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FORTY-SECOND ANNUAL REPORT

OF THE

MASSACHUSETTS

AGRICULTURAL COLLEGE.

JANUARY, 1905.



BOSTON :

WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
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APPROVED BY

THE STATE BOARD OF PUBLICATION.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, JAN. 3, 1905.

To His Excellency JOHN L. BATES.

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

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,

President.

CONTENTS.

	PAGE
Calendar,	7
Report of trustees,	9
Catalogue of officers and students,	19
Graduate courses,	32
Four-years courses,	35
Admission,	36
Entrance examinations,	37
Synopsis of courses,	41
Two-years course for women,	60
Short courses,	61
Equipment,	62
Expenses,	69
Scholarships,	70
Labor fund,	72
Prizes,	72
Reports,	75
Treasurer,	77
Gifts,	84
Farm,	86
Military department,	93
To Secretary of Agriculture,	99
Annual Report of Hatch Experiment Station,	101
Treasurer,	105
Botanist,	107
Meteorologist,	135
Chemist (foods),	137
Chemist (fertilizer-),	194
Entomologists,	211
Agriculturists,	215
Horticulturists,	257
Floriculturist,	268

CALENDAR FOR 1905-1906.

Jan. 4, 1905, 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 } spring recess.

April 4, Tuesday,

April 4, Tuesday, spring semester resumed, at 8 A.M.

June 17, Saturday, Grinnell prize examination of the senior class in agriculture.

June 18, Sunday, Baccalaureate sermon.

June 19, Monday, } Burnham prize speaking
} Flint prize oratorical contest.

June 20, Tuesday, } Class-day exercises.
} Meeting of the alumni.
} Reception by the president and trustees.

June 21, Wednesday, commencement exercises.

June 22, 23, 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 19, 20, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 21, Thursday, fall semester begins, at 8 A.M.

December 20, Wednesday, }
to } winter recess.

Jan. 3, 1906, Wednesday,

January 3, Wednesday, fall semester resumed, at 8 A.M.

February 7, Wednesday, fall semester ends.

February 8, Thursday, spring semester begins, at 8 A.M.

March 28, Wednesday, }
to } spring recess.

April 3, Tuesday.

April 3, Tuesday, spring semester resumed, at 8 A.M.

June 20, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

It has frequently been said that, if the people of this Commonwealth half realized the advantages offered their sons and daughters at the Massachusetts Agricultural College, it would be filled to overflowing. The past year has come nearer realizing this statement than any other, and yet an analysis of the annual report shows how far away we still are from reaching this happy condition, even though we have entered upon its very threshold. There are, roughly speaking, about 350 towns and cities in this State, and there ought to be at least an approximate representation from each one of these centres of population; instead of that, we find barely a 37 per cent. representation. We find our 273 students distributed among 130 towns, as follows:—

Abington,	1	Cochituate,	1
Amesbury,	1	Cohasset,	1
Amherst,	21	Concord,	1
Andover,	1	Curtisville,	1
Ashburnham,	1	Dana,	1
Attleborough,	1	Dedham,	1
Barre,	2	Deerfield,	1
Becket,	1	Dorchester,	1
Belchertown,	4	Easton,	2
Belmont,	1	East Brewster,	1
Bernardston,	2	East Charlemont,	1
Boston,	4	East Northfield,	1
Brimfield,	1	East Pepperell,	2
Brockton,	7	Egremont,	1
Brookfield,	2	Falmouth,	1
Cambridge,	1	Fall River,	2
Campello,	1	Florence,	2
Canton,	1	Framingham,	1
Cheshire,	1	Goshen,	1

Granby,	1	Peabody,	1
Greenwich Village,	1	Pepperell,	2
Hadley,	3	Petersham,	1
Halifax,	1	Pittsfield,	2
Hinsdale,	1	Plainfield,	1
Holliston,	1	Reading,	1
Hopedale,	3	Richmond,	2
Hudson,	1	Rockland,	2
Hyde Park,	2	Roslindale,	1
Jamaica Plain,	2	Roxbury,	3
Lancaster,	2	Rutland,	1
Lee,	1	Salem,	2
Lenox,	1	Saugus,	1
Leominster,	1	Scituate,	1
Lexington,	1	Sherborn,	1
Lincoln,	1	Somerville,	6
Littleton,	1	South Amherst,	2
Long Plain,	1	South Boston,	1
Lowell,	3	Southborough,	1
Ludlow,	1	Southbridge,	1
Lynn,	2	South Framingham,	1
Malden,	4	South Hadley,	1
Marlborough,	1	South Natick,	1
Marshfield,	1	Southwick,	2
Maynard,	1	Spencer,	1
Medford,	1	Springfield,	4
Melrose Highlands,	1	Sterling,	1
Middleborough,	1	Stockbridge,	1
Milford,	1	Stoughton,	2
Millbury,	6	Sunderland,	2
Millis,	2	Swampscott,	3
Monson,	1	Taunton,	1
Montague,	1	Templeton,	1
Natick,	6	Tewksbury,	1
Newburyport,	1	Townsend,	2
New Dorchester,	1	Waltham,	4
Newton,	2	Westborough,	3
Newtonville,	3	West Draeut,	1
North Amherst,	2	Westfield,	2
North Brookfield,	1	Westford,	2
Northampton,	1	West Millbury,	1
Northfield,	1	West Roxbury,	1
North Grafton,	1	Wilkinsonville,	1
North Hadley,	1	Winchester,	1
Orange,	1	Winthrop,	2
Osterville,	2	Worcester,	9

China, Barbados and Japan furnish 1 each; the remaining 36 are distributed in the following States: Connecti-

cut, Illinois, Kansas, New Hampshire, New York, New Jersey, Vermont, Tennessee, Iowa, Maine, California, Georgia.

It seems difficult to secure a foothold in the west and north-west portions of the State, and perhaps it is fortunate that it was so this year, for the attendance has been so large that it has been found impossible to give the students the education offered them in our report. In the senior and graduate classes we have been compelled to refuse 3 students for lack of room in the entomological department, and next year the pressure will be still greater. In the horticultural department we have had to simply say to the junior class, "We cannot give you the education promised, — our accommodations are too small;" and next year we shall find ourselves confronted with a still worse condition of affairs. Our freshman class has suffered the most, for we have been compelled to divide it into three sections, and to debar the last (25 men) from work in botany. How it can ever be made up I do not see, without increased facilities in room and equipment. Your committees, last year, reported a bill advocating increased accommodations, but it did not seem wise to press it. We return this year, asking that you will supply us with the means to adequately furnish the education required by our charter and the laws of this Commonwealth. It is a matter of absolute necessity, and does not admit of any delay. Before this, some kind of provision could be made; but with entering classes of 70 and 80 it is now quite impossible, and means one of two things, — either retrogression and frankly disowning a portion of the course, or else attempting to carry it on in a half-hearted way, — a source of shame to ourselves and a constant element of discontent to the student.

The botanical, horticultural and entomological departments demand immediate assistance. The last mentioned can be easiest and most quickly reached by increasing the length of the building, and repairing the greenhouse used in connection with breeding and destroying insects, at a cost of say \$3,000. The kind of work in which the students are engaged here is mostly microscopic, and necessitates individually more room and more light than in the ordinary

recitation room. These two features, for a limited number, can be secured in the manner above indicated.

For the horticultural department an entirely new building, exclusive of its greenhouse, can be erected and equipped at a cost not to exceed \$40,000, and \$1,000 annual maintenance fund. This will provide for all 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 mentioned. This building is a necessity. The only room the department now can call its own is the botanic museum, where all specimens have been made useless by being pushed back to the wall, to allow room for tables, seats and other equipment.

We have said that \$40,000 would put up, equip and properly furnish a brick building, as nearly fireproof as may be, for carrying on the work of this department. The different items tabulate as follows:—

Building,	\$29,000
Heating,	3,000
Grading and roads,	1,500
Furnishing and equipment,	4,500
Electric lights,	500
Architects' fee,	1,450
Total,	<u>\$39,950</u>

But in addition to these items is the one most important of all,—a modern greenhouse, for the purpose of teaching the growing of crops from the commercial standpoint. If this cannot be taught, then we shall have deplorably failed in all our instruction. The whole object of the investigations of the great father of philosophy was *utility*, and from his day on to this the world has gone on advancing, and its condition has been improving. A greenhouse not costing over \$14,600, and including salesroom and heating, is needed for the practical demonstration of growing for the market flowers and market-gardening stuffs.

The botanical department has for thirty-seven years been handicapped by everything belonging to any other department for which room could not be found elsewhere. It has gladly given shelter to zoölogy, entomology, physiology, geology, and, in fact, to most of the natural sciences it has shown itself a tender mother. Last to ask anything for itself, it has nearly the same old equipment of two-score years ago. Everything has been outgrown, and the demands upon it far exceed its available resources. With rooms, at a maximum, furnishing room and accommodation and apparatus for 30, it now has classes of 75 to 80, with every prospect of increase in the coming years. To provide not only for the necessities of the present, but to look ahead and see that the possibilities of the future are supplied, is the problem that confronts us. It has seemed wiser to group together the buildings of the station and college, in order that the teacher may take advantage of the investigations of the experimenter. This building, then, although absolutely distinct, partakes rather of an addition to the botanical division of the experiment department than to a separate building. It provides for teaching the botany of all the undergraduate as well as the graduate classes. It provides laboratory room, double the capacity of that at present employed. It furnishes lecture rooms for audiences of at least 150, and, most important, presents an up-to-date building, equipped with the most modern appliances and instruments for prosecuting the study of botany. For the erection and equipment of this building there will be required an outlay of \$35,900, and an annual maintenance fund of \$1,000.

Summing up briefly our needs, we require for the —

Entomological division,	\$3,200
Horticultural: —	
Building,	29,000
Heating,	3,000
Grading and roads,	1,500
Furnishing and equipment,	4,500
Architects' fee,	1,450
Electric lights,	500
Greenhouse,	14,600
Annual maintenance fund,	1,000

Botanical : —

Building and equipment,	\$35,900
Annual maintenance fund,	1,000
For duplicate generator of heating and lighting plant, not to exceed	5,000
For painting barn,	1,000
For improvement of live stock,	5,000
For extending heating and lighting plant to vegetable pathology and horticultural buildings,	8,500

In accordance with the Acts and Resolves of the General Court, 1904, creating a forester, it was made one of his duties to deliver a course of lectures at the Massachusetts Agricultural College. It is briefly outlined by State Forester Akerman as follows : —

This is a course of twelve lectures on the art and science of forestry, to be given by the State Forester, in accordance with the statute which established his office. The first five of these lectures will deal with forestry in general, its scope and meaning to civilization; the remaining lectures will be on problems presented by the forest conditions of this Commonwealth, and especially those which arise in connection with farm wood lots. The college wood lot will be used to illustrate some of the subjects dealt with in the lectures. The course is to be given in the early months of the year.

The college exhibit made at the St. Louis fair was participated in by the departments of agriculture, botany, entomology, horticulture, chemistry, veterinary and English, and was intended to show the work of college and station. It seems to have been a success, for the *grand prix* was awarded us. The different articles of exhibit were as follows : —

First. — Each of the departments mentioned contributed a set of photographs, illustrating buildings, lecture rooms and laboratories, and the equipment used in its work. The literary work of the alumni of the college was shown by as complete an exhibit as could be brought together of the books which have been published by alumni. This exhibit included about thirty volumes, treating a considerable variety of subjects; a large proportion pertained

to agriculture, or the sciences closely connected therewith.

Second. — Aside from the general material which has already been mentioned, a number of the departments were represented by special exhibits. The more important features of the exhibit made by each will be made clear by the following statement: —

Agricultural Department. — This department exhibited a large number of specimen sheaves and preserved plants and seeds of the more important crops of the State. Especially prominent were those which were introduced into the United States by the head of the department.

The methods and results of an experiment to determine the relative availability of fertilizers were shown in facsimile by means of artificial plants made to scale, set into the pots actually used in the experiments.

The results of an experiment in feeding hens for eggs were shown by two parallel series of glass jars and cases, in which the contrasted methods of feeding were made clear by showing the different foods in layers. The basis adopted was the average requirements and product of one hen for one month. Besides the actual foods, the exhibit showed the total of nutrients contained in the foods used under the two systems, the number of eggs laid by a single hen in one month under each system of feeding, and the total of the nutrients given in the foods recovered in the eggs.

The results of an experiment with fertilizers in the field were shown to exact scale in high and narrow glass jars, eight in number, each containing the product in shelled corn of one thousandth part of an acre.

Horticultural Department. — Some idea of the nature of the work in this department along educational lines was afforded by means of a collection of drawings, some twenty in number, prepared by students as a regular feature of their work. A line of investigation in which the department has been especially prominent was represented by means of a collection of specimens showing variation in the nature of graft unions. The department also exhibited a collection of wax models, designed to show the originals from which each

of the various cultivated fruits has been developed, and the different highly improved forms which have been produced from these originals.

Department of Botany and Vegetable Pathology. — This department showed a large collection of apparatus employed in determining the percentage of germination of seeds, apparatus which has been used in studying the effect of electricity on the germination of seeds, and models of a number of different types of apparatus employed in sterilizing the soil in greenhouses for prevention of disease. The department showed also a large number of specimens illustrating the effects of fungous diseases. A part of these were mounted in gelatine held between plates of glass, — a method which has been perfected in the department, and which preserves the color and natural appearance in a very perfect manner; while a portion of the specimens had been dried, pressed and mounted on cotton. The department also showed a collection including many of the important mushrooms, represented by means of beautifully made paper models; there were three dozen specimens in this collection.

Department of Entomology. — This department showed eight glass-topped trays of insects, illustrating the following educational topics: —

I. Life history of the gypsy moth: its parasites and insect enemies.

II. Life history of the brown-tail moth: its parasites and insect enemies.

III. Examples of cases of the mimicry of one insect by another, occurring in Massachusetts.

IV. Examples of cases of the imitation of various objects, such as twigs, bark, etc., by insects.

V. The modern ideas as to the genealogy and relation to each other of the different groups of insects, with specimens of each group.

VI. Specimens showing differences of form, color or markings in the sexes (antigeny).

VII. A complete life history of the apple tree tent caterpillar, showing the meaning of a life history.

VIII. Specimens of our chief insect pests, showing which are native to this country and which are introduced.

Chemical Department. — The exhibit of this department filled a large case, and was designed to illustrate educational methods of research in the department. The exhibit included a large number of specimens of chemical compounds prepared in the laboratory.

Veterinary Department. — The exhibit of this department included a large number of models and especially prepared specimens used in illustrating the anatomy of each of the various domestic animals. Many of the prepared specimens were the work of students or alumni of the college.

At the meeting of the trustees in Amherst, June 14, 1904, a committee was appointed to draft resolutions on the death of Charles L. Flint. The following tribute to Mr. Flint was presented to the trustees at their meeting on Jan. 3, 1905: —

TRIBUTE TO CHARLES LOUIS FLINT.

In the death of Charles Louis Flint this Board has lost one of its most faithful members. Although quiet and unassuming in manner, he was forceful and resourceful in character. Always considerate, always honorable in his dealings with men, he won their respect and confidence. His father, a graduate of Harvard, and for many years secretary of this Board, gave his two sons their choice between the Agricultural College at Amherst and Harvard College at Cambridge, hoping they would select the former, which they both did. Mr. Flint, our late associate, never regretted his choice, was always proud of his alma mater, and defended her on every and all occasions. He showed his good will in deeds as well as in kind words, for, when the time came to help the college, he established, and for several years maintained, the "Flint Rhetorical Prizes," which, along with the Burnham prizes, have accomplished so much for our English department. The college has indeed lost a loyal supporter and helpful friend, and this Board a quiet, modest, lovable, yet dignified associate.

We desire to record here our grateful remembrance of his wise generosity and thoughtful service to his alma mater, and to extend to his family our deep sympathy in the loss of a true husband and a devoted father.

His classmate and college chum, Dr. Hills of Vermont, paraphrasing another, wrote concerning him: "I believe that, while Mounts Holyoke, Tom and Toby have never occupied chairs in the faculty of this college, they have been as potent factors in the shaping of the character of its students as have many even of its best instructors; and I think I see their quiet, beauty, dignity and strength reflected in the character and life of our friend, Charles Louis Flint."

WILLIAM WHEELER,

W. H. BOWKER,

E. D. HOWE,

Committee.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,

President.

AMHERST, Jan. 3, 1905.

THE CORPORATION.

	TERM EXPIRES
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
ARTHUR G. POLLARD of LOWELL,	1909
CHARLES A. GLEASON of NEW BRAINTREE,	1909
JAMES DRAPER of WORCESTER,	1910
SAMUEL C. DAMON of LANCASTER,	1910
MERRITT I. WHEELER of GREAT BARRINGTON,	1911
CHARLES H. PRESTON of DANVERS,	1911
WILLIAM R. SESSIONS of SPRINGFIELD,	1912
M. FAYETTE DICKINSON of BOSTON,	1912

• Members ex Officio.

HIS EXCELLENCY GOVERNOR JOHN L. BATES,
President of the Corporation.

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

GEORGE H. MARTIN, *Secretary of the Board of Education.*

J. LEWIS ELLSWORTH, *Secretary of the Board of Agriculture.*

WILLIAM R. SESSIONS of SPRINGFIELD.

Vice-President of the Corporation.

J. LEWIS ELLSWORTH of WORCESTER, *Secretary.*

GEORGE F. MILLS of AMHERST, *Treasurer.*

CHARLES A. GLEASON of NEW BRAINTREE, *Auditor.*

Committee on Finance and Buildings.*

WILLIAM R. SESSIONS, J. HOWE DEMOND,
 ARTHUR G. POLLARD, CHARLES H. PRESTON,
 CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER, ELMER D. HOWE,
 M. FAYETTE DICKINSON, 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,
 J. L. ELLSWORTH, *Chairman.*

Committee on Experiment Department.*

J. LEWIS ELLSWORTH, CHARLES H. PRESTON,
 WILLIAM H. BOWKER, SAMUEL C. DAMON,
 JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER, SAMUEL C. DAMON,
 M. FAYETTE DICKINSON, N. I. BOWDITCH,
 JAMES DRAPER, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

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

Examining Committee of Overseers.

JOHN BURSLEY (<i>Chairman</i>), . . .	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.

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, MAJOR, 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 and Instructor in German.

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 French and Spanish.

HENRY J. FRANKLIN, 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.

ELWIN H. FORRISTALL, M.Sc.,

Farm Superintendent.

Graduates of 1904.*

Ahearn, Michael Francis,	Framingham.
Back, Ernest Adna (Boston Univ.),	Florence.
Blake, Maurice Adin,	Millis.
Couden, Fayette Dickinson,	Amherst.
Elwood, Clifford Franklin,	Green's Farms, Conn.
Fulton, Erwin Stanley,	Lynn.
Gilbert, Arthur Witter (Boston Univ.),	Brookfield.
Gregg, John William (Boston Univ.),	South Natick.
Griffin, Clarence Herbert,	Winthrop.
Haskell, Sidney Burritt,	Southbridge.
Henshaw, Fred Forbes,	Templeton.
Hubert, Zachary Taylor (Boston Univ.),	Pride, Ga.
Newton, Howard Douglas (Boston Univ.),	Curtisville.
O'Hearn, George Edmund,	Pittsfield.
Parker, Sumner Rufus,	Brimfield.
Peck, Arthur Lee (Boston Univ.),	Hartford, Conn.
Quigley, Raymond Augustine,	Brockton.
Raymoth, Reuben Raymond,	Goshen.
Staples, Parkman Fisher (Boston Univ.),	Westborough.
White, Howard Morgan,	Springfield.

Two-Years Course.

Hunt, Justine,	Newton.
Total,	21

* 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 1904.

Senior Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Barnes, Hugh Lester,	Stockbridge.
Bartlett, Francis Alonzo,	Belchertown.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Amherst.
Gardner, John Joseph,	Milford.
Gay, Ralph Preston,	Stoughton.
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.
Munson, Willard Anson,	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
Patch, George Willard,	Lexington.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Swain, Allen Newman,	New Dorchester.
Taylor, Albert Davis,	Westford.
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,	33

Junior Class.

Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.

Craighead, William Hunlie,	Boston.
Ferren, Frank Augustus,	Peabody.
Filer, Harry Burton,	Belchertown.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Hall, Jr., Arthur William,	North Amherst.
Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hood, Clarence Ellsworth,	Millis.
Jones, Louis Franklin,	Somerville.
Kennedy, Frank Henry,	South Boston.
Martin, James Edward,	Brockton.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
Paige, George R.,	Amherst.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civile,	Natick.
Racicot, Jr., Arthur Alphonse,	Lowell.
Rogers, Stanley Sawyer,	Boston.
Russell, Henry Merwin,	Bridgeport, ⁵ Conn.
Scott, Edwin Hobart,	Cambridge.
Sleeper, George Warren,	Swampscott.
Strain, Benjamin,	Mt. Carmel, ³ Conn.
Suhlke, Herman Augustus,	Leominster.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tirrell, Charles Almon,	Plainfield.
Wellington, Richard,	Waltham.
Wholley, Michael Francis,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Total,	34

Sophomore Class.

Alley, Harold Edward,	Newburyport.
Arimoto, Shintaro,	Oharamura, Aidagun, Mimasaka, Japan.
Armstrong, Arthur Huguenin,	Hyde Park.
Barlow, Waldo Darius,	Amherst.
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,	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.
Cutter, Frederick Augustus,	Pelham, N. H.
Dearth, George Augustus,	South Framingham.
Dénham, Edwin Tirrell,	Rockland.
Dickinson, Walter Ebenezer,	North Amherst.
Dudley, Fred Samuel,	Montague.
Eastman, Jasper Fay,	Townsend.
Engstrom, Nils,	Lancaster.
Farrar, Allan Dana,	Amherst.
Gould, Harry Wheeler,	Millbury.
Green, Herbert Henry,	Spencer.
Hall, Jr., Walton,	Marshfield.
Hartford, Archie Augustus,	Westford.
Higgins, Arthur William,	Westfield.
Jones, Arthur Merrick,	Ludlow.
King, Clinton,	Easton.
Larned, Joseph Adelbert,	Amherst.
Leighton, Carl,	Lowell.
Leominster, William,	Long Plain.
Lincoln, Ernest Avery,	Fall River.
Livers, Susie Dearing,	Boston.
Parker, Charles Morton,	Newtonville.
Perkins, Edward Cook,*	Springfield.
Peters, Frederick Charles,	Lenox.
Philbrick, Edwin Daniels,	West Somerville.
Pièrce, 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, Edward Houghton,	Belmont.
Shaw, Frank Elmer,	Brockton.

* Died June 20, 1904.

Stoddard, Calder Sankey,	Canton.
Summers, John Nicholas,	Brockton.
Thompson, Clifford Briggs,	Halifax.
Walker, James Hervey,	Greenwich Village.
Watkins, Fred Alexander,	Hinsdale.
Watts, Ralph Jerome,	Littleton.
Whitney, John Frank,	Dana.
Wood, Herbert Poland,	Hopedale.
Total,	56

Freshman Class.

Allen, Charles Francis,	Worcester.
Allen, Herbert Carpenter,	East Northfield.
Anderson, Albert John,	North Brookfield.
Anderson, Kenneth French,	Roslindale.
Austin, Frank Lee,	Potsdam, N. Y.
Bailey, Ernest Winfield,	Worcester.
Bangs, Bradley Wheelock,	Amherst.
Barry, Thomas Addis,	Amherst.
Bartlett, Louis Warren,	Amherst.
Bates, Carleton,	Salem.
Bennett, Ernest Victor,	Malden.
Blake, Rodman Ruggles,	East Pepperell.
Blakely, Franklin Chambers,	Medford.
Browne, Marcus Metcalf,	Malden.
Caldwell, John Snow,	Lynn.
Carter, Henry Rufus,	Millbury.
Chapman, Lloyd Warren,	Pepperell.
Chase, Henry Clinton,	Swampscott.
Clark, Orton Loring,	Malden.
Cobb, George Robert,	Amherst.
Coleman, William John,	Natick.
Cox, Leon Clark,	Boston.
Cummings, Winthrop Atherton,	Belchertown.
Cutting, Roy Edward,	Amherst.
Damon, Henry Frank,	Belchertown.
Daniel, John,	Osterville.
Davenport, Stearnes Lothrop,	North Grafton.
Davis, Paul Augustin,	Lowell.
Dolan, Clifford,	Hudson.
Draper, James Edwin,	Worcester.

