half of this course Bailey's "Nursery Book" is used as a text. — Mr. Greene.

2. Junior year, first semester. Pomology: this course covers the three natural divisions of the subject, viz.: (*a*) systematic pomology, or the study of the fruits themselves; (*b*) practical pomology, or the practice of fruit growing; (*c*) commercial pomology, or the principles underlying the marketing of fruits. The course is pursued by means of text-books, lectures, laboratory and field exercises. — Mr. Greene.

3. Junior year, first semester, four periods weekly. Plant breeding: based on a thorough examination of the laws of heredity and of variation, and of the principal theories of evolution. Lectures, accompanied by practice and direct experiments in crossing and hybridizing plants. — Professor Waugh.

4. Junior year, second semester, four periods weekly. Market gardening, including vegetables and small fruits; locations, soils, methods of cultivation and marketing. Text-book, Bailey's "Principles of Vegetable Gardening;" lectures and field exercises. — Mr. Greene.

5. Individual problems will be assigned to seniors who elect horticulture. This gives the student an opportunity for specialization in various lines of fruit growing, vegetable culture, greenhouse management, landscape gardening, etc. — Professor Waugh, Mr. Greene and Mr. Canning.

A seminar made up of all students electing advanced work in horticultural or landscape gardening meets at regular intervals for the discussion of any matters pertaining to the subject. Successful and noted horticulturists from outside the college are frequently present at these meetings, to speak on the topics with which they are especially identified.

Landscape Gardening.

The college wishes to promote the work in landscape gardening in every way possible. The aim of the courses is to give the general student an understanding of the fundamental principles of design and of good taste, as applied to gardening; and to prepare advanced students for the practice of landscape gardening in its various branches.

Although a variety of other work along related lines is available, the courses now definitely offered are as follows: —

1. Junior year, four periods weekly. Materials: this course is designed to give the student an intimate acquaintance with the trees, shrubs and other plants used in landscape gardening. — Professor Waugh and Mr. Canning.

2. Junior year, second semester, four hours a week. Elements of landscape design: the fundamental principles underlying the artistic development of parks, estates, gardens and other areas, together with some of the simpler applications to practical conditions. During the first half of the term Waugh's "Landscape Gardening" will be used as a text. — Professor Waugh.

3. Senior year, first and second semesters, four laboratory periods weekly. Advanced landscape gardening: lectures, conferences, field exercises and extensive practice work, with criticism. The student is given definite problems to solve, these problems being arranged in such an order as to develop the subject logically in the student's mind. — Professor Waugh and Mr. Canning.

Chemistry.

This course aims to inculcate accurate observation, logical thinking, systematic and constant industry, together with a comprehensive knowledge of the subject. Instruction is given by text-book, lectures and a large amount of laboratory work under adequate supervision. The laboratory work at first consists of a study of the properties of elementary matter, analysis of simple combinations and their artificial preparation; this is followed by a quantitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products. The advanced instruction takes up the chemistry of various manufacturing industries, especially those of agricultural interest, such as the production of sugar, starch and dairy products; the preparation of animal and plant foods, their digestive assimilation and economic use; the official analysis of fertilizers, fodders and foods; and the analysis of soils, waters, milk, wine and other animal and vegetable products.

The courses are as follows: —

Freshman year, second half of second semester, four hours a week. General chemistry, part 1: principles of chemistry; non-metals. Newth's "Inorganic Chemistry." — Assistant Professor HOWARD.

Sophomore year, first semester, six hours a week. General chemistry, part 2: metals. — Assistant Professor HOWARD.

Second semester, five hours a week. Subject continued: dry analysis. — Assistant Professor HOWARD.

Junior year, first semester, eight hours a week. Qualitative and quantitative analysis; organic chemistry. Four hours a week, special subject. — Professor WELLINGTON.

Second semester, ten hours a week. Organic chemistry. Remsen's "Organic Chemistry." Five hours a week, special subject. — Professor WELLINGTON.

Senior year, elective, first semester, three hours a week. Chemical industries. — Professor GOESSMANN.

Eight hours a week, quantitative analysis and physical chemistry. Reychler-McCrae's "Physical Chemistry." — Professor WELLINGTON and Assistant Professor HOWARD.

Second semester, eight hours a week. Advanced work, with lectures. — Professor WELLINGTON.

GEOLOGY.

1. Mineralogy, junior year, first semester, seven weeks, three hours a week. A course of systematic determinative mineralogy, based on Brush's "Manual." This work is carried on in the laboratory, and consists in determining the minerals by a study of lustre, fusibility, hardness, color, streak, specific gravity, etc., and by some of the simpler chemical tests. — Assistant Professor HOWARD.

2. Geology, junior year, second semester, eleven weeks, three hours a week. Dynamical, structural and historical geology, based upon recitations assigned from Scott's "Introduction to Geology." Topics in economic geology are also assigned, mainly from Tarr's "Economic Geology," to each member of the class in turn, upon which the student is expected to report. Ample opportunity for illustration is afforded by the museum collection and excursions in the Connecticut valley. — Professor LULL.

Zoölogy.

1. Anatomy and physiology, freshman year, one-half of the second semester, four hours a week. Martin's "The Human Body" (advanced course) is used as a text-book, from which recitations are assigned, supplemented by lectures and demonstrations, illustrated by means of anatomical models and charts. — Professor Lull.

2. Zoölogy, sophomore year, first semester, one lecture and recitation and one laboratory period each week. This course aims to give a brief general survey of the animal kingdom, and consists of a series of laboratory studies of a number of different types illustrative of the principal groups, supplemented by a lecture course amply illustrated by the very complete museum collection. Recitations, both oral and written, are assigned upon the knowledge gained in the laboratory, from the lectures, and from Parker and Haswell's "Manual of Zoölogy." — Professor Lull.

3. Zoölogy, junior year (elective for students in the biological course), first semester, four exercises of two hours each; second semester, three exercises of two hours each. A course in systematic zoölogy, based upon Parker and Haswell's "Text-book of Zoölogy." The laboratory course embraces the morphology of an ample series of forms representative of the different types of animals, considerable attention being paid to anatomical and histological methods, as well as to the knowledge gained thereby. Lectures and recitations are of the nature of informal discussions. — Professor Lull.

Political Science.

The purpose of the entire course is to fit the student to understand the economical and political movements of his time, so that he may successfully solve the problems confronting him.

Economics, junior year, second semester, four hours a week. (1) The elements of political economy are taught by means of text-book (this year F. A. Walker's "Political Economy, Briefer Course") and lectures, the aim being to make the student familiar with the generally accepted facts, definitions, principles and laws of the science, and to train him to criticise theories, scrutinize facts and weigh arguments. (2) The industrial history of England and of the United States is studied. Gibbins' "Industrial History of England" is used. (3) The following elective courses are offered: economics of agriculture; banks and banking; problems of the currency; trusts, or monopolistic corporations; transportation;

socialism. (4) Practical economics. Each member of the class selects for investigation a question in which he is interested, and devotes two or three months to its solution.

Papers giving the results of research, prepared by members of the class, are read and discussed by the students. Each student is asked to explain and defend from criticism the statements and the conclusions made in the paper he presents. The department has at its disposal a working library and a collection of material for the use of students. — Professor Walker.

Constitution of the United States, senior year, four hours a week during half of the first semester and the whole of the second semester. (1) Political institutions. By use of text-book (Woodrow Wilson's "The State") and lectures the student is led to understand what is the government, municipal, state and federal, now existing in the United States. This government is compared and contrasted with the governments of England, France and Germany. Care is taken to familiarize the student with the practical methods of legislation, of nominating conventions, of elections and of administrations. (2) Constitutional history of England and of the United States, with discussions relating to the origin, nature, scope, and purpose of government. — Professor Walker.

Lectures on law, second semester, one hour a week. This course treats of laws relating to business, especially to business connected with rural affairs, citizenship, domestic relations, farming contracts, riparian rights, real estate and common forms of conveyance. Practical work is required, such as may fit one to perform the duties of a justice of the peace. — Mr. Lyman.

English.

This department aims to secure: (*a*) ability to give written and oral expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present, logically and forcibly, oral and written arguments on propositions assigned for debate.

The following courses are offered: under (*a*) rhetoric and oratory; under (*b*) American literature and English literature; under (*c*) argumentation. The elective course in the senior year is in language and literature.

1. *Rhetoric.* — This course extends through the two semesters of freshman year and through the second semester of sophomore year. In the first semester of freshman year work is confined to essay writing, and to personal criticism, by the instructor, of the

students' compositions. This criticism is offered at stated intervals to each student individually, according to a posted schedule of appointments. At the beginning of the semester necessary information with regard to the preparation of essays is furnished each student. In the second semester of freshman year the study of literary types is undertaken in the form of class room work in prose composition, including exposition, persuasion, narration, description, and, in prose diction, including usage and style. Special attention is given to the training of the inventive ability of the student. The text-book used is Baldwin's "College Manual of Rhetoric." In the second semester of sophomore year individual work in essay writing is again taken up, largely based upon the previous work of the class in American literature (see 3, below). Here also personal criticism is offered. — Mr. Knight.

2. *Oratory.* — Individual drill in declamation, first in private and then before the class, is given during the second semester of freshman year. The choice of speakers for the Burnham prizes is based upon this work. In the junior year, during the first semester, at least two orations, upon subjects assigned or chosen, are written, and delivered before the class. Every oration is criticised by the instructor before it is committed to memory by the student. The choice of speakers for the Flint prizes in oratory is based upon this work. — Mr. Knight.

3. *Literature.* — American literature is studied in the first semester of sophomore year, four hours a week. The course comprises, first, the careful study of a text-book (Newcomer's "American Literature"), together with recitations based upon the same; secondly, the taking of notes from lectures, dwelling upon topics not fully treated in the text-book; and, thirdly, the reading outside of the class room of assigned selections from the prose and poetical works of standard American authors. — Mr. Knight.

The history of English Literature is studied during the second semester of sophomore year, four hours a week. The work is based upon a text-book, this year Johnson's "History of English and American Literature." The topical method is followed in recitation, and, instead of formal lectures, there are discussions of points requiring a fuller development than the text-book gives. Collateral readings of literature are required. Frequent written tests are given, in which particular attention is given to (*a*) the definition of words used in the text-book; (*b*) the use of English in the development of the topics unfolded in the text-book or discussed in the class room. — Professor Mills.

4. *Argumentation.* — Four hours a week during the first semester of junior year are given to written and oral argumentation. The course is outlined as follows: (*a*) principles of argumentation as laid down in a text-book or by lecture; (*b*) briefs and brief-making; (*c*) briefs developed into forensics and submitted for personal criticism; (*d*) debates. —Professor Mills.

Senior elective course, two semesters, four hours a week. The work in this course is upon the following subjects: (*a*) English language, its origin, history and development, with particular attention to the study of words as outlined in Anderson's "A Study of English Words;" (*b*) English literature, principally of the eighteenth and nineteenth centuries. — Professor Mills.

Veterinary Science.

The course of instruction in veterinary science has been arranged to meet the demands of the students who, after graduation, purpose following some line of work in practical agriculture. Particular stress is laid upon matters relating to the prevention of disease in animals. In addition, the interests of prospective students of human and comparative medicine have been taken into account in the arrangement of the course of study. The subject is taught by lectures, laboratory exercises, demonstration and clinics.

Senior year (elective), first semester, four hours a week. Veterinary hygiene; comparative (veterinary) anatomy; general pathology. — Professor Paige.

Second semester, four hours a week. Veterinary materia medica and therapeutics; theory and practice of veterinary medicine; general, special and operative surgery; veterinary bacteriology and parasitology; medical and surgical clinics. — Professor Paige.

The instruction in bacteriology is given by means of lectures, recitations and laboratory exercises. The object of this course of study is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and their relation to such processes as decomposition, fermentation, digestion and production of disease. The toxic substances resulting from the growth of organisms are considered, as well as the antitoxines used to counteract their action.

Senior year, half of the first semester, four laboratory exercises of two hours each a week required. — Professor Paige.

Botany.

The object of the course in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. The undergraduate work extends through six semesters. The first two semesters are required. An outline of the course follows: —

Freshman year, first semester, five hours a week. Laboratory work and lectures; histology and physiology of the higher plants. This includes a study of the minute structure of the plant organism, such as stems, roots, leaves, seeds, etc., together with their function and chemical and physical properties. This course extends into the next semester. — Mr. Freeman.

Freshman year, second semester, three hours a week. Laboratory work, lectures and text-book; outlines of classification and morphology of the higher plants. This course follows the preceding one, and commences about the first of March. It is devoted to a study of the relationship of plants, their gross structure, together with extensive individual practice in flower analysis. An herbarium of two hundred species of plants is required. — Mr. Freeman.

Junior year, first semester, five hours a week, two laboratory exercises and one lecture period a week. Cryptogamic botany. This includes a study of the lower forms of plant life necessary for a comprehension of the following courses. — Mr. Freeman.

Junior year, second semester, five hours a week, two laboratory exercises and one lecture period a week. Elements of vegetable pathology and physiology. This course includes a study of the common fungous diseases of crops, and consideration of the methods of prevention and control of the same. The plant's function as related to susceptibility to disease is also taken up. All of the junior botany is included in four of the junior elective courses. — Professor Stone.

Senior year (elective), both semesters, three laboratory exercises and one lecture period a week. (*a*) Plant physiology; (*b*) plant pathology. Either course is optional. This course is adapted to students who desire a more detailed knowledge of plant diseases and plant physiology. Extensive use is made of the valuable and constantly increasing experiment station literature. — Professor Stone.

Mathematics, Physics and Engineering.

This department has charge of the instruction in mathematics, physics, civil engineering and drawing. The aim is to secure thorough work in the fundamental principles, and train the mind in clear and logical thinking. The application of the subjects to practical problems is given special attention. The work of the department extends over the four years, as outlined below: —

Mathematics.

Freshman year, first semester, five hours a week. Higher algebra, including ratio and proportion, progressive binomial theorem, series undetermined coefficients, logarithms, continued fractions, permutations. Wells' "College Algebra." — Professor Hasbrouck.

Second semester, two hours a week. Solid geometry. Wells' "Solid Geometry." — Professor Hasbrouck.

Plane trigonometry, two hours a week. Phillips and Strong's "Elements of Trigonometry." — Professor Hasbrouck.

Junior year, for mathematical and chemical students, first semester, four hours a week. Analytic geometry of the line, circle, conic sections and higher plane curves. Wentworth or Bowser's "Analytic Geometry." — Professor Ostrander.

Second semester, four hours a week. Differential and integral calculus. Osborne's "Calculus." — Professor Ostrander.

Physics.

Sophomore year, first semester, four hours a week. Elementary mechanics of solids, liquids and gases, heat and sound. Dana's "Elementary Mechanics," Carhart's "University Physics." — Professor Hasbrouck.

Second semester, four hours a week; electricity, magnetism and light. Carhart's "University Physics." — Professor Hasbrouck.

Senior year, elective for those students who have taken junior mathematics; first semester, four hours a week. Analytic mechanics. Peck's "Analytic Mechanics." — Professor Hasbrouck.

Second semester, four hours a week. Laboratory work. — Professor Hasbrouck.

Civil Engineering and Surveying.

Sophomore year, second semester, two exercises of two hours a week. Plain surveying, with field work, including the use of the usual surveying instruments. "Surveying Manual," Pence & Ketchum. — Professor Ostrander.

Instruction in civil engineering will be given in two distinct courses of one year each, the courses alternating. They will be open to students of the junior and senior classes as indicated below. The course of 1904–1905 will be for students in mathematics only. First semester, three hours' recitation and two hours' draughting a week; stresses in roofs, bridges and graphic statics. Merriman and Jacoby's "Roofs and Bridges," Parts I. and II.

Second semester, four hours a week. Hydraulics and sanitary engineering. Merriman's "Hydraulics and Lectures." — Professor Ostrander.

The course of 1905–1906 will be required of juniors and seniors taking the courses in mathematics and landscape gardening.

First semester, four hours a week. Strength of materials, foundations and masonry construction. Text-book and lectures. — Professor Ostrander.

Second semester, three hours' recitation or lectures, and two hours' field work or draughting, a week. Topographic and higher surveying, highway construction and the measurement of earthwork pavements and railroad construction. Text-book and lectures. — Professor Ostrander.

Drawing.

Junior year, first semester, two two-hour sessions a week for students in mathematics and landscape gardening; freehand drawing.

Second semester, two two-hour sessions a week, mechanical and topographic drawing.

ENTOMOLOGY.

The importance of a knowledge of insects in every department of life is recognized by placing an introductory course in this subject as a required study in the junior elective courses: (1) agriculture, (2) horticulture, (3) biology, (4) landscape gardening. For those who desire a further knowledge of it, because of its importance to their future occupations, a senior elective is offered, so shaped as to be of especial value for those who expect to take up agriculture, horticulture, landscape gardening, forestry or science teaching as life occupations.

Junior year, second semester, four exercises a week, of two hours each. Lectures, laboratory and field work: general consideration of insect structure and life histories; systematic study of the groups of insects, with particular reference to those of economic importance; methods for preventing or checking their ravages; insecticides and apparatus for their use; the collecting, mounting and naming of insects, and examination of the work of insects in the field and laboratory. — Prof. H. T. Fernald.

Senior year (elective), first and second semesters, four laboratory exercises of two hours each a week; lectures, laboratory and field work; advanced morphology of insects; economic entomology; training in the determination of insects; use of literature on entomology; study of life histories; value and application of insecticides; thesis on insects most closely related to future occupation of the student. — Professors C. H. Fernald and H. T. Fernald.

Modern Languages.

French. — Course I.: requires, for the two semesters of the freshman year, four hours a week first semester, four hours a week second semester. The aim of this course is to enable the student to read modern French fluently, especially that found in scientific journals and treatises. The first ten weeks are devoted to gaining a thorough mastery of the accent, and such principles of grammar and syntax as are covered by the first half of Whitney's "French Grammar." Great stress is laid upon the acquisition of a correct accent, a good vocabulary, and a thorough comprehension of the main idiomatic difficulties of the language. This course is further strengthened by constant drill in pronunciation, exercises and composition. — Mr. Herrick.

Course II.: elective for both semesters of the senior year, four hours a week. The aim of this course is to equip the student with a general knowledge of classical literature, and a working knowledge of the language as it is spoken and written in the French capital to-day. Drill is furnished in composition, principles of syntax and sight translation. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Mr. Herrick.

Spanish. — Given this year as a special elective for both semesters, four hours a week. The special aim is to enable students planning future fields of work in Spanish-speaking countries to acquire sufficient speaking and writing knowledge of the Castilian dialect to enable them to start to best advantage. Especial attention is given to conversation, the method employed being that found in Marion and Garennes' "Introdución á la Lengua Castellana." Grammar rudiments, accent and idiomatic difficulties are thoroughly studied; the acquisition of a good working vocabulary is insisted upon, and the course is further strengthened by practice in writing from dictation, constant drill in pronunciation, exercises and composition, and the reading of books characteristic of modern Spanish life and customs. — Mr. Herrick.

German. — Course I.: required for both semesters of sophomore year, four hours a week first semester, three hours a week second semester. Facility in translation is the main object in view, with particular reference to scientific writings. The work consists of a study of the rudiments of grammar and of translation. — Mr. Herrick.

Course II.: elective for both semesters of senior year, four hours a week. In this course special attention is given to the reading of German literature, particularly the literature pertaining to several branches of natural science. A student taking this course in connection with any science is expected to gain the ability to avail himself of the German literature of his subject, within reasonable limits.

Different books are used from year to year, but the following list will give an idea of the nature of the work: —

Course I.: Joynes Meissner's "German Grammar," Guerber's "Märchen und Erzählungen," Hauff's "Das Kalte Herz," Moser's "Der Bibliothekar." — Mr. Herrick.

Course II.: Lessing's "Emilia Galotti," and "Minna von Barnhelm," Hodge's Courses in "Scientific Reading."

Students electing Course II. must have a good record in Course I. or must pass a satisfactory examination therein. — President Goodell.

Military Science.

In compliance with the provisions of an act of Congress of July 2, 1862, military instruction under a regular army officer, detailed for this purpose, is required of all able-bodied male students. Men are excused from attendance upon the exercises of this department only on a surgeon's certificate, given by Dr. Charles F. Branch, the college physician.

The object of such instruction is clearly to disseminate the elements of military knowledge throughout the country, that, in case of sudden emergency, a sufficient number of well-trained, educated men may be found to command and properly to instruct volunteer troops. Military drill also has the object in view of giving the student physical exercise, teaching respect and obedience to those in authority without detracting from pride of manhood, and developing a military bearing and courtesy becoming in a citizen as in a soldier.

In order to further stimulate the study of military science in colleges, the War Department issued General Orders, No. 6, dated Washington, D. C., Aug. 24, 1903, as follows: —

The reports of the regular inspections of the colleges and schools to which officers of the army are detailed, in pursuance of law, as principals or instructors, will annually hereafter be submitted to the general staff for its critical examination, and the chief of staff will report to the Secretary of War, from the institutions which have maintained a high standard, the six institutions whose students have exhibited the greatest interest, application and proficiency in military training and knowledge. The President authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions, provided sufficient vacancies exist after caring for the graduates of the military academy at West Point and the successful competitors in the annual examination of enlisted men. . . .

By order of the Acting Secretary of War,

S. B. M. Young,

Lieutenant-General, Chief of Staff.

Course I.: out of doors, an exercise of one hour, three times a week, Mondays, Tuesdays and Thursdays; infantry drill by squad, company, and battalion; guard mounting, dress parade, inspection and review; artillery drill by detachment; target practice. A guard is mounted five times in each week, and the guard maintained under practical instruction for one hour in each exercise.

All drills are in the drill hall during the winter months and inclement weather.

Students assigned to the college band are given instruction and practice in band music and band evolutions, in place of drills and recitations.

Course II.: theoretical instruction for freshmen, one hour a week for both semesters, comprises recitations in infantry drill regulations; "United States Service Manual."

Course III.: theoretical instruction for seniors for both semesters, one hour a week embraces drill and army regulations; duties of sentinels and guard duty, elements of military science, preparation of necessary reports and returns pertaining to a company of infantry, and a thesis on some military subject; Wagner's "Elements of Military Science." — Captain ANDERSON.

SYNOPSIS OF THE COURSES OF INSTRUCTION.

[The figures indicate the number of exercises a week; light-faced type, recitation periods of one hour each; heavy-faced type, laboratory periods of two hours each.]

FRESHMAN YEAR.

First Semester.

Language,	English,	3	
	French,	4	
Mathematics,	Algebra,	5	
Science,	Agriculture,	4	
	Botany, 2+1,	3	
Military,	Tactics,	1	
History,		2	
		—	22

Second Semester.

Language,	English,	4	
	French,	4	
Mathematics,	Geometry and trigonometry,	4	
Science,	Anatomy and physiology, half semester, Chemistry, half semester,	4	
	Botany, 1+1,	2	
History,		2	
		—	20

SOPHOMORE YEAR.

First Semester.

Language,	English,	4	
	German,	4	
Physics,		4	
Science,	Agriculture,	4	
	Chemistry,	**3**	
	Zoölogy, 1+1,	2	
		—	21

Second Semester.

Language,	English,	4	
	German,	3	
Physics,		4	
Surveying,		**2**	
Science,	Agriculture, 2+1,	3	
	Chemistry,	2½	
	Horticulture,	3	
		—	21½

Junior Year.

First Semester.

Course	Subject	Hours	Total
Course in agriculture,	Agriculture, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in horticulture,	Horticulture,	4	
	Horticulture, 1+3,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	English,	4	
		—	21
Course in biology,	Zoölogy, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in chemistry,	Chemistry,	4	
	Agriculture, 3+1,	4	
	Mathematics,	4	
	Geology,	3	
	English,	4	
	Special subject,	2	
		—	21
Course in mathematics,	Analytical geometry,	4	
	Engineering, 1+3,	4	
	Free hand drawing,	2	
	Landscape gardening,	4	
	Geology,	3	
	English,	4	
		—	21
Course in landscape gardening,	Landscape gardening,	4	
	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Free hand drawing,	2	
	Horticulture,	3	
	Geology,	3	
	English	4	
			22

Second Semester.

Course in agriculture,	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Entomology,	4	
	Economics,	4	
		—	20
Course in horticulture,	Horticulture,	4	
	Botany, 2+1,	3	
	Chemistry,	4	
	Landscape gardening,	2	
	Entomology,	4	
	Economics,	4	
		—	21
Course in biology,	Entomology,	4	
	Zoölogy,	3	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Economics,	4	
		—	20
Course in chemistry,	Chemistry,	5	
	Agriculture, 2+1,	3	
	Mathematics,	4	
	Economics,	4	
	Special subject,	5	
		—	21
Course in mathematics,	Engineering,	5	
	Mathematics,	4	
	Mechanical drawing,	2	
	Landscape gardening,	4	
	Economics,	4	
		—	19
Course in landscape gardening,	Landscape gardening,	4	
	Botany, 2+1,	3	
	Mechanical drawing,	2	
	Engineering,	5	
	Entomology,	4	
	Economics,	4	
		—	22

Senior Year.

First Semester.

The following subjects are required in all courses: —

Bacteriology, half semester, 4, } Constitution of the United States, half semester, 4, }	4	
Military science,	1	
	—	5

Second Semester.

Constitution of the United States,	4	
Military science,	1	
	—	5

From the following the student must elect three courses, closely correlated with his junior year course; only one course in language can be elected: —

Agriculture,	4	Physics,	4
Horticulture, 3+1,	4	Engineering,	4
Veterinary,	4	English,	4
Botany, 3+1,	4	French,	4
Landscape gardening,	4	German,	4
Entomology, 3+1,	4	Spanish,	4
Chemistry, 3+1,	4	Latin,	4

COURSES OF INSTRUCTION FOR SPECIAL STUDENTS.

A Two-Years Course for Women.

Women are received who wish to pursue the studies named below. There is no charge for tuition. Board may be obtained in the dining hall, and also rooms, so far as the accommodations will permit.

First year, first semester: soils, fertilizers and cultivation, four hours a week; elementary botany, five hours; French, four hours; free-hand drawing, four hours.

Second semester: propagation and pruning (horticulture, one hour), three hours; botany, — morphology, plant analysis, five hours; chemistry, descriptive, five hours; vegetable gardening, four hours; French, four hours.

Second year, first semester: pomology, three hours a week; greenhouse construction and management, three hours; botany, — structure and physiology of plants, five hours; zoölogy, two hours; chemistry, five hours; German, four hours.

Second semester: landscape gardening, three hours a week; floriculture, four hours; vegetable pathology, five hours; entomology, three hours; chemistry, five hours; German, three hours.

Short Courses.

These courses are open to persons of both sexes. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. No entrance examination is required. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

I. Dairy Farming.

	Hours per Week.
Soils, tillage and methods of soil improvement; manures and fertilizers and their use; crops and rotations,	4
Breeds and breeding of dairy stock; judging to scale of points,	2
Fodders and feeding farm live stock,	1
Stable construction and sanitation,	1
Common diseases of stock; prevention and treatment,	1
Dairy products: their general characteristics; testing,	2
Chemical composition of milk and of special milk products,	1
Botany,	2
Horticulture,	3
Entomology,	3
Dairy practice, including testing, use of separators, butter-making, preparation of certified and modified milk, and pasteurization,	4
Practice in horticulture,	1

Begins first Wednesday in January, and continues ten weeks.

II. Horticulture.

	Hours per Week.
Soils, tillage, manures, etc.,	4
Plant propagation and pruning,	3
General fruit growing,	3
Market gardening,	3
Botany,	4
Entomology,	3
Practice work in seed testing, seeding, grafting, budding, transplanting, judging fruit, etc.	

Begins first Wednesday in January, and continues ten weeks. This course will not be given unless at least eight men register for it.

III. Short Course in Bee Culture.

	Total Hours.
The structure of bees, with special reference to their work (Prof. H. T. Fernald),	5
Flowers and fruits in their relations to bees (Professor Stone),	10
Honey crops, and how to grow them (Professor Brooks),	5
Bees and bee keepers' supplies (Professor Paige),	10
Work in the apiary, under direction of an expert,	20
Instruction by specialists,	4

This course begins the fourth Wednesday in May, and continues two weeks, but will not be given unless applied for by at least six students.

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables are stocked with the best breeds of horses, cattle, sheep and swine. Attached to the barn is a dairy building equipped with the latest machinery, driven by an electric motor. The laboratory is provided with the latest forms of apparatus for mechanical analysis of soils and determination of their physical characteristics. Provision has been made in the laboratory for the study of seeds and crops and for germination trials. Power has been introduced into the laboratory, so that farm machinery may be operated for purposes of demonstration. The department has also a line of instruments for use in drainage and irrigation practicums. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution and the theory and practice of agriculture. Three large lecture rooms, one in south college and two in the dairy building, and five rooms for laboratory and dairy purposes, have been assigned to this department.

Horticulture.

For illustration of the science and the practice of horticulture the department possesses about one hundred acres devoted to orchards planted with all the leading old and all new varieties of apples, pears, peaches, plums, Japanese and American cherries, quinces, chestnuts, hickory nuts and walnuts; vineyards containing nearly two hundred named varieties of grapes, for sale, beside several hundred seedlings, and about an acre devoted to a commercial crop of a few market varieties; nurseries containing all kinds of fruit and ornamental trees, shrubs and plants, in all stages of growth, from the seed and cuttings to those ready for planting in the orchard or field; small fruit plantations containing valuable varieties, and showing the modern methods of training, pruning and cultivation; extensive greenhouses that contain not only valuable collections of specimen plants, representing types of the flora of the world, but also the most valuable economic plants, such as the orange, banana, lemon, guava, pomegranate, sago palm, arrowroot, tapioca, ginger, pepper, tea, coffee, camphor, India rubber, Manila hemp, banyan tree, etc. All the common greenhouse and outdoor decorative plants are found, and small quantities of roses, carnations, chrysanthemums and other commercial flowering plants are grown, to illustrate the business of horticulture. All vegetable crops, now so largely grown under glass, are grown in limited quantities for purposes of instruction and for market.

For illustration in the work of landscape gardening, the grounds about the greenhouses, as well as that part of the grounds known as the Clark Park, are planted with a very large and complete collection of ornamental trees, shrubs and plants.

For forestry there are two large groves of trees of varying ages, from those of almost primeval growth to the youngest seedlings, besides several plantations of younger growth either natural or planted; and in the Botanical Museum there is a very complete collection of woods of Massachusetts.

All kinds of pumps and other appliances for distributing insecticides and fungicides, as well as various modern tools and implements, are in constant use.

A small cold-storage room makes possible the keeping of the products beyond their natural season, and illustrates one of the most important adjuncts to the business of modern horticulture.

Chemistry.

This department has fourteen rooms, well adapted to their special uses. They are supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor has a seating capacity for seventy students. Immediately adjoining it are four smaller rooms, used for storing apparatus and preparing materials for the lecture table. The laboratory for beginners is a large room on the first floor, furnished with forty working tables. Each table is provided with reagents and apparatus for independent work. A well-filled laboratory for advanced work is also provided on the first floor. A weighing room has six balances, and improved apparatus for determining densities of solids, liquids and gases. The apparatus includes, besides balances, a microscope, a spectroscope, a polariscope, a photometer, a barometer, and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milking products, fibres and other vegetable and animal products, and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished product.

Geology.

Geological teaching is illustrated by a very complete series of minerals, the State collection of rocks of Massachusetts, a series of Ward's fossils and casts of fossils, models and charts.

Zoölogy.

Zoölogical Laboratory. — A large, well-lighted room, situated in the old chapel building, is fitted with necessary tables, trays and general apparatus, microscopes, dissecting instruments, hand lenses and the like. There have lately been added aquaria, in which, as far as possible, the various types studied may be seen in their natural environment. A reference library is kept in the laboratory.

Zoölogical Lecture Room. — An ample lecture room is situated in south college, adjacent to the museum. It is supplied with a set of Leuckart charts and many special ones as well, and with a complete set of Auzoux models, illustrative both of human and comparative anatomy. A special set of typical specimens is being set apart for class illustration, although the more extensive museum collection is drawn upon for the same purpose.

Museum of Zoölogy. — The museum is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth, and those types which show the evolution and the relationship of the members of the animal kingdom. The total number of specimens contained in the museum now exceeds eleven thousand. The museum is open to the public from 3.30 to 5.30 P.M. each week day.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glass ware. One portion of the building is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of nearly fifty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject. This is supplemented by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. As the laboratory is directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room fitted up for the analysis of insecticides and other chemico-entomological work; and a greenhouse, where plants infested by injurious insects are under continual observation and experimental treatment, — all these are available to the student. In addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large greenhouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for study of the attacks of injurious insects under natural conditions.

Veterinary Science.

The department has for its sole use a commodious and modern laboratory and hospital stable, erected in 1899. Both buildings are constructed according to the latest ideas as regards sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The laboratory building contains a large working laboratory for student use, and several small private laboratories for special work. In addition, there is a lecture hall, museum, demonstration room, photographing room and work shop. The hospital stable contains a pharmacy, operating hall, post-mortem and disinfecting room, besides a section for poultry, one for cats and dogs, and six sections, separated from each other, for the accommodations of horses, cattle, sheep, swine and other domestic animals.

The laboratory equipment consists of a dissecting Auzoux model of the horse, Auzoux models of the foot and the legs, showing the anatomy and the diseases of every part. There are skeletons of the horse, cow, sheep, dog and pig, and, in addition, a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams, which are made use of in connection with lectures and demonstrations.

The laboratories are supplied with the most modern high-power microscopes, microtomes, incubators and sterilizers, for the use of students taking the work in bacteriology and parasitology.

Botany.

The botanical department possesses a general laboratory, furnished with tables and benches for microscopical and physiological work, and with a dark closet for photographic purposes. There are forty compound microscopes, twenty-three dissecting microscopes, a micro-photographic and landscape camera and various accessories; also microtomes, paraffine baths, etc., for histological work; a large and useful collection of physiological apparatus for the study of photo-synthesis, respiration, metabolism, transpiration, heliotropism, geotropism, hydrotropism, galvanotropism, chemotropism, and other irritable phenomena connected with plants; a set of apparatus for the study of the mechanical constituents of the soil, and for experimental work in soil physics; a large and unique outfit of electrical appliances for the study of all phenomena related to electricity and plant growing; various devices for the study of mechanics of plant structure; numerous contrivances to determine the power exerted by living plant organisms; several types of self-registering auxanometers, used to measure the rate of growth of plants; self-registering thermometers, and hygrometers for recording constant changes in conditions.

A small special laboratory for graduate students is equipped with microscopes and other apparatus and reagents for advanced work.

Botanical Lecture Room. — The botanical lecture room adjoining the laboratory is adapted for general work in morphology and flower analysis, with opportunity to use dissecting microscopes. It contains a movable chart system, arranged to display over three thousand figures relating to the structure and function of plants.

Mathematics, Physics and Engineering.

Surveying. — The department possesses a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by performing a required amount of field work. Among the larger instruments are two plain compasses, railroad compass with telescope, surveyor's transit, two engineer's transits with vertical arc and level, solar compass, omnimeter with verniers reading to ten seconds, adapted to geodetic work, Queen plane table, two wye levels, dumpy level, builder's level, sextant, hand level, and a large assortment of levelling rods, flag poles, chains, tapes, etc. For draughting, a vernier protractor, pantograph, parallel rule, etc., are available.

Physics. — Among the apparatus in use for general instruction in general physical processes may be found a set of United States standard weights and measures, precision balances, spherometer, vernier calipers, etc.; in mechanics, apparatus to illustrate the laws of falling bodies, systems of pulleys and levers, motion on an incline plane, and the phenomena connected with the mechanics of liquids and gases. The usual apparatus for lecture illustration in heat, light and sound are also in the possession of the department. In electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, among which may be enumerated a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, Mascart quadrant electrometer, Siemens electro-dynamometer, as well as reflecting galvanometers and Wheatsone bridges for ordinary determinations of currents and resistance.

Military Science.

In addition to a large campus, suitable for battalion drill, the military department possesses a special building in which there is a drill room 60 by 135 feet, an armory, a recitation room, an office for the commandant, and a field gun and gallery practice room. The building also has a large bathroom immediately adjoining the armory.

In a plot of ground north of the college buildings there is a rifle range, marked for practice at distances of 100 and 200 yards. The range is furnished with a revolving target suitably protected by earthworks. The national government supplies, for the use of the department, arms and equipments; the Springfield cadet rifle and two breech-loading rifled steel guns, calibre 3.2, with complete equipments and ammunition.

The State supplies instruments for the college band.

Students are held responsible for all articles of public property while in their possession.

The Chapel-Library Building.

One of the most attractive and commodious buildings belonging to the college is the chapel-library. It has a commanding position, approximately in the centre of the group of buildings adjoining the campus. The chapel occupies the entire second story. A large room, capable of seating about four hundred, is used for daily prayers, Sunday services, the various commencement exercises, and not infrequently for lectures or social gatherings. The room has an excellent pipe organ. Two adjoining rooms are used for small religious gatherings, and meetings of the class teachers and of the faculty. The rooms can be thrown open so as to become a part of the main audience hall.

The entire lower story is given over to the library. This library is available for reference or investigation, and is open daily, except on Sundays, from 8 A.M. to 5 P.M. and from 6.30 to 8.30 P.M. It is open on Sundays from 10 A.M. to 1 P.M. The volumes at present number 24,563. The library contains carefully selected books in the departments of agriculture, horticulture, botany, entomology and other natural sciences. Sociology, economics, history, literature, the fine arts and the useful arts are well represented. Constant additions will be made to secure the latest and best works in the several departments of learning.

Dining Hall.

A colonial dining hall, built of brick and equipped with all modern conveniences, was completed and opened February, 1903, for the accommodation of students. A committee composed of two members of the faculty, two members of the student body, and the steward, manages the affairs of the dining hall.

The hall contains a number of suites of rooms which may be secured for occupancy by young women attending any of the departments of the college.

The Heating, Lighting and Power Plant.

This plant is located in the ravine, near the chemical laboratory. It is equipped with two large boilers, an engine and an electric generator. Here steam is generated which heats the college buildings on the west side of the public highway, extending from the dining hall to the veterinary laboratory. Here also is produced the electricity which lights all the buildings and the grounds of the college. Electric power is also generated which is used to drive the machinery in the dairy and in the barn. Connected with the plant is a machine shop in which much work is done for the college. The plant affords opportunity for students in mechanical and electrical engineering to observe the modern utilization of steam and electricity.

EXPENSES.

Tuition. — Tuition is free to citizens of the United States. Citizens of Massachusetts, however, in accordance with an act of the Legislature, must make application to the Senator of the district in which they live for a free scholarship that covers the charge for tuition. Blank forms for such application may be obtained from the president of the college.

Rooms. — It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere. For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. All rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

Board. — Board at the new dining hall has been $3.25 per week; in private families, $4 to $5.

Incidental Expenses. — The military suit must be obtained immediately upon entering college, and used in the drill exercises prescribed. The following fees are applied towards the maintenance of the several laboratories: chemical, $15 per semester used;

zoölogical, $2 per semester used sophomore year, other classes $4 per semester; entomological, $3 per semester used. The fee for use of the botanical laboratory for two periods of one hour during each week is $1 per semester; other periods will be charged for proportionally. Some expense is also incurred for text-books. In exceptional cases incidental expenses necessitate additional charges.

Room rent, in advance,	$15 00	$45 00
Board, $3.25 to $4 per week,	117 00	144 00
Fuel,	13 00	13 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
	$180 50	$256 00

In addition to the above expenses, $120 tuition is charged to foreigners.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator from his district for a scholarship. Blank forms of application will be furnished by the president.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Frank A. Waugh, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

The Hills prizes of thirty-five dollars, given by the late Henry F. Hills of Amherst, will this year be awarded to members of the senior class as follows: fifteen dollars for the best general herbarium; fifteen dollars for the best collection of Massachusetts trees and shrubs; and five dollars for the best collection of Massachusetts grasses.

Winter Course Prizes.

The dairy prizes, given by the Massachusetts Society for Promoting Agriculture, to members of the short winter course. Two sets of prizes are offered: the first set consists of three prizes of fifty, thirty and twenty dollars, respectively, given for general excellence in all branches of the course as offered; the second set consists of three prizes of twenty-five, fifteen and ten dollars, respectively, for excellence in the making of butter.

Award of Prizes, 1903.

Grinnell Agricultural Prizes (Senior). — First prize, Paul Nerses Nersessian; second prize, Elmer Myron Poole.

Hills Botanical Prizes (Senior). — First prize, Albert Vincent Osmun; second prize, Gerald Denison Jones.

Flint Oratorical Prizes (Junior). — First prize, Fayette Dickinson Couden; second prize, George Edmund O'Hearn.

Burnham Declamation Prizes (Sophomore and Freshman). — First sophomore prize, William Hunlie Craighead; second sophomore prize, George Howard Allen; first freshman prize, Vernon Ollise White; second freshman prize, Alonzo Henry Shannon.

Military Honors (Senior). — The following cadets were reported to the Adjutant-General, U. S. A., and to the Adjutant-General of Massachusetts, as having shown special aptitude for military service: William E. Allen, George L. Barrus, Neil F. Monahan.

Winter Course in Dairy Farming. — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, $50, Mrs. Sara E. Folsom; second prize, $30, Samuel W. Dorling; third prize, $20, Nelson Gerber.

Massachusetts Society for Promoting Agriculture: for highest scoring butter, first prize, $25, Clarence H. Stygles; second prize, $15, William A. Gage; third prize, $10, Samuel W. Dorling.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, $10, Samuel W. Dorling; second prize, $7.50, Elmer P. Ramsdell; third prize, $5, Herman Kohles; fourth prize, $2.50, James Gould.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one ton Stockbridge fertilizer, Mrs. Sara E. Folsom.

Special prize, given by B. von Herff, New York, for best knowledge of the use of fertilizers on grass lands, one ton kainite, William A. Gage.

RELIGIOUS SERVICES.

Chapel services are held every week day at 8 A.M. Further opportunities for moral and religious culture are afforded by Bible classes taught by one of the professors and other teachers for an hour every Sunday afternoon, and by a religious meeting Thursday evening under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Millers Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of four hundred acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, Jan. 1, 1903, to Jan. 1, 1904.*

	Received.	Paid.
Cash on hand Jan. 1, 1903,	$6,632 71	–
State Treasurer, Morrill fund,	16,666 66	–
State Treasurer, endowment fund,	11,439 41	–
State Treasurer, endowment fund, special appropriation,	1,115 00	–
State Treasurer, maintenance appropriation,	5,000 00	–
State Treasurer, maintenance appropriation, special,	8,000 00	–
State Treasurer, scholarship appropriation,	10,000 00	–
State Treasurer, labor appropriation,	5,000 00	$4,713 34
Labor fund,	21 03	–
Gassett scholarship fund, income,	40 00	28 75
Mary Robinson scholarship fund, income,	33 31	12 94
Whiting Street scholarship fund, income,	50 40	61 06
Grinnell prize fund, income,	50 00	55 00
Hills fund, income,	344 19	209 49
Library fund, income,	421 84	210 92
Burnham emergency fund, income,	95 00	90 00
Salary,	269 59	30,545 72
Extra instruction,	–	390 00
Botanical laboratory,	160 50	141 03
Chemical laboratory,	640 66	176 08
Entomological laboratory,	88 30	31 83
Veterinary laboratory,	1,009 25	743 79
Zoölogical laboratory,	134 25	114 82
Landscape gardening,	5 00	24 89
Term bill,	3,596 19	1,247 31
Advertising,	–	484 20
Heating and lighting,	2,713 80	10,719 29
Agricultural department,	808 83	1,856 41
Farm,	10,115 66	12,678 81
Horticultural department,	5,111 30	7,736 36
Expense,	1,778 14	11,811 34
Insurance,	–	689 00
Investment,	5 00	–
Individual labor fund,	200 00	18 94
Cash on hand Jan. 1, 1904,	–	6,754 70
	$91,546 02	$91,546 02

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1903, to Jan. 1, 1904, and find the same correct and properly kept. All disbursements are vouched for, the balance being six thousand seven hundred fifty-four dollars and seventy cents ($6,754.70), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Jan. 1, 1904.

Cash on Hand, as shown by the Treasurer's Statement, belongs to the Following Accounts.

Labor fund,	$307 69
Gassett scholarship fund,	48 16
Mary Robinson scholarship fund,	20 37
Whiting Street scholarship fund,	21 20
Grinnell prize fund,	71 24
Hills fund,	205 13
Library fund,	210 92
Burnham emergency fund,	110 56
Individual labor fund,	262 17
Veterinary laboratory,	796 00
College,	4,701 26
	$6,754 70

Bills receivable Jan. 1, 1904.

Farm,	$505 71
Term bill,	879 49
Heating and lighting,	685 60
	$2,070 80

Bills payable Jan. 1, 1904.

Farm,	$951 93
Horticultural department,	152 84
Expense,	901 92
Heating and lighting,	925 15
	$2,931 84

Inventory — real estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 00	
Amounts carried forward,	$130,075 00	$44,350 00

Amounts brought forward,	$130,075 00	$44,350 00
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding house,	2,000 00	
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		248,775 00
		$293,125 00

EQUIPMENT.

Botanical department,	$4,210 00
Horticultural department,	13,506 89
Farm,	18,790 85
Chemical laboratory,	1,981 00
Botanical laboratory,	2,831 53
Entomological laboratory,	15,425 00
Zoölogical laboratory,	2,200 00
Zoölogical museum,	6,000 00
Veterinary laboratory,	5,909 08
Physics and mathematics,	5,500 00
Agricultural department,	3,500 00
Library,	24,973 00
Fire apparatus,	500 00
Band instruments,	350 00
Furniture,	1,250 00
Text-books,	350 00
Tools, lumber and supplies,	240 00
Heating and lighting plant,	50,753 00
	$158,270 35

SUMMARY.

Assets.

Total value of real estate, per inventory,	$293,125 00
Total value of equipment, per inventory,	158,270 35
Bills receivable,	2,070 80
Investment, New York Central & Hudson River Railroad stock,	100 00
Cash on hand,	4,701 26
	$458,267 41

Liabilities.

First National Bank of Amherst, note,	$6,000 00	
Burnham emergency fund, note,	3,000 00	
Bills payable,	2,931 84	
		$11,931 84
		$446,335 57

MAINTENANCE FUNDS.

	Fund.	Income in 1903.
Technical educational fund, United States grant,*	$219,000 00	$7,300 00
Technical educational fund, State grant,*	141,575 35	4,139 41
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890,	–	16,666 66
Hills fund,	8,542 00	344 19
MAINTENANCE APPROPRIATIONS.		
State appropriation made by Legislature of 1900 for four years,	–	5,000 00
Labor appropriation made by Legislature of 1900 for four years,	–	5,000 00
State appropriation made by Legislature of 1900 for four years ($8,000),	–	8,000 00
SCHOLARSHIP FUNDS.		
Whiting Street fund,	$1,260 00	50 40
Gassett fund,	1,000 00	40 00
Mary Robinson fund,	858 00	33 31
SCHOLARSHIP APPROPRIATIONS.		
State appropriations by the Legislature of 1886,	–	10,000 00
PRIZE FUND.		
Grinnell prize fund,	$1,000 00	50 00
MISCELLANEOUS FUNDS.		
Library fund,	$10,546 12	421 84
Burnham emergency fund,	5,000 00	95 00
		$57,140 81

* The above is two-thirds of the income from these funds.

GIFTS.

From German Kali Works, New York, one ton high-grade sulfate of potash; one and nine-tenths tons muriate of potash; one-tenth ton sulfate of potash-magnesia; one-half ton kainite; one hundred pounds nitrate of potash.

Chilian Nitrate Works, New York, five and one-half tons nitrate of soda.

Massachusetts Society for Promoting Agriculture, Boston, two hundred dollars in prizes for dairy school.

B. von Herff, New York, one ton kainite (value $15) for prize in dairy school.

Standard Package Company, Boston, twenty-four butter pails.

D. H. Burrell & Co., Little Falls, N. Y., one eight-bottle Facile tester complete; one four-bottle Facile tester complete.

W. H. Bowker (M. A. C., '71), Boston, one ton Stockbridge fertilizer (value $35) for prize in dairy school.

Hermann Thiemann, Manchester, one Branxholn brooder.

A. A. Southwick (M. A. C., '75), Taunton, one boar.

W. B. Lew, Amherst, specimen of bone tumor.

C. S. Dickinson, North Amherst, calculus from horse.

William Sim, Cliftondale, sixty violet plants.

American Percheron Horse Breeders and Importers Association, Chicago, Ill., one share capital stock of the association.

Loans.

From De Laval Separator Company, New York, seven separators; one milk heater.

The Vermont Farm Machine Company, Bellows Falls, Vt., five separators; two hand testers; one steam turbine tester.

A. H. Reid, Philadelphia, Pa., one hand tester.

P. M. Sharples, West Chester, Pa., two separators.

From The Empire Cream Separator Company, Bloomfield, N. J., two separators.

Cornell Incubator Company, Ithaca, N. Y., one incubator; one brooder.

The Star Incubator and Brooder Company, Lincoln, N. Y., one incubator.

The Cyphers Incubator Company, Buffalo, N. Y., two incubators, one brooder.

FARM REPORT.

The same general policy has been followed on the college farm this year as in previous years, but farm operations have not been attended with the usual success. The comparative failure of a number of our crops is, however, fully accounted for by the abnormalities of the season. First came a period from about the middle of April to about the 10th of June during which we had but little more than one-half an inch of rain. This protracted spring drought, unparalleled, I think, in the recollection of men now living, made the conditions for germination and starting of crops exceedingly unfavorable. Corn required replanting once, and in a portion of our fields twice, and even then the stand was imperfect. The necessity for replanting made the crop exceptionally late at the start; still, with a normal season, fair results might have been obtained. Following the drought, however, came a period of very excessive rainfall and abnormally low temperatures. The summer continued so cold that corn, in common with all other crops requiring relatively high temperatures, made very slow progress; as a consequence, the growth was weak, the crop small, and no part of it ripened. The entire area was put into the silo, but some of it had not reached even such degree of maturity as is regarded desirable for ensilage. The very frequent and abundant rains beginning about the 10th of June rendered the care of all crops, whose growth was relatively feeble, exceptionally difficult. The crops did not furnish the shade, ordinarily of great assistance in keeping down weeds, while the wet condition of the soil and the constant rains rendered frequent cultivation a necessity to keep the fields clean. The cost of caring for our crops, therefore, was exceptionally high. To the credit of the farm superintendent it should be stated that he continued "faithful to the end," and that the fields, in spite of the difficulties, were kept clean.

The only good crops of the year were hay, roots and celery, although potatoes did relatively much better than corn. The nature of the farm operations and the financial results with the several crops are shown in the following table: —

College Farm Crops, 1903.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.*	Labor and Seed.			
Carrots, ...	½	-	11	$13 50	$23 28	$88 00	$51 22	-
Celery, ...	1	200 doz. bunches.	-	23 80	64 56	200 00	111 64	-
Corn, ...	35	-	270	491 05	533 90	945 00	-	$79 95
Hay, ...	66	-	114.5	-	-	2,061 00	-	-
Rowen,†	41	-	39.25	-	-	228 00	-	-
Potatoes, ...	11	1,169 large. 150 small.	-	189 45	396 70	701 40 22 50	137 75	-
Turnips, ...	2	-	6.875	-	19 07	68 70	49 63	-
Mangles, ...	½	-	25	13 50	35 90	100 00	50 60	-
Japanese millet, . . .	4	100	6 straw.	24 69	48 95	220 00	146 36	-

* One-half value of manure and three-fourths the value of the fertilizers. † Rowen on 25 acres pastured.

System of Manuring.

The manures and fertilizers used for the several crops of the year are shown by the following table. Our practice is to take the manure out from the pits in which it is accumulated, for the most part during the winter, and to spread at that season. Much of it, accordingly, lies upon the surface several months. This manure, spread upon the surface during the winter, is plowed in on the old fields in the spring. If applied to sod land which was fall-plowed, then the manure is worked into the ground with a disc harrow in the spring. The fertilizers used for the several hoed crops, with the exception of the nitrate of soda and about half each of the acid phosphate and the potash, are spread broadcast with a machine on the plowed land, and harrowed in. The nitrate of soda and a part of the phosphate and potash are mixed and put into the drill. For the potato crop, about two-thirds of the fertilizers used are commonly put in the drill; for the small crops, such as carrots, turnips and mangles, all the fertilizers are put on broadcast. For our grass lands, fertilizers where used are applied with Steven's fertilizer distributer in early spring.

Manures and Fertilizers for the Several Crops per Acre.

	Celery, One Acre.	Corn, Thirty-five Acres.	Millet, Four Acres.	Old Mowings, Twenty-five Acres.	Potatoes, Eleven Acres.	Carrots, One-half Acre.	Mangles, One-half Acre.
Manure (cords),	8	4	-	-	-	8	8
Nitrate of soda (pounds),	150	100	100	120	125	200	200
Acid phosphate (pounds),	-	-	-	-	400	-	-
Sulfate of potash, high grade (pounds),	200	125	150	-	250	-	-
Muriate of potash (pounds),	-	-	-	120	-	350	350
Dried blood (pounds),	-	-	-	-	150	-	-
Tankage (pounds),	-	-	-	-	250	-	-
Phosphatic slag (pounds),	500	300	500	300	-	600	600

Experiments in the Use of Manures and Fertilizers.

A. Method of Application of Barnyard Manure.

There is possibly a question whether the practice of spreading the manure upon our fields which are to be tilled, and leaving it upon the surface until spring, is wise. We are testing this question in a field which has a considerable slope, on the grounds of the experiment station, and a statement of the results will be found in the report of the agriculturist. We are testing the same question on level land on the grounds of the college farm. Two plots of one acre each are used in this experiment. This experiment began in 1902. The crop for that year was corn. Manure was applied to these plots at the rate of 6 cords per acre. On the one plot this manure was spread as hauled; on the other it was all placed in one large heap, and from this heap it was spread in the spring just before plowing. In manuring the land alternate loads are taken to the two plots, so that we are reasonably sure that manure of the same quality is used on each.

In 1902 the yields on the two plots were as follows: first acre, winter-spread manure, 3,850 pounds corn on the ear; second acre, manure piled in winter and hauled in spring, 3,510 pounds of corn on the ear. For the past season the crop was Longfellow corn. It did not reach sufficient maturity for husking, and so was put into the silo. The yields were as follows: for the winter-spread manure, 5.95 tons; for the manure piled in winter and spread in the spring, 5.59 tons. It will be seen that for both years the crop on the winter-spread manure has slightly exceeded that on manure piled in winter and spread in spring. The differences in both years, however, are comparatively small, and it is not believed they should be regarded as indicating an advantage in favor of winter-spreading. We are justified simply in saying that, so far, the experiment furnishes no evidence that there has been a loss in the fertilizer value of the manure spread in the winter and left on the surface until spring.

B. Experiments with Nitrate of Soda, Muriate of Potash and Phosphatic Slag on Grass Lands.

Plots of about one-half acre each were laid out on some of the farm mowings in 1899, for experiments in the use of nitrate of soda and muriate of potash, each alone and in combination. The fertilizers applied to these plots from 1899 until the present year were as follows: to one plot in each mowing nitrate of soda was applied annually at the rate of 150 pounds per acre; to another plot, nitrate of soda 150 pounds, and muriate of potash 100 pounds, per acre annually; to the third plot, muriate of potash alone at the rate of 100 pounds per acre annually. The results in one of these mowings which has not been plowed for something like twenty years are of much interest, and they will be briefly reported here. The following table shows the fertilizers applied and the rates of yield in the several years: —

Experiments with Nitrate of Soda and Muriate of Potash on Grass Lands.

FERTILIZERS.	Pounds per Acre.	YIELD PER ACRE (POUNDS).				
		1899. First Crop.	1900. First Crop.	1901. First Crop.	1902. First Crop.	1902. Second Crop.
Nitrate of soda, . . .	150	1,960	1,480	2,430	2,230	1,404
Nitrate of soda, . . .	150	–	–	–	–	–
Muriate of potash, . .	100	1,990	1,760	1,730	2,740	2,080
Muriate of potash, . .	100	2,020	1,340	1,930	1,700	1,630

As the result of experiments on the station grounds and of general observation, it was concluded at the end of last year that the product on these plots might be still further improved by the addition of basic or phosphatic slag on some of them. At the same time some changes in the amount of the other fertilizers used were made. The materials applied to the several plots and the rates of yield per acre for the past year are shown in the following table: —

Experiments with Nitrate of Soda, Muriate of Potash and Phosphatic Slag on Grass Lands.

FERTILIZERS.	Pounds per Acre.	YIELD PER ACRE (POUNDS).			
		NORTH PLOTS.		SOUTH PLOTS.	
		First Crop.	Second Crop.	First Crop.	Second Crop.
Nitrate of soda, . .	200	1,450	423	985	640
Nitrate of soda, . .	150	–	–	–	–
Phosphatic slag, . .	500	1,150	721	903	935
Muriate of potash, .	150	–	–	–	–
Phosphatic slag, . .	500	–	–	–	–
Muriate of potash, .	150	1,460*	643	1,275	880

* This plot was cut about a week later than the other two.

Owing to the peculiar character of the season, it is not believed that any of the fertilizers greatly influenced the first crop, and it may be doubted whether the phosphatic slag has yet exercised much influence, as it is well understood that it is a relatively slow-acting fertilizer, especially when left upon the surface. The results for this year, then, as for preceding years, are to be mainly attributed to the influence of the relatively small amounts of fertilizer used previous to the present season.

One of the most interesting points in connection with these experiments is the influence of the fertilizers upon the character of the hay produced and on the proportion of grasses and clovers in the different plots. As was stated last year, the turf on one of these fields (north plots) at the beginning of the experiment was composed chiefly of Kentucky blue-grass, with here and there a few roots of orchard grass and occasionally a clover plant. On the south plots the mowing was reseeded about ten years ago, and there was some timothy and orchard grass, a little clover and considerable Kentucky blue-grass. Where the nitrate of soda is used alone, the product is now made up wholly of grasses, and in the half acre hardly a single clover plant can be found. The product of the plots to which the nitrate of soda and muriate of potash were annually applied, and to which phosphatic slag has now been added, is a good mixture of grass and clover. The product of the third plot, to which potash alone was applied previous to this year, and which now receives potash and phosphatic slag, is very rich in clover, and the character of the turf appears to be improving from year to year. As was stated in my last annual report: "The grasses, which at first did not appear to be much benefited by the application of potash, at the present time appear to be more vigorous than on either of the other plots. It would seem that these are now making use of some of the nitrogen taken from the air by the clovers which are so abundant in this plot. Red clover, which is the prevailing species, is not a long-lived plant. It maintains itself in mowings by seeding, and as the older clover plants die, the grasses growing in the same plot feed upon the products of the decay of the clover roots and stubble; so that in the end we appear to benefit grasses as well as clovers to a marked degree by the continuous use of a fertilizer whose benefits in the first instance are confined almost exclusively to clovers." It is hoped that the application of phosphatic slag, which has now been begun and which will be continued annually, will still further improve the yield on those plots receiving it.

The total cost of the fertilizers applied to the several plots may be readily computed from the following statements: nitrate of soda in the open market costs in considerable quantities about $43 per ton; the phosphatic slag used was imported from England, and laid down in Amherst at a cost of about $12 per ton; the muriate of potash costs in large quantities about $41 per ton.

Live Stock.

During the past year we have had practically no disease among our live stock, with the exception of numerous severe cases of strangles. All our colts and some of the mature horses had this disease; and it most unfortunately terminated fatally in the case of the French Coach stallion "Lance," our most valuable animal. His was a most aggravated attack of this disease, which involved practically all the glands of the throat and head, and ultimately led to pleuro-pneumonia and blood poisoning. Everything possible that veterinary medicine could suggest was done for the animal, but, as post-mortem examination showed, the lesions were so extensive that his case must have been considered as really hopeless almost from the start.

It is a matter for sincere congratulation that the tuberculin test, repeated last winter, showed our herd to be free from tuberculosis.

The kinds and numbers of the several classes of live stock are shown below: —

Horses. — French Coach, 1 stallion, 1 mare, 2 fillies; Percheron, 1 stallion; German Coach, 1 mare; French Coach half-blood, 2 colts; Percheron three-fourths blood, 2 mares; sucking colt, 1; work horses, 5.

Neat Cattle. — Jersey, 1 bull, 3 cows, 2 heifers, 1 calf; Holstein-Friesian, 3 cows, 1 heifer; Ayrshire, 1 bull, 3 cows, 1 heifer; Shorthorn, 1 bull, 1 cow; grade, 36 cows, 10 heifers, 4 calves; total, 68 head.

Sheep. — Southdown, 7 breeding bucks, 50 ewes, 4 lambs; total, 61 head.

Swine. — Berkshire, 1 boar, 5 sows, 5 pigs; small Yorkshire, 2 boars, 1 sow, 5 pigs; Chester White, 8 shoats; total, 27 head.

The Milk Record.

During the past year we have continued the policy of gradually disposing of the least satisfactory milkers in our herd. The average product is not yet entirely satisfactory, but we are undoubtedly making considerable improvement. During the year ten grade heifers have produced their first calves, and many of these have made very satisfactory records. The total number of individuals milked for the year is 42; among these were the ten heifers with first calf above mentioned. The total yield of milk has been 215,-367 pounds, — an average per cow of 5,128 pounds. The average butter fat test for the herd is about 4.2 per cent., which makes the average yield of butter fat per individual cow 218.38 pounds.

Improvements.

The chief improvements of the year are the following: —

About four acres in Durfee pasture, from which the stumps were removed last year, have been plowed and produced a good crop of potatoes. It will be seeded next season. The area devoted to the production of pasture crops for our hogs has been doubled, involving the erection of considerable new hog-proof fence. The New England Anchor fence has been used for this purpose, and promises to give excellent satisfaction.

A number of minor improvements have been made in and about the farm buildings. These include the removal of partitions and laying of cement floors in that part of the barn which was formerly occupied by the boiler and dynamos; the piping of the sheep barn for steam, to be used during the lambing season or after shearing of the sheep in February; the placing of a partition with rolling doors between the sheep and the cattle in the west wing of the barn; the construction of grain bins in the loft of this wing of the barn, with shutes respectively to the sheep floor and the basement where the hogs are kept; and the repainting of the steel roofs of the stable and barns. One of the silos, which has been in use about ten years, was found to need relining; this work has been done in a substantial manner, and the lining has been painted with hot tar.

A large amount of work has been done in grading about the new dining hall and heating plant, and in building new roads and walks connected with these buildings; for this work, however, the farm department has been paid out of the appropriation made for the purpose.

The Farm Finances.

The cash receipts for the year are $9,624.79, and there is due on accounts for sales made during the year the sum of $384.70; this, added to the cash receipts, makes a total of $10,009.49. Last year the similar total was $9,013.59; there is an increase, therefore, for this year of $995.90. The total expenses of this year amounted to $13,593.05. The inventory at the present time amounts to $18,790.85, which is $866.15 greater than the inventory of last year. The cash received during the year has come from the following items: milk and cream, $2,843.33; cattle, including calves for veal, $319.35; horses, including fees for the use of stallions, $859; swine, $682.54; sheep, $133.40; hay, $161.14; potatoes, $550.10; celery, $116.80; team labor, $1,744.53; manual labor, $794.63; onions, $49.98; soy beans, $285; Japanese barnyard millet seed, $317.80; wool, $47.50; pasturage, $21; sawdust, $22.30; lumber, $19.83; ice, $261.46; fertilizers, $57.84; and sundries, $337.06. The increased expenses of the year are accounted for chiefly by the increased cost of caring for crops and fields, due to the abnormal season. Two items, the practical failure of the corn crop and the loss of the stallion "Lance," very nearly account for the financial loss which is the outcome of the operations of the year.

WM. P. BROOKS,
Professor of Agriculture.

AMHERST, Jan. 2, 1904.

MILITARY DEPARTMENT.

Pres. H. H. Goodell, *Massachusetts Agricultural College.*

Sir: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1903.

I have been in charge of the department of military science and tactics during the entire year. The instruction has been both theoretical and practical, and conducted in compliance with college regulations and War Department orders.

Under the provisions of General Orders No. 94, War Department, 1902, this instruction is graded, in respect to the military course, as of the second class, requiring the following minimum of exercises, viz.: —

Practical. — (1) Infantry drill regulations through the school of the soldier, squad, company and battalion both in close and extended order; (2) advance and rear guards, out-posts and marches; (3) the ceremonies pertaining to reviews, inspections and parades, guard mounting and escort of the colors; (4) infantry target practice; (5) instruction in first aid to the injured; (6) a guard to be mounted five times, weather permitting, each week of the college year, and the guard practically instructed for one hour in the posting and relief of sentinels and their duties.

Theoretical. — (1) Infantry drill regulations; (2) the manual of guard duty; (3) small arms firing regulations; (4) army regulations and articles of war; (5) the following records: enlistment and discharge papers, descriptive lists, morning reports, field and monthly returns, requisitions and property returns; (6) lectures, one on the organization of the United States Army, one on patrols and out-posts, one on camps and camp hygiene, three on lines and bases of operations, two on attack and defence of advance and rear guards, outposts and convoys.

This order has been strictly complied with, and additional lectures given on the several subjects. Only seniors and freshmen have been required to take theoretical instruction, each class once per week.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.: —

Mondays, recitation of freshmen, first division, 2.30 P.M.; drill and instruction in the ceremony of guard mounting and duties of sentinels, 3.45 P.M.

Tuesdays, the same practical instruction as for Mondays, with an additional guard at 4.45 P.M.

Thursdays, the same as Mondays, second division of freshmen.

Fridays, recitation of seniors at 4.30 P.M.

Saturdays, inspection of dormitories, including students' rooms, 8.30 A.M.; instruction in guard duty and duties of sentinels, 8.15 to 10.15 A.M. The latter exercise is required only of those students who have incurred demerits in the military department, such as unauthorized absence from drill or inspection, or room not in proper order.

Drills are both in close and extended order; target practice by squad during the drill order hour; battalion drills are usually preceded by parade and review.

The order of drill commences with small squads in the school of the soldier, and proceeds, step by step, with and without arms, until the freshmen become proficient, when they are assigned to companies, after which the exercises include all movements in company and battalion drill.

To avoid tiresome monotony, the drills are varied as much as consistent with official regulations, to embrace field artillery; gallery practice; firing (indoors) at an iron target with a reduced charge of powder, two grains; and Butt's Manual of Physical Drill, the latter in the drill hall during the winter months, when the weather is too inclement to drill out of doors. The progress made from day to day seems tedious, but at the close of the college year the result has been satisfactory.

One hundred and five students have had target practice during the past year, at short ranges, with the Springfield cadet rifle; fair progress has been made, but much more might have been accomplished with more time. This is a subject of the greatest importance, which calls for more time than the schedule permits, but which cannot be remedied without encroaching upon the other departments considered equally important. Only one hour of target practice each regular drill day, during favorable weather, fails to arouse very much enthusiasm. To become a good marksman requires a careful study of the mechanism of the rifle, and frequent practice upon the rifle range under various conditions of weather. If some provision could be made by the State, providing tentage and camp equipage to enable the whole student body to go into camp for one week in each college year, and the time be given to instruction in guard and out-post duty, target practice, construction of shelter trenches and the subject of castrametation, it would, in my opinion, prove of great value; I therefore recommend it.

I also respectfully submit the recommendation that a physician be employed and paid by the State to devote one or two hours each day attending any of the students who may require medical attendance. I am led to make this recommendation by the apparent necessity of it. It is the natural disposition of most men to neglect employing a physician until the illness becomes serious; especially is this the case with young men of limited means, who have to pay for such service, and who have to husband every resource in order to get through college. This reason alone will, I trust, appeal to those who have the interest of the college under consideration in making appropriations. Such a measure will also prevent the spread of contagious disease. The student should be required to pay for the necessary medicine.

The band, under the leadership of Arthur L. Peck, member of the senior class, is doing good work, and merits all the encouragement that has been given it in the way of appropriations. These appropriations have not been large, but sufficient to place the band upon a permanent footing. No provision was made for it last year, but I submit the recommendation that $150 be appropriated for the coming year, made necessary by the following reasons, viz.: two or three new instruments will be required, to replace those that are still the private property of students; also, new music is required from time to time, as occasion arises.

All the buildings under my supervision are in good condition, except that the drill hall is greatly in need of shingling, or what, in my opinion, would eventually prove cheaper, — a slate roof. This recommendation has been embraced in previous reports. The plumbing in all the buildings, as far as I can ascertain, is in good sanitary condition.

Under the provisions of General Orders No. 94, War Department, 1902, the following-named students of the class of 1903 were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown special aptitude in military exercises, viz.: William E. Allen, George L. Barrus and Neil F. Monahan.

Under the provisions of General Orders No. 6, War Department, dated Aug. 24, 1903, the President of the United States authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions of this character that have maintained a high standard, and whose students have exhibited the greatest interest, application and proficiency in military training and knowledge; such appointment to be made after caring for the graduates of the Military Academy at West Point and the successful competitors in the annual examination of enlisted men. This, in my opinion, is a prize of great value, well worth striving for, and should inspire the ambition of every student. There will always be vacancies of this grade in the army to be filled in this way. Although the order provides for the appointment of only one each year from each of the institutions mentioned, yet the others can take a just pride and satisfaction in the honor of helping to raise this college to that high standard, and there is no good reason why we should not accomplish it. An army officered by such young men as this institution graduates will never fail to reflect credit upon the country.

Those who are familiar with the object of military instruction in educational institutions will undoubtedly commend the wise provisions of law and regulations which require it; but, beyond the purpose specifically expressed, it becomes the duty of every instructor of military science to teach those principles of devoted loyalty to our common country, not a mere passive compliance with law, but an aim to higher citizenship, a reverence for the traditions of the country; the benefits that they, as students, derive from it; and an ever-ready willingness to give their best service in upholding the honor of it when such service becomes necessary; a love and respect for the flag as a symbol of those principles upon which our nationality rests. To teach such principles has been and will continue to be my purpose.

The following is a list of ordnance and ordnance stores, property of the United States, in possession of the college: —

2 3.2-inch breech-loading steel guns, with implements complete.
2 8-inch mortars, with implements.
2 mortar beds.
2 carriages and limbers for 3.2 B.L. steel rifles.
147 Springfield cadet rifles, model 1884.
147 sets infantry accoutrements.
51 headless shell extractors.
1 set reloading tools.

6 non-commissioned officers' swords, steel scabbards.
14 non-commissioned officers' waist belts and plates.
14 sliding frogs for waist belts.
100 blank cartridges for field guns.
5,000 metallic rifle ball cartridges, calibre 45.
4,000 metallic blank cartridges, calibre 45.
300 friction primers, radial, for field guns.
18,000 cartridge primers, small arms.
9,000 round balls for gallery practice.
35 pounds of powder for small arms reloading.
7,000 pasters, white and black.
185 paper targets, "A" and "B."
1 set of marking rods, disks and brushes for gallery practice.

All of this property is in good condition and well cared for. There is no signal property on hand.

One hundred and ninety-eight students have received practical instruction in the military department during the year, some for only a short period, on account of not remaining in college. These figures include the class of 1903.

The organization at present is as follows, one battalion of two infantry companies, which, for the purpose of battalion drill and ceremonies, are equalized into four companies and the band: —

Commandant.

Capt. John Anderson, ... U. S. Army.

Staff.

Cadet Adjutant, ... Howard M. White.
Cadet Quartermaster, ... Clifford F. Elwood.
Cadet Sergeant Major, ... Maurice A. Blake.

Company A.

Cadet Captain, ... Fayette D. Couden.
Cadet First Lieutenant, ... Reuben R. Raymoth.
Cadet Second Lieutenant, ... Michael F. Ahearn.
Cadet First Sergeant, ... Sidney B. Haskell.
Cadet Sergeant, ... Frederick L. Yeaw.
Cadet Sergeant, ... Willard A. Munson.
Cadet Sergeant, ... Grenville N. Willis.
Cadet Sergeant, ... Raymond A. Quigley.
Cadet Corporal, ... George W. Patch.
Cadet Corporal, ... Thomas F. Hunt.
Cadet Corporal, ... Bertram Tupper.
Cadet Corporal, ... Zachary T. Hubert.
Privates, 48; aggregate, 60.

Company B.

Cadet Captain, ...	CLARENCE H. GRIFFIN.
Cadet First Lieutenant, ...	HOWARD D. NEWTON.
Cadet Second Lieutenant, ...	Vacancy.
Cadet First Sergeant, ...	FRED F. HENSHAW.
Cadet Sergeant, ...	GEORGE H. ALLEN.
Cadet Sergeant, ...	JOHN J. GARDNER.
Cadet Sergeant, ...	EDWIN W. NEWHALL.
Cadet Sergeant, ...	ALBERT D. TAYLOR.
Cadet Corporal, ...	WALTER B. HATCH.
Cadet Corporal, ...	FRANK F. HUTCHINGS.
Cadet Corporal, ...	LOUIS W. HILL.
Cadet Corporal, ...	JAMES R. KELTON.

Privates, 46; aggregate, 57.

Band.

Cadet First Lieutenant, ...	ARTHUR L. PECK.
Cadet First Sergeant, ...	ERNEST A. BACK.
Cadet Sergeant, ...	PARKMAN F. STAPLES.
Cadet Corporal, ...	ARTHUR W. GILBERT.
Cadet Corporal, ...	JOHN W. GREGG.
Cadet Corporal, ...	SUMNER R. PARKER.

Privates, 14; aggregate, 20.

Total in military department: 2 captains, 4 first lieutenants, 2 second lieutenants, 1 sergeant major, 2 first sergeants, 9 sergeants, 11 corporals, 108 privates; aggregate, 149.

Respectfully submitted,

JOHN ANDERSON,
Captain, U. S. Army, Commandant.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Condition and Progress of the Institution, Year ended June 30, 1903.

The time for the commencement of elective courses has been shifted from senior year to the beginning of junior. This change has been made in the direct interest of the students, to allow them greater choice of subjects and a longer time for pursuing them. A course in agricultural physics is now offered, and connected courses in landscape gardening, horticulture, floriculture and the care and management of greenhouses have been opened. The State has erected and equipped, at a cost of $40,000, a dining hall capable of accommodating 400 students, and furnishing lodging for 15 or 20 female students. In like manner the State has installed, at a cost of $46,505, a heating and lighting plant, which is now in satisfactory use in ten of the college buildings.

II. Receipts for and during the Year ended June 30, 1903.

1. State aid: —	
(*a*) Income from endowment,	$4,263 22
(*b*) Appropriation for current expenses,	33,000 00
(*c*) Appropriations for building or for other special purposes,	86,505 00
2. Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) Additional endowment, act of Aug. 30, 1890,	16,666 66
(*c*) For experiment stations, act of March 2, 1887,	15,000 00
3. Fees and all other sources,	2,824 39
Total,	$165,559 27

III. Property, Year ended June 30, 1903.

Value of buildings,	$248,775 00
Value of other equipment,	124,358 62
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60
Value of farm and grounds,	$42,000 00
Number of acres of land allotted to State under act of July 2, 1862,	360,000
Amount of land grant fund of July 2, 1862,	$219,000 00
Amount of other permanent funds,	141,575 35
Number of bound volumes in library, June 30, 1903,	25,258

IV. Faculty during the Year ended June 30, 1903.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	23
2. Number of staff of experiment station,	20

V. Students during the Year ended June 30, 1903.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	177
2. Graduate courses,	7
Total, counting none twice,	184

APPENDIX.

EXPLANATION OF PLATES.

[All the figures greatly enlarged.]

PLATE I.

Fig. 1.— Larva of second instar (crawling young).

Fig. 2.— Antenna of same.

Fig. 3.— Leg of same.

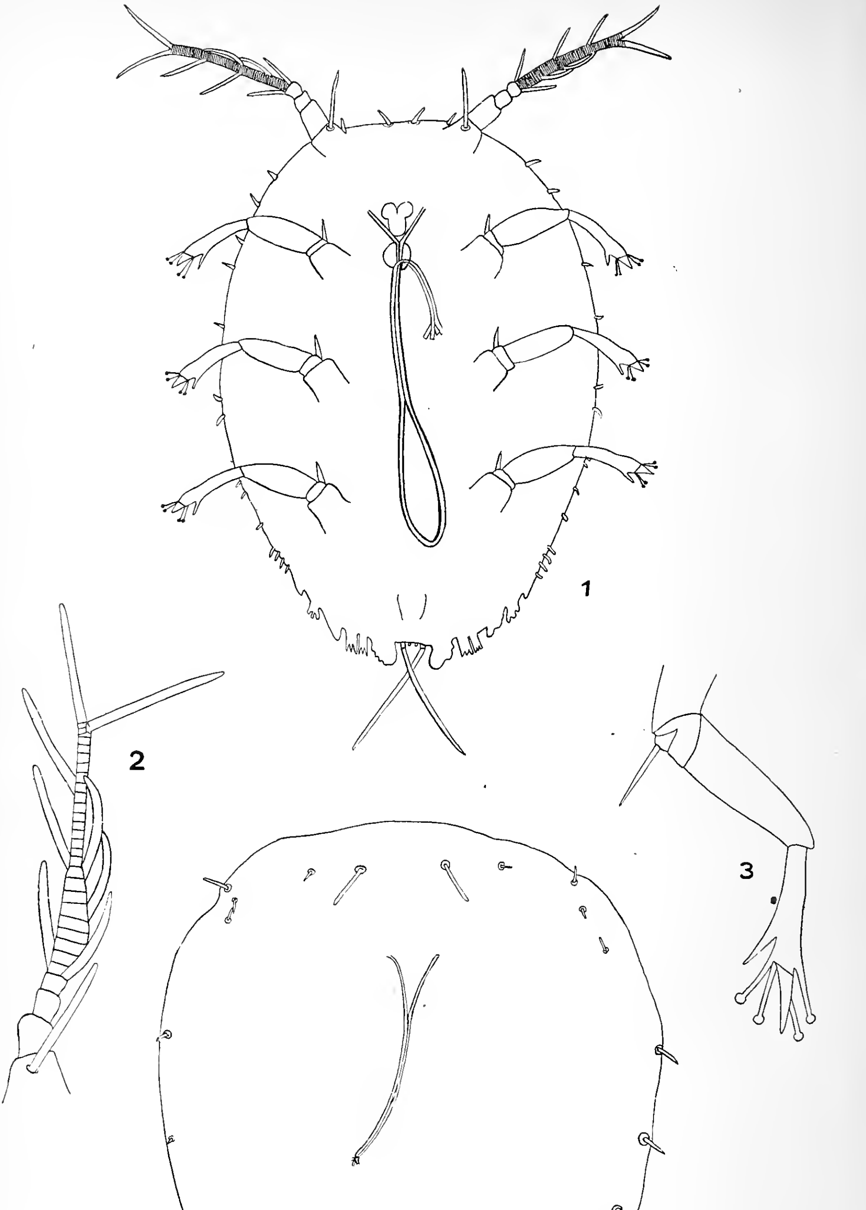
Fig. 4.— Third stage, female.

PLATE II.

Fig. 1.— Adult female.

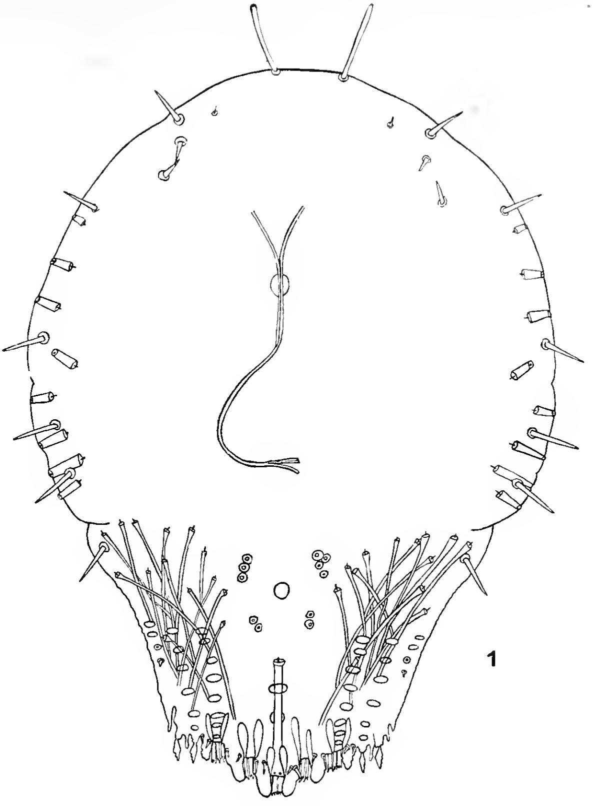
Fig. 2.— Pygidium of female, third stage.

Fig. 3.— Pygidium of female, adult.



H. E. Hodgkiss del.

Plate 1.



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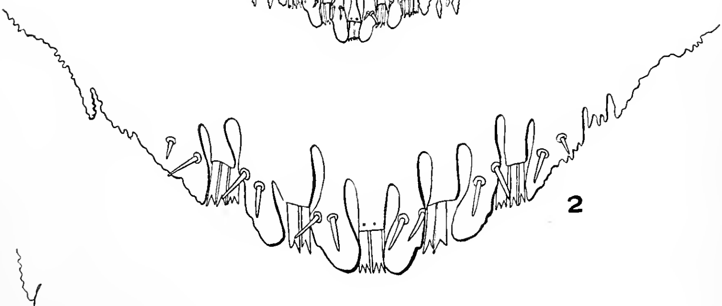

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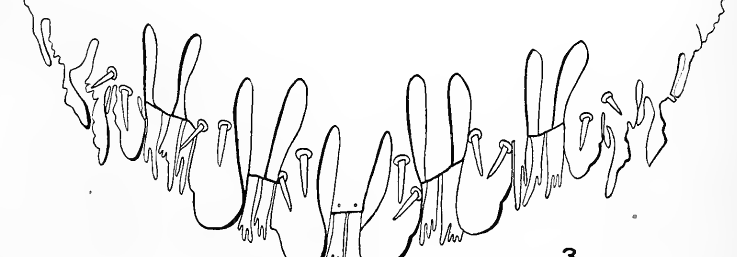

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Plate 2.

THE LIFE HISTORY AND TREATMENT OF A COMMON PALM SCALE.

(*Chrysomphalus dictyospermi* Morgan.)

BY HAROLD E. HODGKISS, B.SC.

Entomological Laboratory, Massachusetts Agricultural College.

This paper is the result of a request from Mr. W. R. Pierson of Cromwell, Conn., for advice on the control of a troublesome coccid in his large palm houses. The writer is greatly indebted to Mr. Pierson for the material with which to make his investigations.

While at work on the treatment it seemed advisable to trace the life history, and to determine, if possible, the true systematic position of the insect, which was found to be a common palm scale, — *Chrysomphalus dictyospermi* Morg. Keeping in mind the fact that the typical *Chrysomphalus dictyospermi* Morg. is not known, the strikingly close resemblance of the named varieties, and the difference between the puparium of the type and of each variety, the writer holds that the species herein described is too close to the type to be distinguished under a varietal name.

It has also seemed wise to present the early stages according to a plan which is not accepted by all, but which seems desirable to most entomological workers. I here regard the ovum as the first instar, the escape from the ovarian membranes as the first ecdysis, etc.

Life History.

First Instar. — Ovum, elongate oval; .15 to .16 mm., longest diameter; .10 to .11 mm., greatest width; amnion transparent, thrown off when the young are thrust out from the body of the parent.

This instar is found entirely within the body of the female. During this period the segmented appendages — legs, antennæ and mouth parts — are formed; spines and a rudimentary pygidial fringe also appear; a pair of medium lobes is quite prominent at this period.

Second Instar (Plate I., Fig. 1). — Elongate oval; length, .60

mm.; width, .40 mm.; color, light yellow. Antennæ with five segments, the distal one twice as long as segments two, three and four together; ringed, and terminating in two long, chitinous hairs; six slightly shorter hairs are situated on this segment, also one hair on the anterior face of the proximal segment.

Legs: coxa large, trochanter smaller, femur much swollen; tarsi represented by a slightly hooked projection. On the upper face of the trochanter is a long, chitinous hair, and near the distal end of the tibia is a projection or spur. The tarsal hook is surrounded by four knobbed hairs. The mouth parts are specialized to form a long, sucking tube or rostral filament. The pygidium is not distinctly constricted. The pygidial fringe shows the following characters: median lobes prominent, large, serrated on the lower lateral margin; second pair of lobes very slightly produced and sometimes faintly serrated; third pair of lobes rudimentary. Between the median lobes are two long, chitinous hairs; the median and second pairs of lobes are separated by two simple plates, and between the second pair of lobes and the rudimentary lobes is one simple plate.

Four small spines mark the adult abdominal constrictions. Between the antennæ are two chitinous hairs, and another is situated just above the basal segments of each antenna. Other hairs are shown in Plate I., Fig. 1.

During the first few hours of this instar the insects are crawling larvæ. Soon after birth, waxy filaments are seen exuding from pores of the body. Within twelve hours after birth the larva becomes quiescent, and the filaments, at first transparent, begin to form an opaque covering; this gradually darkens, the upper surface having the appearance of a hoary incrustation. As the scale grows, it becomes nipple shaped, with a depressed area around the centre.

Second Ecdysis. — About ten days after the larva emerges the second molt occurs; at this period the legs and antennæ are thrown off with the larval skin. From around the margin of the first larval covering a new secretion forms, flattening toward its circumference, or, in a few specimens, rising to form a more or less well-defined circular ridge. The hoary incrustation is present only on the more elevated part of the nipple, where it persists even in the fourth instar.

Third Instar (Plate I., Fig. 4). — Pale yellow; .54 mm. long by .46 mm. cephalic width; not as distinctly pyriform as in adult; body slightly constricted cephalad; spines similar to adult; pygidial fringe showing lobes, plates and spines as in the adult, but slightly smaller. Rudimentary projections of the body chitin occur beyond the third pair of lobes. Tubular spinnerets are present, but at this time are incompletely developed. Anus just above the median lobes. Antennæ replaced by a pair of antennal hairs. Rostral filaments present.

The pygidial lobes become more prominent and more distinctly constricted on their outer lateral margin. The median and second pairs of lobes lose their serrated lateral margin, while the third pair becomes distinctly serrated on the outer margin. The chitinous projections beyond these lobes are in different degrees of development, and do not assume the hastate form peculiar to the adult until the next instar. The hairs between the median lobes (second instar) are replaced by a pair of simple, fringed plates. The plates between the second and third pairs of lobes have increased to the normal number, — three. There is a slight cephalic constriction of the body.

In all coccids at this period there is, generally, a distinction between the sexes. Much time was spent in trying to rear males of this species from the material at hand, but without success; all the young coccids eventually became adult females, and in their turn produced other females only.

Third Ecdysis. — About eighteen or twenty days after casting the first larval skin the insect molts again, this time to assume the adult form. The larval skin becomes surrounded by a flattened, thin secretion, covering the adult insect; and very often this becomes interwoven with the epidermis of the plant, so that the color and texture of the scale is difficult to determine.

Puparium, or Scale of Adult Female. — This is circular or elongate oval; ochreus brown to castaneus, and in older specimens often whitish. Exuviæ central, or nearly so, ochreus, shining; first larval secretion with a central boss and ring; second secretion with or without a well-defined ring; margin flattened to epidermis of leaf, by which, in many cases, it seems to be covered; ventral scale a thin secretion on the leaf. Diameter 1 to 1.75 mm.