Eastman, Perley Monroe,	Townsend.
Edmands, Ernest Carl,	Saugus.
Edwards, Frank Laurence,	Somerville.
Farley, Arthur James,	Waltham.
Farrar, Parke Warren,	Springfield.
Flint, Clifton Leroy,	Amesbury.
Fullam, Charles Francis,	North Brookfield.
Gillett, Chester Socrates,	Southwick.
Gillett, Kenneth Edward,	Southwick.
Gold, Frank Lyman,	Amherst.
Goodwin, Chester Linwood,	Brockton.
Gowdey, Carlton Cragg,	St. Michael, Barbados.
Hamburger, Amos Francis,	Hyde Park.
Hayes, Herbert Kendall,	North Granby, Conn.
Hayward, Warren Willis,	Millbury.
Howe, William Llewellyn,	Marlborough.
Hyslop, James Augustus,	Rutherford, N. J.
Ingalls, Dorsey Fisher,	Cheshire.
Jackson, Raymond Hobart,	Amherst.
Jennison, Harry Milliken,	Millbury.
Johnson, Frederick Andrew,	Westford.
Jones, Thomas Henry,	Easton.
Lacouture, George Louis,	Millbury.
Larsen, David,	Bridgeport, Conn.
Liang, Lai-Kwei,	Tientsin, China.
Miller, Danforth Parker,	Worcester.
Negus, Philip Henry,	Fall River.
O'Grady, James Raphael,	Holliston.
Pagliery, Joseph Cecilio,	New York, N. Y.
Parker, John Robert,	Poquonock, Conn.
Potter, John Sherman,	Concord.
Reed, Horace Bigelow,	Worcester.
Regan, William Swift,	Northampton.
Sawyer, William Francis,	Sterling.
Shattuck, Leroy Altus,	Pepperell.
Smith, George Franklin,	Barre.
Thurston, Frank Eugene,	Worcester.
Turner, Olive May,	Amherst.
Turner, William Franklin,	Reading.
Verbeck, Roland Hale,	Malden.
Warner, Theoren Levi,	Sunderland.
Waugh, Thomas Francis,	Worcester.
Wellington, Joseph Worcester,	Waltham.

Wheeldon, Albert James, . . .	Worcester.
Wheeler, Hermon Temple, . . .	Lincoln.
White, Herbert Linwood, . . .	Maynard.
Whiting, Albert Lemuel, . . .	Stoughton.
Whitmarsh, Raymond Dean, . . .	Taunton.
Wright, Samuel Judd, . . .	South Sudbury.
Total,	79

Short Winter Courses.

Abbott, Chester Denning, . . .	Andover.
Austin, Frank Lee,	Potsdam, N. Y.
Blair, Alfred Wingate,	Roxbury.
Browning, Homer Franklin,	Northfield.
Dorr, Herbert Andrews,	Richmond.
Dunbar, Frank Andrews,	Richmond.
Eldridge, Alvah Gorham,	Amherst.
Farwell, Fred Sherman,	West Fitchburg.
Gaskell, Edward Thompson,	Amherst.
Kendrick, Harry Newell,	East Charlemont.
Kilbourn, Farley Eugene,	Ashburnham.
Knox, Harry Cobb,	Roxbury.
Mead, Albert William,	Hartford, Vt.
Millard, Walter Burton,	Egremont.
Newcomb, Walter Lemuel,	Brattleboro, Vt.
Packard, Ransom Clayton,	Brockton.
Perry, Arthur Asa,	South Pomfret, Vt.
Phillips, Homer Grant,	Hadley.
Pick, Fred Mortimer,	Southborough.
Potter, Lincoln,	Worcester.
Runkle, Gordon,	Waltham.
Seely, Will Campbell,	Hamburg, N. J.
Shaw, Chester Linus,	Brockton.
Smith, George Clarence,	East Haddam, Conn.
Smith, Raymond Burr,	Chicago, Ill.
Stearns, Lynu Lawrence,	Hyde Park, Vt.
Thayer, Charles Hiram,	Hadley.
Trufant, Willard Evander,	Abington.
Twichell, Henry Sessions,	Brookfield.
Wilder, Frank Everett,	Petersham.
Wilmarth, Theoph. Williams,	Sunapee, N. H.
Total,	31

Course in Bee Culture.

Elwell, Maria Huntington,	Brooklyn, N. Y.
French, Jr., Thomas,	Amherst.
Hunt, Justine,	Newton.
Parker, Charles Morton,	Newtonville.
Phelps, Mrs. William Augustus,	Lee.
Smith, Raymond Burr,	Chicago, Ill.
Total,	6

Graduate Courses.*For Degrees of M.S. and Ph.D.*

Back (B.Sc., M. A. C., '04), Ernest Adna,	Florence.
Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.
Hodgkiss (B.Sc., M. A. C., '03), Harold Edward,	Wilkinsonville.
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.
Kibbey (A.B., Harvard, '04), Richards Carroll,	Marshalltown, Ia.
Osmun (B.Sc., M. A. C., '03), Albert Vincent,	Danbury, Conn.
Staples (B.Sc., M. A. C., '04), Parkman Fisher,	Westborough.
Tottingham (B.Sc., M. A. C., '03), William Edward,	Bernardston.
Tower (B.Sc., M. A. C., '03), Winthrop Vose,	Roxbury.
Whipple (B.Sc., Kansas Agr'l College, '04), Orville Blaine,	Olivet, Kan.
Total,	10

Special Students.

Ferguson, Mary Ellie Van Everen,	Central Valley, N. Y.
French, Vida Rachel,	Amherst.
Locke, Ada Elsie,	Somerville.
Magoun, Alice Neal,	Bath, Me.

Redding, Charlotte Wilmarth,	Amherst.	
Spaulding, Olive Mary,	Mapleton, Conn.	
Thayer, Lucy Clarke,	Hadley.	
Total,		7

Summary.

Graduate course:—

For degrees of M.S. and Ph.D.,	10
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Four-years course:—

Graduates of 1904,	20
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Senior class,	33
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Junior class,	34
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Sophomore class,	56
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Freshman class,	79
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Two-years course:—

Graduate,	1
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Winter courses,	31
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Bee course,	6
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Special students,	7
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Total,	277
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Entered twice,	6
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Total,	271
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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; paedogenesis; heterogamy; chemistry of colors in insects; luminosity; deformities of insects; variation; duration of life.

Ecology: 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.

Zoölogy.—This course is offered as a minor subject for candidates for the degree of Doctor of Philosophy.

General and comparative anatomy, both gross and microscopic; ontogeny and phylogeny; life cycles, metamorphosis and metagenesis; animal associations, colonial, commensal and parasitic, and symbiotic associations of animals and plants; adaptation, adaptive radiation and parallelisms.

Geologic, geographic and bathymetric distribution of animals.

Systematic zoölogy, including palæozoölogy; museum and field technique.

Economic zoölogy.

History and development of zoölogical science.

Weekly seminars and journal club meetings are held, in which all advanced students of zoölogy take an active part.

Collateral reading and a general knowledge of current zoölogical literature are required.

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 1905 and 1906 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 1905 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 22 and 23, and on Tuesday and Wednesday, September 19 and 20, 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 Pittsfield, but candidates may be examined and admitted at the convenience of the examiners, at other times in the year, but not during the summer vacation.

ENTRANCE EXAMINATION PAPERS USED IN 1904.

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

ALGEBRA.

1. Factor $\frac{8}{x^3} - 27y^6$.

Factor $a^2x^3 - \frac{8a^2}{y^3} - x^3 + \frac{8}{y^3}$.

2. Simplify $\frac{1-a^2}{(1+ax)^2-(a+x)^2} \div \frac{1}{2} \left\{ \frac{1}{1-x} + \frac{1}{1+x} \right\}$.

3. $\frac{7+x}{3} = \frac{9+y}{5} = \frac{11+x+y}{7}$. Solve for x and y .

4. $\left\{ (x) \left(\sqrt[n]{x^{-1/n}} \right) \right\}^{n^2}$. Express with positive exponents, and reduce to lowest terms.

5. Find square root of the binomial surd $4 - \sqrt{15}$.

6. $\left\{ \frac{x + \sqrt{x^2 - 9}}{x - \sqrt{x^2 - 9}} \right\}^{\frac{1}{2}} = x - 2$. Solve for x .

7. $\left\{ \begin{array}{l} \frac{1}{x^2} + \frac{1}{y^2} = 65 \\ \frac{1}{x} - \frac{1}{y} = 11 \end{array} \right\}$. Solve for x and y .

8. $\left\{ \begin{array}{l} xy + xy^2 = 12 \\ x + xy^2 = 18 \end{array} \right\}$. Solve for x and y .

GEOMETRY.

1. Prove: in any triangle, the product of any two sides is equal to the product of the segments of the third side formed by the bisector of the opposite angle, plus the square of the bisector.

2. The diameters of two concentric circles are 14 and 50 units, respectively; find the length of the chord of the greater circle which is tangent to the smaller.

3. Prove: two rectangles having equal altitudes are to each other as their bases. Prove case of incommensurable bases only.

4. Prove: two similar triangles are to each other as the squares of homologous sides.

5. The side of an equilateral triangle is 6; find the areas of its inscribed and circumscribed circles.

PHYSICAL GEOGRAPHY.

1. Describe the general arrangement of the mountain ranges in North America. How have they influenced the form of the continent? What two agencies have caused its irregularity of outline? Give examples illustrating each.

2. What do you mean by youth, maturity and old age on the part (a) of a river; (b) of a mountain range; (c) of a sea coast? Give the characteristics of each, with examples, preferably such as you have actually seen.

3. Locate and describe the prairies and the great plains, and tell for what industries each is best fitted. Describe also the great desert of the south-west, with its type of vegetation. By what means, if at all, can this desert be made to support mankind?

4. Distinguish between climate and weather. What factors influence the climate of a place? Compare that of Marseilles with that of Portland, Me., and in the same way the climate of London with that of Labrador.

5. Describe a glacier, its origin, moraines and glacial erosion. Are any glaciers found within the limits of the United States; if so, where? Describe the Greenland ice sheet, and tell what evidences we have that such a sheet once covered a part of North America. Give its probable cause, limits and direction of flow.

6. What are the various influences, geographical and climatic, which govern the distribution and migrations of animals and of mankind?

CIVIL GOVERNMENT.

1. Name the four forms through which the government of this country has passed. Explain these four forms. In what year did each end?

2. Write upon any (six) of the following topics. Accuracy of statement and fulness of detail are important in this work.

(a) The preamble to the Constitution of the United States.

(b) The legislative department of the State of Massachusetts.

(c) The legislative department of the United States government.

(d) The present way of choosing the President of the United States.

(e) The present way of choosing United States Senators.

(f) The executive departments of the United States government.

(g) The national bank system.

(h) The Louisiana purchase and its results.

PHYSIOLOGY.

1. Define an organ, a tissue, a cell. How may the tissues be classified? What do you mean by physiological division of labor? Illustrate.

2. Compare the blood and lymph. Where does the latter come from and where does the surplus lymph go, and what carries it there? What is the value of the lymph to the various tissues and organs?

3. Describe carefully the human arm, naming the different sorts of tissues found therein, the various bones and their joints, the different levers, and finally the uses of the arm, telling how it is adapted to these uses in comparison with the fore limb of a horse or dog.

4. Compare the veins, arteries and capillaries, with reference to their coats, muscular development, valves and elasticity. What is the pulse, and why is there no pulse in the veins? What causes the blood to flow in the veins?

5. What do you mean by digestion, by absorption, by assimilation? Where and by aid of what juices are the following substances digested: fats, starch and proteids? How do the digested substances get to the tissues which need them, and how are they utilized?

6. Give as fully as you can the anatomy and physiology of the ear, — the external ear, the tympanum, eustachian tube, semicircular canals and the cochlea.

GENERAL HISTORY.

1. Into what three periods may we divide our study of history? Give as closely as you can the limits of each period, with the reasons for your answer.

2. Describe some of the manners and customs of the early Spartans.

3. Give some of the causes, leaders, chief events and results of the Punic wars.

4. With what do we associate these names: Marathon, Lycurgus, Aristotle, Alexander the Great, Attila, Charlemagne, Peter the Great, the Vandals, Châlons, Richelieu?

5. Tell what you can of the crusades, speaking of their causes, objects, leaders and results.

6. During the Dark Ages two great institutions arose, — the papacy and feudalism. Explain them.

7. 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.

8. The French revolution: its causes and results.

9. What was the English civil war? Explain its causes, and speak of the great leader it developed.

10. Tell about the Louisiana purchase; by whom made, with what results, and of what especial significance just now.

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 in London.
- (c) An outline of Goldsmith's life.
- (d) Goldsmith's rank in English literature.
- (e) What Scott did for the English novel.
- (f) Scott's last days.
- (g) Lowell's life abroad.
- (h) Lowell's early surroundings.
- (i) An outline of Tennyson's life.
- (j) George Eliot's early days.

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) The lesson of the caskets in the "Merchant of Venice."
- (b) Some interesting characters in the "Vicar of Wakefield."
- (c) The character of Richard Cœur de Lion, as depicted in "Ivanhoe."
- (d) Early England, as shown in "Ivanhoe."
- (e) Tell the story of "The Princess."
- (f) The great lesson in "The Vision of Sir Launfal."
- (g) The influence of little Eppie on the character of 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 opera-

tions 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-book, 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 horticulture 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, six 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, twelve weeks, three hours a week. Structural, dynamical, physiographical and historical, based upon Scott's "Introduction to Geology." The course aims to give a review of the physical condition of the earth; the various dynamic agencies, and the results of their activities; the origin and structure of the rocks; and, finally, the geological history of the globe, and the appearance in time and the development of the principal races of animals and plants. The museum, lantern slides and the classic Connecticut valley afford ample means for illustration. — Professor LULL.

ZOOLOGY.

1. Anatomy and physiology, freshman year, one-half of the second semester, four hours a week. A text-book, Martin's "The Human Body," advanced course, is used, from which daily recitations are assigned, supplemented by demonstrations from the charts and models and from microscopic and other preparations. The fact that the subject is required for entrance makes it possible in a comparatively brief period to review the main features

of human anatomy, the generally accepted views concerning the physiology of the various organs, and the more essential laws of health; and, aside from the practical value of the last, the knowledge of the human system thus gained aids greatly in the zoölogical work to come. — Professor LULL.

2. Zoölogy, sophomore year, first semester, two periods a week. This is mainly a laboratory course, the aim being to familiarize the student with the structure of a number of typical forms, representative of the chief phyla of the animal kingdom, to train him to more precise habits of observation, and to lay the foundation for a more thorough understanding of laboratory technique. Lectures, amply illustrated by specimens, charts and lantern slides, supplement and render orderly the knowledge gained in the laboratory. — Professor LULL.

3. Zoölogy, elective, junior year, four periods a week. A course in comparative morphology and systematic zoölogy, based upon Parker and Haswell's "Text-book of Zoölogy." Opportunity is given for the careful dissection of each of the typical forms or its equivalent, described in the text, with a further series of animals for comparative study. Special attention is paid to individual and racial development, adaptation, relationship of animals to one another and to plants, geological and geographical distribution of animals, and the economic importance of the different groups, except the insects, both living and extinct. The lectures are illustrated by the very complete museum collection. — 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, junior year, first semester, four hours a week. (1) The elements of political economy are taught by means of text-book (this year Henry Rogers Seagen's "Introduction to Economics") 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's "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 the last half of the first semester and the whole of the second semester. (1) Political institutions. By use of text-book (Albert Bushnell Hart's "Actual Government") 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. Woodrow Wilson's "The State" is used as a book of reference. (2) Constitutional history of the United States, with discussions relating to the origin, nature, scope and purpose of government. Bancroft's "History of the Constitution of the United States" is used as a book of reference. — 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 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. — Assistant Professor BABSON.

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. — Assistant Professor BABSON.

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. — Assistant Professor BABSON.

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, first 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., and of their functions and chemical and physical properties. This course extends into the next semester. — Mr. FRANKLIN.

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. FRANKLIN.

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, and is necessary for a comprehension of the following courses. — Mr. FRANKLIN.

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 method 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 OSTRANDER.

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. Nichols' "Analytic Geometry." — Professor OSTRANDER.

Second semester, four hours a week. Differential and integral calculus. Osborne's "Calculus." — Professor HASBROUCK.

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. Barton's "Surveying."—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 for 1904-05 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 1905-06 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, the measurement of earth work, 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; free-hand 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. — PROFESSOR 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 Garenes' "Introducción 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. An understanding of the rudiments of grammar, facility in translation and an ability to pronounce the language and to understand simple spoken German are the main objects in view. — Assistant Professor BABSON.

Course II.: elective for both semesters of senior year, four hours a week. Special attention is given to the reading of German, particularly to German of a scientific nature. Work is also required in prose composition throughout the year. Accuracy in pronunciation, the ability to understand German as spoken in the class room, and to converse within reasonable limits, are also features of this course. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Assistant Professor BABSON.

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." — Major 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, }	4
		Chemistry, half semester, }	
		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 in agriculture,	{	Agriculture, 3+1,	4	— 20
		Botany, 2+1,	3	
		Chemistry,	3	
		Geology,	3	
		Horticulture,	3	
		English,	4	
Course in horticulture,	{	Horticulture,	4	— 21
		Horticulture, 1+3,	4	
		Botany, 2+1,	3	
		Chemistry,	3	
		Geology,	3	
		English,	4	
Course in biology,	{	Zoölogy, 3+1,	4	— 20
		Botany, 2+1,	3	
		Chemistry,	3	
		Geology,	3	
		Horticulture,	3	
		English,	4	
Course in chemistry,	{	Chemistry,	4	— 21
		Agriculture, 3+1,	4	
		Mathematics,	4	
		Geology,	3	
		English,	4	
		Special subject,	2	
Course in mathematics,	{	Analytical geometry,	4	— 21
		Engineering, 1+3,	4	
		Free-hand drawing,	2	
		Landscape gardening,	4	
		Geology,	3	
		English,	4	
Course in landscape gardening,	{	Landscape gardening,	4	— 22
		Agriculture, 2+1,	3	
		Botany, 2+1,	3	
		Free-hand drawing,	2	
		Horticulture,	3	
		Geology,	3	
English,	4			

Second Semester.

Course in agriculture,	{	Agriculture, 2+1,	3	— 20
		Botany, 2+1,	3	
		Chemistry,	4	
		Horticulture,	2	
		Entomology,	4	
		Economics,	4	
Course in horticulture,	{	Horticulture,	4	— 21
		Botany, 2+1,	3	
		Chemistry,	4	
		Landscape gardening,	2	
		Entomology,	4	
		Economics,	4	
Course in biology,	{	Entomology,	4	— 20
		Zoölogy,	3	
		Botany, 2+1,	3	
		Chemistry,	4	
		Horticulture,	2	
		Economics,	4	
Course in chemistry,	{	Chemistry,	5	— 21
		Agriculture, 2+1,	3	
		Mathematics,	4	
		Economics,	4	
		Special subject,	5	
Course in mathematics,	{	Engineering,	5	— 19
		Mathematics,	4	
		Mechanical drawing,	2	
		Landscape gardening,	4	
		Economics,	4	
Course in landscape gardening,	{	Landscape gardening,	4	— 22
		Botany, 2+1,	3	
		Mechanical drawing,	2	
		Engineering,	5	
		Entomology,	4	
		Economics,	4	

SENIOR YEAR.

First Semester.

The following subjects are required in all courses : —

Bacteriology, half semester, 4,	. . . . .	}	. . . . .	4
Constitution of the United States, 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 courses, closely correlated with his junior year course ; only one course in language may 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. No admission examinations are required. 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),	3
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, 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.

Sophomore Laboratory. — A large, well-lighted room, situated in the old chapel building, is fitted with tables and apparatus, such as microscopes, dissecting instruments and the like, which are necessary for a beginners' course in zoölogical dissection.

Advanced Laboratory. — The room formerly used as a lecture room has been fitted up as a laboratory for advanced students. It is in South College, adjacent to the museum, and is amply supplied with the best apparatus obtainable. The equipment includes compound and simple microscopes, dissecting instruments and trays, an incubator, paraffin bath, microtomes, etc., also a reference library, containing the current zoölogical journals and a good series of mounted slides for the microscope.

Zoölogical Lecture Room. — The department has the privilege of using the philosophical lecture room, which communicates directly with the advanced laboratory. The lecture equipment includes, besides the museum specimens, the Leuckart series of charts, and many specially made charts as well; the Auzoux

models, illustrative of human and comparative anatomy; and an electric stereopticon.

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 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 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, paraffin 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 Wheatstone 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 building 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 25,829. 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, to be paid in advance, 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 one period of two hours 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,	12 00	12 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
Miscellaneous,	41 00	45 00
	\$220 50	\$300 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 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.

Notwithstanding the death of Mr. Flint, in June, these prizes will be continued under the name of the Flint prizes.

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 her-

barium; ten dollars for the best collection of Massachusetts trees and shrubs; and ten dollars for the best collection of Massachusetts woods.

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, 1904.

Grinnell Agricultural Prizes (Senior). — First prize, Arthur Witter Gilbert; second prize, Sidney Burritt Haskell.

Hills Botanical Prizes (Senior). — First and second prizes, Ernest Adna Back.

Flint Oratorical Prizes (Junior). — First prize, George Howard Allen; second prize, Albert Davis Taylor.

Burnham Essay Prizes (Sophomore). — First prize, Arthur Alphonse Racicot, Jr.; second prize, Edwin Hobart Scott; third prize, Frank Augustus Ferren.

Burnham Declamation Prizes (Freshman). — First prize, Charles Arthur Allenham Rice; second prize, George Whitney Searle.

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: Fayette D. Couden, Howard M. White, Clarence H. Griffin.

Winter Course in Dairy Farming. — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, \$50, Charles H. Thayer; second prize, \$30, Gordon Runkle; third prize, \$20, Fred S. Farwell.

Massachusetts Society for Promoting Agriculture: for highest scoring tub butter, first prize, \$25, Chester D. Abbott; second prize, \$15, Albert W. Mead; third prize, \$10, Alvah G. Eldridge.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, \$10, Fred M. Pick; second prize, \$7.50, Gordon Runkle; third prize, \$5, Homer G. Phillips; fourth prize, \$2.50, Chester L. Shaw.

The Vermont Farm Machine Company of Bellows Falls, Vt.:

for highest scoring print butter, first prize, \$15 ; Albert W. Mead ; second prize, \$10, Alvah G. Eldridge.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one-half ton Stockbridge fertilizer, Gordon Runkle.

Special prize, given by B. von Herff of New York, for best knowledge of the use of fertilizers on grass lands, one ton kainite, Gordon Runkle.

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.

RECEIPTS AND EXPENDITURES FOR YEAR, JAN. 1 TO DEC. 21, 1904.

RECEIPTS.

State Treasurer, Morrill fund,	\$16,666 66	
Endowment fund,	10,127 12	
Maintenance appropriation,	5,000 00	
Instruction appropriation,	11,750 00	
Scholarship appropriation,	13,750 00	
Labor appropriation,	5,000 00	
Special for deficit in coal in 1903,	3,500 00	
Heating and lighting maintenance,	375 00	
Dining-hall maintenance,	375 00	
Labor fund,	19 29	
Library fund,	641 10	
Burnham emergency fund,	150 00	
Botanical laboratory,	117 00	
Chemical laboratory,	652 14	
Entomological laboratory,	58 23	
Veterinary laboratory, appropriation,	\$500 00	
Cash,	15 75	
	<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>	515 75
Zoölogical laboratory,	102 50	
Landscape gardening tax,	54 50	
Term bill,	4,065 49	
Heating and lighting,	2,060 72	
Agricultural department,	875 45	
Farm,	6,730 12	
Horticultural department,	4,881 12	
Expense,	880 68	
Tools and implements,	1 01	
Furniture,	3 00	
	<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>	\$88,351 88

EXPENDITURES.

Labor fund,	\$4,955 97
Library,	3,108 08
Botanical laboratory,	137 74
Chemical laboratory,	185 63
	<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>
<i>Amount carried forward,</i>	\$8,387 42

<i>Amount brought forward,</i>		\$8,387 42	
Entomological laboratory,		111 49	
Veterinary laboratory,		1,156 93	
Zoölogical laboratory,		284 61	
Landscape gardening,		28 90	
Burnham emergency fund,		125 00	
Salary,		30,910 48	
Extra instruction,		185 00	
Term bill,		1,372 89	
Advertising,		450 20	
Heating and lighting,		8,080 22	
Agricultural department,		1,913 68	
Farm,		10,561 45	
Horticultural department,		8,487 44	
Expense,		8,850 26	
Insurance,		15 00	
Tools and implements,		7 75	
Furniture,		235 97	
Dining hall, 1903,		3,774 16	
Dining hall, 1904,		3,669 52	
Total expenditures,		<u> </u>	\$88,608 37
Total receipts,			<u>88,351 88</u>
Excess of expenditures over receipts,			\$256 49

CASH ACCOUNT.

Dr.

Cash on hand Jan. 1, 1904, \$6,754 70

Cr.

Cash on hand and in local bank Dec. 21, 1904,	\$4,698 21	
Deposit with Hampden Trust Company,	1,800 00	
Excess of expenditures over receipts,	256 49	
	<u> </u>	\$6,754 70

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	
	<u> </u>	\$44,350 00

Buildings (Estimated Value).

Drill hall,	\$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
	<u> </u>	
<i>Amounts carried forward,</i>	\$6,575 00	\$44,350 00

<i>Amounts brought forward,</i>	\$6,575 00	\$44,350 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,	1,500 00	
Boarding house,	1,000 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	
	<hr/>	246,775 00
		<hr/>
		\$291,125 00

EQUIPMENT.

Botanical department,	\$4,310 00	
Horticultural department,	14,113 89	
Farm,	17,912 58	
Chemical laboratory,	1,775 00	
Botanical laboratory,	2,866 53	
Entomological laboratory,	15,425 00	
Zoölogical laboratory,	3,286 00	
Zoölogical museum,	6,103 00	
Veterinary laboratory,	6,004 46	
Physics and mathematics,	3,848 60	
Agricultural department,	3,500 00	
Agricultural laboratory,	1,300 00	
Library,	25,973 00	
Fire apparatus,	400 00	
Band,	350 00	
Furniture,	1,400 00	
Text-books,	300 00	
Tools, lumber and supplies,	252 00	
Heating and lighting,	53,423 00	
Dining hall,	5,000 00	
	<hr/>	\$167,543 06

BALANCE SHEET DEC. 21, 1904.