Adult Female (Plate II., Fig. 1). — Pyriform; light yellow; pygidium large, broad at apex, slightly angular; cephalic area slightly constricted; abdominal segments distinct; antennæ present as antennal hairs; rostral filaments longer than body. The pygidium shows the following characters: edge with three pairs of large subequal lobes, their inner lateral margins concave for about one-half their length, abruptly rounding; the outer lateral margin distinctly notched, giving a bilobed appearance; the second pair of lobes similar in shape, but smaller; the third pair smaller, the outer lateral margin of each distinctly serrated. Five pairs of vasiform thickenings of the chitinous integument are situated above and continuous with the margin above the lobes; one pair at the base of each median lobe, one thickening at the inner base of the second pair of lobes and one between the second and third lobes on each side, also one over the inner base of the third pair of lobes. Between the median lobes are two simple, fringed plates, and between the median and second lobes are two plates fringed in a somewhat similar manner; there are three plates between the second and third lobes, the inner plates narrow, elongate, and with lateral serrations, the outer plate wide and with a long fringe. Beyond the lobes are two well-developed hastate projections from the border, serrate on the outer lateral margin. Other projections from the border of the pygidium occur, but these seem to be without special or typical form; they are generally narrow outgrowths of the chitin, about one-half the length of the hastate projections. At the base of each lobe two spines are found, and another occurs beyond the serrations on each side of the pygidium; other spines on the body are shown in Plate II., Fig. 1. Tubular spinnerets are present, the longest extending to the articulation of the pygidium with the preceding segment; a single median spinneret arises from a pore between the median lobes. Circumgenital glands are present in four groups, and generally 4/2, 4/2, but vary considerably, so that the range is $\frac{3,\ 4,\ 5}{2}$, the lower laterals invariably being 2. The adult female is viviparous.

About a week or ten days after the last molt ova may be seen within the female, and the life history is complete, the time required for this ranging from thirty to forty days. The female gives birth to larvæ for a period of about two weeks, during the first part of which the young are the most abundant. The number of young produced by one female is not greater than twenty-five, the average about twenty. The generations run into each other, and no definite time can be stated at which to expect the young, the conditions of each habitat being found to govern the rapidity of reproduction.

Adult Male. — True male not known. As stated above, all the attempts to secure the male of this species have been unsuccessful. As a result of this, and also from statements of other writers that "the perfect male is unknown," it is safe to conclude that in this region, at least, no male form is present, and, this being true, the female must be considered as parthenogenetic.

Food Plants. — The following food plants are given in "Coccidæ of the World:" *Dictyospermum album*, *Erythrina indica*, *Cycas*, *Latania*, palms, rose, mango, etc.

Parasite. — A hymenopterous parasite has been reared from material of *Chrysomphalus dictyospermi* at hand, and proves to belong to the family *Chalcididæ*, sub-family *Aphelininæ*. A specimen sent to Washington, D. C., was determined by Dr. W. H. Ashmead as *Aspidiotiphagus citrinus* Craw.

Systematic Position.

The original description of the type does not give an exact picture of the insect described; on the other hand, it provides considerable latitude within which to place other representatives of the same species. The varietal forms also show a similar latitude, and a critical study indicates considerable variation from what is generally considered as being the typical form.

One of the differences is in the third pair of lobes. The type is described as having the outer lateral margin serrated; * in the variety *arecæ* Newst. no mention is made of serration on these lobes; † in the description of the variety *pinnulifera* Mask., as described under the name *jamaicensis* Ckll., ‡ no reference is made to serrations on these lobes; the variety *mangiferæ* Ckll., once described as a separate species, but now known to be a variety of this insect, has serrated third lobes, but also rudimentary fourth lobes.§ My description follows the type in detail, but differs from the variety *mangiferæ* in showing no trace of rudimentary fourth lobes.

Another difference is in the fringing of the interlobal plates. Here, again, the descriptions of type and varieties allow a wide range; probably the most noticeable difference may be seen between the variety *arecæ* Newst. and the one herein described. The former is described as having short, fringed plates; ‖ the figure gives them an even, regular fringe; my description and figure show an irregular fringe, similar to the type figure.

A third difference is noticed in the hastate projections beyond the third lobes. The type is described and figured as having two, serrated on the outer lateral margin; ¶ the varieties have from two

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* Ent. Mon. Mag., Vol. XXV., p. 352 (1888-89).

† Mon. Brit. Coccidæ, Newst., Vol. I., p. 107, Plate XII., Fig. 6 (1900).

‡ Can. Ent., Vol. XXVI., p. 129 (1894).

§ Bull. 6, T. S. Div. of Ent., United States Department of Agriculture, p. 24 (1897).

‖ Mon. Brit. Coccidæ, Newst., Vol. I., p. 107, Plate XII., Fig. 6 (1900).

¶ Ent. Mon. Mag., Vol. XXV., Plate 5, Fig. 2.

to five, and not all are serrated laterally; my description shows two hastate projections, serrated on their outer lateral margins; it also shows other chitinous projections, the shape and size of which are not definite, and, not being constant, may be ruled out of this discussion.

The well-known differences in the color of the puparium may also be considered. This may vary, however, under different climatic conditions to which it may be subjected. As has been noted, the puparia under observation have a tendency toward a lighter coloration than those hitherto described.

If we can accept the above statement as an explanation of the discrepancy between the type and its known representatives, and then weigh the very slight differences between the type and the insect herein described, as shown by the above comparison, there seems to be good ground to consider this insect as being too near the type to be given a varietal name; therefore, I conclude that this species is the *Chrysomphalus dictyospermi* described in Ent. Mon. Mag., Vol. XXV., p. 352 (1888–89). The bibliography on this species may be found in the "Coccidæ of the World."

Economic Importance.

This scale insect infests greenhouses in greater or less abundance, the physiological condition of the food plant being the factor which determines its increase or decrease. The importance of this palm scale is generally realized only in large palm houses, one palm grower expending about $2,000 per year to check its ravages, and it may be safely stated that many other florists have as large an expense account against this small insect.

The cause of this damage is the method by which the insect procures its nourishment. This is obtained by thrusting its rostral filament through the epidermis of the leaf, and drawing out its fluid nourishment from the tissue. As this process is continued, the epidermis becomes covered with minute punctures, each surrounded by a yellowish ring. This is a serious detriment to the plant, impairing its value, as well as making it unsightly for decorative purposes. The unsightly appearance of the infested plant thus lowering its market value seems to be the only reason for the importance the scale has obtained. In all the plants under observation only one died, and that was not due to the effect of this insect.

Remedies.

Treatment of scale insects can be effected, generally, in one of two ways, or by both together. Sometimes one will fail entirely, and the other will prove partly efficient.

In experimenting for the remedies, the method of soap washes was abandoned because in practical use against this palm scale it had failed to fulfill the requirements. The writer, having used these washes and seen their inefficiency, and having known the experience of one of the largest palm growers in the country, soon abandoned experiments along that line. The alternative method was by fumigation. The most effective fumigant known for coccids is hydrocyanic acid gas, and this seemed also the most feasible, since cheapness as well as efficiency was desired. The data on the experiments with this substance are given below.

The experiments were made at the insectary of the Massachusetts Agricultural College, under the supervision of Prof. C. H. Fernald and Dr. H. T. Fernald, to whom I am much indebted for valuable hints and suggestions on the preparation of this paper.

In order to isolate the palm from other plants in the greenhouse, a fumigating box was used, containing about 15 cubic feet of space, and perfectly tight. The palms were kept under the same conditions as in any greenhouse, and the results of the experiment can thus be directly applied.

Cost of potassium cyanide (KCN), about 50 cents per pound; of sulphuric acid (H_2SO_4), from $2\frac{1}{2}$ to 10 cents per pound, according to the quantity purchased.

Data of Experiments.

1. Rate, .075 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day clear, cool; temperature, 62° F. Foliage covered with moisture in spots; fumigated from 4.30 to 5 P.M., after sun was low, but while quite light. Results: scales partly killed, new growth on plant slightly injured.

2. Rate, .075 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day dull, rainy. Foliage covered with moisture; fumigated from 4.30 to 5.10 P.M., after sun was low, but yet quite light. Results: scales dead, new growth badly injured.

3. Rate, .10 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day cloudy, wet; temperature, 58° F. Plant free from moisture; fumigated from 5.30 to 6.10 P.M.,

after sun was low, but not dark. Results: scales dead, old and new growth badly injured.

4. Rate, .15 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day cool, clear; temperature, 59° F. Plant free from moisture; fumigated at 5.30 P.M., after sun was low, but while quite light. Results: scales dead, new growth badly injured.

5. Rate, .2 gram KCN per cubic foot of space; length of fumigation, thirty minutes. Day clear, cool; temperature, 58° F. Plant free from moisture; fumigated at 6 P.M., at dusk. Results: scales dead, tips of new growth badly injured.

6. Rate, .2 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day cool, cloudy; temperature, 58° F. Plant free from moisture; fumigated at 5 P.M., during fading light. Results: scales dead, palm very badly injured.

7. Rate, .25 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day clear, cool; temperature, 65° F. Plant free from moisture; fumigated at 5.30 P.M., daylight. Results: scales dead, only old growth present, very slightly injured.

8. Rate, .05 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day rainy; temperature, 45° F. Fumigated at 11 A.M., daylight. Results: scales not killed, young growth showed serious injury some weeks afterward.

9. Rate, .075 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day dull, sky overcast, but sun came out after experiment began; temperature, 50° F. Fumigated at 11 A.M., daylight. Results: palm quite sensibly injured, scales dead; young growth only.

10. Rate, .075 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day cool, clear; temperature, 50° F. Plant free from moisture; fumigated at 5 P.M., after sundown, dark. Results: no injury to young growth.

11. Rate, .10 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day cool, clear; temperature, 50° F. Plant free from moisture; fumigated after sundown in total darkness. Results: no damage to young growth.

12. Rate, .075 gram KCN per cubic foot of space; length of fumigation, thirty minutes. Day cool, clear; temperature, 55° F. Plant free from moisture; fumigated after dark. Results: no injury to plant.

13. Rate, .075 gram KCN per cubic foot of space; length of

fumigation, forty minutes. Day cool, clear; temperature, 40° F. Plant free from moisture; fumigated after sundown in total darkness. Results: no damage to young growth.

14. Rate, .10 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day clear, cool; temperature, 40° F. Plant free from moisture; fumigated after sundown, in total darkness. Results: no injury to plants.

Results and Recommendations.

The above experiments were made with reference to the many conditions to which the plants are subjected in the greenhouse. Varying conditions of heat, moisture, daylight and darkness have been studied, until it has been clearly shown that the plants must be treated after dark, and the foliage must be free from moisture, to obtain the best results. If fumigated before dark, the plants are more likely to show the effects of treatment, although none will be killed; even the largest amount of potassium cyanide used has failed to kill the entire palm, but the injury was too serious to warrant further experiments with large amounts. Palms treated in daylight with a small amount of cyanide, and injured, have been uninjured when that same amount was used after dark.

Palms on which water remained during fumigation were injured by an amount of the gas which could be used without danger to plants free from moisture, and the part affected was only that portion of the leaf on which the water remained. In order to kill the insect, the experiments show that a relatively large amount of potassium cyanide must be used; while a larger amount can be used for a shorter period of time without injury to the tender young growth, and with complete destruction of the insects, providing the fumigating is done after dark.

The exact amount of potassium cyanide to recommend for use in any greenhouse is difficult. The difference in the tightness of different houses naturally calls for a greater or less amount of gas to be generated. The danger attending its use can never be too greatly emphasized; and, for the assistance of those not acquainted with its preparation and use, I recommend the book, "Fumigation Methods," by Johnson.* This work is indispensable to any one who has occasion to use hydrocyanic acid gas as an insecticide.

Potassium cyanide to the amount of .075 gram per cubic foot of space for a period of forty minutes destroys all the scales, without

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* Orange, Judd Company, Nos. 52 and 54 Lafayette Place, New York City. Price, $1.

injury to the tenderest growth. A maximum amount that can be safely used is .10 gram per cubic foot of space for a period of twenty minutes; but for ordinary palm fumigation the smaller amount will prove to be the better.

Attention to a proper airing of the house is of great importance, and must be accomplished by means of ventilators opened from the *outside*. The house should be aired for a period of thirty to forty minutes after fumigation before any one enters.

The recommendations may be summed up in the following: —

1. Use .075 gram KCN per cubic foot of space for forty minutes, or a maximum of .10 gram per cubic foot of space for twenty minutes. The minimum amount is preferable.
2. Have palms free from moisture.
3. Fumigate only after dark.
4. Prepare suitable ventilation to be used after fumigation.
5. Open house for forty minutes after fumigation, and then close for the night.
6. *Keep out of the house until it is thoroughly ventilated.*

SIXTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1904.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

The co-operation and assistance of farmers, fruit-growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock, and can be furnished on demand : —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.

No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 85. Concentrated feeds.
No. 86. Orchard treatment for the San José scale.
No. 87. Cucumbers under glass.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 91. Injuries to shade trees from electricity.
No. 92. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1903.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$6,829 37	
for labor,	3,216 52	
for publications,	860 08	
for postage and stationery,	360 32	
for freight and express,	130 65	
for heat, light, water and power,	355 77	
for seeds, plants and sundry supplies,	810 76	
for fertilizers,	716 85	
for feeding stuffs,	587 17	
for library,	56 18	
for tools, implements and machinery,	196 13	
for furniture and fixtures,	35 03	
for scientific apparatus,	87 90	
for travelling expenses,	105 50	
for contingent expenses,	121 00	
for building and repairs,	530 77	
		$15,000 00

Cash received from State Treasurer,	$11,200 00	
from fertilizer fees,	4,215 25	
from farm products,	2,298 12	
from miscellaneous sources,	3,291 04	
		$21,004 41
Cash paid for salaries,	$10,303 59	
for labor,	2,446 47	
for publications,	353 03	
for postage and stationery,	254 39	
for freight and express,	45 41	
Amount carried forward,	$13,402 89	

Amount brought forward, . . .	$13,402 89	
Cash paid for heat, light, water and power, .	605 03	
for chemical supplies, ...	1,025 44	
for seeds, plants and sundry supplies,	378 43	
for fertilizers, ...	14 38	
for feeding stuffs, ...	700 36	
for library, ...	27 91	
for tools, implements and machinery,	39 54	
for furniture and fixtures, . . .	1 50	
for scientific apparatus, . . .	195 41	
for live stock, ...	61 45	
for travelling expenses, . . .	694 94	
for contingent expenses, . . .	245 86	
for building and repairs, . . .	412 71	
Cash on hand, ...	3,198 56	
		$21,004 41

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1903; that I have found the same well kept and classified as above; and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance in the treasury.

CHARLES A. GLEASON,
Auditor.

AMHERST, Sept. 2, 1903.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The close of the present year completes a period of fifteen years of meteorological observations at this station. From the records obtained during this time the mean values of the several weather elements for each month have been computed, and the results will be used as the normals of this station for the purpose of comparison. Charts showing the more important meteorological data are being prepared for the exhibit of this division at the St. Louis Exposition.

Last year, when this station arranged to furnish the United States Weather Bureau with the usual voluntary observer's records, the advisability of changing our times of observation from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., to conform to the times of observation at other stations, was considered, and it was thought best not to make the change at that time. Our printed forms for permanent record being all used, it was thought best to provide for the above change in preparing new record books. This has accordingly been done, and the change from tri-daily to semi-daily observations will be made at the close of a five-year period, on Jan. 1, 1904. The records being largely controlled by our self-registering instruments, the change should not appreciably affect our results for comparison with the normals already deduced.

The usual 4-page bulletins, giving the more important daily records, with the monthly means and summary of the weather, have been issued the first of each month. An annual summary will be prepared and published as a part of the December bulletin.

The local forecasts sent out by the New England section of the United States Weather Bureau have been received during the year, and the signals displayed from the flagstaff on the tower. These forecasts having come this year by the Postal Telegraph and Cable Company, instead of the Western Union Telegraph Company, as formerly. Our telegraph line to the college has been out of service most of the year, and the predictions have been obtained by telephone, causing considerable inconvenience and delay in displaying the signals. Arrangements were finally made with the Postal Company, whereby they connect with our line to the college at the corner of Amity Street and Lincoln Avenue, they maintaining a line from their office to that point, and this division controlling the line from that point to the tower. The receipt of the forecasts by telegraph at the tower was resumed about December 1.

At the request of the section director of the Weather Bureau, the weekly snow reports are being sent to the Boston office, as in previous years.

Two standard thermometers, reading to one-fifth degree F., were purchased during the year, to replace others broken in use. Three new clocks for the Draper instruments in the tower were also bought, to replace others that were worn out.

REPORT OF THE BOTANISTS.

G. E. STONE AND N. F. MONAHAN, ASSISTANT.

Besides the general correspondence work relating to the diseases of plants, which is constantly increasing each year, this division has continued its usual experimental work in the greenhouse on various market garden and floricultural problems.

During the past year this division has published two bulletins, entitled, "Cucumbers under Glass," issued as Bulletin No. 87; and "Injuries to Shade Trees from Electricity," which was issued as Bulletin No. 91.

From the pathologist's point of view, the past season has shown some resemblance to the preceding one. Both seasons have been peculiar, as demonstrated by the second blossoming of a large number of plants and the general upsetting of their seasonal habits. There has been an absence of some fungi, which usually occur more or less commonly, and a predominance of others which generally do not cause much damage. Some indications of the pink mold, a so-called attendant of apple scab, which made its appearance last year for the first time in this State, has shown itself again, although trouble from this fungus has not been serious in this State. The sooty mold of greenings, etc., has been unusually abundant the past two years where spraying has not been properly attended to, causing much disfiguration of the fruit. Considerable damage was done to pear trees by lice, which profusely secreted honey dew on the foliage and stems, thereby furnishing conditions for the luxurious development of a black mold on the stems and leaves, causing much injury to the latter.

The raspberry cane blight, recently described by Prof. F. C. Stewart,[1] has been noted in this State, and specimens have been sent to Professor Stewart, who has reported upon them. How common this disease is, or is likely to become, we are at present not able to say. There has been, moreover, an unusual amount of winter-killing of raspberry canes, resulting from the unusual conditions of the fall of 1902.

Some complaint has been made in regard to a potato stem rot, a disease which is apparently more common in Vermont, where it, with other potato diseases, is receiving serious attention by Prof. L. R. Jones.

An unusual leaf spot disease for this region was noted on corn. This was caused by the fungus *Helminthosporium inconspicuum* C. and E., which gave the leaves a badly spotted appearance, and in one instance rendered the crop practically useless. Probably the extremely abnormal corn weather during the past summer was responsible for this.

A fungus known as *Vermicularia trichella* Fr. caused considerable spotting and damage to the leaves of the English ivy (*Hedera helix*, L.). There has been a minimum number of the usual shade tree fungous blights, although the blight of the horse-chestnut leaves, caused by the fungus *Phyllosticta sphæropsoidea* Ell. and Ev., was troublesome, and a considerable amount of defoliation occurred to maples from sun scorch. The Norway maple leaves were also greatly lacerated by the winds at the time of unfolding, and they were literally covered with honey dew, which in some cases resulted in the development of a black mold on them.

The stem rot diseases of the carnation, aster, campanula, etc., have been rather common on out-of-door plants. The usual blights of the melon and cucumber were present, but these crops did so poorly that the fungus had little material to work on. The general consensus of opinion among growers of melons and cucumbers is that spraying does little or no good when the anthracnose and alternaria are present. This is especially true of the melon, where all attempts at spraying, even when frequently attended to, failed to hold these fungi in check.

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[1] Geneva, N. Y., Experiment Station, Bulletin No. 226, December, 1900.

The most general complaint, however, during the spring and summer, was in regard to winter-killing. It is seldom one finds so many varieties of plants injured from this cause, which can be traced back to the unusually prolonged warm weather, characteristic of the fall of 1902, and the sudden freeze following in early December. Among the plants that have suffered to a considerable extent are the following: —

The Californian privet (*Ligustrum ovalifolium*) and *Ligustrum ibota* were in many cases killed outright. Yellow and crimson rambler roses and certain honeysuckles were killed to the ground. The climbing ivy (*Ampelopsis veitchii*) was badly damaged, so much so, in fact, that buildings that were tolerably well covered with this beautiful ivy were almost bare in mid-summer. Wistarias, deutzia, spiræa thunbergii, spiræa vanhouttei and forsythia had their flower buds injured so severely that they made little show in the spring. The Japanese clematis was in most cases killed to the ground. Euonymus radicans suffered badly, as did many of the viburnums. Many of the choicer aquilegias were killed outright. The fruit buds of cherries, peaches and Japanese plums were practically killed ; in some cases the wood was much injured. Grape vines were in some cases killed to the ground, and strawberries, blackberries and raspberries were much injured. Such wild plants as the beech, plum and buckthorn, and many of the wild roses, had their wood severely injured. Many of these plants appeared to come through the winter successfully, and threw out strong shoots in the spring, when they suddenly collapsed. Blackberries and raspberries showed a marked tendency to die back after having blossomed and fruited. In some other instances plants not supposed to be hardy, such, for example, as the crimson clover and alfalfa, have gone through the winter without trouble. It would appear that, while the severe frost in December, following the unusually prolonged warm spell, was the means of doing great injury to plants that are supposed to be tolerably hardy, those like the crimson clover, etc., which are not hardy, were not affected. The limited amount of frost in the ground, due to the snow cover, eventually proved advantageous to such plants as the crimson clover and alfalfa. It is probable that the unusually slight amount of moisture present in the soil during the past spring had much to do with weakening many plants which might have made some recovery under other conditions.

We append to this report some experiments relating to the influence of electricity on the growth of plants, which have been carried on by us and students in a minor way for some years. Notwithstanding the considerable accelerated growth that electrical stimulation is capable of giving rise to, these experiments are not presented with any idea in mind that they furnish evidence of legitimate lines of forcing, or that the matter will be taken up by practical growers as a means of increasing their crops, especially at the present time. There are many legitimate lines of increasing and improving crops of which growers have not as yet made full use, and, so long as such exist, the wisest policy to pursue is to pay little attention to the so-called freak farming methods. This subject is, moreover, an especially complicated one, and it is a question whether it would be of much value to those who are following commercial methods, even if considerable gain could be obtained. All stimuli to plants are by no means advantageous from the commercial point of view, inasmuch as they do not always induce acceleration in the right direction, since the law of correlation holds good in the plant kingdom, as elsewhere. Whether the scarcity of forcing elements or the development of more refined methods of the gardening of the future will induce gardeners to utilize the various cosmic forces which act as stimuli, and which are not employed at the present time, remains to be seen.

THE INFLUENCE OF CURRENT ELECTRICITY ON PLANT GROWTH.

BY G. E. STONE.

Since 1747, when Dr. Mainbray of Edinburgh electrified two myrtle plants, various experiments have been made to test the effects of electricity on the growth of plants. Many marvelous results have been reported from time to time that have arisen from electrical treatment, and, as a rule, the more ignorance the experimenter displayed in his knowledge of plant physiology, the more startling and marvelous have been the results.

At the time our experiments were undertaken we were unable to find instances where any attempt had actually been made to study, in a methodical way, the influence of current electricity on plants; and in practically all of the previously recorded experiments the data were scant and the scope of the work was extremely limited. In the various haphazard results that had been reported from time to time there had been no attempt made to measure the current or resistance, or to ascertain the electro motive force employed in any of the experiments from which remarkable deductions had been drawn. One of the criticisms which can be made in regard to all of the earlier work, as well as most of the later work, is that, with a very few exceptions, only a few plants were employed in experimenting, — frequently only one or two. As a consequence, the errors arising from individual variation were entirely ignored, since enough plants were not employed to eliminate them. Indeed, in numerous cases the results obtained were nothing more than would be obtained from individual variation, or would naturally arise from a slight difference in environment. The limited amount of current which we have shown to act as a stimulus to plant growth would indicate that in some cases they were not in the range of acceleration (see Fig. 1). That plants respond to electrical stimuli in various ways is well known. The effect, however, which electricity has upon the growth of plants has not been well understood, and the results obtained by various experiments have not been convincing, for reasons already pointed out. The fact has been definitely established that

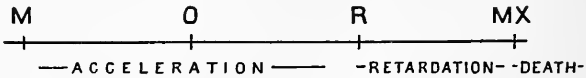

FIG. 1.—Diagram showing range of electric current affecting plants. M, minimum; O, optimum, or current producing greatest stimulus; MX, maximum, or death current; R to MX, retardation current.

electrical currents exist in the soil, and also in the plant; in fact, wherever chemical activity occurs electric currents are likely to be present, although these currents may be comparatively insignificant, and require delicate instruments for their detection.

The following experiments in stimulating plants with electricity have been carried on in this department for some years, and previous to undertaking this work many thousands of plants have been experimented with, and the minimum, optimum and maximum currents have been established by us in a general way. We therefore had more or less a definite idea in mind as to what strength of current we wished to apply at the beginning of our work. The experiments we are about to describe, therefore, represent only a small part of those which we have made, and these were made under conditions resembling those employed for commercial purposes. We shall, however, interpret the results of these experiments in the light of those obtained from our long study given to the subject, rather than from what these particular tables show.

The work was carried on in the greenhouse, during the summer months. The plants utilized were radishes and lettuce, which were selected for special reasons as being suitable for our work. The plants were grown in wooden boxes, 53 inches long, 32 inches wide and 7 inches deep. These boxes were placed on movable trucks, or in some cases on supports 18 inches from the floor. In all cases they were insulated. The soil employed was of a uniform quality and texture, and has been used for these experiments alone for some years. Previous to using the soil it was sifted through a sieve of $\frac{3}{8}$-inch mesh, and thoroughly mixed. After using the soil for a few experiments, it was taken out, resifted and thoroughly incorporated again; and occasionally the boxes were shifted about, that is, the normal or untreated boxes were substituted or changed for those which had been treated. With a

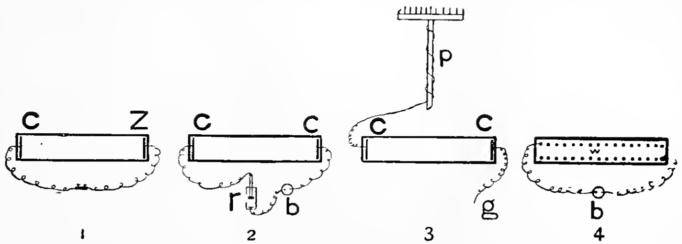

FIG. 2. — Longitudinal section of boxes employed in the electrical experiments, showing different methods of treatment. Size of boxes, 53 by 32 by 7 inches. 1, copper and zinc electrodes connected; 2, direct current with rheostat; 3, atmospheric; 4, wire electrodes. C, copper electrodes; Z, zinc electrodes; r, rheostat; b, gravity cells; w, wires; g, ground wire; p, collecting pole, 47 feet high.

few exceptions, copper or zinc plates were used for electrodes. These were made the same size as the ends of the boxes, and in a few exceptional cases two series of wires, strung on a frame about three inches apart, were employed instead of the plate electrodes. One of these frames of wires was buried near the surface, the other being buried near the bottom of the box. The current, therefore, had to pass from one frame to the other in a vertical direction through the soil. The strength of the currents was in most cases obtained with the aid of a Weston milammeter, capable of reading $\frac{1}{20}$ of a milliampere, or about $\frac{1}{20000}$ of an ampere. The interrupted induced currents were estimated, and represent only approximate determinations.

In the radish experiment the seed was sown directly in the treated boxes, whereas in the case of the lettuce the plants were transplanted into the treated boxes when of suitable size to make good growth; the latter plants, therefore, were not stimulated during the whole period of development. Gravity cells were used in all cases except with the interrupted induced current, in which case sal-ammoniac cells were employed.

Experiments with Radishes.

Table I. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	Treatment.	Number of Plants.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Average of three normals, .	112⅔	4.83	10.55	-	-	-
1	Direct current; one gravity cell; copper plate electrodes, ...	81	4.89	12.58	.012	19.24	13.60
2	Direct current; three gravity cells; wire electrodes, .	110	4.63	9.26	[1] 4.140	[1] 12.22	[1] 9.68
3	Interrupted induced current; copper plate electrodes, .	114	5.85	11.22	21.110	6.35	10.98

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	4.83	5.12	6.00
Of tops, ...	10.55	11.02	4.45
Of whole plant, ...	15.38	16.14	4.93

In Table I., in which six experiments are shown, three normal and three treated, the results are not in every way satisfactory. The current strengths were determined only once or twice in each instance, and these were estimated by means of the electro-motive force of the cell and resistance of the soil, and also by a milammeter. The current strengths given, therefore, represent only those which were found at the time of the measurements; and, since the resistance of soil is constantly changing with the movements of the water currents and with the ever-changing moisture conditions, due to watering, the figures giving strengths of current must not be considered as averages. The strengths of current employed in the experiments shown in the first five tables vary, probably from .05 to 1 milliampere.

In the interrupted induced current experiments the current had a duration of only about ten seconds per hour. This was accomplished with a clock arrangement and with a Du Bois-Reymond induction apparatus. It should be pointed out, however, that with the use of this apparatus only approximate current strengths can be obtained, as it does not constitute a particularly favorable type of instrument for obtaining uniform currents of a definite strength. Our extensive use of the apparatus in other work has enabled us, nevertheless, to use it with some degree of certainty of securing optimum strengths of current. The three gravity cells with wire electrodes apparently furnish too much current, hence we obtained a loss with these. We were beyond the optimum and in the retardation zone (see Fig. 1). This method of applying current was not considered a satisfactory one, and it was subsequently abandoned.

Nos. 1 and 3 showed a gain in both roots and tops, the total gain being 13.60 and 10.98 per cent. respectively. At the bottom of the table is given the total gain from electrical treatment; for example, the weights of the plants from three treated boxes are compared with the weights of those in the three normal boxes. The total gain of 4.93 per cent. is of little significance.

TABLE II. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 39 days.]

No.	Treatment.	Number of Plants.	Average Weight, in Grams, of —		Per Cent. gained in Weight of —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Average of three normals, .	220⅔	5.29	5.55	-	-	-
4	Direct current; one gravity cell; copper plate electrodes, ...	205	6.22	12.65	17.58	127.92	74.07
5	Direct current; one gravity cell; wire electrodes, . .	250	5.88	7.47	11.15	34.59	23.15
6	Amospheric electricity; copper plate electrodes, . .	180	6.60	10.06	24.76	81.26	53.61
7	Copper and zinc plate electrodes, connected, . .	109	14.01	16.61	164.84	199.28	182.38
8	Interrupted induced current; copper plate electrodes, .	220	6.17	6.17	16.63	11.17	13.83

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	5.29	7.77	46.88
Of tops, ...	5.55	10.59	90.85
Of whole plant, ...	10.84	18.36	69.54

In Table II. is shown a similar series of experiments, with modifications in the strengths of currents and methods of treatment. The currents, however, are reduced in all instances with favorable results. Nos. 6 and 7 received different treatment from those shown in the preceding table. In No. 6, termed atmospheric electricity, the current was obtained from a pole 35 feet above the ground; from the top of this pole there projected 24 small copper points, distributed in two circles, the outer arc having a radius of 30 inches. The arrangement was similar to that shown in Fig. 2, but not identical. The copper points were all connected with a single wire leading to the copper plate electrode of Box No. 3, the other electrode being grounded, as shown at G. The electrical potential was not determined in this experiment, but the deflection of the needle of a sensitive galvanometer showed that a current was present in the soil.

In No. 7, copper and zinc plate electrodes were simply connected together with a wire; this formed a cell in itself, and generated a current, usually about the optimum, which could be readily read with the milammeter. The results of the experiments are shown in the last column at the bottom of the table.

TABLE III. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	TOTAL WEIGHT, IN GRAMS, OF—		PER CENT. GAINED IN WEIGHT OF—		Total Per Cent. gained.
		Roots.	Tops.	Roots.	Tops.	
	Normal, ...	700	2,700	-	-	-
9	Direct current; one gravity cell; copper plate electrodes, ...	800	2,900	14.28	7.40	8.82
10	Amospheric electricity; copper plate electrodes, ...	900	3,000	28.59	11.11	14.70

Total weight, in grams:—	Normal.	Treated.	Per Cent. gained.
Of roots, ...	700	850	21.42
Of tops, ...	2,700	2,950	9.25
Of whole plant, ...	3,400	3,800	11.76

TABLE IV. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	Treatment.	Number of Plants.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal,	291	3.09	2.74	-	-	-
11	Direct current; one gravity cell; copper plate electrodes,	294	2.65	2.72	[1] 14.23	[1] .72	[1] 7.89
12	Atmospheric electricity; copper plate electrodes,	281	3.20	4.27	3.55	55.83	28.13
13	Copper and zinc plate electrodes, connected,	289	2.94	5.53	[1] 4.85	101.82	45.28

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	3.09	2.93	[1] 5.50
Of tops,	2.74	4.17	52.19
Of whole plant,	5.83	7.10	21.78

[1] Loss.

TABLE V. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 40 days.]

No.	Treatment.	Number of Plants.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal,	273	3.29	4.02	-	-	-
14	Direct current; one gravity cell; copper plate electrodes,	275	4.00	4.18	21.58	3.98	11.90
15	Atmospheric electricity; copper plate electrodes,	277	3.61	3.97	9.72	[1] 1.24	3.69
16	Copper and zinc plate electrodes, connected,	278	3.74	3.95	13.67	[1] 1.74	5.19

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	3.29	3.78	14.86
Of tops,	4.02	4.03	.02
Of whole plant,	7.31	7.81	6.84

The experiments shown in tables III., IV. and V. followed one another in succession, and were conducted in a similar manner. Some of the data shown in Table III. was unfortunately mislaid or lost, hence it is incomplete.

No. 11, in Table IV., shows a loss, but the average percentage gained by treatment in other cases is important. The gain shown in Table V. as a result of treatment is comparatively small.

TABLE VI. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 30 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal, . . .	241	-	5.1	3.2	-	-	-
17	Direct current; one gravity cell; copper plate electrodes, .	215	.10 (.05-.24)	6.1	4.1	19.60	28.12	22.88
18	Direct current; two gravity cells; copper plate electrodes,	242	.43 (.22-.90)	5.9	5.5	15.68	71.87	37.34
19	Copper and zinc plate electrodes, connected, . . .	198	-	7.4	5.2	45.09	62.50	51.80

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	5.1	6.46	26.66
Of tops, ...	3.2	4.93	54.06
Of whole plant, ...	8.3	11.39	37.22

TABLE VII. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal, . . .	217	-	10.80	4.14	-	-	-
20	Direct current; one gravity cell; copper plate electrodes, .	264	.197 (.10-.33)	12.30	6.60	13.88	59.42	26.50
21	Direct current; two gravity cells; copper plate electrodes, .	292	.516 (.23-1.0)	12.20	7.50	12.96	81.16	31.19
22	Copper and zinc plate electrodes, connected, . . .	272	.305	11.20	4.96	3.71	19.80	8.16

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	10.80	11.90	10.18
Of tops, ...	4.14	6.35	53.14
Of whole plant, ...	14.94	18.25	22.15

The concluding experiments with radishes are shown in tables VI. and VII. In this series the atmospheric experiments were omitted, and two direct current experiments were run in each series, in which different strengths of currents were employed. In these experiments, and all others which follow, an attempt was made to regulate more carefully the current strengths, and to make daily readings of the same. For this purpose a water rheostat was introduced in the circuit in the two direct current experiments; this enabled us to modify resistance, and to maintain a tolerably uniform current throughout. Current records in all the remaining radish experiments are averages for the whole period, and are based on four readings each day. The minimum and maximum currents are given in parentheses. In the direct current series we endeavored to maintain .2 and .4 milliamperes respectively. In No. 17, however, it only averaged .1 milliampere; in Nos. 19 and 22 readings were made every three days, but no attempt was made to modify the current strengths, inasmuch as these boxes generally maintained the desired current.

The results shown in these tables are more uniform than in the preceding ones, as might be expected from the greater care we gave in maintaining a more or less uniform stimulus. No loss is shown by the treated ones; on the other hand, there is considerable acceleration shown by treatment.

SUMMARY. — *Showing the Results with Radishes (Raphanus sativus L.) given in Tables I., II., IV.–VII.*

TREATMENT.	Number of Plants.	PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
		Roots.	Tops.	
Direct current (weak); copper plate electrodes; Nos. 1, 4, 11, 14, 17, 20,	1,334	9.73	39.66	23.67
Direct current (stronger); copper plate electrodes; Nos. 18, 21,	534	14.32	76.51	34.26
Direct current; wire electrodes; Nos. 2, 5,	360	3.50	11.18	6.73
Interrupted induced current; copper plate electrodes; Nos. 3, 8,	334	18.87	8.76	12.40
Copper and zinc plate electrodes, connected; Nos. 7, 13, 16, 19, 22,	1,146	44.49	76.33	58.56
Atmospheric electricity; copper plate electrodes; Nos. 6, 12, 15,	738	12.67	45.28	28.47

Average per cent. of weight gained, in grams: —
Of roots, ... 17.26
Of tops, ... 42.95
Of whole plant, ... 27.34

The results of electrical treatment of various kinds and of different strengths of currents, in which 3,446 treated radish plants were compared with 2,022 normal or untreated ones, are shown in the summary. These comparisons are based on the growth of the normal plants with which the treated were grown, and not on the total normals, since the duration of experiments in one table does not correspond with those in another; or, in other words, there existed some difference in the degree of maturity of the various crops. This method of comparison is necessary, since the treatment varied in time, and the experiments in each table were not parallel throughout. The results show, however, appreciable gains; and, as they are averages, the percentages represent more accurately the influence of electrical treatment, the total gain for roots and tops being 27.34 per cent. A notable feature is seen in acceleration of tops, which showed about two and a half times more growth than that shown by the roots. In the case of the two interrupted induced-current experiments the reverse holds true, there being more than twice as much growth of roots as tops. This current exerts a different physiological effect on plants than the direct current.

Experiments with Lettuce.

The tendency of electrical stimuli to accelerate the growth of the tops of radish plants more than the roots suggested the idea of substituting lettuce. Lettuce possesses a different and more desirable habit of growth, it would seem, for electrical stimulation. The variety of lettuce grown in all cases was that known as the Boston head type, so commonly used by market gardeners in Massachusetts. The plants were grown according to the customary manner of growing lettuce; namely, the seed was sown in a small box of soil. When the seedlings were an inch or two high they were transplanted into larger boxes containing loam; and when they had formed three or four leaves two or three inches long, they were carefully selected, as regards vigor and size, and transplanted into the experimental boxes, as in the radish experiments. The loam in which they were started was of uniform quality and similar texture to that used in the boxes. Twenty-four plants were set in each box, which allowed room for their full development. In transplanting, however, there was little or no loam attached to their roots. We have handled lettuce so extensively in our greenhouse that we were familiar with its characteristic requirements, and usually had on hand an ample supply of material from which to select. The strengths of currents in all lettuce experiments where gravity cells were used are based on four daily records. The minimum and maximum currents are also given in parentheses in all cases. In the copper and zinc electrode connections the currents were recorded every three days and the tables show the averages obtained.

TABLE VIII. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa L.). Normal Plant taken as the Standard at 100.*

[Duration of experiment, 31 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	23	-	798	34.69	-
23	Direct current; copper plate electrodes,	23	.183 (.05-.25)	1,233	53.60	54.22
24	Direct current; copper plate electrodes,	22	.395 (.15-1.0)	1,226	55.72	60.62
25	Copper and zinc plate electrodes,	22	.286 (.1-.5)	1,126	51.18	47.53

Total average weight, in grams: —

Normal,	34.69
Treated,	53.50
Total per cent. gained,	54.22

TABLE IX. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 42 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	-	681	28.12	-
26	Direct current,	24	.199 (.10-.35)	818	34.08	21.19
27	Direct current,	24	.342 (.20-.50)	816	34.00	20.91
28	Copper and zinc plate electrodes, connected,	24	.296 (.05-.60)	725	30.20	7.39

Total average weight, in grams: —

Normal,	28.12
Treated,	32.73
Total per cent. gained,	16.39

In the two preceding tables are shown the results of electrical treatment upon lettuce. The current was set at .2 milliamperes in experiments 23 and 26, and at .4 milliamperes in experiments 24 and 27. The experiments in both tables show the effect of electrical treatment, and where the resistance was modified the results are tolerably uniform. The gain by all treatment is 16.29 and 54.52 per cent. respectively.

TABLE X. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 50 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	-	619	25.79	-
29	Direct current,	23	.171 (.02-.25)	575	25.00	3.06
30	Atmospheric electricity,	23	-	784	34.08	32.14
31	Copper and zinc plate electrodes, connected,	24	.06 (.01-.09)	688	28.66	11.13

Total average weight, in grams:—
Normal, ... 25.79
Treated, ... 29.24
Total per cent. gained, ... 13.37

TABLE XI. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 60 days.]

No.	TREATMENT.	Number of Plants.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	710	29.58	-
32	Direct current,	24	800	33.33	12.67
33	Copper and zinc plate electrodes, connected,	24	1,355	56.45	90.83
34	Atmospheric electricity,	24	1,000	41.66	40.83

Total average weight, in grams:—
Normal, ... 29.58
Treated, ... 43.81
Total per cent. gained, ... 48.10

Tables X. and XI. show experiments arranged similar to the two preceding tables, except that atmospheric electricity is substituted for one of the direct currents. The atmospheric experiments were conducted with some modification from those previously described with radishes. The principal difference, however, consisted in the pole being 47 feet from the ground, instead of 35 feet, and the number of copper points was 124, instead of 24. (See Fig. 2, No. 3.) In the latter case we also used a 28-inch metal bicycle wheel to support the points at the top of the pole; in the former arrangement an inverted umbrella frame was used. In No. 29 we endeavored to maintain a current of .2 milliamperes; Nos. 31 and 33 gave the usual current, but no attempt was made to obtain averages in the latter. A sensitive galvanometer usually showed a deflection of the needle when in circuit with the atmospheric electrodes; and when the wire from the pole was attached to a Thomson self-recording electrometer it was usually sufficient to deflect the needle and to charge slightly a glass case of 30 cubic feet capacity. Only occasional observations were made of the strength of the current in experiments shown in Table XI.

SUMMARY. — *Showing the Results with Lettuce (Lactuca sativa L.) given in Tables VIII.–XI.*

TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Total Per Cent. gained.
Direct current (weak); copper plate electrodes; Nos. 23, 26, 29, 32,	94	0.184	22.78
Direct current (stronger); copper plate electrodes; Nos. 24, 27,	46	0.367	40.76
Copper and zinc plate electrodes, connected; Nos. 25, 28, 31, 33,	48	0.214	36.48
Atmospheric electricity; copper plate electrodes; Nos. 30, 34,	47	-	39.22

Average per cent. of weight gained, in grams, ... 34.81

The average percentage of gain shown by lettuce is slightly higher than that given by radishes, although the acceleration is not so great as that shown in the growth of radish tops over roots. There are, however, no instances in the lettuce treatment where the normal plants have excelled in growth the treated ones, although in No. 21 there is a difference of only 3 per cent. between normal and treated.

Conclusions.

The foregoing experiments with lettuce and radish plants show, in all instances except two, a total gain by the use of electrical stimuli. Those experiments where an attempt was made to maintain a strength of current within narrow limits showed the best results from treatment. Could an absolutely definite strength of current be utilized throughout the period of duration much closer results could be obtained, and the optimum current be more closely determined. Such an arrangement suggested itself to us quite early in our work, but the necessary equipment was not at hand. Since the variations in current strength depend largely upon the variations in soil moisture, tolerably constant currents might be obtained by regulating the water supply; but some automatic resistance appliance would undoubtedly constitute the best mechanism for getting absolutely constant currents. The effect which electricity has in accelerating the growth of plants and on the germination of seeds is positive; and in hundreds of experiments, conducted in a different manner, we have seldom obtained any negative results. We have, moreover, conclusively shown from our experiments that the alternating current is much superior to the direct as a stimulator; therefore the alternating-current experiments, Nos. 3 and 8, given in this series, should by no means be considered as typical, as we have apparently failed to get the optimum strength in these cases.

The question naturally arises, in what manner does electricity stimulate plants; or, in other words, how are accelerated growth and accelerated germination to be explained? There are numerous agencies which act as stimuli to seeds and plants about which little is known in regard to how they stimulate the plant. There are, to be sure, many theories advanced for the purpose of explaining the response of plants to various stimuli.