Assets.

Real estate,	\$291,125 00	
Equipment,	167,543 06	
	<hr/>	\$458,668 06

Quick Assets.

Bills receivable :—		
Farm,	\$245 84	
Horticulture,	497 93	
Heating and lighting,	846 06	
Rents and text-books,	813 15	
Laboratory fees,	478 00	
Dining hall,	534 50	
Mary Robinson fund,	36 76	
Whiting Street fund,	5 24	
	<hr/>	\$3,457 48
Notes,	72 00	
Cash on hand and in local bank,	4,698 21	
Hampden Trust Company,	1,800 00	
	<hr/>	10,027 69
		<hr/>
		\$468,695 75

Liabilities.

Bills payable :—		
Farm,	\$1,401 54	
Horticulture,	392 66	
Expense,	74 09	
Heating and lighting,	846 65	
Library,	221 25	
Furniture,	49 75	
Laboratories,	17 11	
Due Gassett scholarship,	22 00	
Due Grinnell prize,	66 24	
Due Hills fund,	462 43	
Due Burnham emergency,	135 56	
Due labor fund,	371 01	
Due individual labor,	349 72	
Due veterinary laboratory,	154 82	
	<hr/>	\$4,564 83
Burnham emergency fund,	3,000 00	
	<hr/>	7,564 83
		<hr/>
Balance,		\$461,130 92

INVESTMENT.

Endowment Fund.

United States grant,	\$219,000 00	
Commonwealth grant,	142,000 00	
	—————	\$361,000 00

This fund is in the hands of the State Treasurer, and the Agricultural College receives two-thirds of the income from the same (for amount of income, see college receipts).

Individual Labor Fund.

Two bonds American Telephone and Tele- graph 4s,	\$2,000 00	
One bond New York Central debenture 4s, Hampden Trust Company,	1,000 00	
	1,500 00	
Cash,	500 00	
	—————	\$5,000 00

Hills Fund.

Northampton Institution for Savings,	\$2,180 00	
One bond American Telephone and Tele- graph 4s,	1,000 00	
Three American Telephone notes, 5 per cent.,	3,000 00	
One bond New York Central debenture 4s,	1,000 00	
One bond New York Central & Lake Shore 3½s,	1,000 00	
Boston & Albany Railroad stock,	362 00	
	—————	\$8,542 00

Burnham Emergency Fund.

Northampton Institution for Savings,	\$2,000 00	
Massachusetts Agricultural College note,	3,000 00	
	—————	\$5,000 00

(For amount of income, see college receipts.)

Mary Robinson Fund.

Northampton Institution for Savings,	\$820 00	
Boston & Albany Railroad stock,	38 00	
	—————	\$858 00

Whiting Street Fund.

One bond New York Central debenture 4s,	\$1,000 00	
Amherst Savings Bank,	260 00	
	—————	\$1,260 00

Gassett Scholarship Fund.

One bond New York Central debenture 4s,	\$1,000 00	
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Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock,	\$1,000 00
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Massachusetts Agricultural College.

One share New York Central & Hudson River Railroad stock,	\$100 00
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Library Fund.

Amherst Savings Bank,	\$10,546 12
(For amount of income, see college receipts.)	

INVESTMENT CASH ACCOUNT.

FUND.

Receipts.

Hampden Trust Company, individual labor fund,	\$3,000 00	
Northampton Institution for Savings, Hills fund,	\$4,000 00	
Agawam National Bank, Hills fund,	2,000 00	
	<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>	6,000 00
Amherst Savings Bank, Whiting Street fund,		1,000 00
Amherst Savings Bank, Gassett scholarship fund,		1,000 00
Coupons American Telephone notes,		75 00
(Toward payment in premium of same.)		
Cash, individual labor fund,		500 00
		<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>
		\$11,575 00

Expenditures.

Two bonds, individual labor fund,	\$1,859 00	
One bond, individual labor fund,	997 61	
One bond, Hills fund,	969 67	
Two notes, Hills fund,	3,113 75	
One bond, Hills fund,	1,010 08	
One bond, Hills fund,	908 75	
One bond, Whiting Street fund,	988 36	
One bond, Gassett scholarship fund,	988 36	
		<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>
		10,835 58
		<hr style="width: 100px; margin-left: auto; margin-right: 0;"/>
Excess of receipts over expenditures,		\$739 42

INCOME.

Receipts.

Individual labor fund,	\$103 80	
Hills fund,	363 43	
Mary Robinson fund,	34 07	
Whiting Street fund,	45 20	
Gassett scholarship fund,	40 00	
Grinnell prize,	50 00	
Massachusetts Agricultural College,	5 00	
	<hr/>	\$641 50

Expenditures.

Individual labor fund,	\$16 25	
Hills fund,	106 16	
Mary Robinson fund,	91 20	
Whiting Street fund,	71 64	
Gassett scholarship fund,	66 16	
Grinnell prize,	55 00	
	<hr/>	406 41

Excess of receipts over expenditures, \$235 09

This is to certify that I have examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, for the year ending Dec. 21, 1904. All bonds and investments are as represented in the report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

AMHERST, Dec. 23, 1904.

GIFTS.

- FROM W. H. BOWKER (M. A. C., '71), Boston, one-half ton high-grade Stockbridge fertilizer, for prize in dairy school.
- MASSACHUSETTS SOCIETY FOR PROMOTING AGRICULTURE, Boston, one hundred and seventy-five dollars in prizes for dairy school.
- B. VON HERFF, New York, one ton kainite, for prize in dairy school.
- VERMONT FARM MACHINE COMPANY, Bellows Falls, Vt., twenty-five dollars in prizes for dairy school.
- NATIONAL MILK SUGAR COMPANY, New York, four hundred pounds milk albumen.
- CHILEAN NITRATE WORKS, New York, four thousand pounds nitrate of soda.
- S. M. BARNARD COMPANY, Forestville, Conn., two stanchions.
- CYPHERS INCUBATOR COMPANY, Buffalo, N. Y., one gallon napreol.
- STODDARD MANUFACTURING COMPANY, Rutland, Vt., one gallon turbine separator oil.
- MT. TOM SULPHITE PULP COMPANY, Mt. Tom, seventy pounds wood pulp.
- J. A. BENNETT & SON, Gouverneur, N. Y., one incubator, one brooder.
- JOSEPH BRECK & SONS, Boston, one incubator, one brooder.
- M. CAMPBELL FANNING MILL COMPANY, Detroit, Mich., one incubator, one brooder.
- JOHN R. CLISBY, Arcola, Ill., eight ears seed corn.
- EDMUND MORTIMER & Co., New York, one ton Peruvian guano.
- CHEMICAL WORKS, late H. & E. ALBERT, London, Eng., two tons basic slag.
- WESSON STANCHION COMPANY, Cuba, N. Y., two stanchions.
- W. T. SNOW, Westfield, fifty pounds bone charcoal.
- SEED LABORATORY, UNITED STATES DEPARTMENT OF AGRICULTURE, Washington, D. C., two sets of seeds in vials.

FROM GERMAN KALI WORKS, New York, thirty-five hundred pounds potash-magnesia sulfate; twenty-five hundred pounds high-grade sulfate; five thousand pounds muriate; one hundred pounds silicate; two hundred and twenty-four pounds carbonate; five hundred pounds kainite.

PETER HENDERSON & Co., New York, twenty-six varieties of grass seed, seven of clover, seven of oats, four of barley, one of rye.

D. H. BURRILL & Co., Little Falls, N. Y., paint, varnish and transfers for eight testers.

C. S. PLUMB (M. A. C., '82), Columbus, O., herbarium containing one thousand species native American plants.

WALLACE R. PIERSON (M. A. C., '01), Cromwell, Conn., one hundred and sixty rose plants.

Mrs. ANNIE TRUMBULL SLOSSON, New York, collection of Florida Hemiptera.

R. A. COOLEY (M. A. C., '95), Bozeman, Montana, J. R. DE LA TORRE BUENO, New York, and others, insects.

Mrs. CHARLES L. FLINT, Brookline, collection of zoölogical specimens, minerals and curios.

ESTHER C. CUSHMAN (M. A. C., '05), Amherst, partridge.

HAROLD E. HODGKISS (M. A. C., '02), Wilkinsonville, horned toad.

LOANS.

FROM EMPIRE CREAM SEPARATOR COMPANY, Bloomfield, N. J., two separators.

P. M. SHARPLES, West Chester, Pa., three separators.

NATIONAL DAIRY MACHINE COMPANY, Newark, N. J., one separator and stand.

VERMONT FARM MACHINE COMPANY, Bellows Falls, Vt., five separators, one tester.

DE LAVAL SEPARATOR COMPANY, New York, six separators.

DES MOINES INCUBATOR COMPANY, Des Moines, Ia., one incubator, one brooder.

HUMPHREY & SONS, Joliet, Ill., one brooder.

STODDARD MANUFACTURING COMPANY, Rutland, Vt., combined churn and butter-worker, pasteurizer.

FARM REPORT.

During the past year a change has been made in the management of the college farm. Mr. E. A. Jones, who had faithfully discharged the duties of farm superintendent for ten years, sent in his resignation in March, to take effect on the first of May. His place was taken on this date by E. H. Forristall, M.S., of the New Hampshire Agricultural College, who at one time successfully superintended the college farm of that institution, and later accepted and filled the position of superintendent on one of the farms managed for the production of high-grade milk by the Walker-Gordon Company. Mr. Forristall has taken hold of the work of his position with much enthusiasm. It would be manifestly unfair to judge his work on the basis of the results obtained during the past season, for he had not the advantage of beginning as early as would have been desirable, and the season, like those of the two previous years, has been highly unfavorable to success with some of our most important crops. The excessive rainfall during the period from about the 1st of April to the 7th of June, and the abnormally low summer temperatures, are conditions responsible for the partial failure of all crops requiring a long and warm season. The effects of the seasonal peculiarities referred to were greatly aggravated by the fact that the first killing frost came fully three weeks earlier than is usual in this section (September 22). The corn crop, which, on account of the excessive wetness of many of our fields, was not all planted until after the middle of June, was seriously injured by this early freeze. The crops of the year which have given best returns are hay, roots and celery. All of these gave results better than average, both as regards quantity and quality. The nature of the farm operations and the financial results with the several crops are shown in the following table:—

College Farm Crops.

CROPS.	Acres.	TOTAL PRODUCT.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.	Labor and Seed.			
Celery,	1	170 doz. bunches.	-	\$10 47	\$53 45	\$229 50	\$154 58	-
Carrots,	$\frac{1}{3}$	251	-	11 23	15 00	125 50	99 27	-
Mangels,	$\frac{1}{3}$	-	23 $\frac{1}{2}$	11 23	15 90	116 66	89 53	-
Turnips,	-	138	-	-	28 10	34 50	6 40	-
Ensilage corn,	22	-	300	288 70	443 90	1,050 00	317 40	-
Field corn,	8	465 hard. 75 soft.	Stover 22	121 50	259 40	585 60	204 50	-
Potatoes,	8	725 large. 300 small.	-	159 50	443 90	451 01	-	\$152 39
Hay,	71	-	190	-	-	2,376 00	-	-
Rowen,	-	-	60	-	-	960 00	-	-
Rowen pastured,	-	-	10	-	-	50 00	-	-
Oats and peas, green,	1	-	15	-	31 00	45 00	-	-

THE SYSTEM FOLLOWED IN THE USE OF MANURES AND FERTILIZERS.

The manures and fertilizers used for the several crops of the year are shown in the table on the following page. It is our practice to haul manure from the pits in which it accumulates at frequent intervals, and, as a rule, it is spread when hauled. Much of the manure used accordingly lies upon the surface several months. On old land it is plowed under in spring. If applied to sod land, which has been fall plowed, the manure is worked into the ground with a disc harrow in spring. The fertilizers used for the several hoed crops are for the most part spread broadcast after the field is plowed, and harrowed in, although it is our practice to use a moderate amount of nitrate of soda together with a little acid phosphate and potash in the drill. The potato crop is in some respects an exception. We find that with this better results are obtained if a larger proportion of the fertilizer is applied in the drill; and, as a rule, about two-thirds of the total amount is so applied. The fertilizers used on grass lands are applied in mid-spring by the use of the Stevens broadcast fertilizer distributor.

Manures and Fertilizers for the Several Crops per Acre.

	Corn, Campus, Two Acres.	Corn, Eight Acres.	Corn, Ensilage, Twelve Acres.	Field Corn.	Mangels, One- third Acre.	Carrots, One- third Acre.	Potatoes, Eight Acres.
Manure (cords),	-	3	3	2	4	4	4
Nitrate of soda (pounds),	100	100	125	125	200	200	100
High-grade sulfate of potash (pounds),	150	125	150	150	-	-	250
Phosphatic slag (pounds),	500	300	500	500	600	600	-
Lime (pounds),	-	-	-	2,000	-	-	-
Muriate of potash (pounds),	-	-	-	-	350	350	-
Dried blood (pounds),	-	-	-	-	-	-	150
Tankage (pounds),	-	-	-	-	-	-	250

EXPERIMENTS IN THE USE OF MANURES AND FERTILIZERS.

A. Method of Application of Barnyard Manure.

On the grounds of the experiment station we have for a number of years been comparing two systems of handling manures; namely, spreading the fresh manure upon the surface of the ground during the late fall and winter months, in comparison with the system of putting the fresh manure as made during the winter into large heaps, from which it is taken in the spring when the land is ready to plow. The manure in both cases is plowed in, but that spread in winter lies on the surface a variable time, from an extreme period of five months to a few weeks only. The field in the experiment station grounds where these two systems are under comparison is one with a considerable slope. It seemed desirable to compare these same methods upon level land, and a field suited to that purpose was found on the grounds of the college farm. Two plots of one acre each were laid out in the autumn of 1901. The crops of the two following seasons were corn, and for both years the yield of corn on the winter-spread manure was slightly greater than on that spread in the spring. The crop during the past season also was corn for the silo. The yield on the acre on which the manure was spread in winter was 43,855 pounds: on the acre on which it was spread in the spring, 27,240 pounds. The advantage appears to be largely in favor of winter spreading; but, although it is impossible to point to any accidental variation in conditions on the two plots, it seems difficult to believe that the difference in the time of spreading the manure should be responsible for so great a difference in the crops.

B. Experiment in the Use of Fertilizers on Permanent Mowings.

On different portions of the college campus, which is kept permanently in grass, we have laid out a considerable number of plots to which various combinations and amounts of fertilizers have been applied. Nitrate of soda is used alone on a few plots, a potash salt and basic slag on a number of others, a potash salt and basic slag and varying quantities of nitrate of soda on still others. The continuous use of nitrate of soda alone has produced a fair crop of hay, which consists exclusively of grasses. In a half-acre plot, to which nitrate of soda alone has been applied since 1899, there is at present scarcely a single clover plant. On an adjoining plot, with soil of precisely the same character, to which at first potash alone was applied, and to which for the past two years muriate of

potash and basic slag have been applied, clovers predominate. On those plots to which a potash salt and basic slag together with nitrate of soda is applied, there is a considerable proportion of clover, and the crops have been very satisfactory. During the past season the usual rate of application has been: muriate or high-grade sulfate of potash, 150 pounds; basic slag, 500 pounds, per acre; and with these amounts of potash and slag we have used nitrate of soda on different plots in quantities ranging from 150 to 250 pounds per acre. The larger applications of nitrate in general gave most profitable crops, although in one of our fields extensive lodging was the consequence whenever nitrate was applied in quantities in excess of 200 pounds to the acre.

LIVE STOCK.

The general average of health maintained by our live stock during the past year has been good. We have lost one valuable horse, which was found dead in the morning with a ruptured stomach, no doubt the consequence of an attack of colic. One breeding sow was found dead, and post-mortem examination revealed internal hemorrhage as the apparent cause of death. The presence of a skewer in swill fed to our hogs caused the death of another. The kinds and numbers of the several classes of live stock are shown below:—

Horses. — French Coach, 1 stallion, 1 mare, 3 fillies; Percheron, 1 stallion; German Coach, 1 mare; French Coach, half blood, 2 colts; Percheron, three-fourths blood, 2 mares, 1 yearling gelding; work horses, 3.

Neat Cattle. — Jersey, 1 bull, 4 cows, 2 heifers, 1 calf; Holstein-Friesian, 1 bull, 4 cows; Ayrshire, 1 bull, 4 cows; Short-horn, 1 bull, 1 cow; grade, 32 cows, 9 heifers, 12 calves; 1 Jersey bull calf; total, 74 head.

Sheep. — Southdown, 4 breeding bucks, 50 ewes, 2 lambs; total, 56 head.

Swine. — Berkshire, 1 boar, 5 sows; Yorkshire, 5 sows; shoats, 47; total, 58 head.

THE MILK RECORD.

The policy of disposing of the least satisfactory cows in our herd has been continued during the past year, and a few superior grade cows have been purchased. The average product for the year shows a marked improvement, as compared with recent years. The average number of cows milked during the year is $35\frac{1}{2}$. The total yield of milk has been 232,463 pounds,—an average

per cow of 6,610 pounds. The average butter fat test for the herd is about 4.2 per cent., which makes an average yield of butter fat per individual cow of 277.62 pounds, which is the equivalent of about 319 pounds of butter per cow per year.

IMPROVEMENTS.

The principal improvements of the past year are as follows:—

About two additional acres in Durfee pasture have been cleared of stumps, and most of this is plowed and ready for a crop. The four acres which had been previously cleared have been seeded, and the condition of the grass indicates a very satisfactory crop next season.

About one acre of land lying on either side of the road running between the Durfee pasture and the south flat has been improved by the removal of an enormous quantity of rubbish which had been deposited there while the place was used as a public dump, and by grading, plowing and seeding. This work greatly improves the appearance, and the land by the roadside will now yield a profitable crop of grass.

Considerable work in the way of improvement has also been done in the neighborhood of the rifle butt and in the ravine.

THE FARM FINANCES.

The cash receipts for the year are \$6,680.94, and there is due on accounts for sales made during the year the sum of \$79.38; this, added to the cash receipts, makes a total of \$6,760.32. Last year the similar total was \$10,009.49; there is a decrease, therefore, for this year of \$3,249.17. The total expenses of this year have amounted to \$10,470.79. The inventory at the present time amounts to \$17,912.58, which is \$878.27 less than the inventory of last year. Although the machines, implements, vehicles, etc., of the farm have suffered the usual depreciation from use, the decrease in the inventory is the consequence mainly of a more discriminating valuation. The decrease is confined entirely to the items which make up the equipment of the farm. The cash received during the year has been derived from the following sources: for milk and cream, \$3,125.50; cattle, including calves for veal, \$1,385; horses, including fees for the use of stallions, \$241.50; swine, \$198.71; sheep, \$120.27; hay, \$86.61; potatoes, \$445.66; celery, \$122.46; team labor, \$1,084.95; manual labor, \$52.36; and sundries, \$680.33.

WM. P. BROOKS,

Professor of Agriculture.

MILITARY DEPARTMENT.

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, 1904.

Instruction has been both practical and theoretical, conducted in compliance with the college schedule and regulations.

Under the provisions of General Orders, No. 65, War Department, dated April 6, 1904, educational institutions at which regular army officers are detailed for duty are divided into three classes, designated A, B and C, and the course of military instruction prescribed for each. Under the provisions of the above-mentioned order this college is placed in Class B, and the following course of instruction prescribed, viz. : —

Practical. — Infantry drill regulations through the school of the battalion, in close and extended order; advance and rear guards, outposts and marches; the ceremonies of battalion parade, review, inspection and escort of the colors; infantry target practice; instruction in first aid to the injured; a guard to be mounted five times in each week of the school year, weather permitting, and the guard practically instructed for one hour in the posting and relief of sentinels and their duties, the latter to be outside the hours provided for other ceremonies.

Theoretical. — Infantry drill regulations covered by practical instruction; the manual of guard duty; small arms firing regulations, and the most important of the articles of war; records which pertain to the administration of a company; ten lectures during the course of each school year on various military subjects, notes to be taken by the students, and made the basis of subsequent recitations.

This order has been complied with as far as it pertains to theoretical instruction, but only with the senior and freshman classes, as per college schedule. The order relating to practical instruc-

tion has been complied with only as provided by college schedule, — three hours per week, as scheduled, with the addition of certain exercises from 8.30 to 10.30 A.M. every Saturday, instituted to satisfy demerits incurred in the military department, such as unauthorized absence from drill or inspection, or rooms, arms and equipments or uniform not in proper condition.

The hours of regular drill are from 3.45 to 4.45 P.M., every Monday, Tuesday and Thursday. All rooms occupied by students in dormitories, all closets, sinks, etc., are carefully inspected every Saturday morning, and special attention paid to sanitation. Students not otherwise engaged are required to be present at these inspections. The order of drill commences with small squads for freshmen, and continues until they are sufficiently instructed for assignment to companies, after which the exercises include all drills and ceremonies prescribed for company and battalion. On account of the inclemency of the weather during the winter, all drills and ceremonies are conducted in the drill hall, and, in order to avoid tedious monotony, embrace infantry manual of arms; field artillery, single gun detachment only; gallery practice, consisting of firing at an iron target with the service rifle and reduced charge of powder; sighting and aiming drill; Butt's "Manual of Physical Drill;" first aid to the injured; and signal drill.

Most of the students have had target practice during the past year, at short ranges, with the old Springfield cadet rifle. The results obtained have not been entirely satisfactory, owing to the limited time at my disposal. A student who is given an opportunity to practice on the range only a few times during the whole year, and these times limited to the drill hour, cannot be expected to manifest much enthusiasm. This is a subject which is given great weight in all military organizations, both regular and militia, and should receive greater consideration in this college. To become a good marksman requires intelligent instruction on the range, a careful study of the mechanism of the rifle, and frequent practice under various conditions of weather. In all previous annual reports I have recommended that the student body be allowed to go into camp for one week in each college year, about the first week in May, and the time devoted to practical instruction in field service, such as guard and outpost duty, target practice, construction of shelter trenches and castrametation. I consider this of inestimable value to all military students, but have not yet been able to carry it out, from lack of the necessary camp and garrison equipage.

In theoretical instruction I have given more than the required lectures on the subjects prescribed. I have had recitations from the senior class every Monday, and from the freshman class every Monday, Tuesday and Thursday. On account of the large class and the inadequacy of the lecture room it has been divided into three sections, so that I am able to meet all of the class once each week.

I beg to repeat the recommendation made in my last annual report, that a physician be employed and paid by the State, to devote one or two hours each day attending upon any of the students who may require such service. In addition to the reasons assigned in this recommendation, it will also prevent the danger of spreading contagious disease. I respectfully invite special attention to this subject.

All the buildings under my supervision are in good condition except the drill hall, which is greatly in need of shingling. This recommendation has been made in previous reports, but it has been found impossible to carry it out. The plumbing in all the buildings appears to be in good sanitary condition.

By act of Congress of Jan. 21, 1903, every ablebodied male citizen of the United States, between the ages of eighteen and forty-five years, is made a member of the militia, which is divided into two classes, the organized and unorganized, the organized militia to be known as the National Guard, and the unorganized to be known as the Reserve Militia. The same act authorizes the President to call forth such militia, from one or both classes, whenever it becomes necessary to suppress rebellion, to repel invasion or to execute the laws of the United States. The primary object of military instruction in educational institutions is to fit young men to hold commissions in such forces whenever called out. It has also a tendency to inculcate the spirit of patriotism in college students, by making them realize that, as citizens of the country, they owe a duty to it which they are liable to be called upon to discharge in a position of honor and trust. The true spirit of patriotism should dominate all military instruction, for without it tactical education is of little or no value.

Under the provisions of General Orders No. 94, War Department, 1902, the following-named students of the class of 1904 were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown special aptitude in the military department, viz.: Fayette D. Conden, Howard M. White and Clarence H. Griffin.

The following is a list of ordnance and ordnance stores on hand, property of the United States, in possession of the college, viz. : —

- 2 3.2-inch breech-loading steel guns, with implements complete.
- 2 8-inch mortars, with mortar beds and implements.
- 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.
- 50 blank cartridges for field guns.
- 4,000 metallic rifle ball cartridges, calibre 45.
- 4,500 metallic blank cartridges, calibre 45.
- 250 friction primers, radial, for field guns.
- 10,000 cartridge primers, small arms.
- 4,000 round balls for gallery practice.
- 25 pounds of powder, small arms, reloading.
- 8,000 pasters, black and white.
- 150 paper targets, "A" and "B."
- 1 set of marking rods, disks and brushes for gallery practice.

All this property is in good condition and well cared for. The Springfield cadet rifles are old and obsolete. It is very desirable to exchange them for the more modern rifle as soon as it can be done. I am informed, however, that this cannot be done until all the troops of the regular army and national guard have been supplied. It might be possible to obtain the "Krag Jorgensen" rifle, which is a great improvement over the old ones we now have; but this has recently been discarded by the regular army, and the improved Springfield, magazine rifle, calibre 30, adopted in its place, hence the "Krag Jorgensen" is now obsolete. It will, no doubt, be a long time before the new Springfield will be issued to colleges.

The military organization at present is as follows: one battalion of two companies of infantry, staff and band. For the purpose of battalion drill and ceremonies the two companies are equalized into four.