We know perhaps as much about the rationale of electrical action on plants as we do about the effects of light in producing heliotropic bendings, or of gravity in producing geotropic bendings. Some of the various theories pertaining to electrical action, however, possess interest and are worthy of citation. Frecke held the idea that electricity was the great moving force of animate creation, and identical with nervous influence. Marat was of the opinion that electricity exerted a marked influence on the fertility of the soil, and similar ideas have been advanced by others in more recent times. Fichtner and Sohne claimed to have found that electricity rendered soluble the constituents of the soil; and the same opinion was advanced by Tschinkel, who believed that acceleration and growth were brought about by the action of electricity upon the salts and other constituents of the soil. Jodro attached a double function to the action of the soil current: first, it acts chemically on soil, in dissolving those constituents necessary for plant nourishment; and second, it acts mechanically, in setting the particles of the soil into a state of molecular vibration, thus loosening the earth. These views relating to the decomposition of the certain salts in the earth by passing a current of electricity through it have not been confirmed by Wollny. He made a series of careful analyses of soil, electrically treated and untreated, and found absolutely no difference, which could be attributed to the effects of electricity, in the percentages of potassium, ammonia, phosphoric acid, potassium nitrate and carbonic acid gas. The action of electricity upon oxygen, as is well known, gives rise to ozone; and some botanists have believed that the production of ozone in the seed by electric currents is the prime factor in accelerating germination and growth.

Most of these theories are very fanciful, and all inadequately explain the stimulating effect of electricity upon plants, nor is there any reason to believe that this phenommenon can be explained by simple mechanical theories. There may exist a fundamental basis for the theory that electricity is capable of decomposing certain constituents of the soil and rendering them more available, but in all probability the strength of current which is capable of advantageously stimulating plants would produce little effect on the soil; at any rate, it would produce little effect during the short space of time it requires to mature most crops. Moreover, when it is considered that moist seeds and seedlings respond to electrical stimuli in quite a remarkable manner when sown and allowed to develop on moist filter-paper cloth or in porous clay dishes, etc., the complicated soil theory of electrical action falls to the ground.

Electricity affects the protoplasm of the plant, and it is to the effect on the protoplasm that we must look for the solution of the problem, and not to its influence on the soil. This can be seen in plants that show protoplasm movements, such as Chara, etc. It has long been known that weak currents stimulate protoplasm, and induce an accelerated movement; whereas strong currents retard or stop such movements, or, if too strong, they kill the protoplasm.

Current electricity likewise induces bendings in the roots (galvanotropism) when grown in water between electrodes. In such cases weak currents produce negative bendings, — that is, towards the cathode; while strong currents produce positive bendings, — towards the anode. Similar effects are seen in the movements exhibited by many microscopic animals, such as paramœcia and other protozoa.

Plants respond to light, gravity, moisture, etc., in a positive and negative manner; and it is also known that a negative electrotropic irritability exists in certain plants (Phycomyces in this case), or a sensitiveness to Hertz waves which induces negative bendings. The plant organism, whether in the embryonic or adult stage, responds in a positive and negative manner to various cosmic forces which act as stimuli. There is a positive geotropism which induces roots to grow downwards, and a negative geotropism which induces shoots to grow upwards. The force which accomplishes this is termed gravity. Our comprehension of gravity, however, is scarcely more intelligible than that of electricity, and for all we know they may be the same or similar manifestations of force. The results of electrical stimulation to plants are quite similar in their effects to those exhibited by other forms of stimuli.

There is a minimum, optimum and maximum current which gives rise to reactions similar to those obtained from other forms of stimuli. There is also a well-defined latent period, such as we find associated with heliotropic and geotropic stimuli, etc. Moreover, there exists a definite relationship between current intensity and perception, or reaction of the organism, as in chemotactic stimulation.

It was observed by early experimenters that there existed a difference in the growth of plants when subjected to what is termed positive and negative charges. Our limited experiments in this respect have shown that when seeds were treated with a positive charge the growth of the roots was greatly accelerated, while the stems were much less so; and conversely, when treated with a negative charge, the stem showed a greater accelerated growth than the roots. Germination — that is, radical development — was greatly accelerated when seeds were charged positively, although when charged with a negative charge germination at first was much less accelerated than in untreated seed. Thus we have a positive charge stimulating organs which react in a positive manner, and a negative charge stimulating organs which react in a negative manner; also the effect of a positive charge acting as a slight stimulus or retarding organs which act in a negative manner, and the negative only slightly stimulating or retarding positive reacting organs.

It would also appear as if positive charges had a tendency to produce attenuated or elongated root development. In regard to this point, it would be interesting to ascertain whether positive charges increase geotropic irritability. One of the recent conceptions of solutions is that they contain ions which are atoms or groups of atoms positively or negatively charged. It has been observed that solutions with a predominant positive charge, such as acids, and those with a predominant negative charge, bases and salts, have a certain definite effect upon protoplasm which is identical with those produced by positive and negative electrical stimulation. There is also reason to believe that protoplasm consists of particles which are charged positively and negatively. It is possible that in the protoplasm of roots and stems (hypocotyls, as well) of plants there exist opposite predominant charges, — the root carrying predominant negative charges, the stem predominant positive charges. When roots are stimulated with positive charges, acceleration results; and when stimulated with negative charges, acceleration is less marked. In other words, stimulation may arise by changing the predominant charge of the organ, and those organs respond most favorably to electrical stimuli in which opposite charges predominate. In subjecting roots to a positive charge, the predominant negative charges are overpowered or neutralized by the charges, and stimulation results; likewise, in subjecting stems to negative charges, the predominant positive charges are overpowered or neutralized by the negative charges, and stimulation likewise results; but reinforcing predominant positive or negative charges by electrical stimulation causes only a slight stimulus or retardation.

From these experiments it would appear that direct currents appear to stimulate most organs which possess predominant positive charges (radish tops), while interrupted induced currents appear to stimulate most organs which possess predominant negative charges. There is known to exist a difference between the "make" and "break." In the latter current, which is capable of giving rise to a modified physiological reaction, the effects of the opening are always more marked. The effects of the direct current noted above are not so readily accounted for on the basis of this theory.

These experiments have suggested other lines of investigation, and a further report will be made concerning them. It is possible that prolonged stimulation gives rise to different effects than brief stimuli. In prolonged stimulation with direct currents the positive electrode may have a toxic effect, causing inhibition, as is the case with solutions with positive ions. Physiologists have noted that the negative stimulates where the positive current prevents stimulation, although such does not hold in the case of plants, at least when charges of a brief duration are employed.

THE INFLUENCE OF THE ATMOSPHERICAL ELECTRICAL POTENTIAL ON PLANTS.

BY N. F. MONAHAN.

While electrical currents have such an important influence upon the growth and development of plants, as shown in the preceding pages, so also does the electrical potential of the atmosphere have an appreciable influence upon plant life. The atmosphere is always charged to a higher or lower electrical potential, either positive or negative. This has been clearly shown by experiments conducted by the Weather Bureau, United States Department of Agriculture, by Alexander McAdie of the Blue Hill Observatory, and by A. C. Monahan of this station. The conditions governing the amount of electrical potential of the air are not clearly understood, but Monahan found, in a series of experiments extending over nearly a year's time, that the air was charged positively about 90 per cent. of the whole time at a height of 30 feet from the ground. It is enough for us to know, however, that the air is always charged to a higher or lower potential. It is the purpose of this paper to show in a brief way some of the results of preliminary experiments on the effects of atmospherical electrical potential on germination, and the growth and development of plants. Fuller accounts will be published later.

Methods of Experiments and Apparatus used.

In all our experiments we have kept careful records of the exact electrical potential. These records were made by the use of a quadrant electrometer, designed by Sir William Thomson for observations in atmospherical electricity, and built by Eliot Bros. of London. In brief, the instrument consists of a delicate quadrant galvanometer and a self-registering apparatus. A full description of this instrument may be found in the twenty-eighth annual report of the Massachusetts Agricultural College, for 1891.

We used a large glass case, with a wooden frame, 4 feet 3 inches long, 2 feet 9 inches wide, and 2 feet 11 inches high, with a detachable door in the middle of one side, from which every part of the case was accessible. The door was made to fit tightly by a band of rubber around the edge, and was securely held in place by levers. When closed, the case was practically air tight, and was insulated from the stand by glass and rubber insulation. In one corner of the case a small water-dripping apparatus was placed. This apparatus consisted of a light eight-quart copper tank, with a projecting pipe which ended in a fine orifice; the water passing through the pipe immediately broke into drops, and was caught in a glass dish below. An insulated wire connected the case with the electrometer near by. A short time after the dripping started the tank was found to be electrified, presumably to the same potential as the air at the point of the projecting tube. The potential was imparted through the conductors to the electrometer, and a deflection of the needle ensued.

In the case was also placed a self-recording hygrometer (Richard Bros., Paris) and a self-registering thermometer. The case was charged in some instances through a wire at one end leading from a Holtz influence machine. Immediately after charging, the wire was withdrawn from the case, and the hole through which it was inserted was tightly plugged. At other times the case was charged from a Leyden jar through the same wire. This seemed necessary in order to get the required small potential. The air in the case would hold a part of its charge for about three hours; at the end of that time we could find no trace of any electrical potential. The growth of the plants was measured in some instances by a modified Pfeffer-Baranetzky self-registering auxometer, and in other cases by the use of a horizontal microscope with a micrometer scale attachment.

Effect on Germinating Seeds.

Two lots of one hundred seeds of each kind were taken. These seeds were placed in porous clay dishes and soaked for six hours. The first lot was placed in Case 1, and subjected to an electrical charge every eight hours, induced into the air of the case from the Holtz machine. The second lot was placed in Case 2, — a small glass case, where no electrical charge was allowed. In all instances the clay dishes were set in basins of water, so that the seeds were moist at all times. The conditions of the temperature and moisture were practically the same, the former varying from 18° to 20° C., the latter from 76 to 85 per cent. Both cases were closed, and under similar conditions.

Table 1. — *Showing Effect of a Positive Charge upon Germinating Seeds.*

[N, normal; C, charged.]

Kind of Seed.		Total Number of Seeds Germinated in — 24 Hours.	48 Hours.	72 Hours.	96 Hours.	120 Hours.
White clover,	N,	-	-	56	67	76
	C,	2	59	72	79	80
Onion,	N,	5	23	30	34	40
	C,	3	41	47	51	51
Onion,	N,	-	3	13	18	44
	C,	-	5	17	28	37
Lettuce,	N,	-	34	48	56	77
	C,	-	55	82	85	85
Red clover,	N,	-	7	18	35	66
	C,	-	74	88	92	92
Total per cent. acceleration in charged seeds,		-	55.4	23.1	17.11	-

Table 2. — *Showing Effect of a Positive Charge upon Seeds that have lost Vitality.*

Kind of Seed.		Total Number of Seeds Germinated in — 24 Hours.	48 Hours.	72 Hours.	96 Hours.	120 Hours.
Musk melon,	N,	-	-	-	-	-
	C,	-	1	1	1	1
Onion (Red Globe),	N,	-	1	-	2	2
	C,	1	2	2	3	3
Onion (Belden),	N,	9	25	33	33	33
	C,	7	18	20	20	20

Table 2 shows that atmospheric electricity does not increase the total number of seeds germinated over the total germination of those not charged, and that it does not bring to life seeds that have lost their vitality. Seed of a very low per cent. of germination were used.

The results obtained from these experiments confirmed the work done in 1896 at this station by Asa S. Kinney, on "Electro-Germination."[1] Kinney found that: first, electricity exerts an appreciable influence upon the germination of seeds; second, the application of certain strengths of current to seeds for a short period of time accelerates the processes of germination; third, the application of electrical currents to seeds does not increase the total percentage of germination. This latter result shows a direct opposition to the results obtained by Paulin. Paulin claimed that the application of electrical currents awakened to life seeds which had apparently lost vitality, and gave an increased percentage of germination in all seeds thus stimulated.

Effects on Plant Growth.

In some of our experiments three young tomato plants were placed in the large glass case and allowed to stand for eight hours. This was done in order that the plants might become accustomed to the changed conditions and to their new environment before being experimented upon. In these experiments the air in the case was charged every eight hours (at 7 A.M., 3 P.M. and 11 P.M.) to a potential of from 100 to 2,000 volts, as recorded by the electrometer and the growth of the plants recorded by the Pfeffer-Baranetzky self-registering apparatus. This method of measuring the growth proved unsatisfactory and was soon abandoned, and the following method, which proved more satisfactory, was tried. One plant at a time was placed in the case and allowed to stand for a few hours, as above; the plant was then set up near the glass on one side of the case, and the growth measured by means of a horizontal microscope with a micrometer scale attachment, the microscope being placed on the outside

[1] "Electro-Germination." Bulletin No. 43, Hatch Experiment Station.

of the case and focused upon the apex of the plant, measurements being taken every fifteen minutes.

The following figure shows the results of one experiment. A small tomato plant about four inches high was placed in the case, and treated as before described. Measurements of

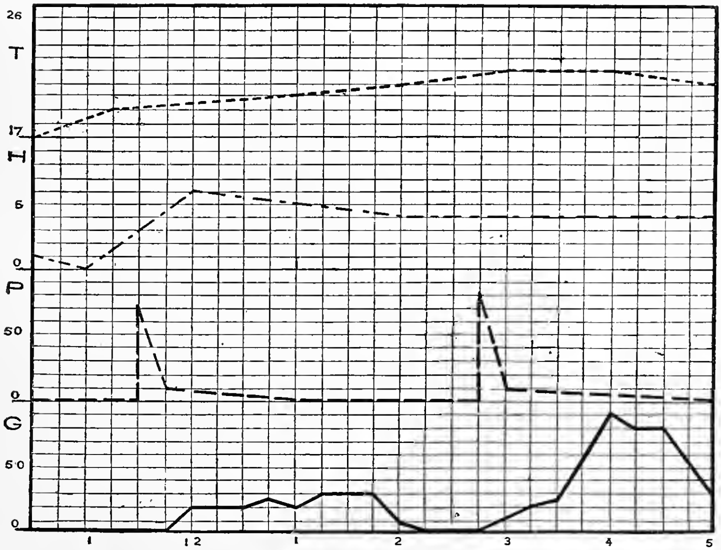

FIG. 1.—Growth curve of tomato plant. The horizontal divisions represent periods of fifteen minutes in time; the vertical divisions represent degrees of temperature, also humidity, electrical potential and increments of growth. T, temperature; H, humidity; P, electrical potential; G, growth.

growth were recorded every fifteen minutes, from 10.15 A.M. to 5 P.M. From 10.15 until 11.30 there was no perceptible growth. At 10.30 the air in which the plant was growing was charged to a potential of 70 volts. Half an hour later, at 12 o'clock, the plant had grown two spaces on the micrometer scale; and at 12.15 had grown two more spaces; and so on until 2.15, when no growth was recorded. At 2.45 the air in the case was recharged to 80 volts, and a greatly increased growth resulted, the maximum acceleration taking place at 1.15 and 4 o'clock respectively, as a result of the two stimuli.

This is but one of many similar figures showing the results of our experiments, tomato plants, corn cotyledons and bread moulds (*mucor* and *Phycomyces nitens*) being used. In all of these experiments the latent period varied from fifteen to thirty minutes.

In several of the experiments where the conditions of temperature and moisture were practically the same, and a large potential was employed, a serious retardation was shown, and in some instances death ensued; in other cases, where a very small potential was employed, no appreciable acceleration was shown.

From these facts we are led to believe that there is a maximum, optimum and minimum voltage; and, from the fact that different potentials were required to stimulate the growth of plants of different species, — and, in fact, of plants of the same variety and apparently of the same size, — it is evident that the maximum, optimum and minimum potentials vary with different varieties and species of plants, and also with plants of the same variety, depending upon the size, structural differentiation, development, etc., of the individual plant.

Summary.

1. Atmospheric electricity exerts an appreciable influence upon the germination of seeds.

(*a*) It accelerates the processes of germination. (In the experiments tried, those seeds charged with electricity show an acceleration in germination of 55.4 per cent. in forty-eight hours, 23.1 per cent. in seventy-two hours, and 17.11 per cent. in ninety-six hours.)

(*b*) It does not increase, to an appreciable extent, the total germination of charged seeds over the normal.

(*c*) It does not awaken to life seeds which have lost vitality.

2. Atmospheric electricity has an appreciable influence upon the growth of plants.

(*a*) From the results of these experiments we are led to believe that there is a maximum, optimum and minimum potential, but these have not yet been accurately determined.

(*b*) That the maximum, optimum and minimum voltages vary not only with the different varieties or species of plants, but with different individuals of the same varieties, and species depending largely upon the size, structural differentiation and degree of development of the plant.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH, W. E. TOTTINGHAM.
Inspector of Feeds, Babcock Machines and Dairy Tester: ALBERT PARSONS.
In Charge of Feeding Experiments: JOSEPH G. COOK.
Stenographer: MABEL SMITH.

Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The correspondence of this department has considerably increased over previous years, due to the execution of the new feed law. The general character of the information desired has been much the same as heretofore. The total number of letters sent out during the year has been about 3,000.

B. Extent of Chemical Work.

The work in the laboratory has been of the same general character as formerly. The number of determinations of butter fat in cream has considerably increased.

There have been sent in for examination 132 samples of water, 229 of milk, 1,766 of cream, 8 of pure and process butter and 170 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 235 samples of milk and 585 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 772 samples of concentrated feed stuffs. This makes a total of 3,897 substances analyzed during the year, as against 3,240 last year and 3,622 in the previous year. Work on moisture, fiber and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists, and required considerable time for its proper execution. In addition, 17 candidates have been examined and given certificates to operate Babcock machines, and 2,240 pieces of glassware have been tested for accuracy, of which 57 pieces, or 2.54 per cent., were condemned.

C. Character of Chemical Work.

(a) *Water.*

In accordance with instructions from the experiment station committee, a charge of three dollars has been made for each sample of water examined by this department during the past year. The reasons for this charge were explained in a small circular sent to each applicant, a copy of which was printed in the last report, page 50. Most applicants have cheerfully paid the fee, while others have refused to send the sample for examination because of the charge. The number of samples examined has been 132, considerably less than formerly; but it is believed that the charge has resulted in holding in check those who have heretofore sent from 4 to 20 samples annually, as well as those who have sent largely out of curiosity, because an analysis could be had free of cost.

Instructions for securing an analysis of water: —

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. Lindsey,
Hatch Experiment Station.

(b) *Dairy Products and Feed Stuffs.*

The number of samples of milk and cream sent largely for the purpose of determining their butter fat content is increasing from year to year. The increase in the number of cream samples comes largely from creameries, while the milk comes from farmers desirous of ascertaining the quality produced by the several animals in the herd. This latter is a very satisfactory sign, and should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of the milk produced by different breeds, as well as full instructions relative to the best methods to be employed in determining the butter-producing capacity of dairy herds. Comparatively little analysis has been done for the Dairy Bureau, because of the pressure of other lines of work.

The number of feed stuffs sent for examination was about the same as usual. They are examined at once, and the results forwarded promptly, with such suggestions as circumstances may advise. Numerous samples are received from dealers, who avail themselves of the station facilities to make sure the materials they are offering are as claimed.

(c) *Chemical Investigation.*

So far as time and facilities permit, this department continues its work of investigating the various problems connected with the chemistry of dairying and animal nutrition. A good deal of attention has been given to the composition and digestibility of feed stuffs, as well as to the effect of feeds and feed combinations upon the quantity and quality of milk. A study of methods of analyses has been referred to elsewhere.

D. Cattle Feed Inspection.

In October and November, 1902, quite a thorough canvass of the State was made, some 320 samples of feeds collected, examined, and the results published in Bulletin No. 85. Because of the limited funds available, a few samples only — principally of cotton-seed meal — were collected in the late winter. The Legislature at its session of 1903 passed a new feed law (chapter 122, Acts of 1903) ; the full text of this law may be found in Bulletin No. 93, recently issued by this department. A brief synopsis of the law is as follows : —

Section 1 defines statements to be attached to all packages of feed stuffs.

Section 2 specifies feed stuffs included in the law.

Section 3 defines feed stuffs exempt from the law.

Section 4 states the penalty for violations of previous sections.

Section 5 mentions duties of director or deputy with reference to collecting and analyzing samples, and states penalty for interference.

Section 6 declares against the adulteration of whole or ground grain or standard by-products, and fixes penalty.

Section 7 requires the director to prosecute violations of the act.

Sections 8, 9 and 10 define the term importer, state the sum to be allowed for carrying out the provisions of the act, etc.

It is believed that the law will prove of great benefit to farmers, and they are to be congratulated upon its enactment. Similar laws are now in force in all of the other New England States, as well as in New York, New Jersey, Pennsylvania, Maryland, North Carolina and Wisconsin.

The new feed law went into effect July 1. Mr. Albert Parsons was appointed inspector, and has made a thorough canvass of the State, collecting some 700 samples. It is proposed to keep the inspector at work in different sections of the State a considerable portion of the year; in this way the station can be kept thoroughly informed concerning the character of the feeds offered. As would naturally be supposed, many feeds were found unmarked and without a guaranty, and it will require some time and considerable patience to bring about a complete conformity to the law. On the whole, it may be said that dealers appear ready and willing to conform to its requirements, and are constantly addressing letters of inquiry to the station concerning the character and value of the manifold feeds offered by manufacturers and jobbers. The station stands ready to co-operate with consumer, local dealer, jobber and manufacturer, to the end that all may be benefited.

The details of this inspection will be found in Bulletin No. 93.

E. Execution of the Dairy Law.

This department issued a special bulletin on the subject in July of the present year, entitled "The Dairy Law and its Results." The bulletin gave the text of the law, an account of the inspection of glassware, of the inspection of Babcock machines, very full information concerning the method of manipulating the Babcock milk test, together with as complete a list as possible of the creameries and milk depots in Massachusetts. This bulletin was sent in lots of from 10 to 100 to all milk depots and creameries in the State.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of sand blast. During 1902 there was examined 2,344 pieces, of which 56 pieces, or 2.39 per cent., were found incorrect. There have been examined the present year (1903) 2,240 pieces, of which 57 pieces, or 2.54 per cent., were not correctly graduated. Manufacturers are now very careful concerning the accuracy of the glassware put out by them.

Examination of Candidates. — Mr. E. B. Holland has continued as heretofore to have charge of this work. During 1901, 45 candidates were examined; in 1902, 13 candidates; and the present year, 17 have been given certificates of competency. It is believed that practically all parties now operating Babcock machines under the law have a good understanding of the principles of manipulation, and are capable of doing accurate work.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Albert Parsons, who makes the following report: —

The third annual inspection of Babcock machines was made in November and December, 1903. Fifty-two establishments were either visited or heard from, 37 being creameries and 15 milk depots. Twenty-four, or half the number, were co-operative, 18 were proprietary, and 10 were managed by stock companies. Forty machines were inspected. Of these, 1 was condemned and 6 needed slight repairs. A few overheated the tests, and a few required additional steam to warm them. All but two of the machines were run by steam power, one was run by hand and one by electricity. About three-fourths of the machines have frames of cast iron, while the other fourth is equally divided between galvanized iron and copper. Of the cast-iron machines, 22 are "Facile," and 9 are "Agos." As a rule, the glassware was found in good condition, although in some cases it was very dirty, in a few cases it was not tested, and a few pieces bore the mark of another State.

F. Testing Dairy Herds.

During the year this department has tested cows at the request of the Jersey, Guernsey and Holstein cattle clubs. Fifteen seven-day tests and 6 yearly tests have been completed and 38 yearly tests are in progress. The tests are made under the rule and regulations of the several clubs. It requires at the present time the services of a man during two weeks in each month, and in addition involves considerable clerical work.

G. Work in Progress and completed.

At the present time, experiments are in progress to note the value of specially prepared dried blood and digester tankage for milk production. It is believed that material of this kind will be used considerably in the near future as a source of protein for farm animals. Other experiments now in operation are: (*a*) to test the efficacy of a well-known condimental or medicated food, for which extravagant claims are made; (*b*) digestion experiments on a variety of coarse and concentrated feeds.

Experiments were also continued with summer-forage crops; but, owing to the very unusual summer conditions, definite results were not obtained, and they will be continued. An experiment is about to be undertaken to see if it is economically possible for the average dairy farmer to get along without the use of wheat bran, using silage as a diluter for the more concentrated by-products. Experiments have been completed with distillers' by-products, — malt sprouts, dried brewers' and distillers' grains, — and the results will soon be published in bulletin form. These experiments emphasize the nutritive and economical value of these several feeds as sources of digestible protein for milk production.

H. Addition to Staff.

Messrs. W. E. Tottingham, Albert Parsons and Joseph G. Cook have been recently added to the staff of this department. Mr. Tottingham serves as assistant chemist, taking the place made vacant by T. M. Carpenter, who secured a more lucrative and responsible position at the Pennsylvania experiment station. Mr. Parsons fills, in a sense, a new position, rendered necessary by the increasing work placed upon the department. He is acting as inspector of feed stuffs under the new feed law, as inspector of Babcock machines under the dairy law, and as dairy herd tester. Mr. Cook has charge of the experiments in animal nutrition at the feeding barn. These several young men have taken hold of the work earnestly and have proved themselves most efficient and satisfactory.

Part II. — Dairy and Feeding Experiments.

A. Effect of Feed on the Composition of Milk and Butter Fat, and on the Consistency or Body of Butter.

J. B. LINDSEY.[1]

Experiment VIII.

A general outline of experiments of a similar character will be found in the thirteenth and fourteenth reports of this station.

Object of the Experiment. — During the autumn and winter of 1901–02 a series of experiments was undertaken, for the purpose of noting, respectively, the effect of corn gluten meal with a minimum percentage of oil, of gluten meal with the addition of corn oil, and of corn meal, upon the relative proportions of the several ingredients in milk and butter fat, and upon the body of butter.

Plan of the Experiment. — Ten cows were divided into two lots of five each. Seven of the cows had calved in the late summer and early autumn, one in the preceding April, and two had been in milk about a year. The average milk product of each cow at the beginning of the trial was about 21 pounds daily. During the first period, both herds received the so-called standard grain mixture; during the three subsequent periods, Herd I. continued to receive the standard grain ration as in the first period; and in case of Herd II., a portion of the standard ration was replaced by gluten meal, by gluten meal and corn oil, and by corn meal, respectively.

[1] With E. B. Holland and P. H. Smith.

TABLE I. — *Duration of Experiment.*

PERIODS.	Character of Rations.	Dates.	Length of Periods (Weeks).
1, . .	Herd I., standard grain ration, Herd II., standard grain ration,	Oct. 20 through Nov. 9, .	3
2, . .	Herd I., standard grain ration, Herd II., gluten meal ration, .	Nov. 23 through Dec. 27,	5
3, . .	Herd I., standard grain ration, Herd II., gluten meal + corn oil,	Jan. 2 through Feb. 28, .	7
4, . .	Herd I., standard grain ration, Herd II., corn meal ration, .	Mar. 16 through Apr. 19,	5

Feeding and Care of the Animals. — The animals were fed twice daily. The corn oil was weighed out each day and carefully mixed with the grain ration, and was eaten without any trouble. Water was supplied constantly, by the aid of the Buckley self-watering device. Each cow was kept in a well-bedded, roomy stall, and was turned into a protected yard during the warmest part of each day when the weather was not actually stormy or severely cold. The feeding barn was heated to a temperature of 50–55° F. during the cold weather, kept clean and well ventilated. The animals were thoroughly cleaned daily, and before milking the udders were brushed and then wiped with a wet cloth. The milkers wore white duck suits.

Disturbances during the Experiment. — Just before the beginning of the second period, cow Folly of Herd II. was taken severely ill, and had to be permanently removed. It was thought best to continue the experiment as planned, using four cows in Herd II., rather than to begin again. In the third period, Red II. of Herd II. suffered an attack of indigestion. For this reason, samples of milk were not taken for two weeks, and butter making was omitted for one week. These interferences will be referred to again under "Composition of the milk," "Composition of the butter fat," etc.

TABLE II. — *Average Daily Rations for Each Cow (Pounds).*

First period: both herds, standard ration.

Herds.	Standard Grain Ration.	Chicago Gluten Meal.	Corn Oil.	Corn Meal Mixture.	First Cut Hay.	Rowen.
Herd I., . . .	8.6	-	-	-	12.4	10.1
Herd II., . . .	8.4	-	-	-	12.8	10.0
Second period: Herd I., standard grain ration; Herd II., gluten meal ration.						
Herd I., . . .	7.9	-	-	-	11.1	10.0
Herd II., . . .	5.3	2.7	-	-	11.5	10.0
Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.						
Herd I., . . .	7.9	-	-	-	10.9	9.9
Herd II., . . .	4.7	2.1	.6	-	9.2	9.8
Fourth period: Herd I., standard grain ration; Herd II., corn meal mixture.						
Herd I., . . .	7.2	-	-	-	10.9	10.0
Herd II., . . .	-	-	-	7	10.5	10.0

Character of the Rations and Feeds. — The standard grain mixture consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meals. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter.

The corn meal mixture was similar to the standard grain ration, excepting that the 5 pounds of ground oats were replaced by an equal amount of corn meal. It is to be understood that the figures given in Table II. represent the average feed consumed daily by each cow in each herd. For example, theoretically each herd in the first period was to consume an equal amount of feed per cow, namely, 8 pounds of grain, 10 pounds of rowen and 12 pounds of first cut hay; but, because of the individual requirements of the several cows, there was a slight difference in case of the average consumed by the two herds.

The spring wheat bran and cotton-seed meal were of good average quality. The oats were of standard quality, purchased whole and ground by the local miller. The Chicago gluten meal contained 40 per cent. of protein and 3.91 per cent. of fat in dry matter, thus furnishing a high percentage of corn gluten and a minimum percentage of corn oil. The corn was grown upon the station grounds, likewise the hay and rowen. The first cut hay was largely timothy, with a small admixture of red-top and clover. It contained 8.24 per cent. of protein in dry matter, and the rowen 14.20 per cent. The corn oil, procured of the Glucose Sugar Refining Company of Chicago, had a golden-yellow color, was clear, and had a marked odor of Indian corn. It was regarded as a very satisfactory sample.

TABLE III. — *Average Dry Matter and Digestible Nutrients in Ration of Each Cow.*

First period: both herds, standard grain ration.

Herds.	Total Dry Matter.	Digestible Organic Nutrients.			Nutritive Ratio.
		Protein.	Carbo-hydrates.	Fat.	
Herd I.,	27.37	2.55	13.33	.68	1:5.8
Herd II.,	27.12	2.52	13.22	.67	1:5.8
Second period: Herd I., standard grain ration; Herd II., gluten meal ration.					
Herd I.,	25.39	2.39	14.42	.63	1:6.6
Herd II.,	25.87	2.92	14.04	.59	1:5.3
Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.					
Herd I.,	25.34	2.39	12.32	.63	1:5.7
Herd II.,	23.41	2.55	11.13	1.14	1:5.4
Fourth period: Herd I., standard grain ration; Herd II., corn meal ration.					
Herd I.,	24.97	2.30	12.17	.61	1:5.9
Herd II.,	24.55	2.10	13.12	.59	1:6.9

TABLE IV. — *Average Quantity of Milk produced by Each Cow.* (*Pounds.*)

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
448.56	458.41	635.75	684.22	924.34	998.27	620.59	636.62

During the first period both herds produced essentially the same average quantity of milk per cow; during the second and third periods, presumably because of the increased supply of protein in the daily ration, Herd II. showed a slightly larger average yield.

Purity of the Milk. — A number of samples of the mixed milk were taken immediately after milking, placed in sterilized glass-stoppered bottles, and kept cold until examined for bacterial content. The number of bacteria varied from 200 to 3,600 to the cubic centimeter, showing the milk to be especially clean. Objectionable odor or flavor could not be detected.

Sampling the Milk. — Composite samples of the mixed milk from each herd were taken for five days in each week, and tested for total solids, fat and nitrogen. The solids were determined by drying in sand, the fat by extracting the dry material with ether, and the nitrogen by the Kjeldahl method. In securing a sample, the milk from each herd was carefully mixed, and a small dipperfull taken immediately.

TABLE V. — *Composition of Milk* (*Per Cent.*).

First period: both herds, standard ration.

Samples.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Oct. 26–30,	14.25	14.10	5.13	5.12	9.12	8.98	.573	.565
Nov. 1–4,	14.63	14.43	5.33	5.32	9.30	9.11	.584	.580
Nov. 4–9,	14.58	14.50	5.43	5.38	9.15	9.12	.576	.569
Average,	14.49	14.34	5.30	5.27	9.19	9.07	.578	.571

TABLE V. — *Composition of Milk* — Concluded.

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

Samples.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Dec. 11-16,	14.97	14.67	5.50	5.28	9.47	9.39	.594	.600
Dec. 17-22,	15.05	14.80	5.59	5.29	9.46	9.51	.599	.616
Dec. 22-27,	14.75	14.50	5.49	5.17	9.26	9.33	.600	.613
Average,	14.92	14.66	5.53	5.25	9.39	9.41	.598	.610
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.								
Dec. 28-Jan. 3,[1]	14.79	14.64	5.40	5.43	9.39	9.21	-	-
Jan. 5-Jan. 10,[1]	14.61	14.49	5.35	5.37	9.26	9.12	-	-
Jan. 12-17,	14.69	14.16	5.29	5.10	9.40	9.16	.586	.567
Jan. 19-24,	14.76	14.23	5.31	5.12	9.45	9.11	.604	.580
Jan. 16-31,	14.74	14.11	5.27	4.97	9.47	9.14	.597	.586
Feb. 2-7,	14.66	14.07	5.29	5.02	9.37	9.05	.597	.579
Feb. 9-14,	14.79	14.13	5.31	4.99	9.48	9.14	.599	.577
Feb. 23-28,	14.75	14.08	5.38	4.97	9.37	9.11	.587	.566
Average,	14.73	14.13	5.31	5.03	9.42	9.12	.595	.576
Fourth period: Herd I., standard ration; Herd II., corn meal ration.								
Mar. 3-8,[1]	14.68	13.69	5.25	4.43	9.43	9.26	.589	.576
Mar. 9-14,[1]	14.59	14.29	5.34	5.18	9.25	9.11	.590	.576
Mar. 16-21,	14.93	14.27	5.42	5.11	9.51	9.16	.606	.586
Mar. 23-28,	14.70	14.28	5.27	4.99	9.43	9.29	.597	.586
Mar. 31-Apr. 4,	14.82	14.52	5.19	5.10	9.63	9.42	.610	.597
Apr. 6-11,	15.00	14.37	5.36	5.12	9.64	9.25	.620	.603
Apr. 13-18,	14.84	14.29	5.13	5.03	9.71	9.26	.619	.608
Average,	14.86	14.35	5.27	5.07	9.58	9.28	.610	.596

[1] Preliminary.

TABLE VI. — *Relation of Fat to Solids not Fat.*

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
1: 1.73	1: 1.72	1: 1.70	1: 1.79	1: 1.77	1: 1.81	1: 1.82	1: 1.83

It is desired at this point to again call attention to the important fact that cow Folly in Herd I. became suddenly ill between the first and second periods, and had to be permanently removed from the experiment. It was thought best, however, to continue the experiment as planned, rather than attempt to start again.

It will be seen, in observing the above tables of analyses, that in the first period, with five cows in each herd and both herds receiving the same ration, the composition of the milk was quite similar. This was, of course, due to the fact that the two herds had been evenly matched. The milk yield of both herds in this period was also essentially the same, namely, 2,243 pounds for Herd I. and 2,292 pounds for Herd II.

In the second period, because of the loss of Folly, it was not possible to make a comparison of the composition of the milk produced by the two herds; hence it was sampled only during the last three weeks, in order to secure a basis of comparison for the two following periods. In this period the relation of fat to solids not fat was 1 : 1.70 and 1 : 1.79 for herds I. and II. respectively.

In the third or corn oil period the composition of the milk produced by both herds is given for the two preliminary weeks as well as for the period proper, although the former is not included in the average. The results show that the milk produced by Herd I. remained quite constant in composition during the entire period. A slight decrease only in the fat percentage is noted, the relation of the fat to solids not fat being as 1 : 1.77. In case of Herd II. the fat percentage suddenly increased from an average of 5.25 to 5.40 during the preliminary period of two weeks, when the corn oil was being added to the ration. The relation of fat to solids not fat during the preliminary period was as 1 : 1.72. The effect of the corn oil appeared to have been lost after two weeks, for during the first week of the period proper the percentage of fat was 5.10, and it declined slightly during the period, with an average of 5.03 and a relation of fat to solids not fat of 1 : 1.81. While the total solids did not change during the preliminary period, they showed a decrease at the close of the period proper of .53 per cent. It is to be noted that the nitrogen during this period was .034 per cent. lower than in the previous period. A similar decrease was noticed when linseed oil was fed.[1]

The percentage of solid matter in both herds suffered a slight decline during the third period, possibly due to winter weather conditions; but it was greater in case of Herd II., due largely to the decrease of the solids not fat.

In the fourth or corn meal period the milk of Herd I. increased a little in total solids, perhaps due to advanced lactation or to warmer weather. In case of Herd II., the sudden removal of the corn oil caused a temporary decrease of .54 per cent. of fat and a slight increase in the nitrogen. The so-called fat equilibrium, however, was gradually restored; for in the second week of the preliminary period it was equal to that yielded during the last week of the former period, and the percentage continued quite regular during the entire period. The percentage of nitrogen gradually increased for several weeks, and during the last week of the period it was equal to the average percentage found during the second period. Similar conditions were observed in former experiments.[2]

Attention is called to the evenness in the composition of the milk produced by Herd I., which had the same feed for a period of six months, the only change worthy of notice being the gradual increase of the solids not fat from 9.19 to 9.58 per cent.

TABLE VII. — *Composition of the Butter Fat.*[3]

First period: both herds, standard ration.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, ...	231.5	230.6	30.03	29.52	33.78	33.43	29.07	30.29
2 samples, ...	231.1	231.0	29.74	29.56	34.43	33.70	29.31	29.75
2 samples, ...	231.1	231.9	29.48	30.25	34.13	33.48	27.76	29.06
Average, . .	231.2	231.2	29.75	29.78	34.11	33.54	28.71	29.70

[1] Thirteenth report of this station, pp. 107–109. [2] *Loc. Cit.*
[3] Methods of the Association of Official Agricultural Chemists.

TABLE VII. — *Composition of the Butter Fat* — Concluded.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.								
2 samples, . . .	231.6	231.9	29.20	29.17	34.53	33.13	26.66	28.63
2 samples, . . .	232.2	232.3	29.52	29.91	34.40	33.43	27.42	29.50
2 samples, . . .	231.1	232.3	29.03	28.66	34.55	32.93	26.91	28.99
2 samples, . . .	232.7	233.7	29.39	28.48	34.58	33.08	26.95	29.59
Average, . .	231.9	232.6	29.29	29.06	34.52	33.17	26.96	29.18
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.								
2 samples, . . .	230.6	226.0	28.80	28.30	33.83	33.33	26.89	36.68
2 samples, . . .	230.2	224.7	30.20	27.80	33.90	32.93	27.47	37.35
2 samples, . . .	229.5	221.9	28.75	24.85	33.73	34.28	28.34	38.58
2 samples, . . .	230.5	219.6	28.55	23.20	34.05	34.40	28.18	40.23
2 samples, . . .	230.5	220.9	28.22	23.61	34.33	34.03	27.94	39.00
Average, . .	230.3	222.6	28.90	25.55	33.97	33.79	27.76	38.37
Fourth period: Herd I., standard ration; Herd II., corn meal ration.								
2 samples, . . .	229.7	229.0	27.83	26.88	34.18	33.58	28.80	29.51
1 sample, . . .	227.8	229.4	26.64	27.47	34.15	33.70	29.55	29.14
1 sample, . . .	228.4	229.6	26.61	27.43	34.10	33.65	29.68	28.86
2 samples, . . .	229.6	232.4	27.35	27.17	34.28	33.58	29.02	28.84
2 samples, . . .	231.5	231.2	27.14	27.53	34.48	33.98	29.59	28.69
Average, . .	229.4	230.3	27.11	27.30	34.24	33.70	29.33	29.01

In the first period the butter fat produced by both herds showed a very similar composition, trifling variations only being noted in the melting point and iodine number.

In the second or gluten meal period it is difficult to note any change in the composition of the butter fat which may be attributed to the influence of the gluten meal. In a former experiment[1] no striking differences between the butter fat produced by the standard grain ration and a gluten meal ration could be noted. The iodine number of the fat produced by Herd I. showed a noticeable drop during this period, gradually returning during the next two periods to the number indicated in the first period. The reason for this temporary depression is difficult to explain. It is not to be overlooked that the cow Folly was removed during this

[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

period, and did not again enter the experiment; it is doubtful, however, if her loss in any way affected the composition of the fat.

In the third period Herd II. was still receiving a trifle over 2 pounds of gluten meal daily, so that the ration was essentially the same as in the second period, excepting for the addition of .6 pound of corn oil. It is in this period that a noticeable modification of the butter fat took place with Herd II., while the character of the fat produced by Herd I. remained constant. The difference consisted in the decrease of the saponification equivalent by 10 points, a decrease of the Reichert-Meissl number of $3\frac{1}{2}$ points, and an increase in the iodine number of a trifle over 9 points. The melting point of the fat, on the other hand, showed no marked change. Similar conditions were noted when cotton-seed and linseed oils were fed,[1] excepting that the two latter oils also raised the melting point of the fat.

In the fourth or corn meal period, when the rations of both herds were similar, excepting that corn meal took the place of ground oats with Herd II., the butter fat produced by the latter herd returned to its normal condition, *e.g.*, similar to that produced in the first and second periods, and closely resembling the fat produced by Herd I. during all four periods.

The only noticeable change in the fat of Herd I during the entire experiment,[2] extending from October 20 through April 19, — a period of six months, — consisted in the slight gradual decline in the Reichert-Meissl number, due to advancing lactation. It is interesting to observe the uniformity in the character of butter fat produced by a herd of five cows having the same feed during such a long period of time.

The Opinion of Experts on the Character of the Butter. — Two lots of cream from each herd, raised by the Cooley process, were ripened and made into butter each week. The ripening process generally lasted twenty-four hours, and some commercial starter was employed. The full details of

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[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

[2] Excepting the temporary depression in the iodine number in the second period already referred to.

the process are on file, but it is hardly considered necessary in this connection to publish them, other than to state that the most approved methods were followed.

Pound samples from each lot were sent to Mr. O. Douglass of Boston and Mr. W. A. Gude of New York, who scored them, each being entirely ignorant of the nature of the experiment or of the feeds employed.

TABLE VIII. — *Douglass Butter Scores.*

Flavor.		Body.		Color.		Salt.		Style.		Total.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds, standard ration.											
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
45.0	44.5	20	20	15	15	10	10	5	5	95.0	94.5
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
43.0	43.0	20	20	15	15	10	10	5	5	93.0	93.0
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
Av., 44.0	43.6	20	20	15	15	10	10	5	5	94.0	93.6
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
43.0	43.5	20	20	15	15	10	10	5	5	93.0	93.5
46.0	45.5	20	20	15	15	10	10	5	5	96.0	95.5
45.0	41.0	20	20	15	15	10	10	5	5	95.0	91.0
41.0	43.0	20	20	15	15	10	10	5	5	91.0	93.0
39.0	40.0	20	20	15	15	10	10	5	5	89.0	90.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.8
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.											
44.0	46.0	20	19	15	15	10	10	5	5	94.0	95.0
43.5	45.0	20	19	15	15	10	10	5	5	93.5	94.0
44.5	43.5	20	20	15	15	10	10	5	5	94.5	93.5
45.0	46.5	20	20	15	15	10	10	5	5	95.0	96.5
44.0	45.0	20	20	15	15	10	10	5	5	94.0	95.0
45.5	46.5	20	20	15	15	10	10	5	5	95.5	96.5
43.0	45.0	20	20	15	15	10	10	5	5	93.0	95.0
42.0	44.0	20	20	15	15	10	10	5	5	92.0	94.0
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
44.5	45.0	20	20	15	15	10	10	5	5	94.5	95.0
Av., 45.0	45.0	20	20	15	15	10	10	5	5	94.0	94.8
Fourth period: Herd I., standard ration; Herd II., corn meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
42.5	45.0	20	20	15	15	10	10	5	5	92.5	95.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
40.0	41.0	20	20	15	15	10	10	5	5	90.0	91.0
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
45.0	40.0	20	20	15	15	10	10	5	5	95.0	90.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
43.0	41.0	20	20	15	15	10	10	5	5	93.0	91.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.5

TABLE IX. — *Gude Butter Scores.*

Flavor.		Body.		Color.		Salt.		Style.		Total.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds, standard ration.											
35.0	31.0	24.0	23.0	14.5	15.0	10	10	5	5	88.5	84.0
35.0	32.0	25.0	24.0	15.0	15.0	10	10	5	5	90.0	86.0
35.0	30.0	25.0	25.0	15.0	15.0	10	10	5	5	90.0	85.0
30.0	37.0	22.0	22.0	15.0	15.0	10	10	5	5	82.0	89.0
38.0	32.0	24.0	23.0	15.0	15.0	10	10	5	5	92.0	85.0
Av., 35.0	32.0	24.0	23.0	14.9	15.0	10	10	5	5	88.5	85.8
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.											
37.0	35.0	24.0	22.0	15.0	15.0	10	10	5	5	91.0	85.0
37.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	90.0
32.0	36.0	23.0	24.0	15.0	15.0	10	10	5	5	85.0	90.0
35.0	33.0	25.0	23.0	15.0	15.0	10	10	5	5	90.0	86.0
36.0	36.0	24.0	23.0	15.0	15.0	10	10	5	5	90.0	89.0
28.0	28.0	23.0	23.0	15.0	15.0	10	10	5	5	81.0	81.0
Av., 34.1	34.0	23.8	23.1	15.0	15.0	10	10	5	5	88.0	86.8
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.											
37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	38.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	92.0
39.0	40.0	24.0	25.0	15.0	15.0	10	10	5	5	93.0	95.0
42.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	96.0	90.0
38.0	41.0	24.0	25.0	15.0	15.0	10	10	5	5	92.0	96.0
38.0	40.0	23.0	25.0	15.0	15.0	10	10	5	5	91.0	95.0
38.0	38.0	23.0	23.0	15.0	15.0	10	10	5	5	91.0	91.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
Av., 37.8	39.1	24.2	24.2	15.0	15.0	10	10	5	5	92.0	93.3
Fourth period: Herd I., standard ration; Herd II., corn meal ration.											
37.0	37.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	91.0
37.0	37.0	24.5	24.0	15.0	15.0	10	10	5	5	91.0	91.0
35.0	36.0	25.0	24.5	15.0	15.0	10	10	5	5	90.0	90.5
30.0	33.0	23.0	25.0	15.0	14.0	10	10	5	5	83.0	87.0
41.0	39.0	25.0	25.0	15.0	15.0	10	10	5	5	96.0	94.0
40.0	36.0	25.0	24.0	15.0	15.0	10	10	5	5	95.0	90.0
39.0	39.0	24.0	24.0	15.0	15.0	10	10	5	5	93.0	93.0
38.0	38.0	25.0	24.5	15.0	15.0	10	10	5	5	93.0	92.5
Av., 37.1	36.9	24.4	24.1	15.0	14.9	10	10	5	5	91.5	91.1

As will be seen from the above scores, Mr. Douglass considered the butter produced by both herds during the several periods of good average quality. The flavor he scored a trifle higher in the first and third periods. He found no fault with the body excepting in case of Herd II. in the third period; this butter he repeatedly pronounced as "light bodied, but acceptable in any market."

Mr. Gude appeared to have been much more critical. He often mentioned a "tainted off flavor, as from stale milk," in the butter produced by both herds during the first and second periods. This defect, in our judgment, was due to the starter, with which considerable trouble was experienced, and could in no way be attributed to the feed. The flavor of the butter produced by both herds during the third period was more satisfactory, although it was occasionally referred to as having only a "faint aroma." Mr. Gude several times mentioned the product of Herd II. during this third or corn oil period as having a "fine aroma," and the average score is rather higher than for Herd I. In the fourth period no particular difference in the flavor was observed.

The body of the butter made from Herd I. during all four periods was repeatedly pronounced "short and crumbly;" the body of that produced by Herd II. in the second and fourth periods was also frequently referred to as being crumbly; while that produced by the same herd in the third or corn oil period was sometimes spoken of as satisfactory and sometimes as rather light and rather soft, but suitable for market. It was evident that Mr. Gude liked the flavor and body of the butter produced by the corn oil ration. The same fact was noticed when King gluten meal, containing 14 per cent. of corn oil, was fed.[1]

Personal Observations on the Body of the Butter. — The writer made no attempt to pronounce critical judgment on the flavor of the butter, but endeavored to note particularly the character of the body. No difference could be observed in the body of the butter produced by both herds in the first period. It might be characterized as being hard and firm.

In the second period, pound samples of the butter produced by each herd were allowed to reach a temperature of 57° F. The butter from Herd I. at this temperature appeared noticeably harder and firmer than that produced by Herd II. This conclusion was reached as a result of pushing a glass rod into the mass at different points, and by

[1] Thirteenth report of this station, p. 120.

touching the same with the finger. The same differences were noted at a temperature of 70° F. As the temperature was gradually increased, Herd II. butter showed a tendency to lose form more quickly than Herd I. butter. When the interior of the lumps had reached 83° F., Herd II. butter had lost form, and collapsed into a shapeless, slushy mass; while Herd I. butter still stood up in print form, although showing a tendency to lose its shape. When the room temperature reached 95° F., and the interior temperature of the butter 85° F., Herd I. butter also lost form. It is quite possible that, if this latter butter had been held at 85° F., or even lower, for a considerable time, it would also have fallen into a slushy condition. It will be understood that it is quite difficult to control the exact temperature of a mass of butter. The temperature of the room may be 95° F., while the temperature of the interior of the lump of butter may be 10° lower.

Though the butter produced by Herd II. was softer, lost its form and became slushy more quickly than that produced by Herd I., but little of the fat actually melted until a higher temperature had been reached.

While the differences in the body of the butter produced by the two herds was quite marked, it was probably not sufficient to effect its commercial value, at least during the cooler portion of the year.

Similar observations to the above were made on the two lots of butter produced in the third or corn oil period, the results being even *more pronounced*. At a temperature of 44° F., Herd I. butter was very hard and firm; Herd II. butter, while being hard, had rather a greasy, salvy look, and yielded more easily to the touch. After standing over night at a temperature of 70° F., this difference was very pronounced, the Herd I. product being still firm, while the Herd II. was yielding and soft to the touch. At 82° F., Herd I. butter still retained its print form, while Herd II. butter lost form and was quite slushy. It is believed that the corn gluten and corn oil rations produced rather a softer butter than did the cotton-seed oil ration.[1]

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[1] Fourteenth report of this station, page 167.

But little difference could be noted in the body of the butter produced by both herds during the fourth or corn meal period. At an interior temperature of 60° F. it was not possible to detect any variation. After the butter had stood twenty-four hours in the same room, and showed an interior temperature of 76° F., Herd II. butter appeared to be a trifle softer than Herd I. butter. The difference was certainly not at all pronounced; both lots would be said to possess a hard, firm body.

TABLE X. — *Degrees of Penetration (Millimeters).*

[Each number represents results with one print.]

FIRST PERIOD (32° F.).		SECOND PERIOD (65° F.).		THIRD PERIOD (57° F.).		FOURTH PERIOD (67° F.).	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.35	4.05	8.39	11.70	6.45	13.30	12.10	13.17
4.15	4.65	8.60	10.80	6.40	13.15	13.96	14.05
4.35	4.50	9.45	11.90	5.95	12.60	15.50	19.08
4.40	4.55	9.10	12.55	5.95	15.10	16.20	15.75
4.25	4.85	11.00	13.10	7.40	14.65	16.15	16.15
-	-	11.10	16.30	7.05	14.70	15.25	16.50
-	-	10.20	15.50	6.30	14.20	15.79	18.46
-	-	-	-	6.55	13.25	16.40	17.75
-	-	-	-	6.00	13.05	-	-
-	-	-	-	6.95	16.15	-	-
Av., 4.30	4.50	9.69	13.12	6.50	14.02	15.17	16.36

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped for a definite height. Unfortunately, through a misunderstanding, the tests of the butter produced by the two herds in the first period were made a temperature of 33° F., so that the plunger had little opportunity to penetrate. In the other periods the butter was taken from the refrigerator and allowed to stand in the dairy room until it had acquired the room temperature. It will be seen that both in the second and third periods, and particularly in the latter, the butter produced by Herd II. was noticeably softer and more yielding than the product of Herd I. In the fourth period little difference was observed. This method of testing has been criticised, on the ground that different portions of the same lump or print would show widely different degrees of firmness. This claim may be to an extent true. In each case, however, a definite number of tests were made in different parts of each print, and results averaged. The variations were not wide, and the differences in the firmness of the butter are quite striking.

Effect of Feed on the Time of Churning the Cream and on the Quantity of Fat left in the Skim Milk and Buttermilk. — The only noticeable difference in the time of churning was in the third period. One-fifth more time was required to bring the butter from the cream produced by Herd II., receiving the corn oil, than from Herd I., receiving the standard ration.

A number of samples of cream, skim milk and buttermilk were taken in each period and the fat percentages determined, the results being tabulated below: —

TABLE XI. — *Fat in Cream, Skim Milk and Buttermilk.*

First Period.						Second Period.					
HERD I.			HERD II.			HERD I.			HERD II.		
Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.
15.50	0.11	0.11	16.88	0.07	0.10	18.88	0.23	0.02	16.13	0.34	0.05
17.13	0.08	0.02	16.38	0.13	0.02	17.63	0.24	0.06	16.63	0.34	0.06
18.50	0.18	0.05	16.88	-	0.05	18.50	0.18	0.04	16.88	0.33	0.08
-	-	-	-	-	-	-	-	0.10	-	-	0.12
Av., 17.12	0.12	0.06	16.71	0.10	0.06	18.34	0.23	0.06	16.55	0.34	0.08
Third Period.						Fourth Period.					
17.63	0.20	0.05	18.75	0.15	0.28	-	-	0.41	-	-	0.38
18.18	0.20	0.08	18.50	0.13	0.27	-	0.39	-	-	0.40	-
17.88	0.16	0.09	19.63	0.14	0.24	-	0.43	-	-	0.28	-
18.13	0.20	0.09	17.13	0.23	0.30	-	-	-	-	-	-
18.25	0.24	0.05	18.83	0.20	0.24	-	-	-	-	-	-
18.25	0.20	0.10	16.63	0.23	-	-	-	-	-	-	-
17.63	0.25	0.13	18.75	0.26	0.31	-	-	-	-	-	-
-	-	0.19	-	-	0.40	-	-	-	-	-	-
Av., 17.99	0.21	0.10	18.32	0.19	0.29	-	0.41	0.41	-	0.34	0.38

The results indicate that there was no particular difference in the percentage of fat left in the skim milk or buttermilk produced by the two herds, excepting in case of the buttermilk obtained from the butter produced by Herd II. in the third period, when .20 per cent. more fat was found than in that produced by Herd I. As the period of lactation became advanced, more fat was left in the skim milk produced by both herds. This, however, is a well-established fact with cream raised by the gravity process.

Conclusions. — The fact must not be overlooked that this experiment, on which the following conclusions are based, extended over a period of six months, with periods varying from three to seven weeks in length; the period proper was always preceded by a preliminary period of two weeks.

1. The immediate effect of the addition of .6 pounds of corn oil to the corn gluten meal ration was to increase the fat percentage in the milk .23 of 1 per cent. (5.17 to 5.40); at the end of two weeks the effect of the corn oil had disappeared, and the milk had returned to its normal fat content.

2. The removal of the corn oil from the daily ration caused a sudden drop of .54 per cent. in the fat (4.97 to 4.43), but after the first week the normal fat per cent. was again present.

3. Corn oil appeared to have depressed the nitrogen percentage in the milk by .034 per cent. (.610 to .576); the nitrogen gradually returned to its normal percentage after the feeding of the corn oil had ceased.

4. It is not considered practicable to feed large amounts of oil to cows, it having a tendency to derange the digestive and milk-secreting organs.

5. Corn meal was without effect on the composition of the milk.

6. There was but little change in the composition of the milk produced by Herd I. for a period of six months, during which time the herd received the same or so-called standard ration; a gradual increase in the percentage of solids not fat only was noted.

7. Corn gluten meal and corn meal were without noticeable influences on the chemical composition of the butter fat.

8. The addition of corn oil to the corn gluten meal ration caused a depression of 10 points in the saponification equiva-

lent, a decrease of $3\frac{1}{2}$ points in the Reichert-Meissl number, and an increase of 9 points in the iodine number, while the melting point of the fat remained unchanged.

9. An analysis of the butter fat will seldom give positive knowledge concerning the firmness or body of the butter.

10. A high iodine number is indicative of a soft or "light-bodied" butter; but a high melting point is not a sure indication of a hard, firm butter.

11. It seems probable that neither the proteid or carbohydrate groups, when fed in normal amounts, have any noticeable influence in changing the proportions of the several milk ingredients, or in modifying the chemical character of the butter fat; such changes, so far as they occur, are due to the presence of the oil in the feed stuff.

12. Corn gluten meal with a minimum percentage of oil produced rather a soft, yielding butter; this condition was noticeably increased by the addition of corn oil to the ration.

13. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, method of butter manufacture, and especially upon the character of the starter employed. Normal feeding stuffs are of secondary importance in establishing butter flavor.[1]

14. The present and previous experiments indicate that starchy feeds produce a hard-bodied butter, vegetable oils a soft butter; some proteids a hard-bodied butter, others butter of a softer, lighter body.

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[1] A possible exception to the above may be made in the case of young, clean pasture grass.

B. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

Digestion experiments with sheep were begun at this station in 1893, and a full description of the method employed will be found in the eleventh report of the Massachusetts State Experiment Station. The following experiments were made in the autumn of 1902 and during the winter and spring of 1903. The full data is given in this report, with the exception of the daily production of manure and the daily water consumption, in which case, to economize space, averages only are presented.

The periods extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were fed each sheep daily, in addition to the regular ration. Water was before the animals at all times. Sheep III. throughout the series gave evidence of strong digestive powers, while Sheep II. and particularly Sheep I. showed at times evidence of weak digestion, and in several cases the results from these two latter sheep were omitted, and the tests will be repeated. The sheep were full-grown grade Southdown wethers, and have been used for a number of years.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

Feed Stuffs.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digestion hay,	7.63	12.03	31.60	45.89	2.85
Apple pomace,	3.93	5.06	16.17	70.00	4.84
Biles XXXX distillers' grains,	1.77	37.75	14.56	34.15	11.77
Merchants distillers' grains,	2.10	34.52	13.71	35.25	14.42
Brewers' grains,	3.83	26.02	17.48	45.30	7.37
Malt sprouts,	4.97	28.27	16.24	49.02	1.50
Soy bean meal,	5.18	41.93	4.40	29.43	19.06
Hominy meal,	3.38	12.23	4.97	69.43	9.99
Waste, Sheep III., Period XXV.,	7.63	12.03	31.60	45.89	2.85

[1] With E. B. Holland and P. H. Smith.

Composition of Fæces (Per Cent.).

Sheep I.

Period.	Fæces from —	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	10.63	11.65	31.88	42.46	3.38
XXI., .	Apple pomace, ...	9.57	13.98	29.32	42.40	4.73
XXII., .	Biles XXXX distillers' grains,	10.26	18.28	26.85	41.40	3.21
XXIII., .	Merchants distillers' grains, .	10.63	18.34	27.04	40.81	3.18
XXIV., .	Brewers' grains, . . .	9.94	11.65	28.73	46.98	2.70

Sheep II.

Period.	Fæces from —	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.08	12.10	28.74	43.45	3.63
XXI., .	Apple pomace, ...	10.58	14.23	26.89	42.70	5.60
XXII., .	Biles XXXX distillers' grains,	10.80	19.13	24.54	42.29	3.24
XXIII., .	Merchants distillers' grains, .	11.79	18.78	23.90	41.94	3.59
XXIV., .	Brewers' grains, . . .	11.46	12.59	26.14	46.78	3.03
XXVII., .	Soy bean meal, ...	13.41	14.22	24.83	43.40	4.14

Sheep III.

Period.	Fæces from —	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.34	13.71	26.72	43.29	3.94
XXI., .	Apple pomace, ...	11.08	15.63	25.75	42.08	5.46
XXII., .	Biles XXXX distillers' grains,	10.88	19.60	23.92	42.25	3.35
XXIII., .	Merchants distillers' grains, .	11.64	19.53	23.61	41.76	3.46
XXIV., .	Brewers' grains, . . .	11.18	12.29	25.19	48.00	3.34
XXV., .	Malt sprouts, ...	12.82	15.06	24.35	44.27	3.50
XXVII., .	Soy bean meal, ...	12.75	14.28	26.81	41.67	4.49
XXVIII., .	Hominy meal, ...	13.06	14.88	24.06	43.41	4.59

Dry Matter Determinations made at the Time of Weighing out the Different Foods, and Dry Matter in Air-dry Manure (Per Cent.).

Sheep I.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	–	–	–	–	–	–	–	–	90.50
XXI., .	86.60	18.56	–	–	–	–	–	–	–	90.48
XXII., .	86.75	–	90 10	–	–	–	–	–	–	94.66
XXIII., .	87.22	–	–	91.23	–	–	–	–	–	93.24
XXIV., .	87.60	–	–	–	84.31	–	–	–	–	93.12

Dry Matter Determinations made at the Time of Weighing out the Different Foods, and Dry Matter in Air-dry Manure (Per Cent.) — Concluded.

Sheep II.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	-	-	-	-	-	-	-	-	90.32
XXI., .	86.60	18.56	-	-	-	-	-	-	-	90.21
XXII., .	86.75	-	90.10	-	-	-	-	-	-	94.74
XXIII., .	87.22	-	-	91.23	-	-	-	-	-	93.15
XXIV., .	87.60	-	-	-	84.31	-	-	-	-	93.00
XXVII., .	87.82	-	-	-	-	-	-	-	-	93.23

Sheep III.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	-	-	-	-	-	-	-	-	90.12
XXI., .	86.60	18.56	-	-	-	-	-	-	-	89.78
XXII., .	86.75	-	90.10	-	-	-	-	-	-	94.02
XXIII., .	87.22	-	-	91.23	-	-	-	-	-	93.11
XXIV., .	87.60	-	-	-	84.31	-	-	-	-	93.32
XXV., .	89.12	-	-	-	-	85.55	-	-	73.50	93.56
XXVII., .	87.82	-	-	-	-	-	86.62	-	-	93.40
XXVIII., .	88.25	-	-	-	-	-	-	88.48	-	92.91

Average Daily Amount of Manure excreted and Water drank (Grams).

Period.	Character of Ration.	Sheep I.			Sheep II.			Sheep III.		
		Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.
XX.,	Digestion hay,	680	31.96	1,815	590	30.49	1,451	628	30.07	1,640
XXI.,	Apple pomace,	703	29.14	518	528	27.69	382	501	25.78	313
XXII.,	Biles XXXX distillers' grains,	654	28.38	1,690	595	27.98	1,097	671	27.41	1,410
XXIII.,	Merchants distillers' grains,	632	27.46	1,758	600	26.72	1,091	722	26.88	1,531
XXIV.,	Brewers' grains,	741	32.86	2,214	707	30.81	1,142	636	29.04	1,694
XXV.,	Malt sprouts,	1,090	31.33	1,623	933	31.51	1,053	721	26.83	1,286
XXVII.,	Soy bean meal,	674	27.78	2,500	617	24.58	2,208	638	26.05	2,316
XXVIII.,	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

Weights of Animals at Beginning and End of Period (Pounds).

Period.	Character of Ration.	Sheep I.		Sheep II.		Sheep III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
XX.,	Digestion hay,	158.75	155.00	150.25	146.25	140.00	139.00
XXI.,	Apple pomace,	153.00	152.00	144.75	146.25	138.00	138.50
XXII.,	Biles XXXX distillers' grains,	152.50	153.50	147.00	146.75	139.50	137.00
XXIII.,	Merchants distillers' grains,	152.50	153.00	148.50	148.25	136.75	139.25
XXIV.,	Brewers' grains,	161.25	155.75	153.25	150.50	144.75	142.75
XXV.,	Malt sprouts,	159.75	156.75	155.25	152.50	145.50	146.25
XXVII.,	Soy bean meal,	154.25	152.00	154.75	154.50	149.00	146.50
XXVIII.,	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Digestion Hay. — Period XX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
319.59 grams manure excreted,	289.23	30.75	33.70	92.21	122.81	9.78
Grams digested,	481.08	28.02	58.97	151.21	230.69	12.17
Per cent. digested,	62.45	47.68	63.63	62.12	65.26	55.44

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
304.86 grams manure excreted,	275.35	33.26	33.32	79.13	119.64	10.00
Grams digested,	494.96	25.51	59.35	164.29	233.86	11.95
Per cent. digested,	64.25	43.41	64.04	67.49	66.16	54.44

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
300.70 grams manure excreted,	270.99	33.44	37.15	72.41	117.31	10.68
Grams digested,	499.32	25.33	55.52	171.01	236.19	11.27
Per cent. digested,	64.82	43.10	59.91	70.25	66.81	51.34
Average per cent. digested (three sheep),	**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**

Average nutritive ratio of rations for three sheep, 1 : 7.29.

Apple Pomace. — Period XXI.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	519.60	39.65	62.51	164.19	238.44	14.81
1,200 grams apple pomace fed,	222.72	8.75	11.27	36.01	155.90	11.79
Total consumed,	742.32	48.40	73.78	200.20	394.34	26.60
291.36 grams manure excreted,	263.62	25.23	36.85	77.29	111.77	12.47
Amount digested,	478.70	23.17	36.93	122.91	282.57	14.13
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	146.16	5.33	–	12.90	125.20	6.13
Per cent. digested,	65.63	60.91	–	35.82	80.31	51.99
Sheep II.						
Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
276.90 grams manure excreted,	249.79	26.43	35.55	67.17	106.66	13.99
Amount digested,	492.53	21.97	38.23	133.03	287.68	12.61
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	159.99	4.13	–	23.02	130.31	4.61
Per cent. digested,	71.83	47.20	–	63.93	83.59	39.10
Sheep III.						
Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
257.81 grams manure excreted,	231.46	25.65	36.18	59.60	97.40	12.64
Amount digested,	510.86	22.75	37.60	140.60	296.94	13.96
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	178.32	4.91	–	30.59	139.57	5.96
Per cent. digested,	80.06	56.11	–	84.95	89.53	50.56
Average per cent. digested (three sheep),	**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**

Average nutritive ratio of rations for three sheep, 1:12.02.

Biles Distillers' Grains. — Period XXII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	563.88	43.02	67.83	178.19	258.76	16.07
250 grams Biles distillers' grains fed,	225.25	3.99	85.03	32.80	76.92	26.51
Total consumed,	789.13	47.01	152.86	210.99	335.68	42.58
283.76 grams manure excreted,	268.61	27.56	49.10	72.12	111.20	8.62
Amount digested,	520.52	19.54	103.76	138.87	224.48	33.96
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	159.64	-	61.03	19.48	53.70	25.28
Per cent. digested,	70.87	-	71.77	59.39	69.31	95.36

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
279.77 grams manure excreted,	265.05	28.63	50.70	65.04	112.09	8.59
Amount digested,	524.08	18.38	102.16	145.95	223.59	33.99
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	163.20	-	59.43	26.56	52.81	25.31
Per cent. digested,	72.45	-	69.39	80.98	68.66	95.48

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
274.09 grams manure excreted,	257.70	28.04	50.51	61.64	108.88	8.63
Amount digested,	531.43	18.97	102.35	149.35	226.80	33.95
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	170.55	-	59.62	29.96	56.02	25.27
Per cent. digested,	75.71	-	70.12	91.34	72.83	95.32
Average per cent. digested (three sheep),	**73.01**	**-**	**70.59**	**77.24**	**70.43**	**95.39**

Average nutritive ratio of rations for three sheep, 1:4.34.

Merchants Distillers' Grains. — Period XXIII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	566.93	43.26	68.20	179.15	260.16	16.16
250 grams merchants distillers' grains fed,	228.08	4.79	78.73	31.27	80.40	32.89
Total consumed,	795.01	48.05	146.93	210.42	340.56	49.05
274.64 grams manure excreted,	256.07	27.22	46.96	69.24	104.50	8.14
Amount digested,	538.94	20.83	99.97	141.18	236.06	40.91
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	176.10	1.36	57.00	21.15	64.35	32.18
Per cent. digested,	77.21	28.39	72.40	67.64	80.04	97.84

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
267.16 grams manure excreted,	248.86	29.34	46.74	59.48	104.37	8.93
Amount digested,	546.15	18.71	100.19	150.94	236.19	40.12
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	183.31	-	57.22	30.91	64.48	31.39
Per cent. digested,	80.37	-	72.68	98.85	80.20	95.44

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
268.76 grams manure excreted,	250.24	29.13	48.87	59.08	104.50	8.66
Amount digested,	544.77	18.92	98.06	151.34	236.06	40.39
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	181.93	-	55.09	31.31	64.35	31.66
Per cent. digested,	79.77	-	69.97	100.00	80.04	96.26
Average per cent. digested (three sheep),	**79.12**	-	**71.68**	**88.83**	**80.09**	**96.51**

Average nutritive ratio of rations for three sheep, 1:4.78.

Dried Brewers' Grains. — Period XXIV.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams hay fed,	438.00	33.42	52.69	138.41	201.00	12.48
400 grams brewers' grains fed,	337.24	12.92	87.75	58.95	152.77	24.85
Total consumed,	775.24	46.34	140.44	197.36	353.77	37.33
328.61 grams manure excreted,	306.00	30.42	35.65	87.91	143.76	8.26
Amount digested,	469.24	15.92	104.79	109.45	210.01	29.07
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	188.92	.88	71.60	16.72	77.35	22.33
Per cent. digested,	56.02	–	81.60	28.36	50.63	89.36

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
308.06 grams manure excreted,	286.50	32.83	36.07	74.89	134.02	8.68
Amount digested,	488.74	13.51	104.37	122.47	219.75	28.65
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	208.42	–	71.18	29.74	87.09	21.91
Per cent. digested,	61.80	–	81.12	50.45	57.01	88.17

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
290.43 grams manure excreted,	271.03	30.30	33.31	68.27	130.09	9.05
Amount digested,	504.21	16.04	107.13	129.09	223.68	28.28
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	223.89	1.00	73.94	36.36	91.02	21.54
Per cent. digested,	66.39	–	84.26	61.68	59.58	86.68
Average per cent. digested (three sheep),	**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**

Average nutritive ratio of rations for three sheep, 1:4.14.

Malt Sprouts. — Period XXV.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay fed,	623.84	47.60	75.05	197.13	286.28	17.78
42.14 grams waste hay,	30.97	2.36	3.73	9.79	14.21	.88
Total hay consumed,	592.87	45.24	71.32	187.34	272.07	16.90
200 grams malt sprouts fed,	171.10	8.50	48.37	27.79	83.87	2.57
Total consumed,	763.97	53.74	119.69	215.13	355.94	19.47
268.33 grams manure excreted,	251.05	32.18	37.81	61.13	111.14	8.79
Amount digested,	512.92	21.56	81.88	154.00	244.80	10.68
Minus hay digested,	379.44	20.36	44.93	125.52	179.57	9.13
Malt sprouts digested,	133.48	1.20	36.95	28.48	65.23	1.55
Per cent. digested,	78.01	–	76.39	102.50	77.78	60.31

Nutritive ratio of ration for Sheep III., 1:5.16.

Soy Bean Meal. — Period XXVII.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams hay fed,	614.74	46.90	73.95	194.26	282.10	17.52
200 grams soy bean meal fed,	173.24	8.97	72.64	7.62	50.98	33.02
Total consumed,	787.98	55.87	146.59	201.88	333.08	50.54
245.80 grams manure excreted,	229.16	30.73	32.59	56.90	99.46	9.49
Amount digested,	558.82	25.14	114.00	144.98	233.62	41.05
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	165.39	4.03	67.41	14.83	47.43	31.59
Per cent. digested,	95.46	44.93	92.80	194.62	93.04	95.67

Sheep III.

Total consumed as above,	787.98	55.87	146.59	201.88	333.08	50.54
260.47 grams manure excreted,	243.28	31.02	34.74	65.22	101.37	10.92
Amount digested,	544.70	24.85	111.85	136.66	231.71	39.62
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	151.27	3.74	65.26	6.51	45.52	30.16
Per cent. digested,	87.32	41.70	89.34	85.43	89.29	91.34
Average per cent. digested (two sheep),	**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**

Average nutritive ratio of rations for two sheep, 1:4.11.

Hominy Meal. — Period XXVIII.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal fed,	265.44	8.97	32.46	13.19	184.29	26.52
Total consumed,	794.94	49.37	96.16	180.51	427.28	41.61
231.44 grams manure excreted,	215.03	28.08	32.00	51.74	93.34	9.87
Amount digested,	579.91	21.29	64.16	128.77	333.94	31.74
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	241.03	3.11	24.03	16.67	173.57	23.59
Per cent. digested,	90.80	34.67	74.03	126.55	94.18	88.95

Nutritive ratio of ration for Sheep III., 1 : 8.32.

Summary of Coefficients.

Ration.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Hay,	Sheep I.,	62.45	47.68	63.63	62.12	65.26	55.44
	Sheep II.,	64.25	43.41	64.04	67.49	66.16	54.44
	Sheep III.,	64.82	43.10	59.91	70.25	66.81	51.34
Average,	. . . .	**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**
Apple pomace,	Sheep I.,	65.63	60.91	–	35.82	80.31	51.99
	Sheep II.,	71.83	47.20	–	63.93	83.59	39.10
	Sheep III.,	80.06	56.11	–	84.95	89.53	50.56
Average,	. . . .	**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**
Biles distillers' grains,	Sheep I.,	70.87	–	71.77	59.39	69.31	95.36
	Sheep II.,	72.45	–	69.39	80.98	68.66	95.48
	Sheep III.,	75.71	–	70.12	91.34	72.83	95.32
Average,	. . . .	**73.01**	–	**70.59**	**77.24**	**70.43**	**95.39**
Merchants distillers' grains,	Sheep I.,	77.21	28.39	72.40	67.64	80.04	97.84
	Sheep II.,	80.37	–	72.68	98.85	80.20	95.44
	Sheep III.,	79.77	–	69.97	100.00	80.04	96.26
Average,	. . . .	**79.12**	–	**71.68**	**88.83**	**80.09**	**96.51**
Dried brewers' grains,	Sheep I.,	56.02	–	81.60	28.36	50.63	89.36
	Sheep II.,	61.80	–	81.12	50.45	57.01	88.17
	Sheep III.,	66.39	–	84.26	61.68	59.58	86.68
Average,	. . . .	**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**
Malt sprouts,	Sheep III.,	**78.01**	–	**76.39**	**102.50**	**77.78**	**60.31**
Soy bean meal,	Sheep II.,	95.46	44.93	92.80	194.62	93.04	95.67
	Sheep III.,	87.32	41.70	89.34	85.43	89.29	91.34
Average,	. . . .	**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**
Hominy meal,	Sheep III.,	**90.80**	**34.67**	**74.03**	**126.55**	**94.18**	**88.95**

Discussion of the Results.

Digestion Hay. — The hay was largely Kentucky blue-grass (*Poa pratensis*), cut in bloom, and was employed in all of the several tests herein reported. It showed a high degree of digestibility.

Apple Pomace. — The pomace was taken fresh from the cider mill, and contained 18.56 per cent. of dry matter. It is the first digestion test of such material on record, either in Europe or the United States. The sheep did not digest it as evenly as could be desired, although they ate it satisfactorily, and no digestion disturbances were noted. The percentage of crude protein (5.06 in dry matter) was small, and no coefficients were obtained. This, in all probability, was partly due to the "digestion depression" known to take place when feeds especially high in carbohydrates are added to a hay ration, the effect being particularly noticeable in the protein, and to a less extent in the fiber. The pomace contained fully as much digestible matter as silage made from the smaller varieties of corn. Whether, per unit of dry matter, it is as valuable a feed as corn silage, is rather uncertain. This point will be ascertained later.

Distillers' Dried Grains. — Considerable has been said concerning the source, composition and digestibility of distillers' grains in the thirteenth report of this station. Briefly stated, these feeds represent the residue in the manufacture of alcohol, spirits and whiskey from the several cereals, and are composed chiefly of the hull, germ and protein matter of the grains. In the better class of such material, containing 28 or more per cent. of protein, the residue consists largely of corn. In the most modern plants, the distillery slop, hot from the stills, is dried immediately in especially constructed driers, and has a slightly sour taste and smell. One of the two samples herein reported — the merchants — had as lightly burned taste, which is not to be desired. The grains are now sold in Massachusetts markets under the following names: Biles XXXX Grains, Ajax Flakes, Merchants Grains, Hall's AAAA Grains, Atlas Gluten Meal and Corn Protegran.

Both samples here reported showed a high degree of digestibility. The sample of Merchants grains proved about 6 per cent. more digestible than the "Fourex" brand, due probably to the character of the cereals used in the mash. The difference was principally in the extract matter. Comparing the coefficients obtained with Sheep III., the difference in case of the total dry matter is reduced to 4 per cent. Marked differences are observed in the digestibility of the fiber. Such variations in fiber digestibility are characteristic of all grains and grain by-products. This matter will be referred to farther on.

In this connection it will doubtless prove of interest to summarize the results obtained at this station with 7 different samples of distillers' grains: —

Composition of the Grains (Per Cent.).

Brand.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Biles X,	8.91	1.68	29.15	9.58	40.03	10.65
Biles XX,	9.53	2.44	25.49	11.22	41.80	9.52
Biles XXX,	7.46	2.05	29.86	10.28	38.52	11.83
Biles XXXX,	8.83	1.70	34.76	11.40	33.50	9.81
Biles XXXX,	9.45	1.55	35.46	13.00	29.87	10.67
Merchants,	8.77	1.92	31.49	12.51	32.15	13.16
Atlas,	8.96	.94	38.80	8.86	28.08	14.36
Average,	8.84	1.75	32.14	10.98	34.85	11.43

The percentage of ash is low, as would naturally be expected. Its exact character has not been determined. The protein percentage is relatively high, and varies considerably, depending upon the material used. The brands offered in Massachusetts have been guaranteed to contain 33 and 34 per cent. Considerable fiber is present, as a result of the incorporated grain hulls. The fiber and extract matter must show a very considerable amount of pentosans, although determinations have not been made. The fat percentage is quite high, being similar in quantity to that contained in the corn gluten feed, before the corn oil was extracted.

Digestion Coefficients of Distillers' Dried Grains (Per Cent.).

[All experiments.]

Number of Sheep.	Brand.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	Biles X grains,	86.50	20.24	65.51	130.11	93.12	93.94
Sheep III.,	Biles X grains,	87.07	–	80.05	127.56	85.15	97.60
Sheep I.,	Biles XX grains,	88.53	13.91	79.94	122.75	88.22	94.45
Sheep VI.,	Biles XX grains,	79.77	–	76.50	97.22	79.77	94.87
Sheep II.,	Biles XXX grains,	79.88	–	73.41	108.91	78.03	91.78
Sheep VI.,	Biles XXX grains,	71.41	–	74.01	66.03	72.69	93.95
Sheep I.,	Biles XXXX grains,	79.82	–	72.08	102.77	81.12	96.99
Sheep VI.,	Biles XXXX grains,	73.47	–	69.22	81.78	76.73	98.45
Sheep I.,	Biles XXXX grains,	70.87	–	71.77	59.39	69.31	95.36
Sheep II.,	Biles XXXX grains,	72.45	–	69.39	80.98	68.66	95.48
Sheep III.,	Biles XXXX grains,	75.71	–	70.12	91.34	72.83	95.32
Sheep IV.,	Merchants grains,	77.21	28.39	72.40	67.64	80.04	97.84
Sheep V.,	Merchants grains,	80.37	–	72.68	98.85	80.20	95.44
Sheep VI.,	Merchants grains,	79.77	–	69.97	100.00	80.04	96.26
Sheep III.,	Atlas gluten meal,	79.53	–	73.04	94.88	84.00	92.43
Sheep IV.,	Atlas gluten meal,	79.75	–	72.56	116.50	84.91	90.06
Average,		78.88	–	72.67	96.67	79.68	95.01

As a result of 16 single digestion trials with 6 different samples, several points may be noted: —

(*a*) The dry matter coefficients differed considerably, but the grains showed a high average digestibility.

(*b*) The ash was apparently little digested. Whether this was literally true, or whether a portion of it was substituted for the digestible ash of the hay, is not clear.

(*c*) The protein in the several brands was quite evenly digested, except in the first two samples.

(*d*) The fiber showed marked variations in digestibility, in common with all feeds of similar character. While it has been generally held that nitrogenous feed stuffs do not affect the normal digestibility of the coarse fodders they supplement, it certainly seems reasonable to conclude that the addition of 200 to 250 grams of the distillers' grains to the hay ration, giving a nutritive ration of 1 : 4, has resulted in increasing the digestibility of the fiber in the hay; which accounts, in the majority of cases, for the apparently very high digestion coefficients obtained. Admitting this to be the case, the fact still remains that, while the digestion coefficient for the fiber is rather of an uncertain quantity, it must be regarded as relatively high.

(*e*) The extract matter digested in the several samples differed to a noticeable extent, depending probably upon the nature of the material composing it, the way in which it is united with the crude fiber, and also upon the digestive capacity of the sheep. Other things being equal, animals in normal condition should digest substantially equal quantities of the same feed stuff, when fed under similar conditions. It often happens, however, that one or the other animal will be a trifle out of condition without giving any external evidence of it, and hence will digest rather more of one fodder group and less of another.

Attention is called to the fact that the higher the digestion coefficients obtained for the fiber, the higher are those obtained for the extract. This is undoubtedly due to the intimate chemical and physiological relations known to exist between these two fodder groups.

(*f*) The fat was quite evenly and largely digested.

Dried Brewers' Grains. — These were grains of good quality, and of a fresh, bright color. Sheep I. showed its inability to digest the fiber and extract matter as well as the other sheep, and even Sheep II. did not utilize the fiber as well as Sheep III. The average coefficients for the three sheep corresponded quite well with former experiments made at this station, and also with German experiments; excepting that in case of the American tests the coefficients for the protein and fiber are somewhat higher, and the extract matter 4 per cent. lower.

Malt Sprouts. — These were of average quality. They contained an exceptionally large portion of their nitrogen, 42.29 per cent., in the form of amids. The experiment was conducted with three sheep, but Sheep I. and Sheep II. digested so much less fiber and extract matter than is customary that the results with these two sheep were discarded, and the test will be repeated. Only one other American test with a single animal is on record, and showed considerably less fiber and extract matter digested than that obtained in the present experiment. The present single test agrees fairly well with the seven German trials reported.

Soy Bean Meal (*Brook's Medium Green*). — This variety is by far the best suited to northern conditions. The sample was grown upon the station grounds, and was coarsely ground before being fed. The seed is green in color, and similar in size to dwarf garden peas. The bean contained 61 per cent. of protein and fat, and these two ingredients are shown to be 91 and 93 per cent. digestible. The extract matter, 29.43 per cent., was 91 per cent. digested. The coefficients of digestibility obtained for the fiber are, of course, incorrect, due probably to the favorable influence of the soy bean, a nitrogenous feed stuff, in increasing the digestibility of the hay carbohydrates. It can be assumed that the fiber contained in the soy bean has a high rate of digestibility. The small amount present, 4.40 per cent., renders a knowledge of the exact percentage digestible of minor importance.

The three American digestion trials, with an unnamed variety, reported in Lindsey's compilation, show the protein and fat to have been nearly as well digested as those in the present trial. The fiber and extract matter, on the other hand, had noticeably lower digestion coefficients (33 and 71). In the two German trials reported the protein and fat are respectively 87 and 94 per cent., and the extract matter 62 per cent. digestible, while the digestibility of the fiber is not stated.

It is evident, from all trials thus far made, that the protein and fat, comprising from 50 to 60 per cent. of the bean is very fully digested. Whether the high digestibility of the fiber and extract in the present experiment is due to the variety of the bean, or is a peculiarity of the sheep employed, will be determined by further tests.

Hominy Meal, or Chop. — As used for cattle feeding this consists of the hull, germ and some of the gluten and soft starch. The sample tested for digestibility was of good average quality. The present trial was made with three sheep, but Sheep I. and Sheep II. digested so unevenly that the results were discarded, it being evident that their digestion powers had become weakened by continued use. The results with Sheep III. show the hominy to be fully as digestible as corn meal. The addition to the hay of even a carbohydrate feed, such as hominy, seemed to have increased the digestibility of the fiber in the hay, judging from the coefficients obtained for the hominy fiber.

C. Raising Dairy Calves without Milk.

J. B. LINDSEY.

With plenty of skim milk available, the rearing of calves intended for the dairy is a comparatively simple matter. There is, however, a constantly increasing demand in Massachusetts for whole milk, and the amount available for butter production is likely to diminish from year to year. With little or no skim milk at his disposal, the dairyman desirous of growing his own young stock is in need of a milk substitute to feed the calf during the first four to six months of its life. The brief experiment here reported was made to test the efficacy, for such a purpose, of Hayward's and Blatchford's calf meals.

(1) *Hayward's Calf Meal.*

Hayward of the Pennsylvania experiment station studied the question of providing a cheap and suitable milk substitute, and published his results in Bulletin No. 60 of that station. He succeeded in rearing ten unselected grade Guernsey calves without the aid of milk after the first fourteen to eighteen days. Most of the calves weighed from 150 to 250 pounds when from four to five months old, and were produced at a food cost of from $8 to $9 each. He concluded that the calf meal was a fairly satisfactory milk substitute, if used judiciously by careful feeders, but that it was not equal to whole milk.

The formula proposed by Hayward for the meal was as follows: —

	Pounds.
Wheat flour,	30
Cocoanut meal,	25
Nutrium,	20
Linseed meal,	10
Dried blood,	2

Hayward employed whole wheat, grown at the station and ground by the local miller. In the test about to be reported St. Louis flour at a cost of 2 cents a pound was used.

Cocoanut meal is a by-product in the manufacture of cocoanut oil, and was obtained of the India Product Food Company, 50 Chatham Street, Boston, Mass. It has a decided cocoanut odor, and tested 21.11 per cent. of protein and 19.23 per cent. of fat. Cocoanut oil is likely to become rancid after a brief period. Hayward believed it to have quite a favorable effect as a part of the calf meal.

Nutrium is a powder prepared by the National Nutrient Company of Jersey City, N. J., and is simply skim milk evaporated at a low temperature. It was very dry and fine, and kept well. This company also puts out the same article in granular form, but the powder is to be preferred.

Dried blood, especially prepared for feeding purposes, is offered by the Armour Fertilizer Works and by Swift & Co. of Chicago. It is also to be had of the agricultural warehouses in the large cities. It was employed by Hayward to check scours.

Cost per Pound of Each Ingredient and of the Mixture.

	Pounds.	Cost (Cents).	Total.
Wheat flour,	30	2	$0 60
Cocoanut meal,	25	1½	38
Nutrium,	20	10	2 00
Linseed meal,	10	1½	15
Blood,	2	4[1]	08
	87	-	$3 21

[1] In small quantities.

The cost per pound figures 3.7 cents, and to this must be added the freight charges on the nutrium, cocoanut meal and blood. Those who are desirous of trying this mixture would, of course, purchase these ingredients in larger quantities than the above, but it is doubtful if the meal could be prepared for much less than 4 cents a pound.

Method of Feeding the Meal. — This station tested the calf meal, using two unselected thrifty grade Jersey calves, a bull and a heifer. The several ingredients were in such good mechanical condition that it was not necessary to grind the mixture. It may not be out of place to add that the meal should be fine, and free from any coarse particles.

One pound was thoroughly stirred into 8 pounds of very hot water, and allowed to stand until milk-warm, in which condition it was fed. Hayward used 6 pounds of water to a pound of meal, and employed a calf feeder; but in our case it was considered better to teach the animals to drink at once.