Commandant.

JOHN ANDERSON, Major, U. S. Army, Retired.

Staff and Non-commissioned Staff.

Cadet Adjutant, First Lieut. EDWIN W. NEWHALL, JR.

Cadet Quartermaster, . . . First Lieut FRANCIS A. BARTLETT.

Cadet Sergeant-Major, . . . EDWARD T. LADD.

Ordinance Sergeant, . . . JOHN J. GARDNER.

Priv. HUGH L. BARNES, battalion clerk.

Band.

CHARLES S. HOLCOMB, Chief musician, with rank of first lieutenant.

PERCY F. WILLIAMS, . Principal musician, with rank of first sergeant.

LEWELL S. WALKER, Sergeant.

LOUIS H. MOSELEY, Corporal.

STANLEY S. ROGERS, Corporal.

Privates, 14; aggregate, 19.

Company A.

FREDERICK L. YEAW, Cadet Captain.

GRENVILLE N. WILLIS, Cadet First Lieutenant.

JOHN F. LYMAN, Cadet Second Lieutenant.

GEORGE W. PATCH, Cadet First Sergeant.

WALTER B. HATCH, Cadet Sergeant.

BERTRAM TUPPER, Cadet Sergeant.

CLARENCE W. LEWIS, Cadet Sergeant.

NORMAN D. INGHAM, Cadet Sergeant.

WILLIAM M. SEARS, Cadet Corporal.

ARTHUR W. HALL, JR., Cadet Corporal.

HERMAN A. SUHLKE, Cadet Corporal.

FRY C. PRAY, Cadet Corporal.

WALTER E. DICKINSON, Cadet Corporal.

WILLIAM W. COLTON, Cadet Corporal.

BENJAMIN STRAIN, Cadet Corporal.

Total, Company A, 3 officers, 5 sergeants, 7 corporals, 54 privates; aggregate, 69.

Company B.

GEORGE H. ALLEN, Cadet Captain.

WILLARD A. MUNSON, Cadet First Lieutenant

ALBERT D. TAYLOR, Cadet Second Lieutenant.

CHESTER L. WHITAKER, Cadet First Sergeant.

THOMAS F. HUNT, Cadet Sergeant.

JAMES R. KELTON, Cadet Sergeant.

RICHARD L. ADAMS, Cadet Sergeant.

HARVEY D. CROSBY, Cadet Sergeant.

DANIEL H. CAREY, Cadet Corporal.

JAMES E. MARTIN, Cadet Corporal

FREDERICK C. PETERS,	Cadet Corporal.
GEORGE T. FRENCH,	Cadet Corporal.
CHARLES A. TIRRELL,	Cadet Corporal.
RALPH W. PEAKES,	Cadet Corporal.
ALEXANDER H. M. WOOD,	Cadet Corporal.

Total, Company B, 3 officers, 5 sergeants, 7 corporals, 55 privates; aggregate, 70.

Total in military department: 2 captains, 7 lieutenants, 14 sergeants, 16 corporals, 124 privates; aggregate, 163. Aggregate in military department last year, 139, — a net increase of 24.

Respectfully submitted,

JOHN ANDERSON,

Major, U. S. Army, Retired, 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. Receipts for and during the Year ended June 30, 1904.

1. State aid:—	
(a) Income from endowment,	\$1,919 19
(b) Appropriation for current expenses,	21,000 00
2 Federal aid:—	
(a) Income from land grant, act of July 2, 1862,	3,650 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,	3,292 00
Total,	<u>\$61,527 85</u>

II. Property, Year ended June 30, 1904.

Value of buildings,	\$248,775 00
Value of other equipment,	184,243 35
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60
Value of farm and grounds,	\$44,350 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, 1904,	25,268

III. Faculty during the Year ended June 30, 1904.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	26
2. Number of staff of experiment station,	22

IV. Students during the Year ended June 30, 1904.

1. College of Agriculture and Mechanic Arts, collegiate and special courses,	213
2. Graduate courses,	7
Total, counting none twice,	<u>220</u>

SEVENTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1905.

HATCH EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

OFFICERS.

HENRY H. GOODELL, LL.D.,	<i>Director.</i>
WILLIAM P. BROOKS, PH.D.,	<i>Agriculturist.</i>
GEORGE E. STONE, PH.D.,	<i>Botanist.</i>
CHARLES A. GOESSMANN, PH.D., LL.D.,	<i>Chemist (fertilizers).</i>
JOSEPH B. LINDSEY, PH.D.,	<i>Chemist (foods and feeding).</i>
CHARLES H. FERNALD, PH.D.,	<i>Entomologist.</i>
FRANK A. WAUGH, M.S.,	<i>Horticulturist.</i>
J. E. OSTRANDER, C.E.,	<i>Meteorologist.</i>
HENRY T. FERNALD, PH.D.,	<i>Associate Entomologist.</i>
FREDERICK R. CHURCH, B.SC.,	<i>Assistant Agriculturist.</i>
NEIL F. MONAHAN, B.SC.,	<i>Assistant Botanist.</i>
HENRI D. HASKINS, B.SC.,	<i>First Assistant Chemist (fertilizers).</i>
EDWARD G. PROULX, B.SC.,	<i>Second Assistant Chemist (fertilizers).</i>
EDWARD B. HOLLAND, M.S.,	<i>First Chemist (foods and feeding).</i>
PHILIP H. SMITH, B.SC.,	<i>Assistant Chemist (foods and feeding).</i>
ERWIN S. FULTON, B.SC.,	<i>Assistant Chemist (foods and feeding).</i>
ALBERT PARSONS, B.SC.,	<i>Inspector (foods and feeding).</i>
SUMNER R. PARKER, B.SC.,	<i>Dairy Tester (foods and feeding).</i>
JOSEPH G. COOK, B.SC.,	<i>Assistant in Foods and Feeding.</i>
GEORGE O. GREENE, M.S.,	<i>Assistant Horticulturist.</i>
GEORGE W. PATCH,	<i>Observer.</i>

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. 57. Fertilizer analyses.
- No. 64. Analyses of concentrated feed stuffs.

- No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
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. 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.
No. 93. Concentrated feeds.
No. 95. Fertilizer analyses; notes on barnyard manure; trade values of fertilizing ingredients.
No. 96. Fungicides; insecticides; spraying calendar.
No. 97. A farm wood lot.
No. 98. Inspection of concentrates.
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 101. Inspection of concentrates.
Special bulletin, — The coccid genera *Chionaspis* and *Hemichionaspis*.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Technical bulletin, No. 2, — The graft union.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904.

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, 1904.

Cash received from United States Treasurer,		\$15,000 00
Cash paid for salaries,	\$6,012 05	
for labor,	3,070 03	
for publications,	1,017 89	
for postage and stationery,	297 42	
for freight and express,	116 30	
for heat, light, water and power,	477 95	
for chemical supplies,	25 40	
for seeds, plants and sundry supplies,	408 19	
for fertilizers,	1,331 20	
for feeding stuffs,	401 28	
for library,	31 70	
for tools, implements and machinery,	221 33	
for furniture and fixtures,	509 31	
for scientific apparatus,	318 21	
for live stock,	313 50	
for travelling expenses,	137 02	
for contingent expenses,	10 00	
for building and repairs,	301 22	
	\$15,000 00	
Cash received from State Treasurer,	\$13,000 00	
from fertilizer fees,	4,204 58	
from farm products,	2,714 79	
from miscellaneous sources,	3,606 92	
Balance June 30, 1903,	3,198 56	
	\$26,724 85	
Cash paid for salaries,	\$13,134 20	
for labor,	1,985 23	
	\$15,119 43	
<i>Amount carried forward,</i>	\$15,119 43	

<i>Amount brought forward,</i>			\$15,119 43
Cash paid for publications,			1,415 18
for postage and stationery,			551 11
for freight and express,			161 96
for heat, light, water and power,			405 88
for chemical supplies,			450 71
for seeds, plants and sundry supplies,			321 52
for fertilizers,			3 70
for feeding stuffs,			840 60
for library,			215 80
for tools, implements and machinery,			100 34
for furniture and fixtures,			340 15
for scientific apparatus,			952 56
for live stock,			375 75
for travelling expenses,			1,757 08
for buildings and repairs,			329 53
Balance,			3,383 55
			<hr/>
			\$26,724 85

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1904; that I have found the same well kept and classified as above; 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 of the \$15,000; and that \$3,383.55 are left of the State appropriation and of funds received from miscellaneous sources.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 15, 1904.

REPORT OF THE BOTANIST.

G. E. STONE, N. F. MONAHAN, ASSISTANT.

With the exception of a continual increase in our correspondence, the same routine has been pursued as in previous years. Experiments have been carried on in the greenhouse as usual on problems connected with roses, carnations, tomatoes, melons and violets. There are obscure diseases connected with these crops, which are in need of further study in order to throw more light on some practical methods of controlling or eliminating them.

Work has been continued on the effects of illuminating gas on trees, — a subject which is becoming important to communities. This matter is receiving attention in various States, on account of the not infrequent destruction of avenues of valuable shade trees. Experiments of various kinds pertaining to electricity and plant life in general have also received some attention. There is an increased interest in this subject, more particularly relating to the injurious effects which are too frequently manifested in valuable shade trees coming in contact with live wires. The department has also given considerable attention to the study of soil organisms, but this work at present is merely in a preliminary stage.

CROPS AS RELATED TO WEATHER CONDITIONS.

Every season is distinctly peculiar as regards the prevalence or non-prevalence of specific fungous growths. The early potato blight appeared in most places to do more injury than usual during the early part of the summer. This is true even where crops were sprayed. As far as this season's results are concerned, it would indicate that spraying was not commenced early enough for controlling this blight.

Most potatoes ought to have been sprayed as early as June 12 or 15, in order to check the blight, or, in other words, when they were less than one-third grown. In regard to the mildew and wet rot on the potatoes, the effects were severe in some localities, and much loss was experienced.

The asparagus rust was more pronounced than last season. A stem rot caused much damage to cultivated dandelions, — a trouble which appears to be an unusual one in this State. Cucumber and melon blight have been exceedingly rare the past summer, being the first for about six years when no trouble has been experienced. The downy mildew (*Plasmopara Cubensis*, (B. and C.) Humphrey) of cucumbers and melons, which is believed to work its way north from the south each year, did not meet our attention once during the season. On the other hand, *Alternaria* and Anthracnose have existed here and there, but did no appreciable harm.

The worst injuries were due to winter-killing. In our last report we alluded briefly to disastrous effects of winter-killing of various shrubs and plants, caused by the unusual prolonged fall of 1902, and the severe and sudden cold occurring in December of that year. The winter of 1903 and 1904 was even more severe than the preceding one in causing injury to plants, and this injury showed itself in a different manner. Last winter was particularly characterized as causing severe injury to native plants, as well as exotic ornamentals. The effect of the extreme cold on plants was, moreover, quite different in the winter preceding, inasmuch as in 1902 and 1903 freezing of the tender wood above ground largely took place, while the effects of last winter's freeze extended both above and below the surface of the ground. The most characteristic feature of the last winter-killing was the injury done to the roots. This was particularly noticeable on apple, pear and plum trees, and the white pine suffered to a considerable extent in some localities. Many ornamental shrubs and vines also show the same characteristic effects of root killing. Numerous apple trees were killed outright, and thousands lost a greater or less number of limbs, due to an inadequate root system to supply them. Pear trees did not seem to be affected so extensively

as the apple. We observed pear trees which had their trunks split open two or three inches by the frost. The crevices eventually closed and commenced to heal over in the spring, although the effects of partial root killing have left many of them in a bad condition. The splitting of the stem is what is termed sun scald or frost crack, and the frost and sun are believed to be responsible for it. One of the characteristic results of partial root killing is that the trees will bear leaves in the spring and appear normal for a while, when suddenly the leaves commence to turn yellow and brown, and finally dry up and drop off. If only part of the root system is injured, the effects will show only on one or more branches or limbs; but when a large portion of the root system is involved, the whole tree is likely to collapse. The development of the leaves of many apple trees, and in some instances of peach and plum trees which had partially leaved out, was suddenly arrested, and they remained in this condition all summer.

White pines in some localities appeared to be injured extensively by cold, and such native species as the white ash, red and sugar maples, birches and poplars showed the effects of the severe winter. The red maples exhibited in many cases a scarcity of foliage, especially near the top; and more dead wood than usual was observed in some of the other species noted. The effects of root killing show more conspicuously when the soil moisture becomes reduced, and in many cases not until the season had become quite advanced did some trees show the effects of winter-killing. The effects on exotic plants were more severe than in 1902, since, in addition to the part above ground, the roots were injured.

Japanese maples, Japanese clematis, California privet, deutzia, roses, barberries, viburnums, etc., suffered to a considerable extent, and many were killed outright. This list could be greatly extended, and if complete would far exceed that noted in our last report. Sycamore and Norway maples have suffered from the loss of new wood during the past two years, as shown by the death of terminal branches. Grape vine roots were affected in many cases, and in some instances the maturing fruit wilted and dried up as if affected by the black rot. .

On the whole, the season can be characterized as showing an unusual amount of winter-killing; in fact, more than has been seen for many years in this State.

TESTING OF SEED.

This department has frequently been called upon to do more or less of this work for farmers, and in many instances for seedsmen. Practically all seedsmen test their own seed; when, however, there is some doubt as to the germinating capacity, it occasionally becomes necessary to submit the seeds to a third party for results; in such cases the station is called upon to make tests. During the past year 120 samples have been tested for farmers and seedsmen.

THE PRACTICE OF SOIL STERILIZATION.

The application of steam under more or less high pressure to greenhouse soils contaminated with sterile fungi, and the use of hot water for partial sterilization, have been practised for a few years by greenhouse growers. We have had considerable experience with growing crops in sterilized soil, and some greenhouse growers have annually resorted to this method of treatment. It is our purpose to give a résumé of the results obtained from this practice.

Sterilization has been the means of lessening the amount of infection in lettuce houses in plants affected with drop and *Rhizoctonia*, and also of ridding houses of eel worms. It has also been the means of greatly stimulating the growth of crops; and in this respect it is likely to do as much harm as good, when intelligent supervision is not given to the crop. Some greenhouse men have resorted to sterilization for no other purpose than merely to try it, their houses being free from any infection for which this method of treatment could be recommended; while others have followed the practice of sterilizing for the purpose of modifying the growth and texture of their plants.

Besides the desired effect upon the eradication of drop and *Rhizoctonia* in lettuce houses, it has been the means of modifying to a large extent the texture of lettuce, and it has been employed as a stimulator. It has also been suc-

cessful in eradicating troublesome insect pests. Its principal drawbacks, however, in growing lettuce, have been due to its stimulating effects on the plant itself, which, where proper precautions are not taken as regards temperature, etc., result in developing a more tender plant, with a loose and less desirable head. A lettuce plant of this type is more tender because it contains more water, and it is not so desirable for the market. Moreover, such plants are inclined to be susceptible to *Botrytis* rot, if not properly handled. We learned very early in our experiments that, on account of the stimulating effect brought about by growing plants in sterilized soils, it is necessary to hold the crop back by maintaining lower night temperatures. If a temperature of from 8° to 10° F. lower than is customary at night is maintained, so that the crop may develop no faster than one grown under normal conditions, the result will be a crop possessing firm heads of equal texture and resisting qualities to that grown under normal conditions. We have repeatedly called attention to the necessity of this practice in growing lettuce in sterilized soils, but this advice has not always been followed.

There has been a slight increased tendency for lettuce plants to become more subject to *Botrytis* rot when grown in either sterilized soil or that treated by hot water, owing to a more accelerated growth, and the production of a head of less firm texture. *Botrytis* rot is the principal disease that most lettuce crops are troubled with at the present time. However, it is not a very serious one with good growers. There will be observed here and there a plant affected with *Botrytis* rot in the best of houses; the ideal conditions, however, require that there should be none. As to the loss by *Botrytis* rot by experienced growers, it is of no practical importance, since the percentage will be represented by a small decimal. *Botrytis* rot can, nevertheless, be eliminated to a greater extent than it is, if lettuce growers would follow certain precautions more carefully. In growing plants in sterilized soil, *Botrytis* rot can be reduced by paying attention to proper temperature conditions at night, or, in other words, by holding the crop within legitimate

limits. The principal sources of Botrytis infection are inferior pricklers or seedlings. All pricklers showing the black root should be discarded, as this is the beginning of the Botrytis rot. No pricklers showing any injuries to the leaves, roots or cotyledons should be utilized, nor should any dead leaves be allowed to form on the plants or be left on them after transplanting. A strict adherence to the above precautions will greatly reduce Botrytis rot.

Another feature which should be considered in connection with the Botrytis rot, as well as rots in general, is watering. Lettuce growers have developed the tendency to do less watering after the crop is set than formerly. They apply most of the water previous to planting, at the present time. This practice induces the plant to develop a better root system. The surface of the soil becomes dry and remains so, which constitutes a great feature in eliminating Botrytis rot, drop, etc. Were it possible for air and sun to obtain access to a lettuce stem, there would scarcely be known such a thing as lettuce rot, with the present skill developed in handling this crop. Some growers have practised for some time the method of thoroughly wetting the soil before planting, and not applying any water after transplanting; while others water occasionally for only two or three weeks after transplanting. We demonstrated quite early in our work the importance of keeping the surface of the soil dry. Subirrigation methods reduce the rots to a considerable extent; and the method of thoroughly wetting the soil previous to planting, and not supplying any water afterwards, is similar in its effects to subirrigation, besides having the advantage of being a much cheaper method. Top coatings of clean, dry sand and other substances have similar effects in reducing rots.

We believe that a great deal can be accomplished in eliminating Botrytis rot and other diseases if more care be taken in selecting seed of a more uniform size and character. Care should be taken in selecting seed that will produce more hardy plants, and that which will produce plants less subject to infection. There is a chance for experimentation and more careful study here.

In one instance we have heard it implied that lettuce

crops grown in sterilized soil were prone to mildew. This may result to some extent when the crop is not properly handled; but mildew is confined to the houses of only a very few commercial growers, and its existence in a house at all can be accounted for otherwise. We introduced the mildew into our house several times, but it always died out, and was never known to live through the summer. On the whole, far better lettuce crops are turned out to-day than five years ago, and there is a decided decrease in the amount of infection, due to the application of improved methods of treatment and culture.

As regards the effects of sterilized soil on the growth of cucumbers, our experiments and those of others have shown favorable results, since cucumbers will stand a considerable amount of forcing without any detriment; and we have none of the drawbacks due to excessive stimulation of the crop, such as we find in lettuce. When cucumbers are grown under single lights of glass, or under favorable conditions as regards light, the stimulating effects due to sterilization act most advantageously; while, on the other hand, where the crop is grown under exceedingly abnormal conditions as regards heat, light and moisture, as it sometimes is, no appreciable results are noticeable, except in so far as the treatment eliminates undesirable pests from the soil. Indeed, no form of stimulation is of any practical value to plants when their conditions of growth are extremely abnormal. Sterilization is especially efficacious in destroying eel worms and preventing timber rot, and also destroys some insect pests which trouble the cucumber. One of the special advantages in growing cucumbers in sterilized soil is connected with the seed and seedling, since germination of the seeds is hastened, the plants are accelerated, and damping-off is prevented. A considerable amount of acceleration is given to the growth of the seedling; and in our experiments, where seeds were sown in sterilized and unsterilized soil, we obtained an increase in the actual germination of the seed equal to 33 per cent. in favor of sterilized soil. The expense of sowing seeds and starting seedlings in sterilized soil would be slight, and the results obtained render this process especially desirable.

The growing of carnations in sterilized soil, according to our limited experiments, shows a slightly beneficial effect on the plant, although others who have had more extensive experience have noted very little difference as the result of this practice. It is especially applicable to carnations in eliminating the wet stem rot caused by the fungus *Rhizoctonia*. In our opinion, there is little reason to believe that sterilizing would succeed in preventing the dry rot caused by *Fusarium*. With carnations, soil sterilization possesses some advantage in the cutting bed where cuttings are affected with *Rhizoctonia* and the damping-off fungus (*Pythium De Baryanum*, Hesse). In our rather extensive use of sterilized soil we have never observed any detrimental influence on the soil itself; we have, however, always made use of a tolerably rich soil, well supplied with organic matter.

The principal forms of appliances now used for this purpose are similar, with some modifications, to those which have been employed for five or six years. Perforated iron pipes made up into frames, 10 to 12 feet long and 8 to 10 feet wide, are most generally used. The harrow form of apparatus, known as the Sargent sterilizer, is also largely used, and consists of an iron frame, 4 or 5 by 8 or 10 feet, provided with perforated teeth about 10 or 12 inches apart and 1 foot long. The teeth are thrust into the soil, and the steam is turned on. With this form of apparatus it is not necessary to shovel the soil, hence the process is cheap. The latter type requires a high pressure of steam, and not so great a volume; while the former apparatus requires a large volume of steam, and can be operated to advantage with 15 or 20 pounds of steam pressure.

THE INFLUENCE OF ELECTRICAL POTENTIAL ON THE GROWTH OF PLANTS.¹

In our last report we gave results of experiments showing the effects of current electricity upon the growth of plants, also the results of subjecting plants and moist seeds to different electrical potentials. We shall give here the results

¹ These experiments were conducted by N. F. Monahan.

of further experiments along similar lines, and present some results relating to differences of electrical potential which exist between locations in trees and corresponding situations more or less removed from them.

In the first series of experiments we will consider the influence of electrical potential upon growth. In subjecting plants to an atmospheric charge of a certain potential we used a glass case such as is described in our preceding report, being, briefly, a glass case 3 feet 4 inches long, 2 feet 9 inches wide and 2 feet 11 inches high, with shellacked wooden frames and bottom. Another case, for comparison, and similar in structure but slightly larger, was also employed. Both cases were tolerably tight when closed, and were placed on movable trucks, from which they were well insulated, in a large greenhouse. The greenhouse screened out, as it were, the atmospheric electricity. At no time have we ever been able to detect any electrical potential in the air in greenhouses. The soil used in growing the plants was of uniform type, very carefully mixed; in fact, every precaution was taken to have the soil conditions the same in each case, and all its various constituents were thoroughly incorporated.

In the case which was to be treated was placed a small water-dripping apparatus, which served as a collector, and which indicated the degree of charging. The air was charged by means of a wire projecting into the case from a Topler-Holtz influence machine. All electrical readings were measured by a Thompson quadrant electrometer.

In the two experiments now described radish plants were employed, as they seemed to be most suitable for the condition under which they were grown. The seeds were of a uniform grade, and were sown in rows 3 inches apart and 1 inch apart in the rows. It was the intention to charge the case each morning to a potential of 150 volts; but this was impossible, as exactly 150 volts could not always be obtained, and at times, on account of the dampness of the air, no charge could be procured from the machine. The doors of both cases were kept closed for four hours after the charge had been induced into the treated case, and at the end of that time they were opened; therefore, for twenty out of every

twenty-four hours all the plants were growing under the same conditions. At all times the conditions of temperature and moisture were practically the same in both charged and normal, or uncharged, cases.

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.).— Showing the Results obtained by electrically charging the Air in a Case.

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF—	
			Tops.	Roots.
Normal case,	-	219	2,211.3	510.3
Electrically charged case, .	167.2	162	2,551.5	623.7

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.).— Showing the Results obtained by electrically charging the Air in a Case— Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF—		PER CENT. GAINED IN WEIGHT OF—		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case,	10.097	2.333	-	-	-
Electrically charged case,	15.750	3.850	55.98	65.67	57.67

The experiment in Table II. is similar to Experiment I., except that the seeds were planted in rows 5 inches apart, instead of 4, as in the preceding one. The cold weather interfered with the development of the plants, and the experiment was brought to a close earlier than was planned.

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.).— Showing the Results obtained by electrically charging the Air in a Case.

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF—	
			Tops.	Roots.
Normal case,	-	136	91	98.5
Electrically charged case, .	141.2	69	66	74.0

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.). — Showing the Results obtained by electrically charging the Air in a Case — Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case, . . . . .	.669	.724	-	-	-
Electrically charged case,	.955	1.072	42.73	49.46	45.58

The results given in tables I. and II. are quite similar. In Table I. there was a gain of 55.98 per cent. in the weight of tops or leaves and 65.67 per cent. in the weight of roots, over the uncharged plants; in Table II., the percentage given for the tops is 42.73 and for the roots 49.46. The total gain in Experiment I. is 57.67 per cent.; in Experiment II. it is 45.58 per cent. The average gain in both experiments was 49.35 per cent. for the tops or leaves, 57.56 per cent. for the roots and 51.62 per cent. as an average total gain for the electrically stimulated plants. The charge in Experiment I. averaged 167.2 volts; in Experiment II., 141.2 volts. The charge only lasted a few seconds in all instances, and practically disappeared from the atmosphere of the case in fifteen minutes.

Some measurements were occasionally made of a dozen typical plants from each case in Experiment I. The object in taking these measurements was, first, to show the difference in size and degree of acceleration, differentiation, etc., of the treated and untreated plants; and, second, to compare the electrically treated plants with those that were not treated, when the latter were practically in the same stage of development; or, in other words, the plants in the electrically charged case were compared with those in the untreated case on the day in which the measurements were made, and also five days later, when the development of the normal plants had reached practically the same stage as that of the plants in the electrically treated case. By this method any changes in the external configuration of the plants brought about by electrical stimulation could be noted.

Table III. shows the results of these measurements, and Table IV. gives a comparison between the leaves of the plants in the charged and uncharged cases, measurements being made August 15 and August 20, respectively.

TABLE III. — *Showing the Average of Some Measurements of Plants in Table I., Experiment I.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 15,	Normal case, . . .	2.13	4.17	2.28	6.49
	Electrically charged case, .	2.66	5.33	4.34	10.16
	Difference, . . .	.53	1.16	2.06	3.67
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
	Electrically charged case, .	3.65	6.95	5.20	12.05
	Difference, . . .	.86	2.12	1.85	3.95

TABLE IV. — *Giving a Comparison between the Leaves of the Plants in the Charged and Uncharged Cases.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
August 15,	Electrically charged case,	2.66	5.33	4.34	10.16
	Difference, . . .	.13	.50	.99	2.06

The results of these experiments show what was readily discernible with the naked eye; namely, that the length of leaves of the electrically treated plants was quite different from those of the normal or untreated plants, and that the width and length of the leaf blade and the length of the petioles of the plants in the electrically treated case exceeded those of the normal or untreated plants. When comparisons, however, are made of the plants in the electrically treated case of August 15 with those of the normal of August 20, or five days later, it will be observed that the width of the blade of the normal exceeded that of the treated one by .13 centimeters, and that the difference in the length of the blades,

petioles and leaves in general was much less marked. The length of the blade, petiole and whole leaf in general was longer for identical periods of development in the electrically treated plants than in the normal or untreated, although the width of the blade was more generally marked in its development in the normal than in the plants in the electrically charged case. The morphological differentiation due to electrical stimulation is shown in these experiments.

The plants in the electrically charged case were of a lighter-green color, and they showed a greater tendency to leaf burn than did the normal plants. They also appeared to be more succulent, but moisture determinations made of the leaves at the close of the experiment showed no difference in this respect. The roots in the treated case were relatively more elongated than those in the untreated case. Whether this form of electrical treatment stimulates plants more than current electricity cannot definitely be determined, from the lack of a sufficient number of comparative results. However, these two experiments would indicate, both from naked-eye observations and from weights and measurements, that static charges act as more pronounced stimuli than current electricity when applied to soils. Electrical stimulation gives rise to effects similar to those caused by lack of light, or such as result from partial etiolation. The light-green color of the foliage and the elongated organs were similar to those noticed in plants grown in poorly lighted greenhouses in winter, and in shaded plants grown in the forest. Other kinds of electrical stimulation appear to have the same general effects on the plant.

Comparison of Atmospheric Electrical Potential in Trees and in the Free Air.

The idea has been advanced that trees, shrubs, and in fact all growing plants, must form a means by which the potential of the air and the earth is held in equilibrium. A living tree does not offer such an enormous resistance to the passage of electricity as dead wood does. We have charged small plants in the laboratory to a sufficiently high potential so that, when placed in the dark, sparks were emitted from

many points of the leaves, and living plants will readily take charges from a static machine. It has also been maintained that trees modify the electrical potential of the atmosphere of their immediate surroundings.

Grandeau¹ and other experimenters have shown that when plants are grown under wire netting they develop less in a given space of time than do plants grown under similar conditions in every respect as regards light, etc., in the free atmosphere. The interpretation of this phenomenon is, that wire screens modify the atmospheric electrical potential, or absorb the electricity, as it were, to the detriment of the plant. This method of experimenting with wire nets we have employed only to a limited extent, and at present have not a sufficient number of results on which to report. Unfortunately, most of the experiments previously made in this line are open to severe criticism, from the fact that too few plants were employed, and different methods of surrounding the plants with wire netting prevailed, which accounts for occasional conflicting results. Grandeau obtained similar results by growing plants under a chestnut tree, as under a wire netting; and he concluded that it is probable that trees modify to a large extent the electrical potential of the atmosphere in their immediate neighborhood. The object we had in view in these experiments was to ascertain, among other things, whether trees did modify in any way the electrical potential of the atmosphere in their immediate vicinity. In order to ascertain whether there is any discernible difference between the atmospheric electrical potential in trees and in the free air, at corresponding height and location, we made a series of three readings daily from April to July, and daily readings during the remainder of the experiment, with collectors and a Thompson quadrant electrometer. These observations were started early in the spring, before any foliage had developed, and continued until after the leaves had fallen. A collector was placed in an elm tree, at a height of 40 feet above the ground, at a fork between two limbs from which it was insulated. The collector was situated about on a level with, or slightly above, the spread of

¹ "Comptes rendus," T. LXXXVII., 1878, pp. 60, 285, 939. "Chimie et Physiologie appliquées à l'Agriculture et à la Sylviculture par L. Grandeau," Paris, 1879, p. 279.

the branches and leaves. The tree, however, was not in every respect a typical elm for this region, the head being high and close, with the branches drooping but little.

The collector in the tree is designated as II. in the following monthly records; and the one in the free air, which was located near a building, is designated as I. Collector III. was in a spruce tree, and Nos. IV. and V. were added in August. Collector III. was located 12 feet high, near the top and under the branches of a small Norway spruce. Nos. IV. and V. represent readings from two small Norway spruce trees, about 2 feet high, in pots; they were located about 16 feet from the ground, on a plank scaffold. No. IV. had a copper plate in the soil, which was connected with the electrometer when readings were made. No. V. had a similar plate, but was grounded with an insulated wire; another wire led from this copper plate in the soil to the electrometer.

Readings were taken from the various collectors on the same electrometer at practically the same time each day. Table V. shows readings taken from April 20 to Nov. 1, 1904, and where readings are omitted they could not be obtained. All readings not otherwise recorded imply negative potential.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.
1904.						
April 21, . .	56.0	56.0	32.0	32.0	0.0	0.0
22, . .	48.0	48.0	32.0	32.0	16.0	16.0
23, . .	8.0	8.0	40.0	40.0	-	-
24, . .	16.0	16.0	16.0	16.0	16.0	-
25, . .	40.0	40.0	40.0	40.0	16.0	16.0
26, . .	32.0	32.0	16.0	16.0	32.0	32.0
27, . .	-	-	60.0	60.0	40.0	40.0
28, . .	8.0	8.0	32.0	32.0	45.0	45.0
29, . .	24.0	0.0	8.0	0.0	0.0	0.0
30, . .	32.0	32.0	-	-	-	-

April 24, trees show signs of budding.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Continued.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I.— Free Air.	Collector II.— Elm.	Collector I.— Free Air.	Collector II.— Elm.	Collector I.— Free Air.	Collector II.— Elm.
1904.						
May 1, . . .	112.0	112.0	32.0	32.0	0.0	0.0
2, . . .	16.0	16.0	12.0	12.0	8.0	8.0
3, . . .	48.0	48.0	40.0	40.0	48.0	48.0
4, . . .	56.0	56.0	24.0	24.0	24.0	24.0
5, . . .	56.0	56.0	56.0	56.0	8.0	0.0
6, . . .	12.0	12.0	24.0	24.0	20.0	20.0
7, . . .	64.0	64.0	28.0	24.5	-	-
8, . . .	-	-	-	-	-	-
9, . . .	-	-	-	-	-	-
10, . . .	24.0	24.0	28.0	28.0	-	-
11, . . .	48.0	48.0	8.0	8.0	16.0	16.0
12, . . .	72.0	72.0	80.0	80.0	40.0	40.0
13, . . .	64.0	64.0	8.0	0.0	24.0	20.0
14, . . .	16.0	14.0	-	-	-	-
15, . . .	8.0	0.0	8.0	0.0	-	-
16, . . .	-	-	-	-	-	-
17, . . .	-	-	32.0	-	-	-
18, . . .	-	-	20.0	8.0	20.0	-
19, . . .	40.0	32.0	32.0	17.0	16.0	12.0
20, . . .	56.0	40.0	32.0	24.0	-	-
21, . . .	8.0	0.0	16.0	9.0	20.0	16.0
22, . . .	32.0	16.0	-	-	-	-
23, . . .	8.0	4.0	16.0	8.0	32.0	24.0
24, . . .	16.0	14.0	20.0	12.0	8.0	8.0
25, . . .	218.0	32.0	16.0	16.0	20.0	16.0
26, . . .	88.0	56.0	32.0	0.0	-	-
27, . . .	-	-	-	-	-	-
28, . . .	24.0	20.0	24.0	20.0	16.0	0.0
29, . . .	32.0	0.0	28.0	0.0	-	-
30, . . .	-	-	-	-	-	-
31, . . .	-	-	-	-	-	-

May 7, leaves beginning to show; May 9, hardly a trace; May 14, trees fairly well leaved, seeds beginning to drop; heavy thunder showers on 26th; 5 P.M. readings gave extremely high and fluctuating potentials.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Continued.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.
1904.						
June 1, . . .	32.0	24.0	16.0	8.0	+8.0	-8.0
2, . . .	-	-	-	-	-	-
3, . . .	-	-	16.0	8.0	-	-
4, . . .	-	-	16.0	8.0	-	-
5, . . .	8.0	0.0	8.0	0.0	112.0	56.0
6, . . .	20.0	0.0	8.0	0.0	0.0	0.0
7, . . .	-	-	-	-	-	-
8, . . .	-	-	-	-	-	-
9, . . .	-	-	-	-	-	-
10, . . .	-	-	16.0	8.0	8.0	0.0
11, . . .	28.0	16.0	32.0	20.0	24.0	16.0
12, . . .	72.0	56.0	8.0	0.0	8.0	0.0
13, . . .	40.0	24.0	40.0	24.0	-	-
14, . . .	8.0	0.0	32.0	0.0	-	-
15, . . .	16.0	8.0	28.0	24.0	-	-
16, . . .	8.0	0.0	8.0	0.0	-	-
17, . . .	16.0	8.0	40.0	24.0	-	-
18, . . .	36.0	24.0	28.0	20.0	16.0	0.0
19, . . .	72.0	48.0	88.0	56.0	8.0	0.0
20, . . .	32.0	20.0	16.0	8.0	8.0	0.0
21, . . .	20.0	16.0	16.0	8.0	8.0	0.0
22, . . .	20.0	8.0	-	-	-	-
23, . . .	-	-	-	-	-	-
24, . . .	-	-	-	-	-	-
25, . . .	-	-	-	-	-	-
26, . . .	-	-	-	-	-	-
27, . . .	24.0	12.0	8.0	0.0	0.0	0.0
28, . . .	16.0	12.0	8.0	trace	8.0	trace
29, . . .	-	-	-	-	-	-
30, . . .	-	-	-	-	-	-

June 2-4, rain; June 6-9, wet wire.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Continued.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.
1904.						
July 1, . . .	-	-	-	-	-	-
2, . . .	-	-	-	-	8.0	4.0
3, . . .	-	-	-	-	-	-
4, . . .	-	-	-	-	-	-
5, . . .	36.0	16.0	32.0	20.0	32.0	20.0
6, . . .	28.0	12.0	24.0	0.0	24.0	0.0
7, . . .	88.0	56.0	8.0	0.0	8.0	0.0
8, . . .	-	-	20.0	8.0	28.0	12.0
9, . . .	12.0	0.0	48.0	24.0	36.0	20.0
10, . . .	-	-	-	-	8.0	0.0
11, . . .	24.0	8.0	24.0	0.0	24.0	0.0
12, . . .	-	-	-	-	-	-
13, . . .	-	-	-	-	-	-
14, . . .	-	-	-	-	-	-
15, . . .	-	-	-	-	-	-
16, . . .	-	-	-	-	-	-
17, . . .	-	-	-	-	-	-
18, . . .	-	-	-	-	-	-
19, . . .	12.0	0.0	8.0	0.0	8.0	trace
20, . . .	12.0	trace	16.0	4.0	16.0	4.0
21, . . .	16.0	trace	28.0	8.0	12.0	trace
22, . . .	-	-	-	-	-	-
23, . . .	-	-	-	-	-	-
24, . . .	-	-	-	-	-	-
25, . . .	-	-	-	-	-	-
26, . . .	-	-	-	-	-	-
27, . . .	-	-	-	-	-	-
28, . . .	20.0	8.0	24.0	8.0	-	-
29, . . .	-	-	-	-	-	-
30, . . .	28.0	8.0	32.0	16.0	16.0	trace
31, . . .	-	-	-	-	-	-

July 12-18, electrometer out of order; July 22-28, rain.

TABLE V.—*Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air—Continued.*

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I.—Free Air.	Collector II.—Elm.	Collector III.—Spruce.	No. IV.—Small Spruce Tree, not grounded.	No. V.—Small Spruce Tree, grounded.
1901.					
August 1, . . .	88.0	52.0	-	-	-
2, . . .	0.0	0.0	-	-	-
3, . . .	8.0	0.0	-	-	-
4, . . .	-	-	-	-	-
5, . . .	-	-	-	-	-
6, . . .	72.0	40.0	-	-	-
7, . . .	32.0	16.0	-	-	-
8, . . .	96.0	56.0	-	-	-
9, . . .	40.0	24.0	-	-	-
10, . . .	8.0	0.0	-	-	-
11, . . .	16.0	8.0	Very slight movement		
12, . . .	56.0	32.0	+4.0	+4.0	+4.0
13, . . .	8.0	trace	+trace	+trace	+trace
14, . . .	96.0	56.0	+6.0	+8.0	+16.0
15, . . .	24.0	16.0	+trace	+4.0	+trace
16, . . .	32.0	16.0	trace	+8.0	+12.0
17, . . .	0.0	0.0	+8.0	+8.0	+12.0
18, . . .	+16.0	+8.0	-8.0	-8.0	-8.0
19, . . .	40.0	20.0	0.0	trace	trace
20, . . .	-	-	-	-	-
21, . . .	72.0	40.0	+8.0	+8.0	+12.0
22, . . .	8.0	+trace	+trace	+trace	+trace
23, . . .	8.0	trace	+8.0	+4.0	+8.0
24, . . .	48.0	24.0	0.0	trace	trace
25, . . .	56.0	28.0	0.0	0.0	trace
26, . . .	96.0	52.0	+8.0	+8.0	+12.0
27, . . .	88.0	40.0	0.0	0.0	0.0
28, . . .	40.0	24.0	0.0	0.0	0.0
29, . . .	8.0	trace	0.0	0.0	0.0
30, . . .	40.0	16.0	+2.0	+2.0	+2.0
31, . . .	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Continued.*

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 3 P.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
August 1, . . .	80.0	40.0	-	-	-
2, . . .	-	-	-	-	-
3, . . .	8.0	0.0	-	-	-
4, . . .	-	-	-	-	-
5, . . .	-	-	-	-	-
6, . . .	24.0	12.0	-	-	-
7, . . .	40.0	24.0	-	-	-
8, . . .	88.0	56.0	-	-	-
9, . . .	24.0	12.0	-	-	-
10, . . .	0.0	0.0	-	-	-
11, . . .	8.0	0.0	0.0	0.0	0.0
12, . . .	40.0	24.0	+4.0	+4.0	+4.0
13, . . .	56.0	4.0	+trace	+trace	+trace
14, . . .	24.0	12.0	+4.0	+trace	+4.0
15, . . .	72.0	40.0	+4.0	+8.0	+12.0
16, . . .	16.0	8.0	trace	trace	trace
17, . . .	0.0	0.0	0.0	0.0	0.0
18, . . .	0.0	0.0	0.0	0.0	0.0
19, . . .	40.0	20.0	0.0	0.0	trace
20, . . .	-	-	-	-	-
21, . . .	40.0	24.0	+4.0	trace	12.0
22, . . .	8.0	0.0	0.0	0.0	0.0
23, . . .	8.0	0.0	+8.0	trace	trace
24, . . .	56.0	32.0	0.0	0.0	0.0
25, . . .	32.0	24.0	0.0	0.0	trace
26, . . .	72.0	40.0	+8.0	+8.0	+8.0
27, . . .	48.0	24.0	0.0	0.0	0.0
28, . . .	8.0	trace	0.0	0.0	0.0
29, . . .	4.0	0.0	0.0	0.0	0.0
30, . . .	16.0	8.0	0.0	0.0	0.0
31, . . .	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Continued.*

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I.—Free Air.	Collector II.—Elm.	Collector III.—Spruce.	No. IV.—Small Spruce Tree, not grounded.	No. V.—Small Spruce Tree, grounded.
1904.					
September 1, .	88.0	52.0	+4.0	+4.0	+4.0
2, .	-	-	-	-	-
3, .	-	-	-	-	-
4, .	96.0	56.0	+8.0	+8.0	+8.0
5, .	72.0	40.0	4.0	2.0	4.0
6, .	-8.0	-trace	+0.0	+0.0	+0.0
7, .	40.0	24.0	0.0	0.0	0.0
8, .	56.0	32.0	0.0	0.0	0.0
9, .	72.0	40.0	0.0	trace	trace
10, .	-	-	-	-	-
11, .	-	-	-	-	-
12, .	-	-	-	-	-
13, .	-	-	-	-	-
14, .	-	-	-	-	-
15, .	-	-	-	-	-
16, .	-	-	-	-	-
17, .	-	-	-	-	-
18, .	-	-	-	-	-
19, .	-	-	-	-	-
20, .	-	-	-	-	-
21, .	-	-	-	-	-
22, .	-	-	-	-	-
23, .	-	-	-	-	-
24, .	-	-	-	-	-
25, .	-	-	-	-	-
26, .	0.0	0.0	0.0	0.0	0.0
27, .	8.0	8.0	0.0	0.0	trace
28, .	-	-	-	-	-
29, .	-	-	-	-	-
30, .	24.0	24.0	0.0	trace	trace

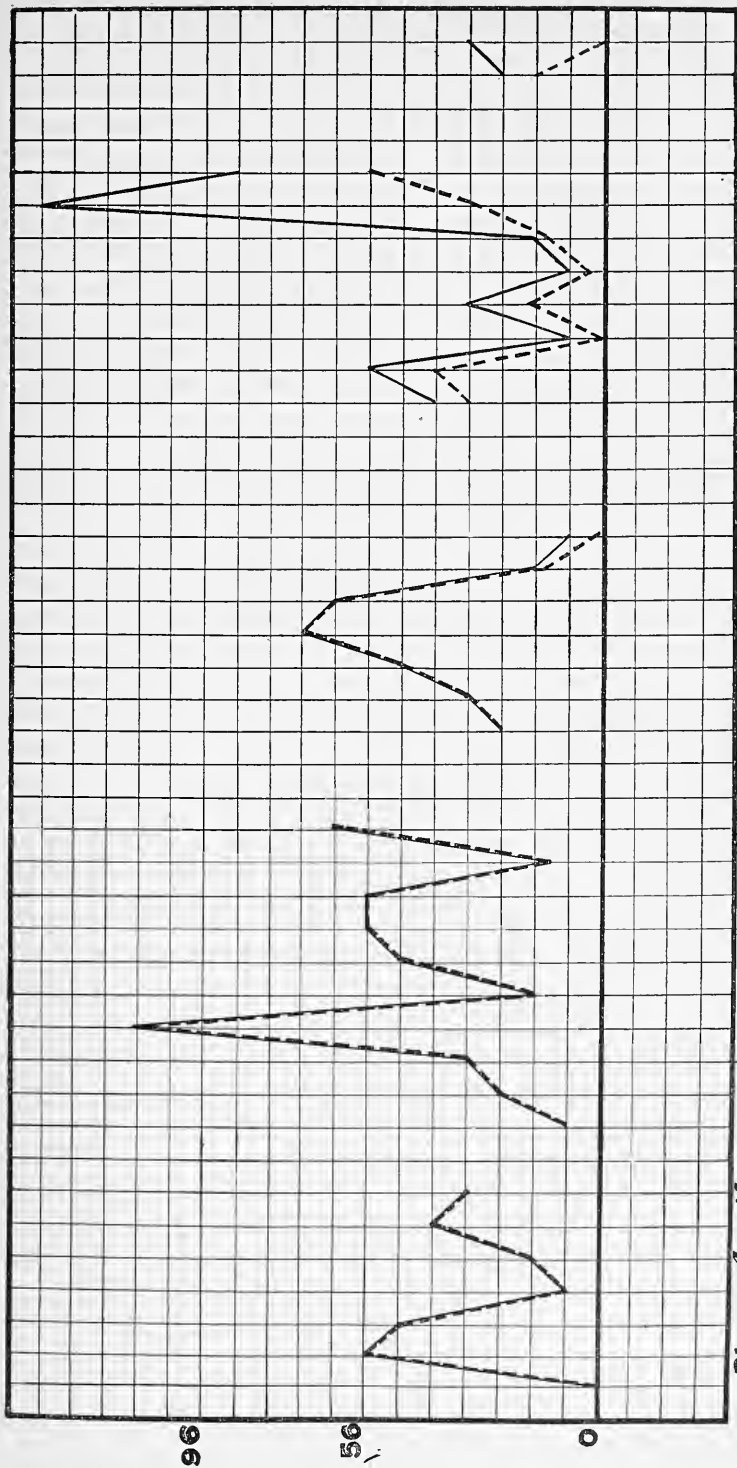
September 6, possibly slight movement toward positive in Nos. III., IV. and V.
Operator away from September 10 to September 25.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air — Concluded.*

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
October 1, .	40.0	32.0	4.0	2.0	4.0
2, .	56.0	48.0	4.0	trace	2.0
3, .	96.0	80.0	8.0	trace	trace
4, .	-	-	-	-	-
5, .	8.0	8.0	4.0	4.0	8.0
6, .	40.0	36.0	trace	trace	trace
7, .	-	-	-	-	-
8, .	-	-	-	-	-
9, .	-	-	-	-	-
10, .	-	-	-	-	-
11, .	-	-	-	-	-
12, .	-	-	-	-	-
13, .	-	-	-	-	-
14, .	8.0	8.0	2.0	2.0	4.0
15, .	40.0	40.0	4.0	trace	4.0
16, .	8.0	8.0	trace	0.0	0.0
17, .	16.0	16.0	2.0	trace	2.0
18, .	40.0	0.0	0.0	0.0	0.0
19, .	24.0	24.0	trace	0.0	trace
20, .	-	-	-	-	-
21, .	-	-	-	-	-
22, .	-	-	-	-	-
23, .	-	-	-	-	-
24, .	40.0	40.0	0.0	0.0	0.0
25, .	8.0	8.0	trace	trace	trace
26, .	-	-	-	-	-
27, .	-	-	-	-	-
28, .	-	-	-	-	-
29, .	8.0	8.0	0.0	trace	trace
30, .	-	-	-	-	-
31, .	-	-	-	-	-

October 5, leaves turning color, very few falling; October 20, leaves taken off by high wind; October 24, leaves entirely off trees.



21 April

May

DIAGRAM I. — Showing the results of electrometer readings from free air, Collector I., and elm tree, Collector II., for the months of April and May. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

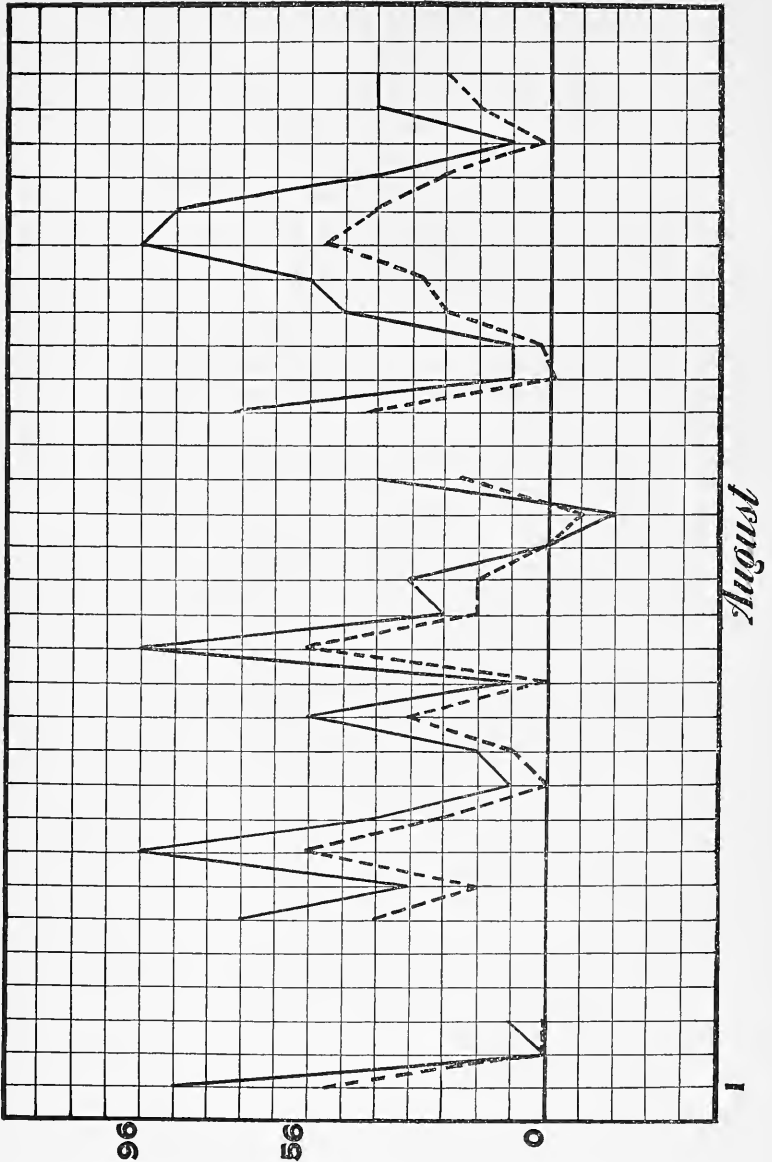


DIAGRAM II. — Showing the results of electrical readings from free air, Collector I., and elm tree, Collector II., for the month of August. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

TABLE VI. — *Summary of Potential Readings of the Preceding Tables, showing the Total and Average Results given by Collector I. (Free Air) and Collector II. (Elm Tree).*

	TOTAL VOLTAGE OF—		AVERAGE DAILY VOLTAGE OF—	
	Collector I.—Free Air.	Collector II.—Elm.	Collector I.—Free Air.	Collector II.—Elm.
April,	240	240	30.0	30.0
May 1 to May 14,	572	572	52.0	52.0
May 14 to May 31,	398	228	44.2	25.3
June,	498	276	38.0	21.2
July,	224	108	37.3	18.0
August,	1,088	592	54.4	29.6
September,	456	276	57.0	34.5
October 1 to October 7,	240	204	48.0	40.8
October 7 to October 31,	152	152	19.0	19.0

While the results obtained from this series of experiments do not possess the same value as the series extending over more than one season, they nevertheless point very strongly to the conclusion that trees do modify to a considerable extent atmospheric electrical potential in their immediate vicinity. By consulting the summary, Table VI., where the total and average potentials for different periods are shown, it will be seen that some important differences occurred between the potentials of the free air and the elm tree collectors. It is significant also that there occurred no difference in the readings between the free air collector and that in the elm tree up to the time when the leaves developed. The few readings which we were able to make in October after the leaves had fallen showed the same results.