The calves were fed whole milk for the first nine to fourteen days, and then skim milk and calf meal gradually substituted, whole milk being entirely taken away at the end of three weeks. Three quarts of skim milk were fed daily, in addition to the calf meal, until the calves were four or five weeks old, when both calves were placed upon an entire diet of calf meal. Hayward used the calf meal entirely after the first ten days, but it seemed wiser to the writer to allow some milk for a longer period, and thus give the animals a better start. Three-fourths of a pound of the meal was fed at first, and the amount gradually increased, until at the close of the experiment Calf I. was receiving 3 pounds and Calf II. 2 pounds of the meal daily.

Average Daily Record of Each Calf.

	Days entirely on Milk.	Average Amount Daily (Quarts).	Days partly on Milk, partly on Meal (Amount Daily).		
			Days.	Milk (Quarts).	Meal (Pounds).
Calf I., ...	14	5.7	19	4.3	1
Calf II., ...	9	5.3	15	4.3	1

Average Daily Record of Each Calf — Concluded.

	Days entirely on Meal (Amount).		Days partly on Milk after feeding Meal as Entire Ration.		Total consumed.	
	Days.	Amount (Pounds.)	Days.	Milk (Quarts).	Milk (Quarts).	Meal (Pounds).
Calf I., . .	143	2.50	2	4.0	152 [1]	374.0
Calf II., . .	101	2.20	44	2.6	229 [2]	306.5

[1] Whole milk, 93 quarts; skim milk, 59 quarts.
[2] Whole milk, 69 quarts; skim milk, 160 quarts.

Effect of the Calf Meal. — No serious trouble was experienced with either calf until February 12, when Calf II. suffered a bad attack of indigestion, which rendered it necessary to take away a considerable portion of the meal and substitute skim milk; and this animal was still receiving some milk when the experiment terminated, although she recovered and made good gains. On January 5 the supply of cocoanut meal became exhausted, and flour middlings was used in its place until March 10. The continued use of the middlings may have been a partial cause of the trouble. Calf I. was rather more robust, and experienced only a slight digestion disturbance about the middle of February, when a portion of the meal was replaced by skim milk for two days. While the calves did not have as sleek an appearance as animals raised on a whole milk diet, they were certainly in a thrifty growing condition, and at the close of the trial appeared especially vigorous.

Weekly Weights of Calves (Pounds).

Dates.	Calf I.	Calf II.	Dates.	Calf I.	Calf II.
November 10,	95 [1]	85 [2]	February 2,	190	182
November 17,	105	95	February 9,	203	191
November 24,	110	97	February 16,	210	177 [3]
December 1,	115	105	February 23,	222	185
December 8,	122	112	March 2,	235	185
December 15,	130	120	March 9,	247	197
December 22,	142	130	March 16,	252	218
December 29,	147	135	March 23,	263	225
January 5,	157	145	March 30,	277	235
January 12,	–	–	April 6,	295	250
January 19,	167	152	April 13,	310	260
January 26,	170	170			

[1] Just after beginning calf meal, three weeks after birth.
[2] Just after beginning calf meal, two and one-half weeks after birth.
[3] Ill with indigestion.

It will be seen from the above tables that the calves made a fair growth during the experiment, especially during the last month of the trial. Calf I. weighed 310 pounds when six months old, and made an average daily growth of 1.4 pounds while receiving the calf meal; while Calf II. weighed 260 pounds when five and one-half months old, and gained 1.1 pounds daily on the calf meal.

Cost of Feed Consumed. — Allowing 3 cents a quart for the whole milk, $\frac{1}{2}$ cent a quart for the skim milk and 4 cents a pound for the calf meal, the food cost in case of Calf I. was $20.20, and in case of Calf II. $15.11. If the calves had been fed largely calf meal at the end of the second week, this cost would have been somewhat reduced. Again, the calves might have been transferred a month earlier to a hay and grain diet. The object, however, in the present test was not to ascertain the minimum cost of raising the calf, but rather to note the effect of the calf meal during the first five or six months of the animal's life.

Conclusions. — 1. It is evident that, with reasonable care and cleanliness, calves can be successfully reared on Hayward's calf meal.

2. The meal is to be preferred only when a supply of skim milk is not available, or as a substitute for a portion of the milk.

3. The cost[1] is likely to be somewhat greater than when skim milk can be had at two cents a gallon. The expense of the meal is largely due to the nutrium, yet it is doubtful if a mixture as satisfactory for young calves could be obtained without the use of this substance.

4. The meal is evidently better utilized by calves after they are three months old than before that period.

5. The best method to be employed would probably be to allow the calf to suck the cow for the first two days, then feed whole milk for five days, to be followed by half whole and half skim milk for a week, gradually reducing the whole milk, so that at the beginning of the fourth week the diet may consist of 3 quarts of skim milk and $\frac{3}{4}$ to one pound of the meal, dissolved in the necessary hot water. At the end of the fourth week the skim milk may be dropped, and the calf put upon a diet of 2 pounds of the calf meal a day. Slight modifications may be made in this method depending on the condition of the animal.

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[1] The writer has grown seven unselected young calves, having an average weight when three days old of 73 pounds, to an average weight when ten weeks old of 173 pounds, on skim milk, together with such common grains as corn meal, wheat flour, flour middlings and gluten feed, at an average food cost of $4.80 each. By this method of feeding, calves ought to be produced that will weigh 200 to 300 pounds when five months old, at a food cost not exceeding $9 or $10. (See eleventh report of Massachusetts State Experiment Station, p. 125.)

6. It may be possible to modify the meal by replacing the cocoanut meal with some more common feeding stuffs, although Hayward did not succeed in finding a satisfactory substitute.

(2) *Blatchford's Calf Meal.*

This material, put out by the Barwell Mills, at Waukegan, Ill., is highly recommended by the manufacturers as a milk substitute. It is composed principally of linseed meal, beans, carob beans, cotton-seed meal and fenugreek, and retails at $3\frac{1}{2}$ cents a pound. It has a very pronounced odor and flavor.

How the Meal was fed. — This article was tested by feeding it to one rugged grade Holstein calf, dropped Dec. 11, 1902. Unfortunately, the detailed record of the early part of this test has been lost, although some notes are on hand. The calf was first fed whole milk, a little later whole and skim milk, and at the end of two or three weeks the calf meal gradually substituted. The calf at first objected to the odor or taste of the meal, and never seemed to thoroughly relish it, although no serious difficulty was found in inducing the animal to take it. One pound of the meal was added to 6 pounds of hot water, thoroughly stirred and fed milk-warm. It was not possible to place the calf entirely upon the meal for a considerable time, hence the daily feed consisted of 4 quarts of skim milk and 2 pounds of the calf meal with the necessary water. On March 23, when a little over three months old, the calf was receiving $2\frac{3}{4}$ pounds of the meal daily, and continued to take this quantity without other food until the experiment terminated, May 4, the calf then being approximately four and one-half months old.

Weight of the Calf.

	Pounds.
March 23 (first record),	203.5
March 30,	205.0
April 6,	214.5
April 13,	221.0
April 20,	232.0
April 27,	242.0
May 14,	251.0

The animal did not suffer any serious digestion disturbances, and certainly grew well, as the above weights indicate, making an average increase of 1.15 pounds daily during the last forty-two days of the test.

Conclusions. — The above single trial is not sufficient to enable one to draw any absolute conclusions. The writer, however, observed the calf closely during the trial, and believes he is justified in making the following statements: —

1. Blatchford's calf meal is hardly as satisfactory as the Hayward mixture during the first three months of the calf's life, and it will probably prove necessary to feed one-third skim or whole milk and two-thirds meal during this period.

2. Used as above indicated, it proved quite satisfactory in the present single trial, can undoubtedly be depended upon as a partial milk substitute for calves under three months of age, and can be used as the entire food after that time and until the animal is ready for hay and the more common grains (five to six months).

3. It is possible that delicate calves would not thrive as well upon the meal as the one in the present trial.

4. The Blatchford meal was in good mechanical condition, and cannot be considered especially expensive.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, RICHARD H. ROBERTSON.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1903.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 35 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 2 in Ohio, 1 in Illinois and 1 in Arkansas.

Three hundred and six brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and eighty-four samples of fertilizer have thus far been collected in the general markets by experienced assistants in the station.

Five hundred and twelve samples were analyzed at the close of November, 1903, representing two hundred and ninety distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 90, July, and No. 92, November, 1903.

During the year 1903 a larger number of fertilizers have been licensed in the State of Massachusetts than for any previous year in the history of our fertilizer inspection laws. This necessitates an increased amount of work in the official inspection of commercial fertilizers. Twenty-three more brands of fertilizers were licensed and eighty more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1902 and 1903: —

	1902.	1903.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee, . . .	20	19
Number with one element above the highest guarantee, ...	83	91
Number with three elements between the lowest and highest guarantee,	183	207
Number with two elements between the lowest and highest guarantee,	87	118
Number with one element between the lowest and highest guarantee,	54	42
Number with three elements below the lowest guarantee, . . .	3	2
Number with two elements below the lowest guarantee, ...	18	24
Number with one element below the lowest guarantee, ...	67	100
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	10	2
Number with one element above the highest guarantee, ...	22	17
Number with two elements between the lowest and highest guarantee,	16	31
Number with one element between the lowest and highest guarantee,	13	13
Number with two elements below the lowest guarantee, ...	4	1
Number with one element below the lowest guarantee, ...	19	14
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	9	11
Number between lowest and highest guarantee, ...	14	13
Number below lowest guarantee, ...	20	18

From the above table it will be seen that there is no material change in the quality of the fertilizers which have been examined, when compared with the results of the previous year. Where a discrepancy has occurred between the results of analysis and the manufacturers' guarantee, we are of the opinion that poor mixing is responsible, rather than a disposition on the part of the manufacturer to furnish an inferior article. As proof of this, we find in most cases that wherever a fertilizer shows a low test in any one ingredient, a corresponding high test is shown on some other element of plant food in the same brand; this usually corrects any difference in commercial value of the fertilizer.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1902 and 1903 (Cents per Pound).

	1902.	1903.
Nitrogen in ammonia salts,	16.50	17.50
Nitrogen in nitrates,	15.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.50	17.00
Organic nitrogen in fine bone and tankage,	16.00	16.50
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	4.50
Phosphoric acid soluble in ammonium citrate,	4.50	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values of fertilizing ingredients for the years 1902 and 1903 shows a higher market cost of nitrogen in form of ammonia salts and in the higher grades of organic substances for the year 1903 than for the previous year; this is, however, largely offset by a corresponding decrease in the market cost of the better forms of phosphoric acid.

The schedule of trade values for 1903 was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of March, 1903; it is based on the condition of the fertilizer market in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1903, and refers to the current market prices of the leading standard raw materials which furnish nitrogen, phosphoric acid and potash, and which enter largely into the manufacture of our commercial fertilizers.

Table A, following, gives the average analysis of officially collected fertilizers for 1903 ; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential elements of plant food in so-called special crop fertilizers put out by different manufacturers.

Table A. — *Average Analysis of Officially Collected Fertilizers for 1903.*

Nature of Material.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.70	2.96	2.77	4.43	3.81	2.33	10.57	8.87	8.24	7.44	5.48	5.19
Ground bones,	7.69	3.23	2.85	-	9.88	14.86	24.74	22.54	9.88	-	-	-
Tankage,	8.04	4.59	3.93	-	10.68	7.54	18.22	17.96	10.68	10.00	-	-
Dissolved bone-black,	12.80	-	-	12.09	3.21	1.56	16.86	16.00	15.30	15.00	-	-
Acid phosphate,	10.30	-	-	14.90	1.70	-	16.60	-	16.60	-	-	-
Wood ashes,	13.05	-	-	-	-	-	1.44	1.50	-	-	5.56	5.00
Cotton-seed meal,	7.41	6.73	7.00	-	-	-	-	-	-	-	-	-
Flax meal,	9.42	5.73	6.08	-	-	-	-	-	-	-	-	-
Nitrate of soda,	2.06	15.41	15.41	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.78	20.40	19.00	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.15	-	-	-	-	-	-	-	-	-	48.88	48.12
Muriate of potash,	2.69	-	-	-	-	-	-	-	-	-	48.98	-
Kainit,	2.70	-	-	-	-	-	-	-	-	-	11.20	12.00

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1903.*

Name of Fertilizer.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	10.70	3.70	1.25	2.24	14.82	8.92	11.29	12.88	5.34	8.85	9.56	1.52	3.64
Fruit and vine fertilizer,	9.94	2.69	2.00	2.48	12.98	9.10	10.99	10.34	7.24	8.78	11.28	6.06	8.11
Grain fertilizer,	10.28	8.13	1.25	3.94	18.04	7.52	11.74	12.88	4.32	8.69	14.60	2.06	5.78
Grass fertilizer,	9.03	8.13	2.23	4.24	18.04	4.22	9.88	11.84	2.68	6.86	14.60	2.18	6.04
Market-garden fertilizer,	9.82	4.54	2.08	3.45	13.90	6.12	10.63	10.85	5.32	8.06	10.82	2.30	6.81
Potato fertilizer,	10.25	5.02	1.07	2.51	13.90	7.08	10.43	9.69	5.02	8.24	10.58	2.12	5.51
Tobacco fertilizer,	9.42	5.94	.59	3.41	13.38	4.22	10.00	10.56	2.94	7.54	17.34	1.66	7.96
Onion fertilizer,	9.26	4.36	1.16	2.64	12.26	6.38	8.72	9.70	5.10	6.56	7.76	4.04	5.76

A careful study of Table B teaches the following lessons. The trade name of a fertilizer is a poor criterion in ascertaining the efficiency of a fertilizer. Many farmers depend too much on trade names in making their selection of fertilizers. With the great variety of fertilizers now found upon the market, it becomes no easy matter for the average farmer to make an intelligent and judicious selection of his fertilizers, unless he is in possession and makes use of the fertilizer bulletins which are issued from time to time. In making a selection of a fertilizer for growing special crops, the needs of the soil and the requirements of the crop should receive careful consideration, and a fertilizer should be selected which will supply the wants of the soil in the most suitable and economical manner. In deciding what brands of fertilizers to purchase for general use, it is self-evident that those fertilizers should be selected which furnish the greatest amount of nitrogen, phosphoric acid and potash in a suitable and available form for the same money.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1903, to May 1, 1904) and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- High-grade Fertilizer with Ten Per Cent. Potash.
- Grass and Lawn Top-dressing.
- Tobacco Starter and Grower.
- Brightman's Fish and Potash.
- Fine-ground Bone.
- Columbia Fish and Potash.
- Abattoir Bone.
- Dissolved Bone-black.
- Muriate of Potash.
- Double Manure Salt.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dry Ground Fish.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass. — *Con.*
- Bradley's Complete Top-dressing for Grass and Grain.
- Bradley's X L Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Church's Fish and Potash.
- Bradley's Seeding-down Manure.

American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A A Ammoniated Superphosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer G. G.
- Clark's Cove Great Planet Manure.
- Clark's Cove Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass. — *Con.*
Clark's Cove Potato Fertilizer.
Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's Corn Phosphate.
Crocker's A A Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
Cumberland Superphosphate.
Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
Darling's Blood, Bone and Potash.
Darling's Complete Ten Per Cent. Manure.
Darling's Potato Manure.
Darling's Farm Favorite.
Darling's General Fertilizer.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
Northern Corn Special.
Vegetable Vine and Tobacco.
Garden Special.
General.
Grass and Oat Fertilizer.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
Pacific High-grade General.
Pacific Potato Special.
Soluble Pacific Guano.
Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
Gardners' Complete Manure.
Animal Corn Fertilizer.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
Quinnipiac Market-garden Manure.
Quinnipiac Phosphate.
Quinnipiac Potato Manure.
Quinnipiac Potato Phosphate.
Quinnipiac Corn Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass. — *Con.*
Quinnipiac Climax Phosphate.
Quinnipiac Havana Tobacco Grower.
Quinnipiac Onion Manure.

The American Agricultural Chemical Co (Read Fertilizer Co., branch), New York, N. Y.: —
Read's Practical Potato Special.
Read's Farmers' Friend.
Read's Standard.
Read's High-grade Farmers' Friend.
Read's Vegetable and Vine.

The American Agricultural Chemical Co (Standard Fertilizer Co., branch), Boston, Mass.: —
Standard Complete Manure.
Standard Fertilizer.
Standard Special for Potatoes.
Standard Guano.

The American Agricultural Chemical Co. (H. F. Tucker & Co., branch), Boston, Mass.: —
Tucker's Original Bay State Bone Superphosphate.
Tucker's Special Potato.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
Williams & Clark's High-grade Special.
Williams & Clark's Americus Potato.
Williams & Clark's Potato Phosphate.
Williams & Clark's Potato Manure.
Williams & Clark's Corn Phosphate.
Williams & Clark's Royal Bone Phosphate.
Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
Corn Fertilizer.
Potato Manure.
Havana Tobacco Grower.
Superior Truck Fertilizer.
Bermuda Onion Grower.
Grass and Oats Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
Abbott's Animal Fertilizer.
Abbott's Eagle Brand.
Abbott's Tobacco Fertilizer.

Abbott and Martin Rendering Co., Columbus, O.: —
Harvest King.
Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Grain Grower.
- Bone, Blood and Potash.
- High-grade Potato.
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Baker's Pure Castor Pomace.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

T. H. Bunch, Little Rock, Ark.: —
- Cotton-seed meal.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Universal Brand.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Manure.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash (D Brand).
- Bowker's Corn Phosphate.
- Bowker's Bone, Blood and Potash.
- Bowker's Early Potato Manure.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Market-garden Manure.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Bowker's Kainit.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Bristol Fish and Potash.
- Bowker's Fine-ground Fish.
- Bowker's Tobacco Ash Elements.
- Bowker's Ground Bone.
- Bowker's Wood Ashes.
- Bowker's Superphosphate.
- Sulfate of Ammonia.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.

Chicopee Rendering Co., Springfield, Mass.: —
- Pure Ground Bone.
- Tankage.
- Complete Animal Fertilizer or Lawn and Garden Dressing.

Chas. M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Excelsior Potato Fertilizer.
- E. Frank Coe's Fish Guano and Potash (F. P.).
- E. Frank Coe's Columbian Corn Fertilizer.
- E. Frank Coe's Columbian Potato Fertilizer.
- E. Frank Coe's New Englander Corn Fertilizer.
- E. Frank Coe's New Englander Potato Fertilizer.
- E. Frank Coe's Columbian Ammoniated Bone Superphosphate.
- E. Frank Coe's Red Brand Excelsior Guano.
- E. Frank Coe's Ground Bone.
- American Farmers' Market-garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Chemicals for Imperial Liquid Plant Food.
- Chemicals for Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Ashes (Star Brand).

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Canada Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.
- Hardy's Complete Manure.

Hargraves Manufacturing Co., Fall River, Mass.: —
- Fine-ground Bone and Tankage.

C. W. Hastings, Jamaica Plain, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

John Joynt, Lucknow, Ontario, Can.: —
- Canada Hard-wood Ashes.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's Potato Manure.
- Lister's High-grade Special for Spring Crops.
- Lister's Animal Bone and Potash.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Potato Manure.
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Animal Brand.
- Swift's Lowell Ground Bone.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market-garden Manure.
- Swift's Lowell Nitrate of Soda.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Potato Manure.
- Tobacco Starter Improved.
- Tobacco Manure Wrapper Brand.
- Economical Potato Manure.
- Average Soils Complete Manure.

Mapes Formula and Peruvian Guano Co., New York, N. Y. — *Con.*
- Vegetable Manure or Complete Manure for Light Soils.
- Corn Manure.
- Complete Manure (A Brand).
- Cereal Brand.
- Complete Manure Ten Per Cent. Potash.
- Top-dresser Improved, Half Strength.
- Tobacco Ash Constituents.
- Grass and Grain Spring Top-dressing.
- Complete Manure for General Use.
- Fruit and Vine Manure.
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.

D. M. Moulton, Monson, Mass.: —
- Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's High-grade Special for Tobacco.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.

New England Fertilizer Co., Boston, Mass.: —
- New England Corn Phosphate.
- New England Potato Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

The Ohio Farmers' Fertilizer Co., Columbus, O.: —
- Corn, Oats and Wheat Fish Guano.
- Tobacco and Potato Special.
- High-grade Truck Guano.

Parmenter & Polsey Fertilizer Co., Boston, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.
- Lawn Dressing.
- Special Fertilizer for Strawberries.
- Grain Grower.
- Acid Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Sulfate of Potash.

R. T. Prentiss, Holyoke, Mass.: —
- Complete Fertilizers.

Benjamin Randall, Boston, Mass.: —
- Randall's Market Garden.
- Randall's Farm and Field.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- High-grade Complete Corn and Grain.
- Fish and Potash Fertilizer.
- High-grade Soluble Tobacco and Potato.
- High-grade Fertilizer for Oats and Top-dressing.
- High-grade Grass and Grain.
- High-grade Soluble Tobacco Fertilizer.
- Pure Fine-ground Bone.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Oats and Top-dressing.
- Hubbard's Grass and Grain.
- Hubbard's Soluble Corn Manure.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Potato Phosphate.
- Hubbard's '02 Top-dressing.
- Hubbard's Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Ross Brothers, Worcester, Mass.: —
- Ross Brothers' Lawn Dressing.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex Corn Fertilizer.
- Essex A. I. Superphosphate.
- Essex X X X Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Tobacco Starter.
- Essex Special Tobacco Manure.
- Essex Rhode Island Special Fertilizer.
- Essex High-grade Sulfate of Potash.
- Essex Nitrate of Soda.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Pure Ground Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sulfate of Potash.
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Corn Superphosphate,
- Sanderson's Special with Ten Per Cent. Potash.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

W. H. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Wilcox Potato, Onion and Tobacco Manure.
- Wilcox Potato Manure.
- Wilcox Complete Bone Superphosphate.
- Wilcox Fish and Potash.
- Wilcox High-grade Tobacco Fertilizer.
- Wilcox Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Pure Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- All Crops.
- Potato Plowman.
- Corn Success.
- Ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

A. H. Wood & Co., South Framingham, Mass.: —
- Special Fertilizer for Corn, Potatoes, etc.
- Special Manure for Market Gardening, Top-dressing, etc.

Part II. — Report on General Work in the Chemical Laboratory.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on soil analyses.
3. Notes on wood ashes and lime ashes.
4. Notes on Peruvian guano.
5. Notes on sugar-beet refuse.
6. Notes on city garbage products.

1. Analyses of Materials forwarded for Examination.

During the season of 1903, 235 samples of fertilizing materials and miscellaneous substances have been received from farmers within our State for analysis. Many of these materials are refuse or by-products from some manufacturing industry. Some of these by-products contain only nitrogen, some contain phosphoric acid or possibly potash compounds, others contain two, and many of them contain all, of the essential elements of plant food. In either case the material possesses a distinct commercial value, which can be ascertained only by a careful chemical analysis.

As in the past, the investigation of materials for general fertilizing purposes has been carried on free of charge to farmers within our State. Our practice has been to analyze this class of materials in the order in which the samples arrive at this office. Beginning about April 1 and continuing through the summer and early fall, work of this nature has to give place to our official inspection work on commercial fertilizers. For this reason we would advise those sending samples for analysis free of charge to send as early in the season as possible. The winter season usually offers more time to attend to this kind of work, and therefore enables us to furnish results of analysis more promptly than at any other period of the year.

During the year we have taken an active part in the work of the Association of Official Agricultural Chemists, which aims to investigate any new modes of analysis in agricultural chemistry. The result of our labors along this line, as well as other investigation work of a technical nature, does not appear in our publications, as its chief value is in the establishment of new methods of analysis.

Following is a list of materials received during the past season: —

Wood ashes,	41	Dry ground fish,	6
Complete fertilizers,	34	Ground bones,	6
Soils,	70	Minerals,	12
Lime ashes,	10	Phosphatic slag,	4
Cotton-seed meal,	8	Nitrate of soda,	4
Dissolved bone-black,	2	Peat,	2
Tankage,	3	Tannery lime waste,	2
Cotton hull ashes,	2	Muriate of potash,	3
Superphosphate,	1	Cotton-seed dust,	1
High-grade sulfate of potash,	2	Cotton-seed droppings,	1
Cocoanut fiber pith,	1	Refuse ashes,	1
New York horse manure,	1	Sulfate of ammonia,	1
Sheep manure and wool waste,	1	Belgian phosphate,	1
Lime refuse,	1	Cassava waste,	1
Garbage tankage,	1	Manure,	1
Waste lime, plastering,	1	Mill refuse,	1
Acid phosphate,	1	Peruvian guano,	1
Coal and wood ashes,	1	Granite,	1
Sugar-beet refuse,	1	Bat guano,	1
Cotton waste,	1	Dried blood,	1
Lime,	1	Wool waste,	2

2. Notes on Soil Analyses.

In the above list of materials which have been forwarded for analysis during the season we would call attention to the increased number of samples of soil which have been received, as compared with previous years. The information desired by parties sending soil samples for analysis is, in most cases, What are the necessary fertilizing ingredients to be applied to this particular soil, and in what proportion in order to produce successfully any given crop? We are trying to aid in answering this inquiry by every means within our power, and shall continue, as in the past, to analyze samples of soil; yet we must insist that the samples of soil forwarded for investigation are taken according to our instructions, which are of late published in every March bulletin of this division (see Bulletin No. 89, March, 1903), otherwise the analysis can be of little practical value. The information furnished by a chemical analysis of soil is still of an arbitrary nature, and furnishes only the amount of the various ingredients of plant food present in the soil, without reference to their availability to any particular plant. Knowing that our present methods for the determination of the availability of plant food in soils is not as satisfactory as could be desired, we are studying the subject continually, believing that more satisfactory ones can be secured only by a constant attention to the questions involved.

3. Notes on Wood Ashes and Lime Ashes.

(*a*) *Wood Ashes.* — During the season of 1903, 17.4 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 24 per cent. for the year previous. The following compilation shows their general chemical character: —

Analysis of Wood Ashes.

	Number of Samples.
Moisture from 1 to 10 per cent.,	11
Moisture from 10 to 20 per cent.,	14
Moisture from 20 to 30 per cent.,	9
Moisture above 30 per cent.,	3
Potassium oxide above 8 per cent.,	2
Potassium oxide from 6 to 7 per cent.,	4
Potassium oxide from 5 to 6 per cent.,	8
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	8
Potassium oxide below 3 per cent.,	3
Phosphoric acid from 1 to 2 per cent.,	34
Phosphoric acid below 1 per cent.,	3
Average per cent. of calcium oxide (lime), 29.39.	
Insoluble matter below 10 per cent.,	7
Insoluble matter from 10 to 15 per cent.,	12
Insoluble matter from 15 to 20 per cent.,	9
Insoluble matter above 20 per cent.,	8

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes for the Season of 1903.

	Maximum.	Minimum.	Average.
Moisture,	37.34	2.27	15.23
Potassium oxide,	8.15	1.68	4.76
Phosphoric acid,	1.80	.46	1.37
Calcium oxide,	35.75	22.33	29.39
Insoluble matter,	28.85	1.40	15.07

We advise farmers, before buying ashes, to ascertain if the party of whom they are to purchase is on record as having complied with our State laws, and holds a license for the sale of his article in Massachusetts. Protection by our State laws is only secured by patronizing dealers and importers who have complied with our laws for the regulation of the trade in commercial fertilizers.

There are indications that more care is taken by some of our importers in the collection and shipment of ashes than has been the case in the past. In some cases as high as 8 and 9 per cent. of potassium oxide has been guaranteed in carloads of ashes imported from Canada; this is 3 or 4 per cent. higher than the usual guarantee of this element. The importance of buying ashes on a specified guaranteed composition of each of the essential elements, — potash, phosphoric acid, and also lime — cannot be too strongly urged upon our farmers.

(*b*) *Lime Ashes.* — Judging from the increased number of samples of lime ashes that have been received during the season for analysis, this material is used more commonly than heretofore to furnish lime to those soils which require an application of this ingredient. Although being a valuable source of lime, it is well to remember that lime ashes are a refuse product in the production of burned lime, and are therefore apt to vary widely in chemical composition (see following table), depending largely upon the mode of handling as well as exposure to the weather. Lime ashes should therefore be bought on a statement of guarantee of the quantity of lime, potash and phosphoric acid which they contain. The small quantity of phosphoric acid in lime ashes is derived from the wood that is used in charging the kiln; the potash is derived partially from this same source and partially from the limestone; both of these elements are therefore apt to vary widely in different samples.

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes for the Season of 1903.

	Maximum.	Minimum.	Average.
Moisture,	23.16	10.47	15.66
Potassium oxide,	3.32	.76	1.86
Phosphoric acid,	1.66	.03	.63
Calcium oxide,	55.44	32.42	41.15
Insoluble matter,	26.50	1.10	6.46

4. Notes on Peruvian Guano.

Analysis of Peruvian Guano reeently introduced into our Markets.

	Per Cent.
Moisture,	17.10
Total phosphoric acid,	21.26
Soluble phosphoric acid,	2.81
Reverted phosphoric acid,	10.47
Insoluble phosphoric acid,	7.98
Potassium oxide,	4.20
Nitrogen,	3.23

The above-stated article has of late been again introduced into our markets; it is evidently a genuine sample of Peruvian guano, and of a valuable composition as a general fertilizer. As Peruvian guanos are known to vary more or less in regard to their chemical composition, they should always be bought and sold on a statement of their guaranteed composition. A detailed discussion of the occurrence of Peruvian guanos, their merits as a fertilizer and their historic importance with reference to the introduction of commercial fertilizers, will be found in the annual report of the inspector of commercial fertilizers to the Massachusetts State Board of Agriculture for the years 1875–76.

5. Notes on Sugar-beet Refuse.

Analysis of Sugar-beet Refuse forwarded for Investigation.

	Per Cent.
Moisture,	7.70
Phosphoric acid,	none
Total potassium oxide,	9.72
Water soluble potassium oxide,	8.36
Total nitrogen,	6.39
Nitrogen as nitrates,	3.86
Nitrogen as ammoniates,	.05
Nitrogen in organic form,	2.48
Calcium oxide,	none
Sodium oxide,	7.00
Sulphuric acid,	2.82
Chlorine,	1.87
Carbonic acid,	none

The above material is a waste product from the sugar-beet industry; it is produced in the process of manufacturing alcohol from the beet-sugar molasses; it is rich in potash and nitrogen, and deserves special attention in the production of tobacco and other industrial crops. The successful introduction of the beet-sugar manufacture as a home industry already benefits our agricultural interests in many ways, as was predicted by the friends of the sugar-beet industry years ago.

6. Notes on City Garbage Products.

Sample No. 1 represents what is known as garbage tankage; sample No. 2 represents the ashes from the cremation of city garbage.

Analysis of Garbage Products.

	Per Cent.	
	Sample No. 1.	Sample No. 2.
Moisture,	7.42	3.01
Potassium oxide,	none.	5.13
Total phosphoric acid,	6.06	8.77
Available phosphoric acid,	4.40	–*
Insoluble phosphoric acid,	1.66	–*
Nitrogen,	5.96	none.

* Not determined.

The above-mentioned materials are products obtained by hygienic treatment of city garbage. Sample No. 1 was obtained by heating the selected garbage in vats under pressure; by this method the fats are recovered; and the organic nitrogenous matter is preserved for use as a nitrogen source in fertilizers. In this process, however, the greater part of the potash and other salines are leached out. Sample No. 2 represents the product obtained by the cremation of city garbage. In this material the nitrogen has been sacrificed, but the potash is retained in the ashes. The products from both of these processes furnish valuable material for fertilizing purposes; they should always be bought and sold on a statement of guaranteed composition.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

The entomological division during 1903 has continued its work along lines similar to those of preceding years. The correspondence has received careful attention, but has been less than usual, probably because fewer insects have made their presence felt, owing to the peculiar weather conditions of the spring and summer.

The experiments to determine a simple and successful treatment for the San José scale have been continued according to a plan which promises well, and which, so far as can be learned, has not been tried elsewhere in this country. Certain difficulties have arisen, however, and whether it will be possible to proceed with these experiments during 1904 cannot now be determined.

Much attention has been given to the collections of insects at the insectary during the year, and, as a result, they are now more nearly expressive of our present knowledge than ever before.

The card catalogue has now entirely outgrown the cases intended to contain it, thus rendering it less useful for reference, but it is hoped that this difficulty may be soon overcome.

It is a generally recognized fact that original investigation and publication are among the most important functions of an experiment station. That the entomological division of the station has not fallen behind in this portion of its duties is seen by the following list of articles on entomology published during the present year by persons working at the insectary, either for the station, or by those fitting themselves for that work: —

C. H. Fernald: "The Brown-tail Moth" (with A. H. Kirkland), under direction of the State Board of Agriculture, Boston, March, 1903; "Colour Blindness in Entomologists," Canadian Entomologist, July, 1903.

H. T. Fernald: "Orchard Treatment for the San José Scale," Bulletin No. 86, Hatch Experiment Station, February, 1903; "How shall we arrange our Collections?" Entomological News, April, 1903; "First Annual Report of the State Nursery Inspector," Agriculture of Massachusetts for 1902, June, 1903; "Plant Lice," Nature Leaflet No. 18, Massachusetts Board of Agriculture, July, 1903; "Some Important Scale Insects," Massachusetts Crop Report for September, October, 1903; "Notes on the Species of Isodontia," Canadian Entomologist, October, 1903; "The Plum Webbing Saw Fly" (with E. A. Back), Entomological News, November, 1903; "Two New Species of Sphex," Psyche, October–December, December, 1903.

Mrs. M. E. Fernald: "Notes on the Coccidæ," Canadian Entomologist, January, 1903; "Lepidosaphes *versus* Mytilaspis," Canadian Entomologist, April, 1903; "Catalogue of the Coccidæ of the World," Bulletin No. 88, Hatch Experiment Station, July, 1903.

H. J. Franklin: "Notes on Acanthothrips," Psyche, October–December, December, 1903.

A. W. Morrill: "Life History and Description of the Strawberry Aleyrodes," Canadian Entomologist, February, 1903; "Notes on some Aleyrodes from Massachusetts, with Description of New Species," Psyche, April, 1903; "Notes on the Early Stages of Corylophodes marginicollis Lec," Entomological News, May, 1903; "New Apoidea from Montana," Canadian Entomologist, August, 1903; "Notes on the Immature Stages of Some Tingitids of the Genus Corythuca," Psyche, August, 1903; "The Greenhouse Aleyrodes and the Strawberry Aleyrodes," Technical Bulletin No. 1, Hatch Experiment Station, August, 1903.

Besides these, several other papers are either in press or well advanced in preparation, and will soon be published.

Insects of the Year.

The present year has seen the great abundance of a few kinds of insects, but taken as a whole the season has been unfavorable for their rapid increase. The early spring was apparently normal in its character, but about the first of May a period of drought began, which continued well into June. During this period the grass dried up and in many places became brown and dead, and large numbers of insects were found clinging to it, having seemingly died of starvation. The result was that the hay crop, though late, was but little affected by insects; and similar results were more or less evident with nearly all crops, as regards their insect foes.

In a few cases, however, these weather conditions were favorable to insect life. The plant lice, which are usually destroyed in large numbers by cold spring rains, were this year almost entirely unchecked, and, increasing rapidly, did much injury to trees and plants already suffering from the lack of rain. The damage caused by plant lice was particularly noticeable on fruit stock, elms and maples, many of which suffered severely; and even when the heavy rains came later, destroying myriads of the lice, so many were present that large numbers survived, thus continuing the injury to more than an ordinary amount till quite late in the fall.

The spring weather also seemed to be unusually favorable for root maggots of various kinds, the onion maggot causing a large amount of loss to the onion growers in the Connecticut valley in particular, while the work of the cabbage maggot was seen everywhere. During the year more inquiries were received by this division about maggots than during the preceding eight years taken together.

The apple-tree tent-caterpillar was more abundant last spring than for a number of years, but whether the peculiar season has had the effect of destroying these insects sufficiently to prevent their appearance in large numbers in 1904 cannot now be determined.

The elm-leaf beetle began the season actively, and by May 21 their egg clusters were very abundant everywhere, but particularly on those trees which were not treated in 1902. Later in the season, however, their work was less noticeable than usual, and, in fact, there were many places where spraying seemed unnecessary. Whether the nature of the season or factors yet undiscovered were the cause of their slight importance is not known.

The San José scale has increased rapidly during the year, wherever it occurs. Crawling young were found last spring on June 9, nearly two weeks earlier than the year before, and during the summer and fall this insect seemed to increase in abundance more rapidly than usual.

During the year 1902 a new plum pest appeared in the Connecticut valley, spinning its webs entirely over the trees in May and early June. On investigation it proved to be a saw fly hitherto known only from South Dakota and Manitoba. Of this insect, which is known as *Neurotoma rufipes* Marl., the life history has been worked out at this station during the present year and published. While this insect has already shown great possibilities as a serious pest on the plum, it is too soon to predict that it will actually become such; but the results of the studies made here show that, if treated when it first appears, it should be easily controlled.

The plum curculio is always in evidence on the plums, and to some degree on the apples; but this year it has paid particular attention to the latter fruit, and by its punctures has reduced many thousands of bushels of apples from first class to a lower grade. Whether the unusually large amount of injury to apples by the curculio this year was due to a greater number of the insects which succeeded in passing through the preceding winter alive, or whether it was due to an insufficient supply of plums for them to attack last spring, is difficult to determine; possibly both factors occurred.

For several years the imported willow-borer (*Cryptorhynchus lapathi*) has been present in great abundance. The injuries which it causes to willows, poplars and similar soft-wooded trees are frequently serious; and it is now almost impossible to raise these trees in some localities, thus greatly reducing their value for planting as holders of the soil in such places as on sandy beaches. No satisfactory method of combating this insect has as yet been discovered.

The brown-tail moth has continued to enlarge its area of occupation, and it is only a question of time how soon it will be a pest all over New England.

The gypsy moth has now to a considerable extent recovered from the attacks made upon it by the State, which ceased in 1899, and in many places is as abundant as it ever was. A careful examination of a large part of the infested territory shows one change from former conditions; then, in towns not generally badly infested, the insect would be found in colonies, while elsewhere the trees and plants were not infested; at the present time the colonies in such towns are not as populous perhaps as formerly, but the insects are generally scattered, a few here and a few there, thus producing what may be termed a general distribution. This probably settles the possibility of extermination in the negative for the future. The State has lost its opportunity, and must abide by the results. No new important parasitic or predaceous foes have appeared thus far, and man must depend almost entirely on his own exertions to control this pest.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, F. R. CHURCH.

The agricultural department during the past season has followed up the main lines of inquiry pertaining to the selection of manures and fertilizers for the various crops of the field and garden previously undertaken. It is recognized that the inevitable variations due to seasonal and other conditions beyond control make necessary numerous repetitions of an experiment before results justify general conclusions. It is comparatively easy, for example, to determine whether a given fertilizer is useful to a given crop upon a given field in any one year. One is not, therefore, justified in concluding that it will prove useful every year; one does not know that it will prove useful in other combinations of fertilizer materials, nor even that its continued use may not ultimately prove harmful in certain directions.

Results must be tested by experiments again and again, and yet again, before the conditions affecting them can be estimated at their true value, safe deductions drawn therefrom that will be generally useful, or advice founded upon them. The past season, so exceptional in character, affords striking illustration of the necessity of such repetition in the nature of the results from the use of a number of materials which it was believed we quite fully understood. As a means of testing the results in plot experiments in the open field, where numerous conditions are beyond control, we have the past season continued the system of closed plot and vegetation experiments.

We have begun a series of experiments with asparagus, for which we have been making preparation for the past two years, having laid out forty-two plots for that purpose, with a view to seeking light as to the manurial needs of the crop, both as regards the selection and amount of materials required and the time of application. One-year-old plants of our own growing were set last spring, and have made a good start.

Forty-eight new varieties of potatoes have been given a preliminary trial, but will not be reported until after another year.

Our grass garden, with forty-eight species and seven varieties, has been thoroughly cared for, and one-half the plot of each species lawn-mowed throughout the season.

Exclusive of these plots of grass, our work has involved the care of two hundred and twenty-three plots in the open field and one hundred and fifty closed plots, while our vegetation experiments have required the care of two hundred and fifty-four plots.

The work with poultry has been of practically the same amount as in recent years, as we some time ago reached the limit with our present equipment. The study of the relations of feeds to egg production has engaged the greater share of the time devoted to this line of work.

In this report will be presented a statement of results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers. Other results are reserved for discussion in bulletins which it is hoped may be published within the near future. A brief statement only will be made in this report of the general results obtained in our experiments with poultry.

The nature of the principal subjects of inquiry and the more important conclusions will be made clear by the following statement: —

I. — The relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. Soy beans, the crop of this year, gave yields on the basis of which the materials rank in the following order: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate of soda ranks relatively lower this year than in most previous years, but the general average to date ranks the materials as follows, on the basis of increases in the crops as compared with the no-nitrogen plots: nitrate of soda, 100; barnyard manure, 77.8; dried blood, 65.1; sulfate of ammonia, 63.6.

II. — The relative value of muriate and high-grade sulfate of potash for field crops. The results of this year indicate the sulfate to be superior to the muriate for potatoes. For the soy beans the two salts gave nearly equal yields, while the crops of cabbages and onions were practical failures on both salts, largely, it is believed, because of the unfavorable season.

III. — *A.* The relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure, as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank for this year in the following order: for the early crops, — including dandelions, strawberries, peas and beets, — dried blood, nitrate of soda, sulfate of ammonia; for the late crops, nitrate of soda ranks first, followed by dried blood and sulfate of ammonia. *B.* Relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for strawberries, tomatoes, cucumbers, celery and turnips; while the muriate has given slightly superior results with dandelions, peas and beets.

IV. — The relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate and silicate. The crop of this year was clover, mixed with timothy. As indicated by the yields of clover, the best results were obtained on the high-grade sulfate; while the silicate, carbonate, low-grade sulfate and nitrate gave results almost as good. The yield of timothy was heaviest on the kainite and muriate. As last year, one of the most striking results of the experiment was the injury to the clover due to potash salts containing chlorine, — especially to the kainite.

V. — The relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was cabbages, and those which gave satisfactory growth and yield in the order of their rank are: dissolved bone meal, South Carolina rock phosphate, raw bone meal, phosphatic slag, steamed bone meal, and dissolved bone-black. Three phosphates gave results much inferior to any of the others, viz., Tennessee phosphate, apatite, and Florida soft phosphate.

VI. — *A.* Soil test with corn. The crop of this year was very small on all plots, owing to the unfavorable season; but the potash increased the crop to a far greater extent than any other plant-food element. *B.* Soil test with mixed grass and clover. The results demonstrate the close dependence of the grass crop upon the supply of nitrate of soda. They indicate also the increased tendency of continued use of nitrate and muriate of potash to bring the soil into an acid condition. Another marked result is the effect of an application of lime in increasing the proportion of timothy in a mowing sown to a mixture of timothy, red-top and clover.

VII. — To determine the economical result of using in rotation on grass lands: the first year, barnyard manure; the second year, wood ashes; and the third year, ground bone and muriate of potash. The average yield of hay, all three systems of manuring being represented, is at the rate of 8,104 pounds per acre in two crops. The average on that portion of the field reseeded last summer is on one plot at the rate of 8,546.5 pounds for the reseeded portion; for the portion not reseeded, 6,243 pounds. On another plot the average yield on the reseeded portion is at the rate of 10,003 pounds, and on the portion not reseeded 5,642 pounds, per acre.

VIII. — Winter compared with spring application of manure. The field where this experiment is tried slopes moderately lengthwise of the plots. The crop this year was soy beans, and the crops under the two systems of application were not far from equal, but with the advantage slightly in favor of the winter over spring application. This result appears to have been due to the fact that the ground beneath its covering of snow remained unfrozen throughout the winter, and that there was practically no wash over the surface.