Our interpretation of the results of these observations is, that the elm tree took some electricity from the air immediately surrounding it during the period in which it was in foliage. If this single series of observations is typical of what takes place in nature, then we can conclude that the atmospheric electrical potential is not affected much by trees in the immediate vicinity except when they are in foliage. There are a few instances where collectors I. and II. showed

positive potentials, and practically the same relative differences are shown here as in the numerous negative potential readings.

The collector in the branches of the spruce tree, 12 feet from the ground (Collector III.), from which it was well insulated, invariably showed the opposite potential from that obtained in the free air and from the elm tree. It will appear from this that the air surrounding the collector in the spruce tree was charged with the same kind of potential (positive or negative) as that of the earth; and the readings taken from Nos. IV. and V., which were very close to this tree, although four feet higher, gave the same kind of potential as that of Collector III., or larger spruce tree. In other words, all the potentials in Nos. III., IV. and V. are opposite to that of the air. There were some difficulties experienced in obtaining readings of the three spruce trees, — partly because the readings had to be taken too close to the ground, and partly, perhaps, because we were dealing with the same kind of potential in the air that the earth was charged with; and that, therefore, when the potential of the air in the branches of the spruce tree and the potential of the earth were the same in degree and kind, differences in potential would not exist, and therefore measurements would be impossible. Evergreen trees, which are supplied with a large number of pointed leaves, may possibly be better adapted to discharge electricity than deciduous trees. It is quite possible that evergreen trees behave quite differently from deciduous trees as regards their relationship to atmospheric electricity. In our opinion, there is a strong probability that all living plants act as conductors, or that they serve to keep the potential of the earth and the air in more or less equilibrium; and that trees and vegetation in general take part in this, although in all probability all species do not act in the same specific manner.

This phase of the subject has not been studied as much as is desirable. We infer from our own observations that some trees show a great tendency towards conducting the electricity from the air to the earth, and that other trees show the same tendency for conducting electricity from the earth to the air; and that in all probability this exchange of electricity from the air to the earth, and *vice versa*, does not take

place at the same time through the same tree; and that, under normal conditions, — that is, when no great electrical disturbance is taking place, — some species of trees always conduct the electricity to the air from the earth, while other species conduct electricity from the earth to the air. It is not at all unlikely that in the vicinity of large trees there is exhibited a detrimental influence on crops, and vegetation in general, to an extent which cannot be accounted for by the lack of sunshine and soil moisture.

SOME IMPORTANT LITERATURE RELATING TO DISEASES, ETC.,
OF CROPS NOT GENERALLY BELIEVED TO BE CAUSED BY
FUNGI OR INSECTS.

The publication by Dr. W. C. Sturgis¹ of a host index relating to economic fungi has proved of great value to students, and to those interested in the literature pertaining to fungous diseases of our important cultivated crops. Unfortunately, the host index of Dr. Sturgis does not include those troubles generally termed physiological, or those of an unknown nature.

The following list is compiled to supplement his host index to literature pertaining to fungous diseases. It is by no means complete, but includes at least some of the more important publications of the agricultural experiment stations and United States Department of Agriculture relating to functional and unknown disorders.

APPLE (*Pirus malus*, L.).

Baldwin Fruit-spot, Brown-spot. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 215-219. Vt. Agr. Exp. Sta., Rept. 1899; 1900, pp. 159-164.

Frost-blisters (Leaves). — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 217-224. See *Quince*. Mass. Hatch Exp. Sta., Rept. No. 15, 1903, pp. 32-34.

Frost-cracks (Fruit). — Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100. See *Pear Rosette*. — Col. Agr. Exp. Sta., Bull. No. 69, 1902, pp. 4-6.

Scald. — Vt. Agr. Exp. Sta., Rept. 1896-97, pp. 55-59; also 11th Rept. 1898, pp. 198, 199.

Spraying and Bloom. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 196, 1900.

Spraying Injuries. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 225-230.

APRICOT (*Prunus*).

Leaf-scorch or Sunburn. — Ariz. Agr. Exp. Sta., Rept. 1898, pp. 163-165.

¹ Conn. (State) Agr. Exp. Sta., Bull. No. 118, 1893; Repts. 17, 1893; 21, 1897; and 24, 1900.

ASTER (*Callistephus hortensis*, Cass.).

Yellows.—Mass. Hatch Exp. Sta., Bull. No. 79, 1902, p. 11.

BEET (*Beta vulgaris*, L.).

Leaf-scorch (*Sugar Beet*).—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 167-171.

CAULIFLOWER (*Brassica oleracea*, L.).

Leaf-scorch or Tip-burn.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 176, 177.

CELERY (*Apium graveolens*, L.).

Pithiness.—Maryland Agr. Exp. Sta., Bull. No. 83, 1902; also Bull. No. 93, 1904.

CHERRY (*Prunus Cerasus*, L.).

Leaf-scorch.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 171-176. See *Maple*, etc.

COTTON (*Gossypium*, spp.).

Red Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 31, 32.

Shedding of Bolls.—Ala. Coll. Sta., Bull. No. 41, 1892, pp. 50-53.

Yellow Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 2-31.

CUCUMBER (*Cucumis sativus*, L.).

Leaf-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, pp. 30, 31.

Stem-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32.

Wilt.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32; also Rept. 1899, pp. 159-163.

GRAPE (*Vitis*, spp.).

California Vine Disease.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892.

U. S. Dept. Agr., Farmers' Bull. No. 30, pp. 1-11.

Chlorosis.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 179-181.

Coulure.—U. S. Dept. Agr., Div. Veg. Path., Farmers' Bull. No. 30, pp. 11-14.

Mal Nero, Rougeot and Folletage.—N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 420, 421. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181-198.

Sunstroke.—Cal. Agr. Exp. Sta., Rept. 1887-93, pp. 450, 451.

Pourriture.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181, 182.

Shelling.—Conn. (State) Agr. Exp. Sta., Rept. 1896, pp. 278-281. Mich. Agr. Exp. Sta., Bull. No. 121, 1895, p. 51. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 413-440, 452-454.

LETTUCE (*Lactuca sativa*, L.).

Top-burn.—Mass. Hatch Exp. Sta., Bull. No. 69, p. 38; also Rept. 1897, pp. 82-84.

LILY (*Lilium*, spp.).

Bermuda Lily Disease.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 14, 1897.

MELON (*Cucumis Melo*, L.).

Top-burn.—Ga. Agr. Exp. Sta., Bull. No. 57, 1902, p. 190.

ORANGES, LEMONS, ETC. (*Citrus*, spp.).

Blight.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 9-14. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 32-34.

Die-back or Exanthema.—Cal. Agr. Exp. Sta., Bull. No. 138, 1902, pp. 40, 41. Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 157-161. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 14-20. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 29, 30.

- Foot-rot or Mal di Gomma.*—Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 151–155. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 28–33. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 30–32.
- Melanose.*—Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 168, 169. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 33–38.

PEACH (*Prunus Persica*, Benth. and Hook.).

- Bordeaux Injury.*—Conn. (State) Agr. Exp. Sta., 24th Ann. Rept. 1900, pp. 219–254. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 385–388. See *Plum*. Tenn. Agr. Exp. Sta., Bull., Vol. XV., No. 2, 1902.
- Droprical Swellings of Twigs and Branches.*—Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 206–208.
- Fruit-crack or Sun-scald.*—Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18.
- Gum Disease.*—Mich. Agr. Exp. Sta., Rept. 1896, pp. 123, 124; also Rept. 1897, p. 96. Mich. Agr. Exp. Sta., Bull. No. 156, 1898, p. 304.
- Little Peach.*—Mich. Agr. Exp. Sta., Rept. 1896, pp. 121, 122; also Bull. No. 156, 1898, pp. 303, 304.
- Mechanical Injuries, etc.*—Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 189, 190.
- Rosette.*—Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 221. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 160–162. Oklahoma Agr. Exp. Sta., Bull. No. 20, 1896, p. 21. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, pp. 13–17. U. S. Dept. Agr., Journ. Mycol., Vol. VI., pp. 143–148. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 226–232.
- Twig Diseases, — Gum-flow.*—Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 199–206.
- Twig Spots.*—Ohio Agr. Exp. Sta., Bull. No. 92, 1898, p. 208.
- Yellows.*—Conn. (State) Agr. Exp. Sta., Bull. No. 111, 1892, pp. 7, 8; also Bull. No. 115. Delaware Agr. Exp. Sta., Rept. 1893, pp. 152, 153; also Rept. 1897, pp. 168–173. Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 220. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 157–160. Mass. Bull. Bussey Inst. (Harvard Univ.), Vol. III., Pt. 1, 1901. Mass. Hatch Exp. Sta., Bull. No. 8, 1890, pp. 6–12. Mich. Agr. Exp. Sta., Bull. No. 103, 1894, pp. 46–53. N. J. Agr. Exp. Sta., Rept. 1898, pp. 357–359; also Rept. 1899, pp. 417, 418. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 25, 1890, pp. 178–180; also Bull. No. 75, 1894, pp. 392–408. No. Car. Agr. Exp. Sta., Bull. No. 92, 1893, pp. 101, 102, 112; also Bull. No. 120, 1895, pp. 300, 301. Ohio Agr. Exp. Sta., Bull. No. 104, 1899, pp. 212–216; also Bull. No. 92, 1898, pp. 190–199. Pa. Agr. Exp. Sta., Bull. No. 37, 1896, pp. 21–23. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 4, 1893. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, 1894. U. S. Dept. Agr., Sec. Veg. Path., Bull. No. 9, 1888. W. Va. Agr. Exp. Sta., Bull. No. 66, 1900, pp. 214, 215.

PEAR (*Pirus communis*, L.).

- Frost Injuries.*—Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18 (tree trunk). See *Plum* and *Peach*. Conn. (State) Agr. Exp. Sta., 19th Rept. 1895, p. 190 (on fruit). Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100 (on fruit). See *Apple*.

PLUM (*Prunus*, spp.).

- Frost-cracks and Sun-scald.*—Cal. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18. Del. Agr. Exp. Sta., Bull. No. 57, 1902, pp. 13–15.
- Gummosis.*—Ohio Agr. Exp. Sta., Bull. No. 79, 1897, pp. 121, 122. Oregon Agr. Exp. Sta., Bull. No. 45, 1897, pp. 68–72.
- Yellows.*—Consult *Peach* literature. Mass. Hatch Exp. Sta., Rept. 1903, p. 35.

POTATO (*Solanum tuberosum*, L.).

- Arsenical Poisoning.*—Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 97, 98; also Bull. No. 72, 1899, pp. 9, 10.

- Internal Brown Rot.* — Minn. Agr. Exp. Sta., Bull. No. 39, 1894, pp. 212, 213.
Minn. Agr. Exp. Sta., Bull. No. 45, 1895, p. 310. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, pp. 78-83; also Rept. 1896, pp. 504-509.
- Pimplly Potatoes.* — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 84, 85; also Rept. 1896, p. 511.
- Stem-blight.* — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 83, 84; also Bull. No. 138, 1897, pp. 632-634.
- Sun-scald.* — Vt. Agr. Exp. Sta., Bull. No. 72, 1899, pp. 12, 13.
- Tip-burn.* — U. S. Dept. Agr., Farmers' Bull. No. 91, p. 10. Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 98, 99; also Bull. No. 72, 1899, pp. 10-12.

QUINCE (*Pirus Cydonia*).

- Frost-blisters (Leaves).* — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 224, 225.

RASPBERRY (*Rubus*, spp.).

- Yellows.* — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 226, 1902, pp. 362-364.

RICE (*Oryza sativa*, L.).

- Blast.* — S. C. Agr. Exp. Sta., Bull. No. 41, 1899, pp. 3-7.

ROSE (*Rosa*, spp.).

- Bronzing of Leaves.* — Mass. Hatch Exp. Sta., Rept. 1899, pp. 156-159. N. J. Agr. Exp. Sta., Rept. 1891, pp. 303, 304.

TOBACCO (*Nicotiana Tabacum*, L.).

- Mosaic Disease, "Calico" or Mottled Top.* — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 242-260; also Rept. 1899, pp. 252-261. U. S. Dept. Agr., Beau. Plant Indus., Bull. No. 18, 1902.
- Spotting.* — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 254-260; also, Rept. 1899, pp. 252-261.

TOMATO (*Lycopersicum esculentum*, Mill.).

- Dropping of Buds.* — Fla. Agr. Exp. Sta., Bull. No. 21, 1893, pp. 37, 38; also Bull. No. 47, 1898, pp. 148-151.
- Hollow Stem.* — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 151-153.
- Edema.* — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 146-148. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 53, 1893. Vt. Agr. Exp. Sta., 6th Rept. 1892, p. 88.

MISCELLANEOUS.

- Arsenical Injuries.* — Cal. Agr. Exp. Sta., Bull. No. 151, 1903.
- Lichens, Mosses, etc.* — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 169-173.
- Shade Trees.* — Mechanical injuries, etc.: Conn. (State) Agr. Exp. Sta., Bull. No. 131, 1900; also 24th Rept. 1900, pp. 330-351. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 205, 1902.
- Leaf-scorch or wilt: Vt. Agr. Exp. Sta., 13th Rept. 1899-1900, pp. 281, 282. Mass. Hatch Exp. Sta., Rept. 1897, pp. 81, 82. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 177, 178.
- Illuminating gas, steam, etc.: Mass. Hatch Exp. Sta., Rept. 1899, pp. 163-167.
- Loss of foliage: Mass. Hatch Exp. Sta., Rept. 1899, pp. 153, 154.
- Current electricity, lightning: Mass. Hatch Exp. Sta., Bull. No. 91, 1903.
- Sunstroke: Kentucky Agr. Exp. Sta., Bull. No. 47, 1893, pp. 6-8.
- Smoke and Atmospheric Gases.* — Pa. State Coll. Publication (Prof. Buckhout), 1900 (effects on trees). Utah Agr. Exp. Sta., Bull. No. 88, 1903 (effects on crops).

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

At the beginning of the year a change was made in the times of observation, from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M. This was done in order to make them synchronous with those of the United States Weather Bureau, this station being one of the voluntary stations of that service. This change has made no appreciable difference in the daily means compared with those of previous years, excepting those of relative humidity, where the omission of the observation near midday seems to have resulted in a higher mean. The effect, however, can be more definitely determined after the change has been in operation for a number of years.

As in previous years, much of the work of this division has been that of observation and transcription of the records in permanent form. The usual bulletins have been regularly issued at the beginning of each month, containing the more important daily records, together with the monthly means, and remarks on any unusual features that occurred. An annual summary will be made a part of the December bulletin.

The local forecasts have been regularly received from the Boston office of the United States Weather Bureau, and the signals displayed from the flag-staff on the tower. This station is furnishing the weekly reports for the "snow and ice" bulletin, as has been done the last few years.

In addition to furnishing the section director of the Weather Bureau with the voluntary observers' reports, as well as our printed bulletin, at his request early in the year all the records at this station were examined and the data tabulated to be used in a climatological directory of the principal stations

of the United States. A phenological record was also kept during the growing season, and two copies furnished the section director as requested.

As a part of the college exhibit for the Louisiana Purchase Exposition at St. Louis, this division prepared a number of charts in water colors, showing many of the meteorological features of the station. Photographs of most of our self-recording instruments were also sent.

Two new clocks for the Draper instruments were purchased during the year, to replace others that had become unreliable.

Mr. F. F. Henshaw retired as observer upon his graduation in June, and was succeeded by the assistant observer, Mr. G. W. Patch.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH and E. S. FULTON.

Inspector of Feeds and Babcock Machines: ALBERT PARSONS.

Dairy Tester: SUMNER R. PARKER.

In Charge of Feeding Experiments: JOSEPH G. COOK.

Stenographer: MABEL C. SMITH.

PART I.—THE WORK OF THE YEAR.

1. Correspondence.
2. General laboratory work.
3. Character of laboratory work.
 - (a) Water.
 - (b) Dairy products and cattle feeds.
 - (c) Chemical investigations.
4. Inspection of concentrates.
5. Execution of the dairy law.
6. Test of pure-bred cows.
7. Work completed and in progress.
8. Changes in staff.

PART II.—EXPERIMENTS IN ANIMAL NUTRITION.

1. Digestion experiments with sheep.
2. The digestibility of galactan.
3. The feeding value of apple pomace.
4. Blomo feed for horses.

PART I. — THE WORK OF THE YEAR.

J. B. LINDSEY.

1. CORRESPONDENCE.

The general character of the correspondence has been much the same as in former years, and the amount has been approximately 4,000 letters and postals, in addition to some 1,000 circulars relative to adulterated mixed feeds.

2. GENERAL LABORATORY WORK.

The work in the laboratory has been of the same character as formerly. The number of determinations of butter fat in milk has greatly increased.

There have been sent in for examination 104 samples of water, 773 of milk, 1,779 of cream, 2 of butter and 153 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 234 samples of milk and cream and 530 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 686 samples of concentrated feed stuffs. This makes a total of 4,261 substances analyzed during the year, as against 3,897 last year and 3,240 in the previous year. Work on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 20 candidates have been examined and given certificates to operate Babcock machines, and 2,026 pieces of glassware have been tested for accuracy, of which 200 pieces, or 9.87 per cent., were condemned.

3. CHARACTER OF LABORATORY WORK.

(a) Water.

In accordance with instructions from the experiment station committee, this department continues to charge the sum of \$3 for a sanitary analysis of water. The number of samples

examined has been 104, which is considerably less than when the work was done free of cost. It is believed that this charge has held in check those who have heretofore abused the privilege by sending in a large number of samples, in some cases out of mere curiosity.

Instructions for securing an analysis of water:—

Those wishing to secure a sanitary analysis of water must first make application, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return express 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.

Address

Dr. J. B. LINDSEY,
Hatch Experiment Station, Amherst, Mass.

(b) *Dairy Products and Cattle Feeds.*

The station received about the usual number of samples of milk and cream. Many samples are sent by farmers to ascertain the quality of milk produced by their herd or by individual cows, and this should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instructions relative to the best methods of determining the productive capacity of the dairy herd. The station also tests a large number of samples of milk and cream for creameries at a charge sufficient to cover the cost.

About the usual number of feed stuffs were received during the year. These come from practical feeders, who either suspect adulteration, or desire to know the value of a feed new to their locality. The results of the examination are returned promptly, together with such information as is suited to the particular case. A considerable number of samples are also received from feed dealers, who wish to make sure as to the intrinsic value of the materials they are offering. It is believed that this desire for information should be encouraged as much as the limited resources of the department permit.

(c) *Chemical Investigations.*

In so far as time and opportunity permit, the department aims to make a study of chemical methods that will facilitate the accurate and rapid determinations of the different substances connected with animal or plant life. In this study of methods the department co-operates yearly with the Association of Official Agricultural Chemists.

4. INSPECTION OF CONCENTRATES.

The passage of the feed law by the Legislature of 1903 makes it possible to give the attention to this line of work which its importance demands. A regular inspector is now employed, who travels through the State from six to eight months in the year, so that the station is kept well informed regarding the variety and character of the feeds offered for sale. The results of the several inspections were published in Bulletins Nos. 93 and 98, issued in January and August. These bulletins contained 52 and 36 pages respectively. It may be said that the major portion of the feeds now offered are properly branded and free from adulteration; still, some manufacturers and local dealers continue to be careless about attaching the proper form of guarantee, and, while the station has not prosecuted any cases as yet, there will be no hesitation in doing so if occasion makes it necessary.

A tendency is noted on the part of both manufacturers and dealers to mix more or less oat offal or other filler with standard by-products, thus reducing the cost of the article sufficiently to enable them to slightly undersell their competitors. The station is taking a firm stand against such deceptions.

During the present autumn a considerable quantity of wheat mixed feed, bran and middlings, was found considerably adulterated with ground corn cobs and wheat screenings. The prompt attention of the jobbers was called to the matter, and they took steps immediately to attach the proper guarantee. A special circular relative to this fraud was sent to all the principal grain dealers in the State, as well as to the agricultural press.

It is not necessary to make a chemical analysis of as many samples as formerly. More attention is being given to the work of careful inspection and to the collecting of those samples which are suspected of being below standard or adulterated. The correspondence in connection with this police work, as it may be termed, requires a great deal of time and patience. It is believed that all farmers and dairy-men can now keep themselves well posted upon the character and value of the large variety of feeds offered, if they are disposed to do so. Interested parties are referred to the various feed bulletins for details. Bulletin No. 101, comprising the results of the autumn inspection, is now in press, and will be issued during the present month (December).

5. EXECUTION OF THE DAIRY LAW.

The enforcement of this law has been given the same careful attention as in previous years.

Inspection of Glassware.—All glassware found to be correctly graduated has been marked "Mass Ex St." There were 2,026 pieces examined, of which 200, or 9.87 per cent., were condemned. Inaccurate graduation of bottles has been rather more noticeable of late than at any time since the early days of the inspection. This is to be regretted, and it is hoped the manufacturers will take immediate action to prevent a possible recurrence. Bulb cream bottles (Bartlett) have been previously passed on accuracy of total graduation, as the usual charge of 5 cents apiece would not permit of additional testing. The continued use of these bottles by some of the prominent milk depots has rendered it necessary to test the three distinct portions of the scale, at a corresponding increase in cost.

Examination of Candidates.—A few more candidates than usual were examined, and 20 certificates of competency issued. A considerable number showed very poor manipulation, and lacked a thorough understanding of the method. In case of failure, applicants are obliged to wait a month before a second examination will be given.

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 annual inspection of Babcock machines was made in November of 1904. Fifty-six establishments were either visited or heard from, 36 being creameries and 20 milk depots. Twenty-one, or one-third the number, are co-operative, while the other 35 are proprietary, or managed by stock companies. Thirty-six machines were inspected. The number is 4 less than last year, due to the fact that 2 creameries and 1 milk depot have been discontinued, and 1 milk depot does not use its tester. Some machines overheated the tests, and a few required additional steam to warm them. One needed slight repairs of the steam gauge, but the others were in satisfactory condition, and in general showed an improvement over last year. Steam was the motive power in every case except one, where electricity was used. All but 5 of the machines have frames of cast iron, which is taking the place of galvanized iron and copper. Of the cast-iron machines, 19 are "Facile," 10 "Agos," and 2 "Wizard." The last named has only recently been placed upon the market. As a rule, the glassware was found in good condition, although in a few cases it was very dirty. In addition to the regular inspection, two city milk inspectors were visited. Each had a "Wizard" cast-iron machine, one being run by electricity and the other by a water motor. The electrical machine did not have sufficient power for the necessary speed. The other was in good condition, and a certificate was given.

6. TESTS OF PURE-BRED COWS.

This work has increased to such an extent as to render necessary the employment of a regular tester, Mr. Sumner R. Parker of the class of 1904 of this college, who gives it his whole time. The testing is conducted under the supervision of the American Guernsey and Jersey cattle clubs and the Holstein-Friesian Association. The work consists largely in determining the yearly milk and butter fat yields of pure-bred cows of the several breeds. The inspector visits the farms monthly, weighs the milk for one or two days, determines the butter fat by the Babcock method, and reports his findings to the secretary of the respective clubs, together with such other data, relative to feed, scattered milkings, etc., as are required. These tests are known as "yearly milk and butter fat tests," or "authenticated butter fat estimate and milk record." There are at present

51 Guernsey and Jersey cows under test, belonging to F. Lothrop Ames of North Easton, N. I. Bowditch of Framingham, W. L. Cutting of Pittsfield, R. F. and A. H. Parker of Westborough, A. H. Sagendorph of Spencer, C. I. Hood of Lowell, A. F. Pierce of Winchester, N. H., and R. A. Sibley of Spencer.