IX. — To determine the best nutritive ratio or the best mixture of feeds for laying hens. The results of the year appear to indicate that it is not essential to feed a mixture of feeds giving a narrow nutritive ratio for satisfactory egg production. They indicate, further, that the proportion of fat in the ration is a matter of much importance, a large proportion favoring egg production; and that, on the other hand, a large proportion of fiber in the ration, such as would be furnished when grains like oats and barley are largely used, is unfavorable to egg production. A ration in which corn is prominent has given results considerably superior to those obtained with the ration in which wheat is prominent; and the economic results in feeding corn largely in connection with a suitable amount of animal food are much superior to the similar results with wheat.

I. — Manure and Fertilizers furnishing Nitrogen compared. (Field A.)

A full description of the plan of the experiment on Field A was given in the twelfth annual report of the Hatch Experiment Station. There are two objects in view: first, to compare the efficiency (as measured by crop production) of a few of the standard materials that may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a crop belonging to the clover family is capable of rendering the application of nitrogen to a succeeding crop of another family unnecessary. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. There are eleven plots in the field, and with few and practically unimportant exceptions each has been manured in the same way since 1899. All plots are liberally manured each year with materials supplying phosphoric acid and potash, and in quantities to furnish these elements in equal amounts. Manure or fertilizers supplying nitrogen are applied yearly to eight of the eleven plots, and in quantities to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three, and dried blood to two plots. Three plots have had no nitrogen applied to them since 1884. The potash applied to these plots is supplied in the form of muriate to six plots, viz., 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, viz., 2, 4, 5 and 10. The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes. The crop of this year was the medium green soy bean.

It will be generally understood that, if the object in view in an experiment should be simply the determination of the relative value of different materials applied as sources of nitrogen, such a crop as the soy bean (which belongs to the clover family, and which therefore under the right conditions can draw upon the air for a portion or perhaps for all of its nitrogen) would not be selected; but we are testing not simply the relative value of the different nitrogen manures, but also the effect of the legume grown on the no-nitrogen plots upon the succeeding crop. Accordingly, the soy bean, which is one of the most successful of the legumes grown as a hoed crop, was our choice, as it has been several other years, during the progress of this experiment.

The crop was planted on May 20, and was well cared for throughout the season. No accident or inequality in extent of insect or other damage on the several plots interfered with the normal results of the experiment; but the season was highly unfavorable to the growth of the crop, which is one requiring protracted warm weather.

Although the yield on the plots to which the nitrate of soda was applied was fairly satisfactory, attention is here called to the fact that this fertilizer seems to exert an adverse influence upon the early development of the soy bean. It has been repeatedly noticed that where nitrate of soda is the source of nitrogen, the leaves, especially in the early stages of growth, assume a crinkled or wrinkled appearance, and fail to reach full size and normal development. This crinkling appears to be due to the death of the marginal tissues of the leaf, and such death is supposed to be due to an accumulation of nitrates in injurious amounts in these tissues. The margin of the leaf ceasing to grow, while its main body still continues to develop, the inevitable consequence is the crinkling effect which has been alluded to. As the season advances, the soy bean plants as a rule show a more normal leaf development; and, although the crinkling this season was excessive, the yield on the nitrate of soda plots does not appear to have been materially decreased, as a consequence.

Attention is here called, with regret, to the fact that there was undoubtedly an error made in determining the weight of the straw on Plot 10. Close observation throughout the season leads to the conclusion on the part both of my assistant and myself that the relative growth of vines as compared with seed on this plot was quite as large as on any other in the field, and yet the weight as reported shows it to have been in proportion to seed less than on any other plot.

The yields obtained on the several plots and the sources of nitrogen on each are shown in the following table: —

Yield of Soy Beans per Acre.

Plots.	NITROGEN FERTILIZERS USED.	Beans (Bushels).	Straw (Pounds).
0,	Barnyard manure (most of potash used contained in the manure).	23.8	2,010
1,	Nitrate of soda (muriate of potash),	20.5	1,700
2,	Nitrate of soda (sulfate of potash),	24.8	2,080
3,	Dried blood (muriate of potash),	16.7	2,015
4,	No nitrogen (sulfate of potash),	17.1	1,705
5,	Sulfate of ammonia (sulfate of potash),	16.9	1,480
6,	Sulfate of ammonia (muriate of potash),	11.6	1,160
7,	No nitrogen (muriate of potash),	11.1	1,125
8,	Sulfate of ammonia (muriate of potash),	14.8	1,390
9,	No nitrogen (muriate of potash),	8.8	745
10,	Dried blood (sulfate of potash),	21.7	1,225

It will be noticed that the crop, even on the best plot, this year is small. In 1901, when the same crop was grown, the yield on the poorest plot was at a higher rate (25.86 bushels of seed) than that on the best plot this year; while the average yield on all plots, including those to which no nitrogen was applied, was at the rate of 29.9 bushels per acre in 1901. The inferiority of the crop of this year was undoubtedly largely the consequence of the unfavorable season, although there is some evidence that this soil may once more need an application of lime. It has received no lime since 1898, when this material was applied at the rate of one ton to the acre. An abundance of lime in the soil is well known to be highly important to nearly all legumes.

The average yields of this year, as affected by the fertilizers used, are clearly shown in the following table: —

Fertilizers used.	Beans (Bushels).	Straw (Pounds).
Average of the no-nitrogen plots (3),	12.3	1,192
Average of the nitrate of soda plots (2),	22.7	1,890
Average of the dried blood plots (2),	19.2	1,620
Average of the sulfate of ammonia plots (3),	14.4	1,343

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	93.10
Sulfate of ammonia,	92.00
Dried blood,	90.80
No nitrogen,	73.80

Similar averages for this year are shown below: —

Fertilizers used.	Beans (Per Cent.).	Straw (Per Cent.).
Barnyard manure,	100.00	100.00
Nitrate of soda,	95.38	94.03
Dried blood,	80.67	80.60
Sulfate of ammonia,	60.50	66.82
No nitrogen,	51.68	59.30

The nitrate of soda, as last year, stands relatively lower than it usually has done. It is believed that the excessive rains of the past two seasons have caused the loss of some of the nitrate of soda; which may well have washed through the soil and been carried away in the drainage waters.

The average yield of all the nitrogen plots, as compared with the average of those receiving no nitrogen, is shown below: —

	Beans (Bushels).	Straw (Pounds).
Average, 8 nitrogen plots,	18.85	1,633
Average, 3 no-nitrogen plots,	12.33	1,192

It will be noticed that the no-nitrogen plots give only about 65 per cent. as much seed as the plots receiving nitrogen, and about 73 per cent. as much straw. The nodules in which are found the bacteria connected with the assimilation of atmospheric nitrogen were very abundant upon the roots of the plants upon all plots, as was determined by frequent examination. In spite of this fact, the supply of nitrogen at the disposition of the plants on the no-nitrogen plots appears to have been inadequate for even fairly vigorous growth. No reason can be assigned, unless it be that the acid condition of the soil prevented the normal action of the agencies connected with the assimilation of atmospheric nitrogen.

In conclusion, attention is called to the fact that nitrate of soda must be regarded as one of the most desirable of the materials that can be purchased as a source of nitrogen. The cost of nitrogen in this form is lower than in most other materials, and in this as well as in other experiments upon our grounds it usually shows itself to be more effective than any other nitrogen fertilizer. Its superiority to the other materials used in this experiment is made more evident if in place of comparing total yields we compare the increases in yields produced by the several nitrogen fertilizers. On this basis, including all crops raised to date, but taking into account the seed only for this year, the different materials rank as follows: —

Relative Increases in Yields, Average for Fourteen Years.

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	77.80
Dried blood,	65.10
Sulfate of ammonia,	63.60

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The experiments on this field are in continuation of work which has been in progress since 1892, and I cannot do better in introducing what is to be reported for this year than to quote from my last annual report. The object of this experiment "is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Most of these crops have been grown during several years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done much the best on sulfate of potash; the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash."

The crops of the past year have been potatoes, cabbages, onions, and soy beans, while on two plots perennial garden crops and small fruits, viz., rhubarb, asparagus, raspberries and blackberries have been started. The crops both of onions and cabbages were practically failures; in both cases, it is believed, largely on account of the abnormally cold and otherwise very unfavorable season. The onion crop throughout this entire section was in general the poorest known for years. The cabbages made a healthy growth, but, as the season proved, were started much too late. With average summer temperatures the crop would have matured, but under the conditions of the past season few heads reached marketable development. The number of such heads on the muriate of potash was considerably more than on the sulfate, and the total weight of the crop on the muriate was at the rate of about 4,400 pounds per acre greater than on the sulfate. In the case of the onions the total weight of crop produced, including scallions and tops, was at the rate of about 1,000 pounds per acre greater on the muriate than on the sulfate, but there were only 5 bushels more of good onions. In view of the nature of the results with these two crops, further details concerning them will not be given.

1. *Soy Beans (Sulfate v. Muriate of Potash).*

The variety of soy beans grown in this experiment was the medium green. This crop occupied two plots (17 and 18), which last year produced a crop of cabbages. The yield of cabbages last year on the sulfate of potash was at the rate of about 5 tons to the acre more than on the muriate. The crop this year suffered from no accidental conditions affecting results, but owing to the unfavorable season the yields were very small. The results are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Medium Green Soy Beans, Yields per Acre.

Fertilizers used.	Beans (Bushels).	Straw (Pounds).
Muriate of potash, ...	11.20	1,000
Sulfate of potash, ...	10.73	689

It will be noted that the yield of beans is slightly greater on the muriate than on the sulfate; the difference, however, is exceedingly small, and no especial significance can be attached to it. In previous years the sulfate of potash has usually given the better crop of this variety of beans, and I am still inclined to advise its selection. The greater depletion of the soil as a result of the heavy yield of cabbages last year on the plot receiving the sulfate of potash may in part account for the fact that the sulfate of potash this year fails to show its usual superiority.

2. *Potatoes (Sulfate v. Muriate of Potash).*

The potatoes in this experiment were of the Beauty of Hebron variety; the seed was grown in northern Maine. This crop occupied two plots (11 and 12), which last year produced a mixed crop of timothy and clover. The sod was broken this spring, and the seed, which had been previously treated with formalin for destruction of scab spores, and budded, was planted on May 16. An effort was made to protect the crop from insects and blight by the use of prepared insecticides and fungicides offered in our markets. These proved fairly satisfactory in the destruction of the potato beetle, but were not entirely effective in preventing blight. The vines began to show signs of blight on July 18, but its progress was slow; there was but very little rot, and the yield was fairly satisfactory. The potatoes were dug after the vines were entirely dead, and the yields were as shown below.

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

Fertilizers used.	Merchantable.	Small.
Muriate of potash,	171.71	29.94
Sulfate of potash,	194.58	29.09

It will be noticed that the yield of small tubers was practically identical on the two potash salts, but that the sulfate of potash gave a yield of merchantable tubers at the rate of nearly 23 bushels per acre greater than the muriate. This result is in exact agreement with the results of many other experiments which have been tried upon our grounds; and it seems to be impossible to doubt that sulfate of potash should be generally selected for the potato, rather than the muriate, for all soils which have a fair capacity to retain moisture, Farmers raising the crop on such soils should demand potato fertilizers in which this salt has been used as the source of potash. Not only is the crop almost invariably larger on the sulfate, but it is of superior eating quality. Previous experiments here have shown that it almost invariably contains from 2 to 3 per cent. more starch, and that when cooked the potatoes are whiter, of better flavor, and more mealy.

III. — Fertilizers for Garden Crops. (Field C.)

The object in this experiment is to study the influence of a few standard fertilizers used continuously upon the same land upon the yield of garden crops. The experiments were begun in 1891, and from that date to 1897 inclusive fertilizers alone were applied to the land. During the past six years stable manure also has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the fertilizers have been used in the same amounts and applied to the same plots as at first. The original number of plots in the experiment was six, of about one-eighth of an acre each. On all of these fertilizers were used. When we first began to apply manure as well as fertilizers, we introduced into the experiment a seventh plot of the same area as the others, but which had had different previous manurial treatment. To this we have since applied manure only at the above-named rate. This plot was introduced in order that we might have a basis for determining whether the materials used were in any degree beneficial when added to the somewhat liberal quantity of manure employed. It was found that at first the yields of almost all crops on the manure alone were almost as good as those where the fertilizers also were used. In a few cases the manure alone gave the better crops. It is not believed that we are justified in concluding that the fertilizers have been used without beneficial effect, for the no-fertilizer plot introduced in 1898 had, previous to that year, been more heavily manured than the other plots. The superiority of the plot receiving manure alone seems to be gradually decreasing, and this plot will doubtless ultimately serve as a basis for making fair comparisons between the results obtainable with manure alone and results obtained with equal manure and fertilizers. Up to the present time it is not considered to have furnished such a basis, and no reference accordingly will be made in this report to the yields upon this plot.

All the prominent out-door garden crops in this locality have been grown in rotation upon each plot, and each crop during several years. The list of crops so far grown includes spinach, lettuce, onions, garden peas, table beets, early and late cabbages, potatoes, tomatoes, squashes, cucumbers, turnips, sweet corn, celery, and one small fruit, — strawberries. Asparagus and rhubarb were set in 1902, but no cuttings have yet been made, and these will not therefore be referred to in this report.

As stated in my last annual report, these "experiments have been planned with reference to throwing light especially upon two points: *A.* The relative value of nitrate of soda, sulfate of ammonia and dried blood used as sources of nitrogen. *B.* The relative value of sulfate of potash and muriate of potash. These two points will be separately discussed."

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers compared as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot (at the rate of 60 pounds per acre), and each fertilizer is always applied to the same plot. An application supplying per acre the amount of nitrogen above named requires the annual application of materials at about the following rates per acre: —

	Pounds.
Nitrate of soda,	375
Sulfate of ammonia,	300
Dried blood,	850

Each of these nitrogen fertilizers is used on two plots, on one with sulfate of potash, on the other with muriate, — in both cases in such quantities as to furnish equal actual potash.

The results with some of the crops, especially where sulfate of ammonia is the source of nitrogen, have been widely different on these two potash salts, the yields on the sulfate being greatly superior to those on the muriate. The potash salts are applied in such quantities as to furnish potash at the rate of 120 pounds per acre, which requires the use of about 240 pounds of commercial muriate or high-grade sulfate of potash. Dissolved bone-black is used on all plots as the source of phosphoric acid, and in such quantity as to furnish phosphoric acid at the rate of about 50.4 pounds per acre. To furnish this, dissolved bone-black is applied at the rate of about 320 pounds per acre.

The results previous to this year may be summarized as in our last annual report. For the early crops, *i.e.*, the crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, spinach, early cabbages and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers, as measured by the total yields, including leaves, vines and tops as well as the marketable product, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	93.70
Sulfate of ammonia,	57.30

For the late crops, including late cabbages, turnips, celery, tomatoes and squashes: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	99.00
Sulfate of ammonia,	78.40

The crops grown in this experiment this year for which results will be reported include strawberries, followed by celery ; dandelions, followed by cucumbers ; tomatoes ; beets ; and garden peas, followed by turnips. The weather conditions have been highly unfavorable to the normal growth and development of some of these crops, especially tomatoes, but a small proportion of which ripened, and cucumbers. The excessively dry weather of the month of May, followed by the equally excessively wet weather of the month of June, gave us conditions no doubt extremely unfavorable to the action of all the nitrogen fertilizers, but apparently particularly so in the case of the nitrate of soda. Moreover, considerable damage was done both to dandelions and strawberries through the burning of the leaves, caused by the application of the nitrate of soda and the sulfate of ammonia. The application of either of these chemicals as a top-dressing to a growing crop requires the utmost care. It was not the belief of the assistant applying the materials that these chemicals adhered to the leaves when applied in such quantity as to prove injurious; but the result proved that he was mistaken in his judgment, for the injury through burning of the leaves both of the dandelions and the strawberries where nitrate of soda and sulfate of ammonia were applied was very serious. Doubtless as a consequence chiefly of the conditions to which attention has been called, the dried blood, as compared with the other nitrogen fertilizers, ranks this year relatively higher than in any previous year.

The average rate of yield per acre obtained with each of the nitrogen fertilizers, used it will be remembered in addition to the manure, for the present season is shown in the following table: —

Nitrogen Fertilizers for Garden Crops. — Rate of Yield per Acre (Pounds), Average of Two Plots.

Fertilizers used.	Dandelions.	Strawberries.	Peas.		Beets.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Sulfate of ammonia,	37,857	5,010	11,210	9,758	37,866	43,507
Nitrate of soda,	35,098	5,489	9,880	8,710	44,319	49,643
Dried blood,	48,312	10,072	11,694	11,129	46,429	41,689

Nitrogen Fertilizers for Garden Crops, etc. — Concluded.

Fertilizers used.	Tomatoes.			Cucumbers.		Celery.	Turnips.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Sulfate of ammonia.	8,613	26,891	18,293	2,772	5,979	16,870	33,442	12,662	29,221
Nitrate of soda,	8,293	24,726	16,768	4,701	8,016	34,553	44,351	7,598	33,442
Dried blood,	8,171	23,842	12,805	2,718	4,076	24,797	48,701	3,896	27,923

The relative influence of the nitrogen fertilizers has differed widely for the different crops, as is evident on examination of the above tables, and each must therefore be separately discussed.

Dandelions. — This crop was started in the summer of 1902. The fertilizers this year were applied evenly on April 14. The leaves, as above stated, were badly burned whereever nitrate of soda or sulfate of ammonia was used. The crop was cut May 6, at which time it was judged that the leaves had reached their maximum development. The plants were in blossom, and of course somewhat beyond the stage at which the crop is commonly cut for market. On the basis of the yields obtained, the relative standing of the different nitrogen fertilizers was as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	78.36
Nitrate of soda,	72.66

There can be no doubt that, as a result of the burning effect alluded to, both the sulfate of ammonia and nitrate of soda actually decreased the yield.

Strawberries. — The vines from which the fruit harvested this year was picked were set in the spring of 1902. The fertilizers used were evenly spread broadcast on April 14. Within a few days the leaves began to show marked injury on the nitrate of soda and sulfate of ammonia plots. On the basis of total weights of ripe fruit, the nitrogen fertilizers ranked in the following order: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	54.50
Sulfate of ammonia,	49.74

Without doubt both the nitrate of soda and the sulfate of ammonia proved actually injurious.

Garden Peas. — The fertilizers applied to this crop were spread broadcast after plowing on April 30, and harrowed in. On the basis of weights of pods and vines harvested, the nitrogen fertilizers take the following relative rank: —

Fertilizers used.	Pods (Per Cent.).	Vines (Per Cent.).
Dried blood,	100.00	100.00
Sulfate of ammonia,	95.86	87.68
Nitrate of soda,	84.55	78.26

The yields on the sulfate of ammonia were slightly greater than where no fertilizer was added to the manure. On the nitrate of soda they were considerably less, and there is no evidence that the latter benefited the crop.

Table Beets. — The fertilizers for this crop were applied at the same time and in the same manner as for the peas. As indicated by the yields, the relative standing of the different nitrogen fertilizers for this crop is as follows: —

Fertilizers used.	Beets (Per Cent.).	Tops (Per Cent.).
Dried blood,	100.00	83.97
Nitrate of soda,	95.47	100.00
Sulfate of ammonia,	83.50	87.62

The fertilizers were apparently moderately beneficial to this crop, but the nitrate of soda stands relatively much lower than in previous years.

Tomatoes. — Fertilizers were applied as in the case of garden peas. The relative standing of the nitrogen fertilizers, as indicated by the yields (ripe and green fruit and vines), is as follows: —

Fertilizers used.	Ripe Fruit (Per Cent.).	Green Fruit (Per Cent.).	Tops (Per Cent.).
Sulfate of ammonia,	100.00	100.00	100.00
Nitrate of soda,	96.28	91.97	91.67
Dried blood,	94.86	88.66	70.00

Cucumbers. — The cucumbers were planted on June 30, being put in to replace squashes, which had been killed by too heavy an application of kerosene emulsion. The relative standing of the nitrogen fertilizers, as indicated by the weights of the fruit and vines, is as follows: —

Fertilizers used.	Fruit (Per Cent.).	Vines (Per Cent.).
Nitrate of soda,	100.00	100.00
Sulfate of ammonia,	58.96	74.53
Dried blood,	57.80	50.81

The vines in this experiment were somewhat affected by fungi, which doubtless influenced both yield of fruit and growth. The nitrate appears to have exerted a very favorable influence, but the reasons, in view of the character of the season and the lateness of the crop of cucumbers, are not evident. Both the amount of fruit, however, and the weight of the vines produced where the nitrate was used were materially greater than where no fertilizers were employed.

Celery. — This crop followed the fruiting strawberries, and the manure applied this year to these plots was turned in with the strawberry vines. The fertilizers called for on the several plots had been applied in the spring as a top-dressing to the strawberries. The relative standing of the different nitrogen fertilizers, as indicated by the total weight of the crop when dug in the fall and the roots freed from earth, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	71.76
Sulfate of ammonia,	48.94

Turnips. — This crop was sown on July 30, following garden peas. The variety was the White Egg. The relative standing of the nitrogen fertilizers, as indicated by the weights of roots of the different qualities and leaves, is as follows: —

Fertilizers used.	Merchantable (Per Cent.).	Culls (Per Cent.).	Leaves (Per Cent.).
Dried blood,	100.00	30.61	83.33
Nitrate of soda,	91.20	60.20	100.00
Sulfate of ammonia,	68.80	100.00	87.21

The relative standing of the different nitrogen fertilizers for the early crops of this year, including dandelions, strawberries, peas and beets, as indicated by the combined weights of merchantable products, tops and vines, is: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	83.13
Sulfate of ammonia,	82.67

For the late crops, including tomatoes, cucumbers, celery, cabbages and turnips, the relative standing determined in the same manner is: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.20
Sulfate of ammonia,	85.74

Combining the results of 1903 with the twelve previous years, the relative standing of the nitrogen fertilizers is: —

	Per Cent.
For the early crops: —	
Nitrate of soda,	100.00
Dried blood,	95.42
Sulfate of ammonia,	60.03
For the late crops: —	
Nitrate of soda,	100.00
Dried blood,	98.76
Sulfate of ammonia,	78.96

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The general conditions under which these experiments have been tried have been already outlined. It will be remembered that these salts are under trial in connection with the sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen when used in addition to manure for garden crops. The crops grown on these two potash salts, therefore, are the same as those which have been named in discussing the relative value of the different nitrogen fertilizers. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results for the past year are shown by the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Acre (Pounds), Average of Three Plots.

Fertilizers used.	Dandelions.	Strawberries.	Peas.		Beets.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Muriate of potash,	41,385	6,531	11,586	9,570	44,502	45,541
High-grade sulfate of potash,	39,459	7,183	10,269	10,162	41,840	44,351

Sulfate and Muriate of Potash compared, etc. — Concluded.

Fertilizers used.	Tomatoes.			Cucumbers.		Celery.	Turnips.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Muriate of potash.	8,069	24,797	14,431	2,699	4,982	24,119	42,208	7,143	28,918
High-grade sulfate of potash.	8,648	25,508	17,480	4,094	7,065	26,694	42,121	8,961	31,472

Examination of the table reveals the fact that the results for this season are the precise opposite of the results which have been obtained in most of our previous experiments. The muriate of potash gives the greater yield in the case of all the early crops, and the sulfate of potash the larger yield in the case of all the late crops. It is well understood that muriate of potash dissolves and diffuses through the soil somewhat more readily than sulfate, and, further, that it makes soils more retentive of moisture; and it may be that the great deficiency in rainfall which prevailed during the season until early in June left the soil so dry that the sulfate of potash did not become sufficiently dissolved and diffused to become available to the early crops.

The relative average standing of these two salts, as indicated by the total yields of all crops grown previous to this year, is shown in the following table: —

Fertilizers used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.00	100.00
Muriate of potash,	93.20	102.90

The relative average standing for this year, determined upon the same basis, is as follows: —

Fertilizers Used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Muriate of potash, ...	100.00	92.66
Sulfate of potash, ...	98.36	100.00

Combining these results with those of the twelve previous years, the average standing, as indicated by total yields, is as shown in the following table: —

Fertilizers Used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.00	97.97
Muriate of potash, ...	93.84	100.00

The total rainfall during the past season from April 17, the date when the fertilizers were applied to the dandelions and strawberries, to June 7 was .48 inches. Such a rainfall must have been quite insufficient to bring the less soluble fertilizers into circulation, and the failure of the sulfate of potash to produce its usual effect on the early crops is not surprising. It has been repeatedly noticed in experiments here that in excessively dry seasons the muriate of potash usually excels the sulfate for all crops, even those which ordinarily do better on the sulfate. Following this period of excessive drouth came a period extending from the 7th of June to the end of the month with equally excessive rainfall, the total precipitation for that period amounting to 7.79 inches. July was also a comparatively rainy month, and it seems probable that the more soluble muriate of potash may have been largely carried into the subsoil. In this position it would not be equally available to the late crops as the less soluble sulfate.

It is not the belief of the writer that the fact that the relation of the two potash salts for this season to early and late crops respectively is exactly the reverse of what it has been in previous years, should lead to a modification of the advice which has been previously given, viz., that the sulfate should generally be preferred for the early crops and the muriate for the late on all soils with a fair capacity to retain moisture.

IV. — Comparison of Different Potash Salts for Field Crops. (Field G.)

The experiment for comparison of different potash salts was begun in 1898. The field contains forty plots, of about one-fortieth of an acre each. The plots are fertilized in five series of eight plots each, each series including a no-potash plot and one plot for each of the potash salts under comparison. Those salts are kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such amounts as to furnish equal potash to each plot. In the quantities employed the different salts supply annually actual potash at the rate of 165 pounds per acre. All plots are equally manured with materials furnishing fairly liberal amounts of nitrogen and phosphoric acid. The crop of the past season was mixed clover and timothy. This is the second year that this crop has occupied the land. The table which follows, showing yields, does not quite accurately show the effect of the fertilizers. It was out of the question to separate weeds and grasses from the clover in an experiment conducted on the scale of this. Most careful examination often repeated during the season made the following points self-evident: —

1. That on the no-potash plots the clover was very thin, but the weeds of various kinds were relatively abundant.

2. That on the plots to which kainite was applied the clover was weaker than on any of the other plots receiving potash. The timothy, on the other hand, was more abundant and apparently more vigorous on the kainite plots than on the others.

3. On the muriate of potash plots the clover was inferior to all other plots receiving potash except the kainite, and here also timothy was relatively abundant and vigorous.

4. The clover on the low-grade sulfate of potash plots was distinctly inferior to that on the high-grade sulfate.

The fact that the differences above noted were repeated with little variation in each of the series of plots leaves no room to doubt the highly unfavorable influence on the development of the clover of the kainite and the muriate, and the moderately unfavorable effect of the low-grade sulfate.

The field was cut twice, the hay carefully cured, to a considerable extent in cocks, and without much loss of leaf or head. The table shows the rates of yield per acre for both first and second cut, as well as the total for each plot: —

Clover. — Yield per Acre (Pounds).

Plots.	Potash Salt.	Hay.	Rowen.	Total.
1,	No potash,	3,462	1,653	5,115
2,	Kainite,	3,462	3,592	7,054
3,	High-grade sulfate,	3,307	1,586	4,893
4,	Low-grade sulfate,	3,150	2,100	5,250
5,	Muriate,	3,441	2,368	5,809
6,	Nitrate,	2,927	2,234	5,161
7,	Carbonate,	2,882	2,011	4,893
8,	Silicate,	3,128	2,279	5,407
9,	No potash,	3,239	1,698	4,937
10,	Kainite,	4,424	2,435	6,859
11,	High-grade sulfate,	4,021	2,011	6,032
12,	Low-grade sulfate,	3,977	1,921	5,898
13,	Muriate,	3,753	2,055	5,808
14,	Nitrate,	3,977	2,100	6,077
15,	Carbonate,	3,462	2,011	5,473
16,	Silicate,	4,155	1,988	6,143
17,	No potash,	3,753	1,720	5,473
18,	Kainite,	4,357	1,698	6,055
19,	High-grade sulfate,	4,066	1,698	5,764
20,	Low-grade sulfate,	4,200	2,190	6,390
21,	Muriate,	4,379	2,145	6,524
22,	Nitrate,	3,843	1,899	5,742
23,	Carbonate,	4,021	1,609	5,630
24,	Silicate,	3,999	1,966	5,965
25,	No potash,	2,458	1,609	4,067
26,	Kainite,	4,021	2,122	6,143
27,	High-grade sulfate,	3,753	1,519	5,272
28,	Low-grade sulfate,	4,446	1,966	6,412

Clover. — Yield per Acre (Pounds) — Concluded.

Plots.	Potash Salt.	Hay.	Rowen.	Total.
29, . . .	Muriate, ...	3,820	1,765	5,585
30, . . .	Nitrate, ...	3,664	1,430	5,094
31, . . .	Carbonate, ...	3,664	1,452	5,116
32, . . .	Silicate, ...	4,021	1,787	5,808
33, . . .	No potash, ...	3,619	1,519	5,138
34, . . .	Kainite, ...	4,088	1,921	6,009
35, . . .	High-grade sulfate, ...	3,709	1,631	5,340
36, . . .	Low-grade sulfate, ...	4,111	1,564	5,675
37, . . .	Muriate, ...	3,932	1,832	5,764
38, . . .	Nitrate, ...	3,441	1,698	5,139
39, . . .	Carbonate, ...	3,753	1,810	5,563
40, . . .	Silicate, ...	3,887	1,787	5,674

The influence of the different potash salts is somewhat more clearly brought out by the table below, which gives the average results for each of the potash salts employed : —

Clover. — Average Yield per Acre (Pounds).

Potash Salt.	Hay.	Rowen.	Total.
No potash (plots 1, 9, 17, 25, 33), ...	2,066	1,025	3,091
Kainite (plots 2, 10, 18, 26, 34), ...	2,544	1,471	4,015
High-grade sulfate (plots, 3, 11, 19, 27, 35), . .	2,357	1,056	3,413
Low-grade sulfate (plots 4, 12, 20, 28, 36), . .	2,485	1,218	3,703
Muriate (plots 5, 13, 21, 29, 37), ...	2,416	1,271	3,687
Nitrate (plots 6, 14, 22, 30, 38), ...	2,232	1,170	3,402
Carbonate (plots 7, 15, 23, 31, 39), ...	2,223	1,112	3,335
Silicate (plots 8, 16, 24, 32, 40), ...	2,399	1,226	3,625

The average yield on the plot receiving no potash is much lower than on the other plots, in spite of the fact that weeds helped to a considerable extent to make up the deficiency in clover and timothy. The kainite gives the highest total yield of hay. This was doubtless in part due to the fact that the large mixture of timothy enabled the crop to stand up better during the heavy rains of the month of June than on those plots where the clover so largely predominated. The plots receiving high-grade sulfate of potash lodged very badly, — more seriously than any other plots in the field; and, as bad weather necessitated cutting the crop somewhat late, the vigor of the plants was undoubtedly lowered, as shown by the relatively low yield of rowen on these plots. They without doubt exhibited the highest average development of clover during the early part of the season, and with a more normal season should have given the heaviest rowen.

What is true of the high-grade sulfate of potash plots is doubtless also true in somewhat lesser degree of the plots manured with the silicate, carbonate and nitrate.

The experiment of this year lends additional support to the advice which has previously been given, viz., that "on soils with good retentive qualities sulfate of potash should generally be preferred to muriate or kainite for clovers," in spite of the fact that the total yields, including timothy, are heavier on these plots.

V. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

In this experiment, which has now been in progress seven years, we are endeavoring to determine by means of the growing crops the relative availability of a number of different phosphates. Those under comparison are as follows: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved boneblack, raw bone, dissolved bone, steamed bone, and acid phosphate.

All phosphates under comparison are used in amounts sufficient to furnish actual phosphoric acid at the rate of 96 pounds per acre, and each is applied annually in finely ground form to the same plot. The field contains thirteen plots, of about one-eighth of an acre each. Three of these plots have received no application of phosphoric acid since the beginning of the experiment. One of these is at either end, and the other in the middle, of the field. All plots are supplied alike with materials furnishing nitrogen and potash in available forms in liberal amount and in equal quantities to each. The materials used as sources of nitrogen and potash furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some crops a supplementary application of a quick-acting nitrogen fertilizer has been made to all plots alike. The crops which have been grown in this field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, and onions. With the exception of the onions, all the crops previously grown in this field have given good yields, even on the three plots in the field which have received no phosphate.

The soil of the field at the beginning of the experiment was not quite even in quality throughout. Plot 1 surpassed any other in the field in fertility at the start, and on the whole (although the difference is not very marked) there appears to be a gradual natural decline in productiveness from this end of the field toward the other.

The crop of the present season was cabbages. The variety is the Danish Ball-head. The seed was sown at the usual time for the crop in this locality, but so abnormally cold was the season that the crop was far from mature when cold weather set in. Still, the yields (which include weight of stumps, loose leaves and soft heads, as well as the weight of hard heads and totals) make it possible to estimate the relative availability of the different phosphates to the crop grown. The rates of yield per acre are shown in the following table: —

Cabbages on Plots with Equal Amounts of Phosphoric Acid.

Plots.	FERTILIZERS USED.	Number of Hard Heads.	Hard Heads (Pounds).	Soft Heads, Leaves and Stumps (Pounds).	Total Crop (Pounds).
1,	No phosphate,	1,184	4,040	9,360	13,400
2,	Apatite,	776	3,560	17,360	20,920
3,	South Carolina rock phosphate,	2,928	12,040	24,480	36,520
4,	Florida soft phosphate,	816	3,840	21,840	25,680
5,	Phosphatic slag,	2,232	9,920	28,040	37,960
6,	Tennessee phosphate,	440	1,720	29,160	30,880
7,	No phosphate,	104	400	14,120	14,520
8,	Dissolved bone-black,	2,336	8,392	31,520	39,912
9,	Raw bone,	2,304	11,800	32,440	44,240
10,	Dissolved bone meal,	2,384	12,760	29,320	42,080
11,	Steamed bone meal,	1,632	8,720	28,200	36,920
12,	Acid phosphate,	1,296	6,200	24,120	30,320
13,	No phosphate,	120	440	8,080	8,520

The most important points to which it seems desirable to call attention are the following: —

1. The no-phosphate plots give very low yields both of hard heads and total, indicating the marked dependence of the cabbage upon the supply of phosphoric acid.

2. Apatite and soft Florida phosphate are the least effective among the phosphates employed.

3. South Carolina rock gives a surprisingly good return, being exceeded in yield of hard heads by only one plot, — the one receiving dissolved bone, — while in total yield it is materially exceeded by but few.

4. The phosphatic slag ranks among the best of the phosphates used. It is exceeded in yield of hard heads by the dissolved bone-black, the South Carolina rock and the raw bone, in the order named; while in total weight of crop it is exceeded by the dissolved bone, the raw bone and the dissolved bone-black.

5. The most valuable crop in the field is that produced by the dissolved bone, although it is slightly exceeded in total yield by the crop on the raw bone.

6. Particular attention is called to the fact that this year, as in preceding years, the raw bone meal gives a crop much superior to that obtained by the use of steamed bone meal.

The differences in the development of the cabbages on the different plots in the field, as affected by the phosphates applied, became manifest at a very early date. The plants were scarcely a week old before marked differences could be seen; and the relative development throughout the season, as recorded after several examinations, was in about the order indicated by the final yields, although most observers ranked the crop on the phosphatic slag while growing relatively higher than indicated by the final result.

In estimating the significance of the results upon this field, it is important to keep in mind the facts as regards the character of the soil. It is what would be called a strong and moderately heavy loam, and has great capacity to retain moisture. The relatively insoluble phosphates are known to give better results on soils of this character than on those which are lighter and drier.

Our experiments indicate that the cabbage is one of those crops most closely dependent upon the supply of available phosphoric acid, and yet this crop gives us a good return upon phosphates ordinarily regarded as very slowly available. The opinion in general held concerning the necessity for acidulated phosphates may need modification. We have not, it is true, raised on the South Carolina rock or the raw bone crops of the highest rank, as measured by the number and weight of hard heads. The total yields are excellent, and the weights of hard heads in a more normal season would without doubt have been much higher. It appears reasonable to believe that on soils of the character of this field the farmer may safely depend for a considerable portion at least of the phosphoric acid needed by his crops upon the cheaper natural phosphates, such as finely ground South Carolina rock and finely ground bone, while phosphatic slag also promises to prove a most useful fertilizer upon soil of this character.

VI. — Soil Tests.

Two soil tests, both upon our own grounds and both in continuation of previous work upon the same fields, have been carried out during the past season. Fertilizers have been applied in accordance with the co-operative plan for soil tests, with one or two small exceptions. Lime and plaster have been applied to the plots calling for these fertilizers in double the usual soil test amounts. Each plot annually receives an application of the same kind or kinds of fertilizers. Such experiments are not adapted to securing the production of heavy crops, but rather to throwing light upon the general question as to the particular plant food requirements of different crops. By study of the results, the effects of the different leading elements of plant food on the several crops can be determined with much accuracy.

Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Both fertilizers and manure (where the latter is introduced for purposes of comparison) are always applied broadcast after plowing, and harrowed in. The kinds and the amounts per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre).

This acre has been used in soil tests for fifteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, and corn. Since 1889 this field has therefore borne seven corn crops, and during this time it has been four years in grass. The crop last year was corn, following grass; this year, corn follows corn. The season was the most unfavorable for this crop which has been known within the lifetime of most men now living, and the crop of this year was exceedingly poor, even on the land which has for fifteen years received an annual application of manure at the rate of 5 cords per acre. Last year, although the season then also was somewhat unfavorable, this plot gave a yield almost double that of this year. It is not surprising, therefore, that the yield on most of the plots receiving fertilizers was very low. Four of the plots have received neither manure nor fertilizer throughout the entire fifteen years, and these now show a degree of exhaustion amounting to almost absolute sterility. Allowing 90 pounds of ears as husked to the bushel of shelled grain, the average product of these plots was at the rate of about $1\frac{1}{2}$ bushels to the acre. The average yield of stover on these plots is at the rate of 560 pounds per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1903.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels 90 Pounds).	Stover (Pounds).
1, .	Nitrate of soda, ...	.56	360	—.44	—390
2, .	Dissolved bone-black, . .	.94	360	—.06	—390
3, .	Nothing, ...	.94	300	-	-
4, .	Muriate of potash, . . .	16.61	1,880	15.61	1,130
5, .	Lime, ...	.15	160	—.85	—590
6, .	Nothing, ...	1.06	1,200	-	-
7, .	Manure, ...	37.39	3,600	36.39	2,850
8, .	Nitrate of soda and dissolved bone-black.	3.89	800	2.36	430
9, .	Nothing, ...	1.28	340	-	-
10, .	Nitrate of soda and muriate of potash.	18.00	2,200	16.47	1,830
11, .	Dissolved bone-black and muriate of potash.	20.39	2,320	18.86	1,950
12, .	Nothing, ...	1.78	400	-	-
13, .	Plaster, ...	2.06	400	.53	30
14, .	Nitrate of soda, dissolved bone-black and muriate of potash.	25.56	3,040	24.03	2,670

In view of the highly unfavorable season, the development of the corn was far from normal, and extended discussion of the results does not seem called for. It will be noticed that, as in previous years, the potash among the fertilizer elements used is the one exercising by far the greatest effect in increasing the crop. The addition of either nitrate of soda or phosphoric acid, as shown by the results on plots 10 and 11, does not very materially increase the yield produced on potash alone (Plot 4). The addition of nitrate of soda to the mixture of potash and dissolved bone-black used on Plot 11 caused a considerable increase, — greater this year than in previous years, as shown by the yield on Plot 14. This difference in effect may very well be due to the gradual exhaustion of the supply of humus in the soil on these plots, which for so many years have been manured with fertilizers alone, and subjected to tillage throughout most of the time.

Though no combination of fertilizers gives what can be considered a good crop, the lesson is just as clear this year as in previous years, viz., that fertilizers for corn should be rich in potash.

B. — Soil Test with Mixed Grass and Clover (North Acre).

The field on which this test was carried out has been used in similar tests with various crops for fourteen years, beginning in 1890. The fertilizers have been applied in accordance with the system regularly used in soil tests, save as regards amounts. During the years when potatoes or onions have been grown, double the usual quantities have been employed. One other peculiarity in treatment must be reported. In the spring of 1899 one-half of each plot received an application of freshly slaked lime, at the rate of 1 ton per acre. This lime was spread after plowing, and worked in with a harrow. The crops in order of succession have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions for four years (1898 to 1901 inclusive), potatoes, and grass and clover. The crop upon which we are reporting followed potatoes. The seeds sown included the following varieties: timothy, red-top, and mammoth red and alsike clover. The seeds of the timothy (18 pounds), red-top (8 pounds), red clover (5 pounds) and alsike clover (4 pounds) were mixed and sown broadcast Sept. 15, 1902. The date of sowing was so late that the grass made relatively little growth during the autumn months and the clover winter-killed. The winter was, however, favorable for the grasses, and they came through without injury, and 15 pounds of red clover seeds were sown on April 4.

As has been pointed out in another connection, there was less than one-half inch of rain from the middle of April to the 7th of June. The conditions, therefore, were most unfavorable for the germination of the clover and for the growth of the young and therefore very shallow-rooted grass plants. The yields, therefore, were small, but the results are nevertheless of considerable interest. The fertilizers applied to the several plots and the rate of yield per acre with the gain or loss where the different fertilizers were employed are shown in the following table: —

Grass and Clover. — North Acre Soil Test, 1903.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing, ...	360	1,150	-	-
2, .	Nitrate of soda, ...	1,520	3,140	1,096.7	2,036.7
3, .	Dissolved bone-black, . .	950	1,560	463.3	503.3
4, .	Nothing, ...	550	1,010	-	-
5, .	Muriate of potash, . . .	660	950	135.0	50.0
6, .	Nitrate of soda and dissolved bone-black.	1,830	3,180	1,330.0	2,390.0
7, .	Nitrate of soda and muriate of potash.	1,820	2,190	1,345.0	1,510.0
8, .	Nothing, ...	450	570	-	-
9, .	Dissolved bone-black and muriate of potash.	620	920	177.5	207.5
10, .	Nitrate of soda, dissolved bone-black and muriate of potash.	2,330	2,830	1,895.0	1,975.0
11, .	Plaster, ...	430	480	2.5	—517.5
12, .	Nothing, ...	420	1,140	-	-

Examination of the table makes the fact evident that it is the nitrate of soda chiefly which determined the rate of yield. It is further evident that this is able to exert its full influence only on the half of the plot which received the application of lime that has been referred to. Nitrate of soda alone on the limed half of the plot after fourteen years continuous use still gives a crop of hay at the rate of rather over $1\frac{1}{2}$ tons per acre; used with dissolved bone-black, it gives almost exactly the same yield; used with muriate of potash, it gives a smaller yield, — only a little over 1 ton to the acre.

Much evidence is afforded, by a study of the relative proportions of the different species on the different plots and on the limed and unlimed portions of the several plots, that the soil in some parts of this field is once more becoming acid. It is likely that this is the case on Plot 7, for to that plot have been applied large quantities both of muriate of potash and nitrate of soda, both of which tend to aggravate the conditions leading to development of a sour condition of the soil. To Plot 10 dissolved bone-black has been added, as well as the nitrate of soda and muriate of potash, and this, because of the lime it contains, has helped to lessen the tendency to the development of acidity; but even on this plot the yield is less than on the nitrate of soda alone, and probably because of the acid condition induced by the continued use of the fertilizers the plot has received.

A careful determination of the relative proportions of the timothy, red-top and clover in the product of a square yard on both the unlimed and limed portions was made. On the unlimed portion of every plot the red-top was more abundant than the timothy. There was practically no clover on the unlimed portion of any plot. Timothy exceeded red-top on the limed portion of all plots except Plot 7. This is the plot to which both the nitrate of soda and muriate of potash have been applied; and here, in spite of the lime which was put on in 1899, the soil is undoubtedly again acid, as shown by the fact that the red-top exceeds the timothy. Clover was found in appreciable quantities only on the limed portion of plots 9 and 10. The lessons of the experiment, it seems to me, are clear, the following being the most important points: —

1. Nitrate of soda, as in many previous experiments, proves the controlling element in the production of grass; but this exerts the full effect of which it is capable only on soils which are not excessively acid.