In addition, seven-day butter tests are occasionally called for by the Jersey Cattle Club, in which case it becomes necessary to weigh, sample and test not only the milk but the skim milk, buttermilk and butter; and the total fat in the three latter, together with that in the test samples, should balance the fat in the original milk, with the exception of small mechanical losses. The butter is analyzed at the station laboratory. Seven-day tests are also made for the Holstein-Friesian Association, which simply calls for the amount of milk and butter fat produced by the animal during that period.

7. WORK COMPLETED AND IN PROGRESS.

In addition to Bulletins Nos. 93 and 98, devoted to the inspection of feeding stuffs, this department has published during the year Bulletin No. 94, on distillery and brewery by-products, and Bulletin No. 99, on dried molasses beet pulp, and nutrition of horses. An experiment has been completed on the use of dried blood as a source of protein for milk production, showing that digestible protein in this material is equal in feeding value to a similar amount in cotton-seed meal. An experiment has also been completed with Pratts food as an aid to milk production. The results make clear that the claims put forward by the manufacturers relative to the wonderful influence of this food in increasing the quantity and quality of milk are entirely without foundation. Bibby's dairy cake has also been compared with gluten feed for the production of milk, and, while the results are not yet entirely tabulated, it is quite evident that the Bibby cake possesses no particular merits over other feed stuffs of a similar composition, and that the price asked is out of proportion to its actual feeding value. A number of experiments have been in progress with green forage crops, but, as the results at present are only of a tentative charac-

ter, they will not be published until it is possible to deduce more definite conclusions.

Some 34 tons of corn and soy beans were grown together the past season on a little less than 3 acres of land, and the fodder ensiled. The silo has been recently opened, the silage appears in good condition and is readily eaten. It was not found possible to cut this mixture satisfactorily with a corn harvester, and the writer is forced to the conclusion that, until this can be accomplished, it will be doubtful economy to attempt to grow it to any extent for silage purposes. It is believed that the value of the extra protein obtained is more than offset by the increased cost of harvesting the crop.

Experiments are in progress relative to the value of molasses and molasses feeds as food for dairy stock and horses, and will occupy a considerable portion of the winter months. Attention is called to the several completed experiments published in Part II. of this report.

8. CHANGES IN STAFF.

Mr. W. E. Tottingham, employed in this department as assistant chemist for a year, resigned September 1 to continue his studies in the chemical department of the college. His work was very satisfactory. Mr. E. S. Fulton of the class of 1904 of the college succeeded Mr. Tottingham. Mr. S. R. Parker, another graduate of the class of 1904, began his duties August 1 as dairy tester. He is kept constantly employed in this line of work.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. DIGESTION EXPERIMENTS WITH SHEEP.

J. B. LINDSEY.¹

This station has given considerable time and study to the digestibility of coarse and concentrated cattle feeds. The first experiments were made in the autumn and winter of 1892-93, and the results published, together with a description of the method employed, in the eleventh report of the Massachusetts State Experiment Station. The results of further experiments were published in the twelfth report. A summary of all experiments made between 1894 and 1902 will be found in the fifteenth report of the Hatch Experiment Station, pp. 82-101. Experiments made during 1902 appeared in the sixteenth report of this station.

The experiments here described were made during the autumn of 1903 and winter and spring of 1904. The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, only averages are presented.

The period extended over fourteen days, the first seven of which were preliminary, collection of feces 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.

Two lots of sheep, grade Southdown wethers, were employed in the several trials, known as the old and the young sheep. The former were five to six years of age, and had been used by the station for a number of years; the latter were dropped in 1902, and were employed for the first time during the autumn and winter of 1903-04.

¹ With E. B. Holland, P. H. Smith, W. E. Tottingham and J. G. Cook.

The digestion coefficients for the digestion hay, used in calculating the results of the several experiments with the old sheep, were those obtained with Sheep II. and III., Sheep I. having been disposed of before the digestibility of the hay was determined.

The individual coefficients were used for the young sheep, being obtained from the average of the two trials in the case of Sheep I. and II., and that of the single trial for Sheep III.

Hay Coefficients used (Per Cent.).

	Old Sheep.	YOUNG SHEEP.		
		I.	II.	III.
Dry matter,	58.50	49.89	54.34	51.53
Ash,	22.00	13.86	22.60	16.55
Protein,	42.50	37.37	37.72	36.66
Fiber,	61.00	49.98	55.85	53.13
Extract matter,	64.00	56.29	59.77	57.02
Fat,	46.50	38.54	44.19	36.97

In calculating the digestion coefficients when English hay was used, excepting in periods IV., V. and XII., the average analysis of the two samples of hay was employed.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Soy bean fodder,	11.82	20.03	22.12	42.55	3.48
Waste soy bean fodder, Sheep II.,	8.64	4.85	55.47	30.33	.71
Eureka silage corn fodder,	6.19	9.34	27.41	55.52	1.54
Apple pomace,	3.05	5.13	16.10	69.32	6.40
Cotton-seed meal fed with pomace,	6.95	52.16	5.88	25.91	9.10
English hay fed to new sheep,	6.53	6.23	33.00	52.27	1.97
Waste English hay, ¹ Sheep III., fine hay and seeds.	29.19	6.76	21.67	40.25	2.13
English hay fed to old sheep,	6.25	6.24	31.95	53.15	2.31
Bibby's dairy cake,	9.14	23.52	9.28	48.06	10.00
Bibby's dairy cake (1903),	8.38	21.39	9.19	50.42	10.62
Alma dried molasses-beet-pulp,	5.64	9.87	17.17	66.74	.58

¹ Contained 21.39 per cent. of salt.

Composition of Feed Stuff's (Per Cent.)—Concluded.

[Dry matter.]

FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Armour's blood meal,	3.37	95.24	.88	—	.51
Corn meal fed with blood meal,	1.41	9.87	2.09	82.25	4.38
Soy bean meal, coarse ground,	5.73	40.69	4.71	27.77	21.10
Hominy feed,	3.15	11.66	5.46	70.11	9.62
Hominy meal (1903),	3.38	12.23	4.97	69.43	9.99
Eureka silage corn fodder (dry),	7.85	9.82	32.70	47.90	1.73
Waste corn stover, Sheep II.,	9.85	9.16	34.13	45.07	1.79
English hay, ¹	6.46	6.74	32.28	52.16	2.36
Waste English hay, Sheep I.,	6.94	6.17	32.72	52.05	2.12
Waste English hay, ² Sheep II.,	14.99	6.95	27.41	48.22	2.43

¹ Used in Period XII.² Contained 7.38 per cent. of salt.*Composition of Faeces (Per Cent.).*

[Dry matter.]

Old Sheep I.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I.,	Soy bean fodder,	18.55	8.62	33.83	35.99	3.01
II.,	Eureka silage corn fodder,	9.87	8.77	33.67	46.28	1.41
III.,	Apple pomace,	9.93	18.53	24.38	40.21	6.95
XXVI. (1903),	Bibby's dairy cake,	12.88	14.93	27.19	41.62	3.38
XXVIII. (1903),	Hominy meal,	11.31	13.41	28.49	43.33	3.46

Old Sheep II.

I.,	Soy bean fodder,	19.95	9.44	33.48	34.05	3.08
II.,	Eureka silage corn fodder,	11.47	9.85	31.70	45.30	1.68
III.,	Apple pomace,	9.93	17.97	23.24	41.07	7.79
V.,	English hay,	11.78	8.42	30.93	46.03	2.84
VII.,	Alma dried molasses-beet-pulp,	12.37	10.80	29.21	44.15	3.47
IX.,	Soy bean meal,	12.87	9.82	29.50	44.64	3.17
XI.,	Eureka silage corn fodder (dry),	12.73	11.58	26.04	47.87	1.78
XXVI. (1903),	Bibby's dairy cake,	13.89	14.86	26.54	41.23	3.48
XXVIII. (1903),	Hominy meal,	12.91	14.22	25.99	43.21	3.67

Composition of Faeces (Per Cent.)—Concluded.

[Dry matter.]

Old Sheep III.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I., . . .	Soy bean fodder,	19.96	9.34	32.18	35.34	3.18
II., . . .	Eureka silage corn fodder, . . .	10.92	9.14	32.41	45.89	1.64
III., . . .	Apple pomace,	11.44	20.82	19.82	40.40	7.52
V., . . .	English hay,	12.15	9.01	29.49	46.18	3.17
VII., . . .	Alma dried molasses-beet-pulp, .	12.51	11.21	27.82	45.04	3.42
IX., . . .	Soy bean meal,	12.02	10.67	26.56	46.96	3.79
XI., . . .	Eureka silage corn fodder (dry), .	12.79	11.84	25.27	48.29	1.81
XXVI. (1903),	Bibby's dairy cake,	13.93	15.59	24.63	41.87	3.98
XXVIII. (1903),	Hominy meal,	13.06	14.88	24.06	43.41	4.59

Young Sheep I.

IV., . . .	English hay,	11.16	7.86	32.51	45.75	2.72
VI., . . .	Bibby's dairy cake,	12.62	11.19	30.20	43.41	2.58
VIII., . . .	Armour's blood meal,	10.64	13.03	31.49	42.29	2.55
X., . . .	Marshall's hominy feed,	10.98	10.81	29.89	45.47	2.85
XII., . . .	English hay,	11.12	8.38	32.64	45.34	2.52

Young Sheep II.

IV., . . .	English hay,	10.70	8.40	31.51	46.74	2.65
VI., . . .	Bibby's dairy cake,	12.03	12.50	30.29	42.61	2.57
VIII., . . .	Armour's blood meal,	10.47	15.57	29.30	42.23	2.43
X., . . .	Marshall's hominy feed,	10.72	11.30	30.08	45.36	2.54
XII., . . .	English hay,	11.21	9.26	31.72	45.24	2.57

Young Sheep III.

IV., . . .	English hay,	10.92	7.97	32.20	46.40	2.51
VI., . . .	Bibby's dairy cake,	12.90	11.08	31.30	42.36	2.36
X., . . .	Marshall's hominy feed,	10.62	9.97	30.60	46.14	2.67

Dry Matter Determinations made at Time of Weighing out the Different Foods, and Dry Matter in Manure excreted, determined from Air-dry Faeces (Per Cent.).

Old Sheep I.

PERIODS.	English Hay.	Soy Bean Fodder.	Eureka Silage Corn Fodder.	Apple Pomace.	Cotton-seed Meal.	Alura Dried Molasses-beet pulp.	Soy Bean Meal.	Eureka Silage Corn Fodder (Dry).	Bibby's Dairy Cake.	Hominy Meal.	Waste.	Manure.
I., . . .	87.27	23.94	-	-	-	-	-	-	-	-	-	91.02
II., . . .	-	-	17.42	-	-	-	-	-	-	-	-	89.82
III., . . .	87.05	-	-	19.83	89.34	-	-	-	-	-	-	92.28
XXVI. (1903),	88.82	-	-	-	-	-	-	-	89.80	-	-	92.43
XXVIII. (1903),	88.25	-	-	-	-	-	-	-	-	88.48	-	92.98

Old Sheep II.

I., . . .	87.27	23.94	-	-	-	-	-	-	-	-	96.37	90.82
II., . . .	-	-	17.42	-	-	-	-	-	-	-	-	89.93
III., . . .	87.05	-	-	19.83	89.34	-	-	-	-	-	-	92.00
V., . . .	88.10	-	-	-	-	-	-	-	-	-	-	92.50
VII., . . .	87.82	-	-	-	-	92.62	-	-	-	-	-	93.55
IX., . . .	88.37	-	-	-	-	-	86.96	-	-	-	-	94.42
XI., . . .	-	-	-	-	-	-	-	40.08	-	-	51.19	93.84
XXVI. (1903),	88.82	-	-	-	-	-	-	-	89.80	-	-	92.66
XXVIII. (1903),	88.25	-	-	-	-	-	-	-	-	88.48	-	92.54

Old Sheep III.

I., . . .	87.27	23.94	-	-	-	-	-	-	-	-	-	90.77
II., . . .	-	-	17.42	-	-	-	-	-	-	-	-	89.81
III., . . .	87.05	-	-	19.83	89.34	-	-	-	-	-	-	91.88
V., . . .	88.10	-	-	-	-	-	-	-	-	-	-	92.56
VII., . . .	87.82	-	-	-	-	92.62	-	-	-	-	-	93.60
IX., . . .	88.37	-	-	-	-	-	86.96	-	-	-	-	94.61
XI., . . .	-	-	-	-	-	-	-	40.08	-	-	-	93.84
XXVI. (1903),	88.82	-	-	-	-	-	-	-	89.80	-	-	92.84
XXVIII. (1903),	88.25	-	-	-	-	-	-	-	-	88.48	-	92.91

*Dry Matter Determinations, etc. — Concluded.**Young Sheep I.*

PERIODS.	English Hay.	Bibby's Dairy Cake.	Armour's Blood Meal.	Corn Meal.	Marshall's Hominy Feed.	Waste.	Manure.
IV., . .	87.90	-	-	-	-	86.65	93.36
VI., . .	88.05	89.45	-	-	-	-	93.78
VIII., . .	87.85	-	88.70	86.13	-	-	93.45
X., . .	89.30	-	-	-	88.53	-	94.06
XII., . .	89.77	-	-	-	-	87.00	93.22

Young Sheep II.

IV., . .	87.90	-	-	-	-	-	93.27
VI., . .	88.05	89.45	-	-	-	-	93.55
VIII., . .	87.85	-	88.70	86.13	-	-	93.33
X., . .	89.30	-	-	-	88.53	-	93.78
XII., . .	89.77	-	-	-	-	87.80	92.84

Young Sheep III.

IV., . .	87.90	-	-	-	-	88.50	93.25
VI., . .	88.05	89.45	-	-	-	-	94.16
X., . .	89.30	-	-	-	88.53	87.80	94.08

Average Daily Amount of Manure excreted and Water drunk (Grams).

Period.	CHARACTER OF RATION.	OLD SHEEP I.			OLD SHEEP II.			OLD SHEEP III.		
		Manure excreted daily.	Sample Air Dry.	Water drunk daily.	Manure excreted daily.	Sample Air Dry.	Water drunk daily.	Manure excreted daily.	Sample Air Dry.	Water drunk daily.
I,	Soy bean fodder,	639	35.09	1,409	684	34.26	1,492	679	34.67	1,296
II,	Eureka silage corn fodder,	630	23.53	-	506	20.70	-	481	21.77	-
III,	Apple pomace,	669	27.29	536	581	24.68	414	818	25.95	-
V,	English hay,	-	-	-	806	36.94	1,067	717	33.92	1,391
VII,	Alma dried molasses-beet-pulp,	-	-	-	613	27.13	1,379	623	28.69	1,386
IX,	Soy bean meal,	-	-	-	736	27.48	1,264	860	30.62	1,638
XI,	Eureka silage corn fodder (dry),	-	-	-	400	16.61	516	506	18.55	1,006
XXVI. (1903),	Bibby's dairy cake,	423	31.86	2,370	703	27.13	1,688	784	30.68	1,992
XXVIII. (1903),	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

Average Daily Amount of Manure excreted, etc. — Concluded.

Period.	CHARACTER OF RATION.	YOUNG SHEEP I.			YOUNG SHEEP II.			YOUNG SHEEP III.		
		Manure excreted daily.	Sample Air Dry.	Water drunk daily.	Manure excreted daily.	Sample Air Dry.	Water drunk daily.	Manure excreted daily.	Sample Air Dry.	Water drunk daily.
IV,	English hay,	979	39.76	1,369	831	37.47	2,477	875	36.80	1,827
VI,	Bibby's dairy cake,	956	32.47	1,368	881	32.52	2,156	915	32.99	2,104
VIII,	Armour's blood meal,	628	27.88	1,369	628	27.72	2,206	-	-	-
X,	Marshall's hominy feed,	837	29.49	1,389	912	29.16	1,894	844	30.87	2,076
XII,	English hay,	994	35.08	1,354	799	33.20	2,467	-	-	-

Weights of Animals at Beginning and End of Period (Pounds).

Period.	CHARACTER OF RATION.	OLD SHEEP I.		OLD SHEEP II.		OLD SHEEP III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
I, . . .	Soy bean fodder,	167.25	168.00	154.50	155.25	152.75	149.50
II, . . .	Eureka silage corn fodder,	167.50	164.75	156.00	154.50	149.00	145.75
III, . . .	Apple pomace,	170.75	171.50	157.50	158.25	152.75	153.50
V, . . .	English hay,	-	-	164.00	162.00	159.50	160.00
VII, . . .	Abma dried molasses-beet-pulp,	-	-	162.00	162.75	160.50	160.25
IX, . . .	Soy bean meal,	-	-	163.00	163.25	161.00	158.25
XI, . . .	Eureka silage corn fodder (dry),	-	-	159.75	157.00	153.75	153.50
XXVI. (1963),	Bibby's dairy cake,	159.00	154.75	155.00	154.25	149.00	146.75
XXVIII. (1963),	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Weights of Animals, etc. — Concluded.

Period.	CHARACTER OF RATION.	YOUNG SHEEP I.		YOUNG SHEEP II.		YOUNG SHEEP III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
IV, . . .	English hay,	98.50	95.00	97.00	98.25	97.00	96.00
VI, . . .	Bibby's dairy cake,	95.25	93.00	93.75	92.25	90.25	90.75
VIII, . . .	Armour's blood meal,	96.25	97.50	91.25	93.50	-	-
X, . . .	Marshall's hominy feed,	94.00	94.50	88.00	90.25	89.00	89.25
XII, . . .	English hay,	98.75	96.50	91.50	94.25	-	-

*Period I.**Old Sheep I.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
2,000 grams soy bean fodder,	478.80	56.59	95.90	105.91	203.73	16.66
Amount consumed,	827.88	79.07	117.68	219.29	387.70	24.13
350.87 grams manure excreted,	319.36	59.24	27.53	108.04	114.94	9.61
Grams digested,	508.52	19.83	90.15	111.25	272.76	14.52
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	304.31	14.88	80.89	42.09	155.02	11.05
Per cent. digested,	63.56	26.29	84.35	39.74	76.09	66.33

Old Sheep II.

2,000 grams soy bean fodder fed,	478.80	56.59	95.90	105.91	203.73	16.66
Minus 36 grams waste,	34.69	3.00	1.69	19.24	10.52	.25
Soy bean fodder consumed,	444.11	53.59	94.22	86.67	193.21	16.41
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
Amount consumed,	773.19	76.07	116.00	200.05	377.18	23.88
342.59 grams manure excreted,	311.14	62.07	29.37	104.17	105.94	9.58
Grams digested,	482.05	14.00	86.63	95.88	271.24	14.30
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean digested,	277.84	9.05	77.37	26.72	153.50	10.83
Per cent. digested,	62.51	16.89	82.12	30.83	79.45	66.00

Old Sheep III.

Amount consumed same as for Sheep I.,	827.88	79.07	117.68	219.29	387.70	24.13
346.71 grams manure excreted,	314.71	62.82	29.39	101.27	111.22	10.01
Grams digested,	513.17	16.25	88.29	118.02	276.48	14.12
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	308.96	11.30	79.03	48.86	158.74	10.65
Per cent. digested,	64.53	19.97	82.41	46.13	77.92	63.93
Average per cent. three sheep digested,	63.53	21.05	82.96	38.90	77.82	65.42

*Period II.**Old Sheep I.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
235.29 grams manure excreted,	211.34	20.86	18.53	71.16	97.81	2.98
Grams digested,	380.94	15.80	36.79	91.18	231.02	6.14
Per cent. digested,	64.32	43.10	66.50	56.17	70.26	67.32

Old Sheep II.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
207.01 grams manure excreted,	186.16	21.35	18.34	59.01	84.33	3.13
Grams digested,	406.12	15.31	36.98	103.33	244.50	5.99
Per cent. digested,	68.57	41.76	66.85	63.65	74.35	65.68

Old Sheep III.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
217.69 grams manure excreted,	195.51	21.35	17.87	63.36	89.72	3.21
Grams digested,	396.77	15.31	37.45	98.98	239.11	5.91
Per cent. digested,	66.99	41.76	67.70	60.97	72.72	64.80
Average per cent. three sheep digested,	66.63	42.21	67.02	60.26	72.44	65.93

*Period III.**Old Sheep I.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
250 grams English hay,	217.63	14.02	13.58	70.69	114.69	4.66
150 grams cotton-seed meal,	134.01	9.31	69.90	7.88	34.72	12.19
2,000 grams apple pomace,	396.60	12.10	20.35	63.85	274.92	25.38
Amount consumed,	748.24	35.43	103.83	142.42	424.33	42.23
272.89 grams manure excreted,	251.82	25.01	46.66	61.39	101.26	17.50
Grams digested,	496.42	10.42	57.17	81.03	323.07	24.73
Minus hay digested,	127.31	3.08	5.77	43.12	73.40	2.17
•	369.11	7.34	51.40	37.91	249.67	22.56
Minus cotton-seed meal digested,	101.85	2.23	61.51	2.52	22.22	11.34
Apple pomace digested,	267.26	5.11	-	35.39	227.45	11.22
Per cent. digested,	67.39	42.23	-	55.43	82.73	44.21

Old Sheep II.

Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.33
246.76 grams manure excreted,	227.02	22.54	40.80	52.76	93.24	17.68
Grams digested,	521.22	12.89	63.03	89.66	331.09	24.55
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	292.06	7.58	-	44.02	235.47	11.04
Per cent. digested,	73.64	62.64	-	68.94	85.65	43.50

Old Sheep III.

Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.23
259.46 grams manure excreted,	238.39	27.27	49.63	47.25	96.31	17.93
Grams digested,	509.85	8.16	54.20	95.17	328.02	24.30
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	280.69	2.85	-	49.53	232.40	10.79
Per cent. digested,	70.77	23.55	-	77.57	84.53	42.51
Average per cent. three sheep digested,	70.60	42.81	-	67.31	84.30	43.41

Period IV.
Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 35.86 grams waste,	31.07	2.03	1.94	10.25	16.24	.61
Amount consumed,	716.08	46.76	44.61	236.31	374.30	14.11
397.61 grams manure excreted,	371.21	41.43	29.18	120.68	169.83	10.10
Grams digested,	344.87	5.33	15.43	115.63	204.47	4.01
Per cent. digested,	48.16	11.40	34.59	48.93	54.63	28.42

Young Sheep II.

850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
374.71 grams manure excreted,	349.49	37.40	29.36	110.12	163.35	9.26
Grams digested,	397.66	11.39	17.19	136.44	227.19	5.46
Per cent. digested,	53.22	23.34	36.93	55.34	58.17	37.09

Young Sheep III.

850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 56.29 grams waste,	39.16	3.89	3.37	10.80	20.05	1.06
Amount consumed,	707.99	44.90	43.18	235.76	370.49	13.66
368.01 grams manure excreted,	343.17	37.47	27.35	110.50	159.23	8.61
Grams digested,	364.82	7.43	15.83	125.26	211.26	5.05
Per cent. digested,	51.53	16.55	36.66	53.13	57.02	36.97
Average per cent. three sheep digested,	50.97	17.10	36.06	52.47	56.61	34.16

*Period V.**Old Sheep II.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
369.38 grams manure excreted,	341.68	40.25	28.77	105.68	157.28	9.70
Grams digested,	451.22	10.10	20.71	147.65	264.15	8.62
Per cent. digested,	56.91	20.06	41.86	58.28	62.68	47.05

Old Sheep III.

900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
339.15 grams manure excreted,	313.92	38.14	28.28	92.58	144.97	9.95
Grams digested,	478.98	12.21	21.20	160.75	276.46	8.37
Per cent. digested,	60.41	24.25	42.85	63.45	65.60	45.69
Average per cent. two sheep digested,	58.66	22.16	42.36	60.87	64.14	46.37

Period VI.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	528.30	34.02	32.97	171.59	278.41	11.31
200 grams Bibby's dairy cake,	178.90	16.35	42.08	16.60	85.98	17.89
Amount consumed,	707.20	50.37	75.05	188.19	364.39	29.20
324.71 grams manure excreted,	304.51	38.43	34.07	91.96	132.19	7.86
Grams digested,	402.69	11.94	40.98	96.23	232.20	21.34
Minus hay digested,	263.57	4.72	12.32	85.76	156.72	4.36
Bibby's dairy cake digested,	139.12	7.22	28.66	10.47	75.48	16.98
Per cent. digested,	77.76	44.16	68.11	63.07	87.79	94.91

Young Sheep II.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
325.20 grams manure excreted,	304.22	36.60	38.03	92.15	129.63	7.82
Grams digested,	402.98	13.77	37.02	96.04	234.76	21.38
Minus hay digested,	287.08	7.69	12.44	95.83	166.41	5.00
Bibby's dairy cake digested,	115.90	6.08	24.58	.21	68.35	16.38
Per cent. digested,	64.78	37.19	58.41	1.27	79.50	91.56

Young Sheep III.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
329.87 grams manure excreted,	310.61	40.07	34.42	97.22	131.57	7.33
Grams digested,	396.59	10.30	40.63	90.97	232.82	21.87
Minus hay digested,	272.23	5.63	12.09	91.17	158.75	4.18
Bibby's dairy cake digested,	24.36	4.67	28.54	.80	74.07	17.69
Per cent. digested,	69.51	28.56	67.82	-	86.15	98.88
Average per cent. three sheep digested,	70.68	36.64	64.78	32.17	84.48	95.12

*Period VII.**Old Sheep II.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	526.92	33.93	32.88	171.14	277.69	11.28
300 grams beet pulp,	277.86	15.67	27.42	47.71	185.44	1.61
Amount consumed,	804.78	49.60	60.30	218.85	463.13	12.89
271.34 grams manure excreted,	253.84	31.40	27.41	74.15	112.07	8.81
Grams digested,	550.94	18.20	32.89	144.70	351.06	4.08
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	241.69	10.74	18.92	40.30	173.34	-
Per cent. digested,	86.98	68.54	69.00	84.47	93.47	-

Old Sheep III.