2. Whenever, in a mowing seeded with a mixture of timothy and red-top, the latter largely predominates, it is an evidence that the productivity of the field would be increased by an application of lime.

3. Clover cannot be made to thrive in a soil unless it is free from acidity; and in those cases where on seeding clover fails, acidity may reasonably be looked for.

VII. — Experiment in Manuring Grass Lands.

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about nine acres. It is divided into three approximately even plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall, ashes and the bone and potash in early spring. A portion of the land was broken up as described in the annual report for last year, on account of having become somewhat infested with weeds, and reseeded. That portion which was plowed after the removal of the first crop in the summer of 1902, repeatedly harrowed, and then seeded on August 15, has this year produced a very heavy crop. This, no doubt, may be in part attributed to the very thorough preparation which the land received before seeding, although the liberal manuring which it has received for so many years was no doubt also a most important factor. The past season, although it promised at the start, on account of the excessively dry weather from the middle of April to about the 10th of June, to be a very poor one for the hay crop, eventually proved decidedly favorable, as the frequent rains during the last three weeks in June produced a heavy growth. Conditions for the rowen crop were also exceptionally favorable. The yields of hay and of rowen and the totals for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	5,886	2,664	8,550
Bone and potash,	4,648	3,333	7,981
Wood ashes,	5,188	2,591	7 779

The average total yield of the entire area for this year is 8,104 pounds. The average for the entire period (1893 to the beginning of the present year) was 6,413 pounds. The average to date is 6,597 pounds. The average yield when top-dressed with manure has been 6,827 pounds; when top-dressed with wood ashes, 6,427 pounds; when top-dressed with bone and potash, 6,562 pounds. The average yields for this year, as will be seen, are much above the general average to date.

Old and New Seeding compared.

As has been stated, the yield on the part of the land reseeded last summer was very exceptionally heavy. The advantage of reseeding is made evident by comparison of the yields on that portion of plots 1 and 2 not reseeded with the yield on the portion which was reseeded. These comparisons are shown by the following table: —

	Yield per Acre (Pounds).		
	Hay.	Rowen.	Totals.
Plot 1, wood ashes: —			
Not reseeded,	4,305.0	1,938.0	6,243.0
Reseeded portion,	5,629.5	2,917.0	8,546.5
Plot 2, barnyard manure: —			
Not reseeded,	3,966.0	1,676.0	5,642.0
Reseeded portion,	6,845.5	3,157.5	10,003.0

The yields obtained on the reseeded portion, amounting to rather over 4¼ tons on one plot and to almost exactly 5 tons on the other, are certainly exceedingly satisfactory.

The Seed sown.

An effort is being made to render the results of the experiments on this land more valuable by comparing two different mixtures of grass seeds. As the result of experience, it has been found that on this land, under the system of manuring followed, timothy, and to a lesser degree red-top, tend to die out, and are replaced to a considerable extent by Kentucky blue-grass, — a species far less valuable for mowings. Tall and meadow fescue will, it is believed, prove more persistent, and it is hoped they may be able to hold the ground against the Kentucky blue-grass. With a view to testing these species as regards this point, equal areas of the reseeded portions of plots 1 and 2 have been sown with each of the two mixtures shown below: —

Fescue Mixture (Pounds per Acre).

Timothy,	6
Red-top,	8
Red clover,	5
Alsike clover,	4
Kentucky blue-grass,	4
Meadow fescue,	6
Tall fescue,	4

Timothy Mixture (Pounds per Acre).

Timothy,	18
Red-top,	8
Red clover,	5
Alsike clover,	4

These mixtures may be for convenience called respectively fescue mixture and timothy mixture. The relative yields in the first year on the two different seed mixtures is shown below: —

	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Plot 1: —			
Fescue mixture,	5,042	2,648	7,690
Timothy mixture,	6,217	3,186	9,403
Plot 2: —			
Fescue mixture,	6,521	2,921	9,483
Timothy mixture,	7,129	3,394	10,523

It will be seen that the timothy mixture has given the larger crops this year on both plots, both at the first and second cuttings. During the past dozen years many mixtures of grass seeds have been tried on different parts of the college estate, but none has been found which, everything considered, exceeds in value a mixture substantially that which is so generally used of timothy, red-top and clover. This mixture in the first year is clearly superior to the other, but whether it will maintain its superiority cannot of course be determined at present.

VIII. — Experiment in the Application of Manure.

The experiment upon which the results for the past year are to be reported was begun in 1899. The object in view is to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large heaps, to be spread just before plowing the land in the spring. A full account of the plan of this experiment will be found in the thirteenth annual report of this experiment station. The field contains five plots, each subdivided into two sub-plots, on one of which the manure is spread when hauled out during the winter and on the other put into a large heap from which it is hauled out and spread in the spring. We have in reality five parallel experiments yearly, the area of each sub-plot being about one-quarter of an acre. The crop last year was ensilage corn. On three plots the yield where the manure was spread in the spring was considerably greater than where it was spread in the winter; on the other two plots the yields under the two systems of application were practically equal. Rye was sown in the standing corn on August 20, to furnish winter cover. This rye had made considerable growth, which was fairly even on all the plots when it was plowed under, the middle of May. The crop of this year was soy beans, five different varieties being planted, each kind in equal area on all the plots. Owing to the cold weather, the growth was not altogether satisfactory, and the yield even of the earliest varieties was small. It was seen that one variety would not ripen, and accordingly it was cut when in ensilage condition and put into the silo. We have, therefore, to report for each plot the rate of yield per acre of dry beans and straw, and of green forage for the silo. The rates of yield per acre and the relative standing of the several plots are shown in the tables: —

Actual and Relative Yields of Green Forage.

Plots.	Manuring previous to 1889.	Actual Yields (Rates per Acre, Pounds).		Relative Yields (Per Cent.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	10,785	9,729	100	90.21
2, .	Wood ashes, . . .	9,821	8,811	100	89.72
3, .	No manure, ...	9,041	9,408	100	104.06
4, .	Fine-ground bone and muriate of potash.	9,546	11,519	100	120.67
5, .	Fine-ground bone and sulfate of potash.	10,509	11,840	100	112.66

Actual and Relative Yields of Soy Beans and Straw.

Plots.	Manuring previous to 1889.	Actual Yields (Rates per Acre).			
		Beans (bushels).		Straw (pounds).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	14.56	15.56	1,021	1,212
2, .	Wood ashes, . . .	16.27	15.50	1,272	1,319
3, .	No manure, ...	15.04	14.42	1,232	1,119
4, .	Fine-ground bone and muriate of potash.	15.22	12.55	1,284	1,045
5, .	Fine-ground bone and sulfate of potash.	14.26	15.21	1,252	1,269

Actual and Relative Yields of Soy Beans and Straw — Concluded.

Plots.	Manuring previous to 1889.	Relative Yields (Per Cent.).			
		Beans.		Straw.	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	100	106.87	100	118.71
2, .	Wood ashes, . . .	100	95.27	100	103.69
3, .	No manure, ...	100	95.88	100	90.83
4, .	Fine-ground bone and muriate of potash.	100	82.46	100	81.39
5, .	Fine-ground bone and sulfate of potash.	100	106.66	100	101.36

In previous years the south half (spring manured) of each plot has, with two insignificant exceptions, above noted in the case of the ensilage corn of last year, given a greater yield than the north half. The yield of the winter-manured portion for each year being considered 100 for the several plots, the yields of the spring-manured portion of the same plots has varied in the different years as follows: in 1900, from 103 to 125; in 1901, from 118 to 177; in 1902, from practical equality in two cases to 150. This year, it will be noted, there is but little difference in the yields under the two systems of manuring, and the advantage is on the side of the winter application. The winter application considered as 100 as in previous years, the yields for the spring application of manures has varied as follows: for the beans, 82.46 to 106.87; for the straw, 81.39 to 118.71; and for the green forage, 89.72 to 120.67.

In attempting to understand the reasons for such differences as have been noted in the different years, we find, on a study of the weather conditions, that those of the winter of 1902 and 1903 were for this locality quite exceptional. A heavy snowfall came during the first week in December, at which time the ground was not frozen. This snow, with occasional additions from time to time, though sometimes wasting to some extent, lay upon the ground throughout the winter in sufficient amount to prevent the ground from freezing. The winter was without those frequent sudden thaws, accompanied by heavy rains, which with frozen ground lead to excessive washing. So remarkable was the winter that the roots of one of our exceptionally hardy summer crops, dwarf Essex rape, came out in the spring uninjured, and with the approach of warm weather sprouted and made vigorous growth. Under such conditions it is not strange that loss of the soluble plant food constituents of the manure spread upon the surface took place to a very slight extent, if at all. Could we depend upon such winters as the last, the practice of spreading manure and leaving it upon the surface during the winter would undoubtedly be wise, as it saves on the cost of handling; but, as every one familiar with our climate understands, such winters cannot be depended upon, and accordingly the weight of evidence in our experiments is still in favor of hauling the manure into heaps, to remain over winter and to be spread in the spring.

IX. — Poultry Experiments.

In our experiments with poultry during the past year our attention has been confined almost exclusively to questions connected with the feeding of fowls for eggs. We are endeavoring to obtain light on the question as to the proper relation between the different nutrients in the ration fed. Our work during the year may be summarized as follows: —

1. We have compared two rations, in one of which corn is prominent, in the other wheat, using animal meal as a source of animal food. The nutritive ratio of the ration including wheat has been 1 : 4.34; for the one including corn, the ratio has been 1 : 6.24.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food in each, and with an addition of corn oil as a source of fat, in which the milk albumin is very poor. The nutritive ratio of the ration including wheat is 1 : 4.44; for the ration including corn, 1 : 6.48.

3. We have compared two rations in one of which wheat is prominent, in the other rice, with milk albumin as the source of animal food in each. Both of these rations were very low in fat. The nutritive ratio of the first (in which wheat is prominent) is 1 : 4.3; of the second (in which rice is prominent), 1 : 6.4.

The most important points in connection with the results appear to be as follows: —

1. In the comparison of wheat with corn, where animal meal was the source of animal food, the egg production for the entire period from December 14 to September 4 was practically equal. For the winter period, December 14 to April 1, the corn ration produced eggs at an average rate of .3005 per hen day; the wheat ration, at the rate of .2792 per hen day. In other words, 100 hens on the corn ration would have given an average daily yield of a slight fraction over 30 eggs, while the wheat ration would have given from the same number of hens almost 28 eggs per day. For the summer period, April 1 to September 4, the corn ration gave an average of .4365 eggs per hen day; the wheat ration,

.4541; or, in other words, the average daily product from 100 hens would have been for the wheat ration 44.4 eggs; for the corn ration, about 43.7. The average food cost per egg produced was on the wheat ration, a very slight fraction over 1 cent; on the corn ration it was .85 of a cent.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food in each, and with corn oil added as a source of fat, the egg product was considerably better than in the first experiment. For the entire period the hens receiving corn produced more eggs, — an average at the rate of .4166 eggs per hen day. For the wheat the similar average was .3570. For the winter period, December 14 to April 1, similar averages were: for the wheat ration, .2606; for the corn ration, .2862. For the summer period, April 1 to September 4, the averages were: for the wheat, .4251; for the corn, .5107. For the entire period the average food cost per egg laid was for the wheat ration 1 cent, for the corn ration .8 cent. The product obtained in this experiment, at the rate respectively for the wheat of 35.7 eggs per day and for the corn at the rate of 41.66 eggs per day, for 100 hens is considered good, for fowls kept in close confinement, especially in view of the fact that the pullets used in the experiment were rather late hatched, and laid but few eggs until the first of February, viz., 125 for the fowls receiving wheat and 48 for the fowls receiving the corn ration.

3. In the comparison of wheat with rice, with milk albumin as the source of animal food in each, the results were decidedly in favor of the ration including the rice. For the entire period the product of these fowls was at the rate of .3732 eggs per hen day; for the fowls receiving the wheat, at the rate of .3328 eggs per hen day. For the winter period, December 14 to April 1, the averages were: for the rice ration, .3097; for the wheat ration, .2241 eggs per hen day. For the summer period, April 1 to September 4, similar averages were: for the rice, .4188; for the wheat, .4080. The production in this experiment is inferior on both rations to that obtained in either of the other experiments; and, although the yield on the rice is fairly good, this cannot be

regarded as a practical food for ordinary use, on account of its high cost. The food cost for the eggs produced in this experiment was at the rate of about $1\frac{1}{5}$ cents for the wheat ration, and nearly 2.1 cents per egg for the rice ration.

As the result of experiments in previous years, corn had been found superior to wheat rations when animal meal was used as the source of animal food, while with scraps the two rations gave nearly equal numbers of eggs. In previous experiments, with milk albumin as the source of animal food, the egg production has usually been unsatisfactory when wheat has been the principal grain. These facts had led to the belief that possibly the amount of fat in the ration played an important part in determining the egg yield; and the experiments of this year were planned with a view to throwing light upon this point. In some particulars they seem to confirm this theory. The production of eggs on milk albumin, which is very low in fat, has in previous years been quite unsatisfactory. This year, with the addition of fat, more eggs have been produced. Further, in other experiments the egg production where corn is the principal grain has much exceeded that where wheat is the principal grain, when animal meal is used as the source of animal food. The results this year were very similar. On the other hand, the ration lowest in fat of all, viz., that including rice, has given many more eggs than the ration including wheat, which furnishes a far greater quantity of fat.

A study of the rations of this year shows an apparent relation between the quantity of fiber in the food and the egg production. The rations furnishing exceptionally large amounts of fiber, derived principally from such grains as oats and barley, have given very inferior yields of eggs.

In conclusion, we are justified in saying that our experiments do not lend support to the belief that the nutritive ratios of rations fed to hens must necessarily be narrow to produce a satisfactory product. We have obtained more eggs in winter in all experiments this year on the combinations of foods with the wider nutritive ratios, and in two out of three experiments the result was the same for the summer period. I am still inclined to the belief that the amount of fat in the ration is a matter of much importance. I believe, further, that care should be taken that the ration does not include too large a proportion of fiber, as this without doubt increases the labor of digestion, and probably decreases the proportion of the various nutrients digested and assimilated. It is well understood that animal matter of some kind is essential to good egg production. Our earlier experiments have shown the great superiority of animal to vegetable protein in rations for laying hens. It is believed, however, that suitable animal feeds, under which class may be included all such as are well preserved and sweet and palatable, may be wisely used in connection with a large proportion of our cheapest grain, — corn.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

F. A. WAUGH, HORTICULTURIST; GEO. O. GREENE, ASSISTANT.

The work of the department of horticulture during the year just closing has been devoted largely to reorganization, and to the beginning of new lines of experiment and new systems of record. The various experiments undertaken will be reported upon as fast as valuable results develop. Meanwhile, the department continues to find a large part of its public service in answering various inquiries from all over Massachusetts and neighboring States. Such inquiries, touching all the subjects connected with fruit and vegetable growing, arboriculture and landscape gardening, are answered promptly, and as fully as circumstances permit.

The work of testing new and old varieties of fruits and vegetables has been considerably abated, but has not been suddenly nor inconsiderately abandoned. The comparison of varieties of strawberries, for example, which has long been a feature of the department work, has been continued for the present on a somewhat different plan, and some report of results is a part of the present publication.

Mr. George A. Drew, who has been assistant horticulturist and in charge of various lines of experimental work for several years, resigned that position in September, to take up more remunerative work elsewhere. The vacancy was filled October 1 by the appointment of Mr. George O. Greene, assistant horticulturist of the Kansas Experiment Station. The high character of the service performed by Mr. Drew during his term as assistant should be a matter of special recognition and record here.

Strawberry Experiments.

Experiments with strawberries, which have been carried on for many years in the department of horticulture, have been continued for the present. This work has been under the direct charge of Mr. George A. Drew, and the following notes have largely been made up by him.

Season and Soils.

The season of 1903 was a disappointment in many respects to strawberry growers. To start with, a number of the early varieties were damaged by spring frosts; then, when the later fruit was about ready to mature, a severe drought set in, lasting practically throughout the fruiting season, and very naturally reducing the yield.

While disappointing from the commercial grower's standpoint, the season was not without some instructive features as regards behavior of varieties and the ability of certain soils to retain moisture. Where the soil had been very thoroughly prepared, and there was an abundance of vegetable matter present, the strawberry plant withstood the dry weather without very serious damage; on the other hand, where the soil was of a gravelly nature, and the amount of vegetable matter limited, the plant easily succumbed to the effects of the drought.

It cannot be emphasized too much or repeated too often how great a part thorough preparation of the soil takes in the yields obtained. The strawberry naturally has a very limited root system, and any means that will induce the fibers to penetrate deeper is labor well spent.

A medium deep loam is, all things considered, about the ideal soil. If one depends on a sandy or gravelly soil, irrigation facilities must be provided, and, taken one year with another, some system of irrigation will undoubtedly pay. If one does not feel justified in the outlay this would necessitate, and one has several kinds of soil to choose from, it is well to select two different types: one gravelly, light and early; the other more loamy, heavier and later. Then, after a series of years, one could balance up accounts, so to speak, and find which was the most profitable in the long run.

Notes on Varieties.

Many new and old varieties have been compared on different soils, ranging from rather dry gravel to fine rich loam. Those varieties which, on account of their novelty, their special value or other interest, seem worthy of report, are described and commented on below.

August Luther. — Fruit: oblong; size, small; core, melting; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early; calyx, small, loose; texture, medium; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, many; rust, none.

Sets a large amount of fruit, but has no special points of merit.

Belmont. — Fruit: oblong, flattish, irregular; size, very large; core, slightly hollow; external color, crimson; color of flesh, red to core; flavor, slightly acid; season, medium to late; calyx, large, loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; runners, numerous; rust, very slight.

Not very productive, but attractive in appearance, and one of the good old kinds.

Bismarck. — Fruit: roundish; size, medium large; core, small, hard and closed; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, prominent; quality, very good; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A good home berry, and fairly productive.

Blonde. — Fruit: conic, regular; size, medium large; core, slightly open; external color, light crimson; color of flesh, reddish; flavor, acid; season, late; calyx, large, loose; texture, firm; seeds, brownish, prominent; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, good; runners, numerous; rust, slight.

Brandywine. — Fruit: round, conic, tapers to sharp point; size, large; core, slightly open; external color, dark crimson; color of flesh, red throughout; flavor, acid; season, medium to late; calyx, green, loose and prominent; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, fair. Blossom, a good pollenizer, perfect; plant, vigorous; foliage, dark, large and regular; runners, numerous; rust, slight.

Productive generally, but the fact of berry turning black where exposed to the air proves a great drawback; erratic in different localities.

Brunette. — Fruit: round, conic; size, large; core, slightly hollow; external color, crimson; color of flesh, crimson; flavor, insipid; season, medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A valuable home variety.

Bubach. — Fruit: flat, conical; size, large; core, hollow; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, early to medium; calyx, medium; texture, medium; seeds, greenish, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium dark, medium large; runners, medium; rust, slight.

Deficient in vigor, and, like the Marshall, succeeds only in favored localities, where one can get a fine healthy stock of plants.

Bush Cluster. — Fruit: usually conical; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, acid; season, medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, poor; shipping quality, fair. Blossom, imperfect; plant, fairly vigorous; foliage, large, medium dark; runners, numerous; rust, slight.

A disappointment in all respects.

Clyde. — Fruit: irregular, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, early; calyx, loose, large; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium, large, light; runners, very numerous; rust, slight.

Extremely productive, and tends to set more fruit than it is capable of maturing; somewhat subject to disease.

Cobden Queen. — Fruit: round, irregular, conic; size, medium large; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, prominent outside; quality, good; shipping quality, good. Blossoms, rather few, imperfect; runners, numerous; rust, slight.

Foliage unhealthy; fruit seedy.

Corsican. — Fruit: round to roundish, conic; size, medium; core, slightly hollow; external color, scarlet; color of flesh, pinkish; flavor, insipid; season, early to medium early; calyx, medium; texture, soft; seeds, yellow, outside; quality, fair; shipping quality, poor. Blossom, perfect; plant, vigorous; foliage, inclined to discolor; runners, fair; rust, slight.

Too soft for commercial use; always a disappointment here.

Darling. — Fruit: round, conic; size, medium; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, medium; texture, medium; seeds, yellow, prominent; quality, fair. Blossom, perfect; plant, deficient in vigor; rust, slight.

Too poor for commercial use.

Delaware. — Fruit: flat, conical, irregular; size, medium; core, medium to large; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather prominent; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, very good. Blossom, perfect; plant, medium in vigor; foliage, medium; runners, medium; rust, little.

Rather unproductive, but set some fine fruit of good color and shipping quality.

Dewey. — Fruit: long, conic; size, medium large; core, small, hard; external color, scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, medium; rust, slight.

Inclined to be deficient in vigor, and nothing of special merit to recommend it.

Dole. — Fruit: irregular, conical; size, medium large; core, medium large; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, medium; calyx, medium; texture, rather soft; seeds, yellow, imbedded; quality, good; shipping quality, poor. Blossom, imperfect; plant, vigorous; foliage, good; runners, many; rust, little.

Unproductive; possesses no special advantage over others.

Drought King. — Fruit: round, conical, and irregular; size, medium; core, slight, hard; external color, scarlet; color of flesh, whitish; flavor, very acid, sour; season, medium; calyx, medium; texture, firm; seeds, brownish, prominent; quality, very good; shipping quality, good. Blossom, imperfect; rust on plant, slight.

Unworthy of its name; very poor.

Gibson. — Fruit: flat, conical; size, large to very large; core, small, hollow; external color, dark crimson; color of flesh, red throughout; flavor, slightly acid; season, medium; calyx, medium large; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, healthy, vigorous; runners, few; rust, slight.

Unproductive here, but very fine fruit, and worthy of further trial.

Gladstone. — Fruit: irregular, conic, like Glen Mary; size, large to very large; core, hard; external color, scarlet; color of flesh, pinkish; flavor, acid; season, medium; calyx, loose medium; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, medium green; runners, numerous; rust, slight.

Resembles Glen Mary closely.

Glen Mary. — Fruit: irregular, conical; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, good. Blossom, perfect; plant, very vigorous; foliage, large, vigorous; runners, numerous; rust, slight.

Greatest fault in uneven ripening of tips of berries, but large and productive.

Haverland. — Fruit: long, conical; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, slightly imbedded; quality good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, large, long; runners, many; rust, slight.

Very productive, and one of the best for commercial and domestic use; one of the leaders still.

Hawaii. — Fruit: long, conic; size, medium; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, yellow, slightly imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, resembles Haverland; runners, numerous; rust, slight.

Resembles Haverland closely, but not so productive nor so large fruit.

Hero. — Fruit: flat, conical; size, medium large; core, medium; external color, dark scarlet; color of flesh, red to core; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, good; runners, few; rust, slight.

Not very vigorous or productive, and a disappointment here.

Howard 7. — Fruit: irregular, inclined to be in two parts; size, large; core, large, open, hollow; external color, crimson; color of flesh, crimson to core; flavor, acid; season, medium; calyx, large, upturned; texture, firm; seeds, yellow, imbedded; quality, poor; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, dark, medium large; runners, average; rust, slight.

Worthy of further trial.

Howard 14. — Fruit: very long, tapering at each end; size, large; core, slight, slightly hollow; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, medium large; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, very tall, long leaf stalks; runners, many; rust, little.

Inclined to run small after first few pickings.

Howard 36. — Fruit: long, flat, conical, somewhat tapering at point; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, slightly acid; season, medium to early; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium large, vigorous; runners, many; rust, little.

One of the most productive and profitable varieties on our ground.

Howard 103. — Fruit: round, conical; size, large; core, closed, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, very early; calyx, medium, rather loose; texture, rather soft; seeds, yellow, deeply imbedded; quality, fair; shipping quality, fair.

Blossom, imperfect; plant, fairly vigorous; foliage medium, dark and vigorous; runners, medium; rust, none.

A good, productive, very early berry, and for this purpose excels.

Howard's Clyde 3. — Fruit: round, conic, slightly irregular, often divided; size, large; core, slight, closed; external color, scarlet; color of flesh, scarlet; flavor, slightly acid; season, early; calyx, medium large, loose; texture, slightly soft; seeds, light yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, medium dark, large; runners, numerous; rust, none.

Does not set as much fruit as Clyde, but matures it better; an improvement on Clyde, and valuable.

Joe. — Fruit: round, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, medium; calyx, loose, medium large; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossoms, medium in number, large, perfect; plant, vigorous; foliage, large, dark; runners, fair; rust, slight.

Not very productive, but promising as a large, juicy berry; fancy.

Jucunda. — Fruit: roundish; size, large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, green; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, dark, on short stalks; runners, medium; rust, slight.

Still worthy of cultivation, though deficient in vigor.

Kansas. — Fruit: round, conic; size, medium; core, slightly hard; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, medium vigorous; runners, very numerous; rust, slight.

Not to be recommended, according to its behavior on our grounds.

Klondike. — Fruit: irregular, conic; size, very large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, medium; calyx, large; texture, medium; seeds, brown, imbedded; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, light; runners, numerous; rust, slight.

Inclined to ripen unevenly, and too soft for transportation a long distance; valuable home variety.

Latest. — Fruit: irregular, conic; size, large to very large; core, hard; external color, dark scarlet; color of flesh, whitish; flavor, insipid; season, late; calyx, loose; texture, medium firm; seeds, brown, deeply imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, medium vigorous; foliage, medium; runners, few; rust, slight.

Plants stock up well and are fairly productive; promising late variety.

Leheman 2. — Fruit: irregular, conical; size, large; core, hard; external color, dark scarlet; color of flesh, light scarlet; flavor, acid; mid-season; calyx, small; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, leaves long, medium large; runners, numerous; rust, slight.

Productive and reliable.

Lester. — Fruit: conical; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, large, loose, prominent; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, thick; runners, fair; rust, none.

Lyon. — Fruit: long, conic; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, loose; texture, medium; seeds, prominent; quality, good; shipping quality, good. Blossom, thrifty, imperfect; plant, vigorous; runners, numerous; rust, slight.

Very productive, medium-sized berries.

M. A. C. Seedling 24. — Fruit: round, conic; size, large to very large; core, inclined to be hollow; external color, crimson; color of flesh, light crimson; flavor, insipid; season, early to medium; calyx, medium; texture, rather soft; seeds, brown, imbedded; quality, fair; shipping quality, fair. Blossom, not very vigorous, perfect; plant, only fair in vigor; foliage, medium large; runners, fair; rust, considerable.

Inclined to be soft for long transportation, but otherwise very good.

Margaret. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, pinkish; flavor, sweet; season, early to medium; calyx, loose, prominent; texture, very firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, fair; rust, slight.

Not very productive, but occasionally to be recommended.

Marshall. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, loose, prominent; texture, firm; seeds, yellow, prominent; quality, standard; shipping quality, good. Blossom, perfect; foliage, large, dark, heavy; rust, slight.

Not productive, but fine for home use; success with this variety depends mainly on selection of plants and favored localities and on high cultivation.

McFarland's Seedling. — Fruit: elongated; size, very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, large, loose; texture, firm; seeds, brownish, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, large, dark; runners, numerous; rust, slight.

Very productive and promising, where large fancy fruit is desired.

McKinley. — Fruit: irregular, long, flat; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, loose, large, prominent; texture, rather soft; seeds, golden, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, vigorous; runners, fair; rust, slight.

Greatest fault is soft fruit and uneven ripening; similar to Meggansett Dew Drop.

Mead's Seedling. — Fruit: round, conic; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, medium; calyx, medium, loose; texture, medium; seeds, yellow; quality, fair; shipping quality, fair or rather poor. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Originated by H. O. Mead of Lunenburg, Mass. Inclined to become soft on standing.

Meggansett Dew Drop. — Fruit: long, irregular, conical; size, large to very large; core, slight; external color, scarlet; color of flesh, whitish; flavor, insipid; season, early to medium; calyx, loose; texture, medium fine; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very vigorous; foliage, dark; runners, numerous; rust, none.

General tendency to color unevenly, and rather soft for shipping; resembles McKinley somewhat; productive.

Morgan. — Fruit: long, flattish; size, large to very large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium early; calyx, large, rather loose; texture, medium firm; seeds, yellow, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Greatest fault is general tendency to color unevenly; productive.

Nettie. — Fruit: long, irregular, conic; size, very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, loose, large; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, dark, large; runners, fair; rust, slight.

Appears to be a promising late variety, where size and appearance count; fancy.

New York. — Fruit: long, irregular, conic; size, large; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; calyx, medium loose; texture, medium firm; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, fair; rust, slight.

Inclined to be too light colored, otherwise a productive fancy berry.

Nick Ohmer. — Fruit: roundish; size, large; core, slight; external color, scarlet; color of flesh, whitish; flavor, sweetish; season, medium; calyx, medium, rather loose; texture, firm; seeds, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, diseased; runners, numerous; rust, slight.

Plant deficient in vigor, and not productive; some very good fruit, but not to be relied upon.

Pacific. — Fruit: broad, flattish, conical; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, acid; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium; runners, numerous; rust, slight.

Productive, and a good early berry.

Paris King. — Fruit: long, irregular, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, rather acid; season, early; calyx, medium loose; texture, firm; seeds, yellow; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, numerous; rust, slight.

A good, productive, early berry.

Parson's Beauty. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, early to medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossoms, numerous, perfect; plant, vigorous; foliage, dark, medium thick; runners, very numerous; rust, slight.

Productive, but berries not uniform, and hence not very attractive in appearance.

Pennell. — Fruit: flattish, irregular, conic; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, very prominent, numerous; quality, rather poor; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Prominent seeds on outside give unattractive appearance, otherwise a valuable addition.

Plymouth Rock. — Fruit: roundish; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sweet; season, medium; calyx, loose; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, vigorous; plant, fairly vigorous; foliage, fair; runners, fair; rust, slight.

Fairly productive, but fruit not uniform.

Pocomoke. — Fruit: irregular, conical; size, large to very large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, vigorous, perfect; plant, has good vigor; foliage, medium large; runners, fair; rust, slight.

Productive and promising; a good commercial variety, to be recommended.

Pomona. — Fruit: round, conic; size, medium large; core, slight;

external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, early to medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, full, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Averages favorably with the commercial sorts.

Porto Rico. — Fruit: long, conical, small neck; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sub-acid; season, medium; calyx, loose, upturned; texture, firm; seeds, brownish; quality, good; shipping quality, very good. Blossoms, medium in number, imperfect; plant, fairly vigorous; foliage, fair; runners, average, or below; rust, slight.

Parker Earle type; productive, and worthy of more extended trial.

Premium. — Fruit: conical; size, medium large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, early to medium; calyx, medium; texture, firm; seeds, imbedded; quality, rather poor; shipping quality, good. Blossom, imperfect; plant, fairly vigorous; foliage, medium dark; runners, numerous; rust, slight.

Good average berry, but inclined to run small by mid-season.

Pride of Cumberland. — Fruit: round, conic; size, medium large; core, slight; external color, light crimson; color of flesh, light crimson; flavor, sub-acid; mid-season; calyx, medium loose; texture, very firm; seeds, yellow, protruding; quality, very good; shipping quality, very good. Blossoms, medium in number, perfect; plant, fairly vigorous; foliage, fair; runners, comparatively few; rust, slight.

Not very productive on our soil, but otherwise a good commercial berry.

Putnam's Seedling X. — Fruit: round, conic; size, large; core, medium; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, large; texture, very firm; seeds, yellow, slightly imbedded; quality, good; shipping quality, very good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium; runners, average; rust, slight.

Fine, firm, regular late berry.

Rochester. — Fruit: irregular, conic; size, medium large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, medium; texture, firm; seeds, yellow, protruding; quality, poor; shipping quality, good. Blossoms, many, perfect; plant, fairly vigorous; foliage, medium; runners, numerous; rust, slight.

Not to be recommended for commercial planting, from its behavior on our grounds.

Rough Rider. — Fruit: irregular; size, medium large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather loose, medium; texture, firm; seeds, yellow, imbedded; quality, rather poor; shipping quality, good. Blossoms, medium in number, perfect; plant, poor in vigor; foliage, fair; runners, fair; rust, slight.

Nothing to recommend it, according to its behavior here.

Sample. — Fruit: round, conic, regular; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; mid-season; calyx, medium; texture, medium; seeds, brownish; quality, fair; shipping quality, fair to good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium green; runners, numerous; rust, slight.

A fine, productive, uniform commercial berry, inclined at times to be a little soft; still the most reliable. under various conditions.

Sawyer's Seedling. — Fruit: round, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, medium to late; calyx, medium; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, fairly vigorous, perfect; plant, very good in vigor; foliage, large, vigorous; runners, average; rust, slight.

Satisfactory on our grounds; productive and valuable.

Shuster's Gem. — Fruit: round, conic; size, large; core, slight; external color, crimson; color of flesh, lightish; flavor, sub-acid; mid-season; calyx, large; texture, medium; seeds, yellow, protruding; quality, fair; shipping quality, fair. Blossom, perfect; plant, has good vigor; foliage, medium dark; runners, average; rust, slight.

An old reliable berry, and worthy of culture.

Springdale Beauty. — Fruit: irregular, roundish; size, medium to large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, loose; texture, medium; seeds, yellow, slightly imbedded; quality, fair; shipping quality, fair. Blossom, vigorous, perfect; plant, vigorous; foliage, medium dark; runners, average in number; rust, slight.

A good general-purpose berry.

Uncle Jim. — Fruit: long, conical; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very good in vigor; foliage, resembles Marshall; runners, numerous; rust, none.

Sets moderate amount of fruit, and matures it; one of the most promising newly introduced varieties; fancy.

Uncle Sam. — Fruit: round, conic; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium late; calyx, large, loose; texture, firm; seeds, brown, imbedded; quality, fair; shipping quality, good. Blossom, perfect, and good pollenizer; plant, vigorous; foliage, dark; runners, comparatively few; rust, slight.

Stocks up well in hill system, but rather light color for a market berry, and only moderately productive.

Cultural Methods.

The department has constantly experimented with methods of cultivation; and, since this work has covered many years and a diversity of soils, some general remarks on the management of strawberry plantations may appear to be in place. While the cultural methods of growing the strawberry vary widely, and each system has its special devotees, nearly all methods have merits and demerits worth considering.

Shall the strawberry plant be allowed to fruit one or two years? Nearly all the best growers now practise the former method. By this quick rotation fungous and insect pests are avoided to a greater extent, and the fruit is generally considered enough better to warrant the extra labor and expense.

Shall the plants be set in the early spring, or in autumn? Generally speaking, our experience has shown that spring setting is best, as the root system gets a better chance to develop, and the crown to store up nutriment for fruit bearing the following year. However, in special cases good results are obtained by selecting vigorous plants in July and August, setting in beds close together, and allowing no runners to form.

There are four general systems, modified more or less to suit special conditions; these are commonly practised with spring setting: the hill system, hedge-row system, narrow matted row and wide matted row systems.

The hill system is more generally advocated by amateur than commercial growers. The plants should be set out about two and one-half by two feet, and no runners allowed to form. Everything that will aid the crown to increase in size and strength should be provided. The larger and more vigorous the crowns, the greater the results; the strength of the plants goes to building up a fruit-producing organism alone. Another great advantage is the exposure to air and sunlight on all sides, and the consequent production of better-colored, better-flavored and firmer fruit, worthy of a fancy price.

The hedge-row system is a modification of the hill system in many respects. The plants should be set out about the same distance apart, or possibly in rows three feet apart. The first vigorous runners are then trained in a line with the parent plants, but not detached from them. When this line is filled out so as to make one continuous row, with plants about four or five inches apart, no more runners should be allowed to form. This system possesses nearly all the advantages of the former, and besides gives larger yields. Some varieties, like Clyde, which are naturally light-colored and rather soft, gave surprisingly better results as regards color and firmness the past season when grown in this way. The mass of fruit on one side of the rows, fully exposed to the air and sun, was a sight worth seeing.

The wide matted row and narrow matted row are really a modification of one system. By this plan the plants are set some three and one-half or four feet wide by one and one-half feet in the rows. No runners are allowed to grow until the parent plant has become well established, and then all or a limited number of runners, according to the wide or narrow row system, are allowed to root. The general tendency of this system is to grow vines at the expense of the fruit. Large yields are sometimes obtained, but generally of smaller and poorer fruit.

Whatever the system adopted, or the character of the soil on which the plants are grown, it is of the utmost importance to start with plants of unimpaired vigor, and keep them thus. Feed liberally, and spray with Bordeaux mixture occasionally. Cultivate frequently. Experiment, and study the varieties and adaptation to soil.

Marketing Apples in Boxes.

A feeling has been steadily gaining ground among the growers of good apples that some package smaller and neater than the common barrel should be used in marketing the fruit. It seems unnecessary to here review all the considerations which have influenced fruit growers in coming to this conclusion. There are many things to be said in favor of smaller packages. There are also some few objections and many qualifications to be made. The movement toward the use of boxes has been emphasized during the shipping season of 1903 by the great scarcity and unreasonably high price of barrels. Inquiries regarding the use of boxes have accordingly been frequent; and on this account it has been thought that a brief note of our experience in the department of horticulture would prove of general interest.

Bushel boxes of two common patterns have been used during the two shipping seasons of 1902 and 1903, though not in large numbers. Both early apples and winter varieties were shipped in these packages. In every case the results were gratifying. The apples always brought as much money, or more, than the same quantity of fruit in barrels; in fact, the cash returns were nearly always greater, and sometimes surprisingly so. In one instance, in 1902, Gravensteins were shipped both in barrels and in bushel boxes on the same day and to the same dealer, the fruit being from the same trees, and graded precisely the same throughout; the apples in boxes, however, were wrapped in papers. In this instance the barrels sold at $2 each, and the boxes at the same price. Since the boxes hold very nearly one-third of a barrel, the price was approximately three times as much for the fruit in boxes.

This case, however, is extreme; no such greatly disproportionate price was secured in any other instance for box apples. Still, every shipment of apples in boxes showed a fair margin in favor of the package, and several times the difference was a handsome one.

According to our experience, it seems that the bushel box is especially advantageous for early apples, — say up to the end of the Gravenstein season. Fancy grades of all varieties, however, may be expected to show good results in boxes. Sutton Beauty, shipped as late as Christmas time, realized high prices.

Our experience also favors the use of wrapping papers on fancy apples, more especially on highly colored and on soft-fleshed early varieties. These papers are best bought ready cut for the purpose, and are supplied by various dealers.

There are several forms of boxes in use. Those which we have specially examined are as follows: —

The vegetable box in use throughout the State for potatoes, beets and similar garden truck has been considerably tested for apples. We have used it ourselves to some extent, but do not consider it suitable. This box is 18 inches square and 8 inches deep, thus having a capacity of 2,592 cubic inches, or considerably more than a standard bushel (United States standard bushel contains 2,150.42 cubic inches). The ends of this box are of $\frac{3}{4}$-inch lumber, and the sides, top and bottom of $\frac{1}{2}$-inch stuff.

The box most used and recommended by large apple shippers is represented in our collection by samples bought from a New York manufacturer. This is the box which we have chiefly used, and which we prefer. The inside dimensions are 10 by 11 by 20 inches, thus giving a capacity of 2,200 cubic inches, — very nearly the exact measure of the standard bushel. It weighs a trifle over 50 pounds, filled. The ends are of $\frac{7}{8}$-inch stuff, and the sides, top and bottom of $\frac{1}{4}$-inch stuff. It will be seen that the sides, top and bottom are very light, thus allowing a considerable spring. There is a difference of opinion among shippers as to whether this elasticity is desirable, or objectionable. Some favor it strongly; others insist that a perfectly rigid box is better. Our own opinion is that the rigid box is better for long shipments, as, for example, to Europe; but that the box with plenty of spring is better for near-by markets.

Another box, having exactly the same interior dimensions, is manufactured in Wisconsin, and is represented in our collection by a sample. We have not used this box, but are pleased with its appearance. It is better made and more attractive than the New York box, just described. The ends are of $\frac{7}{8}$-inch stuff, the top and bottom are of $\frac{1}{4}$-inch stuff, and on the sides at each corner is a strip of $\frac{3}{8}$-inch lumber, about $2\frac{1}{2}$ inches wide. This holds in place a sheet of thin veneer, which forms the principal portion of the side. The box is light and strong, as well as good looking.

These boxes can all be bought in the knock-down, and made up at home. The price is about $15 per hundred.

Another box, used in Ontario, Can., is very well made and attractive, but too expensive for the domestic trade. It measures $10\frac{1}{2}$ by $11\frac{1}{2}$ by 22 inches inside, giving a capacity of $2,656\frac{1}{2}$ cubic inches, or considerably over a bushel, — in fact, more nearly five pecks. This box is made with ends of $\frac{1}{2}$-inch lumber, sides, top and bottom of $\frac{3}{8}$-inch wood, the whole being firmly dovetailed at the corners. It forms a fine package for the foreign trade, though it is larger and more expensive than necessary.

We would not recommend any one to undertake the use of the bushel box for apples on a large scale without considerable preliminary experiment; but we consider it well worth trying. We shall be glad to answer any inquiries on this subject, so far as our experience and information allow.

Notes on Quinces.

One of the most profitable crops during the last two years on the farm of the horticultural department has been furnished by the quince orchard. This consists of about 250 trees, of all sizes, ages and varieties. The larger part of them are growing on a springy slope at the base of a hill. The soil is good, rich alluvium, excellent for garden crops when dry enough. The particular spot where these trees stand has been partially drained by tile some time ago, but these drains have now become so much clogged that the land is quite wet during a considerable part of the year.

Under these conditions the plantation gave an abundant crop of very fine fruit in 1902, and a very fair crop of nearly as good quality in 1903. These were sold mostly at wholesale, — that is, to market men and dealers, or through commission men in Boston, Worcester and Springfield.

In 1902 the No. 1 fruit, which constituted by far the bulk of the crop, sold for $2 a bushel. In most cases this price was received for the fruit *f. o. b.* at Amherst, though that shipped on commission to the three cities named sold for $2 in those markets, and charges had to be deducted. The No. 2 fruit sold for 75 cents, $1, $1.25 and $1.50 a bushel, averaging about $1.25.

In 1903 quinces were very scarce, but at the same time the crop on the trees was not so large nor of quite such good quality. The No. 1 fruit brought $2 and $2.25 (mostly the latter figure), net. The No. 2 fruit brought various prices, averaging about $1.25.

In both years the profit from the trees was considered very satisfactory. The good prices secured were attributed largely to the method of marketing the fruit. In the first place, it was well ripened; the fruit was allowed to remain on the trees until it had attained a bright, rich color. In the second place, it was very rigidly graded, only prime specimens being put into the first grade. Next, each specimen was carefully wrapped in clean fruit paper, specially cut for the purpose. These fruits were then packed in fresh, clean, attractive bushel boxes. A few were sold, some wrapped and some unwrapped, in 16-quart peach baskets, but the box was thought to be much the better package.

The use of the bushel box, or some similar small package, and the wrapping, are thought to be essential points in marketing fancy quinces, except when the fruit is delivered direct to the consumer. Quinces bruise very easily, and even the slightest bruise on a ripe quince quickly becomes discolored, and the fruit presents a highly unattractive appearance. Quinces packed in barrels and shipped some distance to market come out with nearly every specimen bruised; but the wrapping and the small package both prevent such injury.

The small package is desirable on another account, namely, because very few customers care for more than a bushel of quinces at a time; even market men with a very fair trade prefer to buy in bushel lots.

The character of the soil on which the college quince trees grow has been mentioned. Wet clay land is frequently recommended for quinces, but the trees do better on well-drained soil. Even fairly light loam will sometimes support thrifty trees for some years, though the ideal soil is moderately heavy clay. Light and sandy soils give small prospect of success.

The quince tree grows slowly, and does not require rigorous pruning. If only reasonable and seasonable attention is given to keep the head open and well balanced, nature will do the rest.

No diseases or insects of any consequence have troubled us. The trees have been sprayed with Bordeaux mixture, and this has probably helped to hold in check the scab, a fungous disease which attacks the leaves and fruit to some extent nearly every year, but which, with us, does not assume serious proportions.

The principal varieties grown are Orange, Champion and Rea (Rea's Mammoth). All succeed perfectly, and we have found them all equally acceptable in the market.