Amount consumed as above,	804.78	49.60	60.30	218.85	463.13	12.89
286.94 grams manure excreted,	268.58	33.60	30.11	74.72	120.97	9.19
Grams digested,	536.20	16.00	30.19	144.13	342.16	3.70
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	227.95	8.54	16.22	39.73	164.44	-
Per cent. digested,	82.04	54.50	59.15	83.27	88.68	-
Average per cent. two sheep digested,	84.51	61.52	64.08	83.87	91.08	-

*Period VIII.**Young Sheep I.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	527.10	33.95	32.89	171.20	277.78	11.28
100 grams corn meal,	86.13	1.21	8.50	1.80	70.84	3.77
100 grams Armour's blood meal,	88.70	2.99	84.48	.78	-	.45
Amount consumed,	701.93	38.15	125.87	173.78	348.62	15.50
278.77 grams manure excreted,	260.51	27.72	33.94	82.03	110.17	6.64
Grams digested,	441.42	10.43	91.93	91.75	238.45	8.86
Minus hay digested,	262.97	4.71	12.29	85.57	156.36	4.35
	178.45	5.72	79.64	6.18	82.09	4.51
Minus corn meal digested,	76.66	-	5.95	-	66.59	3.43
Blood meal digested,	101.79	-	73.69	-	15.50	1.08
Per cent. digested,	100.+	-	88.41	-	-	-

Young Sheep II.

Amount consumed as above,	701.93	38.15	125.87	173.78	348.62	15.50
277.21 grams manure excreted,	258.72	27.09	40.28	75.80	109.26	6.29
Grams digested,	443.21	11.06	85.59	97.98	239.36	9.21
Minus hay and corn meal digested,	343.09	7.67	18.36	95.62	166.03	4.98
Blood meal digested,	80.12	3.39	67.23	2.36	73.33	4.23
Per cent. digested,	90.33	-	79.58	-	-	-
Average per cent. two sheep digested,	-	-	84.00	-	-	-

*Period IX.**Old Sheep II.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay,	618.59	39.84	38.59	200.92	326.00	13.24
200 grams soy bean meal,	173.92	9.97	70.77	8.19	48.30	36.70
Amount consumed,	792.51	49.81	109.36	209.11	374.30	49.94
274.77 grams manure excreted,	259.44	33.39	25.48	76.53	115.81	8.22
Grams digested,	533.07	16.42	83.88	132.58	258.49	41.72
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	171.19	7.66	67.48	10.02	49.85	35.56
Per cent. digested,	98.43	76.83	95.35	122.20	103.20	96.89

Old Sheep III.

Amount consumed as above,	792.51	49.81	109.36	209.11	374.30	49.94
306.24 grams manure excreted,	289.73	34.83	30.91	76.95	136.06	10.98
Grams digested,	502.78	14.98	78.45	132.16	238.24	38.96
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	140.90	6.22	62.05	9.60	29.60	32.80
Per cent. digested,	81.01	62.39	87.68	104.90	61.28	89.37
Average per cent. two sheep digested, . . .	89.72	69.61	91.51	113.55	82.24	93.13

Period X.
Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay,	491.15	31.63	30.65	159.53	258.84	10.51
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	712.48	38.60	56.46	171.61	414.01	31.80
294.91 grams manure excreted,	277.39	30.46	29.99	82.91	126.13	7.91
Grams digested,	435.09	8.14	26.47	88.70	287.88	23.89
Minus hay digested,	244.93	4.38	11.45	79.73	145.70	4.05
Hominy feed digested,	190.16	3.76	15.02	8.97	142.18	19.84
Per cent. digested,	85.87	53.95	58.19	74.25	91.63	93.19

Young Sheep II.

Amount consumed as above,	712.48	38.60	56.46	171.61	414.01	31.80
291.64 grams manure excreted,	273.50	29.32	30.91	82.27	124.06	6.95
Grams digested,	438.98	9.28	25.55	89.34	289.95	24.85
Minus hay digested,	266.89	7.15	11.56	89.10	154.71	4.64
Hominy feed digested,	172.09	2.13	13.99	.24	135.24	20.21
Per cent. digested,	77.75	30.56	54.20	1.99	87.16	94.88

Young Sheep III.

550 grams English hay,	491.15	-	-	-	-	-
Minus 8.86 grams waste hay,	7.78	-	-	-	-	-
Total hay consumed,	483.37	31.13	30.16	157.00	254.74	10.34
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	704.70	38.10	55.97	169.08	409.91	31.63
308.66 grams manure excreted,	290.39	30.84	28.95	88.86	133.99	7.75
Grams digested,	414.31	7.26	27.02	80.22	275.92	23.88
Minus hay digested,	249.08	5.15	11.06	83.41	145.25	3.82
Hominy feed digested,	165.23	2.11	15.96	-	130.67	20.06
Per cent. digested,	74.65	30.27	61.84	-	84.21	94.22
Average per cent. three sheep digested,	79.42	38.26	58.08	38.12	87.67	94.10

*Period XI.**Old Sheep II.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,200 grams Eureka silage corn fodder (dry), .	480.96	37.76	47.23	157.27	230.38	8.32
Minus 96.86 grams waste,	49.58	4.88	4.54	16.92	22.35	.89
Amount consumed,	431.38	32.88	42.69	140.35	208.03	7.43
166.06 grams manure excreted,	155.83	19.84	18.05	40.58	74.60	2.77
Grams digested,	275.55	13.04	24.64	99.77	133.43	4.66
Per cent. digested,	63.88	39.66	57.72	71.09	64.14	62.72

Old Sheep III.

1,200 grams Eureka silage corn fodder (dry), .	480.96	37.76	47.23	157.27	230.38	8.32
185.54 grams manure excreted,	174.11	22.27	20.61	44.00	84.08	3.15
Grams digested,	306.85	15.49	26.62	113.27	146.30	5.17
Per cent. digested,	63.80	41.02	56.36	72.02	63.50	62.14
Average per cent. two sheep digested, . . .	63.84	40.34	57.04	71.56	63.82	62.43

*Period XII.**Young Sheep I.*

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 48.57 grams waste,	42.26	2.93	2.61	13.83	22.00	.90
Amount consumed,	675.90	43.46	45.79	217.99	352.59	16.05
350.83 grams manure excreted,	327.04	36.37	27.41	106.75	148.28	8.24
Grams digested,	348.86	7.09	18.38	111.24	204.31	7.81
Per cent. digested,	51.61	16.31	40.14	51.03	57.95	48.66

Young Sheep II.

800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 32.57 grams waste,	26.27	2.18	1.99	7.84	13.79	.69
Amount consumed,	691.89	44.21	46.41	223.98	360.80	16.26
331.97 grams manure excreted,	308.20	34.55	28.54	97.76	139.43	7.92
Grams digested,	383.69	9.66	17.84	126.22	221.37	8.34
Per cent. digested,	55.46	21.85	38.50	56.35	61.36	51.29
Average per cent. two sheep digested,	53.54	19.08	39.32	53.69	59.66	49.98

Period XXVI. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay,	577.33	44.05	69.45	182.44	264.94	16.45
250 grams Bibby's dairy cake,	224.50	18.81	48.02	20.63	113.19	23.84
Total consumed,	801.83	62.86	117.47	203.07	378.13	40.29
318.61 grams manure excreted,	294.49	37.93	43.97	80.07	122.57	9.95
Amount digested,	507.34	24.93	73.50	123.00	255.56	30.34
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	137.85	5.11	29.75	.77	80.70	21.46
Per cent. digested,	61.40	27.16	61.95	-	71.29	90.02

Old Sheep II.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
271.31 grams manure excreted,	251.40	34.92	37.36	66.72	103.65	8.75
Amount digested,	550.43	27.94	80.11	136.35	274.48	31.54
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	180.94	8.12	36.36	14.12	99.62	22.66
Per cent. digested,	80.59	43.17	75.72	68.44	88.01	95.05

Old Sheep III.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
306.77 grams manure excreted,	284.81	39.67	44.40	70.15	119.25	11.34
Amount digested,	517.02	23.19	73.07	132.92	258.88	28.95
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	147.53	3.37	29.32	10.69	84.02	20.07
Per cent. digested,	65.71	17.92	61.06	51.82	74.23	84.19
Average per cent. three sheep digested,	69.23	29.42	66.24	60.13	77.84	89.75

Period XXVIII. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal,	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
287.33 grams manure excreted,	267.16	30.22	35.83	76.11	115.76	9.24
Amount digested,	527.78	19.15	60.33	104.40	311.52	32.37
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	188.90	.97	20.20	-	151.15	24.22
Per cent. digested,	71.16	10.81	62.23	-	82.02	91.33

Old Sheep II.

Total consumed as above,	794.94	49.37	96.16	180.51	427.28	41.61
262.46 grams manure excreted,	242.88	31.36	34.54	63.12	104.95	8.91
Amount digested,	552.06	18.01	61.62	117.39	322.23	32.70
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	213.18	-	21.49	5.29	161.96	24.55
Per cent. digested,	80.31	-	66.20	40.11	87.88	92.57

Old Sheep III.

Total consumed as above,	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	126.38	94.18	88.95
Average per cent. three sheep digested,	80.76	22.74	67.49	-	88.03	90.95

Summary of Coefficients (Per Cent.).

RATION.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Soy bean fodder,	Old Sheep I., Old Sheep II., Old Sheep III.,	63.56	26.29	84.35	39.74	76.09	66.33
		62.51	16.89	82.12	30.83	79.45	66.00
		64.53	19.97	82.41	46.13	77.92	63.93
	Average,	63.53	21.05	82.96	38.90	77.82	65.42
Eureka silage corn fodder (green).	Old Sheep I., Old Sheep II., Old Sheep III.,	64.32	43.10	66.50	56.17	70.26	67.32
		68.57	41.76	66.85	63.65	74.35	65.68
		66.99	41.76	67.70	60.97	72.72	64.80
	Average,	66.63	42.21	67.02	60.26	72.44	65.93
Eureka silage corn fodder (dry).	Old Sheep II., Old Sheep III.,	63.88	39.66	57.72	71.09	64.14	62.72
		63.80	41.02	56.36	72.02	63.50	62.14
		63.84	40.34	57.04	71.56	63.82	62.43
	Average,	63.84	40.34	57.04	71.56	63.82	62.43
Apple pomace,	Old Sheep I., Old Sheep II., Old Sheep III.,	67.39	42.23	-	55.43	82.73	44.21
		73.64	62.64	-	68.94	85.65	43.50
		70.77	23.55	-	77.57	84.53	42.51
	Average,	70.60	42.81	-	67.31	84.30	43.41
English hay,	Young Sheep I., Young Sheep II., Young Sheep III.,	48.16	11.40	34.59	48.93	54.63	28.42
		53.22	23.34	36.93	55.34	58.17	37.09
		51.53	16.55	36.66	53.13	57.02	36.97
	Average,	50.97	17.10	36.06	52.47	56.61	34.16
English hay,	Young Sheep I., Young Sheep II.,	51.61	16.31	40.14	51.03	57.95	48.66
		55.46	21.85	38.50	56.35	61.36	51.29
		53.54	19.08	39.32	53.69	59.66	49.98
	Average,	53.54	19.08	39.32	53.69	59.66	49.98
English hay,	Old Sheep II., Old Sheep III.,	56.91	20.06	41.86	58.28	62.68	47.05
		60.41	24.25	42.85	63.45	65.60	45.69
		58.66	22.16	42.36	60.87	64.14	46.37
	Average,	58.66	22.16	42.36	60.87	64.14	46.37
Bibby's dairy cake,	Young Sheep I., Young Sheep II., Young Sheep III.,	77.76	44.16	68.11	63.07	87.79	94.91
		64.78	37.19	58.41	1.27	79.50	91.56
		69.51	28.56	67.82	-	86.15	98.88
	Bibby's dairy cake (1903),	Old Sheep I., Old Sheep II., Old Sheep III.,	61.40	27.16	61.95	-	71.29	90.02
80.59			43.17	75.72	68.44	88.01	95.05
65.71			17.92	61.06	51.82	74.23	84.19
Average,		69.95	33.03	65.51	46.15	81.16	92.44
Alma dried molasses-beet pulp.	Old Sheep II., Old Sheep III.,	86.98	68.54	69.00	84.47	93.47	-
		82.04	54.50	59.15	83.27	88.68	-
		84.51	61.52	64.08	83.87	91.08	-
	Average,	84.51	61.52	64.08	83.87	91.08	-
Armour's blood meal,	Young Sheep I., Young Sheep II.,	100.+	-	88.41	-	-	-
		90.33	-	79.58	-	-	-
		-	-	84.00	-	-	-
	Average,	-	-	84.00	-	-	-
Medium green soy bean meal.	Old Sheep II., Old Sheep III.,	98.43	76.83	95.35	122.20	103.20	96.89
		81.01	62.39	87.68	104.90	61.28	89.37
		89.72	69.61	91.51	113.55	82.24	93.13
	Average,	89.72	69.61	91.51	113.55	82.24	93.13

Summary of Coefficients (Per Cent.) — Concluded.

RATION.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Marshall hominy feed, .	Young Sheep I.,	85.87	53.95	58.19	74.25	91.63	93.19
	Young Sheep II.,	77.75	30.56	54.20	1.99	87.16	94.88
	Young Sheep III.,	74.65	30.27	61.84	-	84.21	94.22
Hominy meal (1903), .	Old Sheep I., .	71.16	10.81	62.23	-	82.02	91.33
	Old Sheep II., .	80.31	-	66.20	40.11	87.88	92.57
	Old Sheep III., .	90.80	34.67	74.03	126.38	94.18	88.95
Average, . . . . .	. . . . .	80.09	32.05	62.78	60.68	87.85	92.52

The Results discussed.

The more important results obtained from the several digestion experiments, the details of which are reported in the previous tables, are discussed as follows:—

Soy Bean Fodder (Brooks Medium Green). — The yield of fodder was light (about 6 tons to the acre), due to the cool summer of 1903. The plants were quite green, thickly set with leaves, well podded and the seed fairly well developed. In common with other legumes at a similar stage of growth, the fodder showed a noticeably high protein percentage, and only moderate quantities of fiber and extract matter. The three sheep ate the fodder readily and digested it quite evenly. Sheep II. refused small quantities of the coarse stems. The results agree fairly well with those already on record.¹

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I.,	1	1	63.56	26.29	84.35	39.74	76.09	66.33
Sheep II.,	1	1	62.51	16.89	82.12	30.83	79.45	66.00
Sheep III.,	1	1	64.53	19.97	82.41	46.13	77.92	63.98
Average,	1	3	63.53	21.05	82.96	38.90	77.82	65.42
Average, previous experiments,	5	12	265.00	-	75.00	46.00	75.00	48.00
Clover for comparison,	3	7	66.00	-	70.00	54.00	72.00	64.00
Cow peas for comparison,	2	4	268.00	23.00	76.00	60.00	81.00	59.00

¹ See especially Phelps' work in the reports of the Storrs Experiment Station for 1896 and 1898, and the summary reported in Lindsey's compilation, fourteenth report of the Hatch Experiment Station, p. 198.

² Organic matter.

The total dry matter of the soy bean fodder appears to be slightly less digestible than that of other legumes, — clover, Canada field peas and cow peas, — due to its characteristic hard, woody stems. Attention is called to the fact that the digestion coefficient of the fiber in the soy beans is relatively low (39 and 46 per cent.), as compared with those for the clover and cow peas (54 and 60 per cent.). Soy beans will find their chief use in the farm economy as a soiling and silage crop. This subject will be discussed more fully at a later date.

Eureka Silage Corn.—This was a large southern dent variety, 12 to 13 feet tall, which is held in high esteem for silage purposes by the farmers of Worcester County. It is claimed that it will produce several matured ears to each stalk under average summer conditions. The season of 1903 was noticeably cool, and when the corn was cut, September 12–18, it was quite green, the kernels just forming. This variety is being further studied during the present season (1904), and its value as compared with the smaller varieties will be discussed in a subsequent report.

The three sheep showed only slight variations in their ability to digest the corn. The following figures show the average results of all trials with immature dent varieties, as compared with Eureka. The results are quite similar, except that the fiber in case of the Eureka showed a slightly lower digestibility.

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Dent corn fodder, immature, . . .	4	11	68.00	-	66.00	67.00	71.00	68.00
Eureka (present trial), . . .	1	3	67.00	42.00	67.00	60.00	72.00	66.00

Apple Pomace.—In the sixteenth report of this station (pp. 63–80) are given the results of a digestion test with apple pomace. In that experiment the pomace was fed with a reasonable quantity of hay. In the present trial a smaller amount of hay was fed, and in addition each sheep

was given 150 grams of cotton-seed meal, in the hope of increasing the digestibility of the protein in apple pomace.¹ For the sake of comparison, the coefficients obtained in both experiments follow:—

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
<i>Former Experiment, Hay and Pomace.</i>						
Sheep I.,	67.29	42.23	—	55.43	82.73	44.21
Sheep II.,	73.64	62.64	—	68.94	85.65	43.50
Sheep III.,	70.77	23.55	—	77.57	84.53	42.51
Average,	70.60	42.81	—	67.31	84.30	43.41
<i>Present Experiment, Hay, Cotton-seed Meal and Pomace.</i>						
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
Average, both trials,	71.50	48.70	—	64.40	84.40	45.30

Both experiments were made with the same lot of sheep. The sheep digested the total dry matter of the pomace rather more evenly in the present than in the former trial. It is evident that Sheep I. was unable to utilize as much as the other two sheep. It will be seen that the fiber, extract matter and fat, comprising the larger part of the dry matter of the pomace, were digested to approximately the same degree in both experiments. The protein content of the pomace is small, about 1 per cent., and it has not been possible by present methods to fix its digestibility. It probably is digested to a considerable degree, although the results do not make it apparent. The several experiments show the pomace to be as digestible as the better grades of corn silage. Its value for feeding purposes will be further discussed under a separate heading.

English Hay.—The hay used in the present series consisted of a mixture of timothy and redtop, cut in late bloom, and well cured. Two different analyses of this hay are reported in the table of composition. It contained rather less

¹ In determining the digestibility of the apple pomace, average digestion coefficients were taken for the cotton-seed meal. See fourteenth report of this station, p. 209.

protein and more fiber than the hay usually employed by us for digestion experiments.

The young sheep (Period IV.) did not digest the hay as fully as did the old sheep (Period V.) The experiment was repeated with two of the young sheep in Period XII., in which case higher coefficients were obtained, though they did not equal those secured with the old sheep. The hay showed a fair digestibility, and no extreme variations were noted among the several sheep in the same trial. The results, however, do not agree as closely as most of the former experiments with hay carried out at this station.

Bibby's Dairy Cake, made by J. Bibby & Sons of Liverpool, Eng., is composed principally of ground cotton-seed, cereals such as barley and wheat, molasses, fenugreek and salt. It has a pleasing taste and smell, and appears to be highly relished by farm animals. The results of two distinct trials are reported, the first made during the winter of 1903 with three old sheep, and the second made during the winter of 1904 with three young sheep. The first sample was purchased from the stock of a retail grain dealer, and the second was obtained directly from a recent importation. Both lots were in good condition, and resembled each other closely in chemical composition. In the second trial the cake was not relished by Sheep III., although he was induced to eat it after a few days. The cake, which was ground before being fed, acted as a laxative, at first producing soft feces, which gradually hardened as the period advanced.

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old, . . .	61.40	27.16	61.95	-	71.29	90.02
Sheep II., old, . . .	80.59	43.17	75.72	68.44	88.01	95.05
Sheep III., old, . . .	65.71	17.92	61.06	51.82	74.23	84.19
Average, three sheep,	69.23	29.42	66.24	60.13	77.84	89.75
Sheep I., young, . . .	77.76	44.16	68.11	63.07	87.79	94.91
Sheep II., young, . . .	64.78	37.19	58.41	1.27	79.50	91.56
Sheep III., young, . . .	69.51	28.56	67.82	-	86.15	98.88
Average, three sheep,	70.68	36.63	64.78	32.17	84.14	95.11
Average, six sheep, . .	69.95	33.02	65.51	46.15	80.99	92.43

Especially wide variations are noted in the case of the old sheep. Sheep II. seemed to have a strong digestion, while Sheep I., judging from the results, was slightly out of condition. Such extreme variations are not apparent in case of the young sheep. In both experiments considerable difficulty was experienced in digesting the crude fiber, due probably to the fact that it was derived largely from cottonseed hulls. The protein was moderately digestible, while the extract matter and fat yielded fairly high coefficients. In general it may be said that the dairy cake was only moderately digested, and possessed a nutritive value similar to standard wheat middlings. An experiment with Bibby's cake fed to four dairy cows has been completed, and the relative commercial and nutritive value of this concentrate will be more fully discussed in that connection.

Dried Molasses-beet-pulp. — This material, manufactured by the Alma Sugar Company of Alma, Mich., consisted of beet pulp and crude molasses dried.¹ In appearance it resembled ordinary black tea. The analysis showed it to be low in protein and high in fiber and extract matter; only traces of fat were found. A more detailed analysis of the product showed that the crude protein consisted of 7.01 per cent. of true albuminoids and 2.90 per cent. of amides; the extract matter contained 13.80 per cent. of cane sugar and 1.83 per cent. of dextrose. The pentosans (18.40 per cent.) were in all probability largely in the form of a hemi-cellulose, and would also be included in the extract matter. The above figures are based on the material in its natural state, with 8.58 per cent. moisture. The results of the experiment with two old sheep follow: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II.,	86.98	68.54	69.00	84.47	93.47	-
Sheep III.,	82.04	54.50	59.15	83.27	88.68	-
Average,	84.51	61.52	64.08	83.87	91.08	-
Corn meal for comparison,	89.00	-	70.00	-	94.00	91.00

¹ See Bulletin No. 99 for a description of the process and a full discussion of its value.

The sheep ate the material readily and digested it without trouble. From the high average digestibility and an experiment with dairy animals elsewhere reported,¹ it is believed the dried pulp has a feeding value about 10 per cent. less than corn meal.

Armour's Blood Meal, especially prepared for cattle feeding, was found to contain 95.24 per cent. of protein and only traces of fat and fiber. Its mechanical condition was all that could be desired. As the detailed experiment shows, it was fed to two young sheep in combination with hay and corn meal. In figuring the digestibility of the blood the coefficients for the corn meal were taken from Lindsey's compilation.¹ The two sheep digested the dry matter of the blood quite thoroughly, namely, 95.14 per cent. The protein was not as thoroughly digested, — 83.99 per cent. ; but this must be more apparent than real, and due to the influence of the other constituents. It is probable that the protein of the hay and corn meal was not quite as thoroughly digested as the coefficients call for, leaving a slight excess undigested, which must of necessity be charged against the blood. This supposition is strengthened by the fact that there is a small plus balance of extract matter and a minus balance of fiber, which show digestible divergences from the established hay and corn meal coefficients. Judging from the digestibility of the dry matter of the blood, we may safely conclude that the blood protein must be quite thoroughly utilized by farm animals. An experiment with dried blood as a source of protein for dairy animals has been completed, and its economic value will be discussed when the results of that experiment are published.

Soy Bean Meal (Brooks Medium Green). — The beans were grown at the station, and coarsely ground before being fed. They were of the usual good quality, containing 40.69 per cent. of protein and 21.10 per cent. fat in dry matter. The coefficients obtained in 1903 follow, and also those secured in the present trial : —

¹ *Loco citato.*

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, 1903,	95.46	44.93	92.80	194.62	93.04	95.67
Sheep III., old, 1903,	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
Sheep II., old, 1904,	98.43	76.83	95.35	122.20	103.20	96.51
Sheep III., old, 1904,	81.01	62.39	87.68	104.90	61.28	89.37
Average,	89.72	69.61	91.51	113.55	82.24	92.94
Average, four trials,	90.56	56.47	91.29	126.79	86.71	93.23
Average, two German trials for comparison,	185.00	-	87.00	-	62.00	94.00

1 Organic matter.

The soy bean, in common with other concentrates rich in nitrogen, frequently causes digestive irregularities. In the present trial Sheep III. was not able to digest the feed as thoroughly as Sheep II. The same condition was apparent last year, although not quite as marked. It is evident that the beans are as a rule quite thoroughly digested, especially the protein and fat, which are the two important constituents. The coefficients for the fiber are, of course, incorrect, due probably to the favorable influence of the rich protein concentrate in increasing the digestibility of the hay carbohydrates. The small amount of fiber present—about 5 per cent.—renders a knowledge of the exact percentage digestible of minor importance. The extract matter was also largely digested,—probably 80 or more per cent.,—although the trials made thus far have not given sufficiently definite results to enable one to fix any exact coefficient.

Hominy Feed, or Chop.—As used for cattle feeding, this consists of the hull, germ, some of the gluten and soft starch. The two samples tested were of good average quality. The results of six trials are presented. Three of them were made with old sheep in 1903, and three with young sheep in 1904.

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old, 1903, . . .	71.16	10.81	62.23	—	82.02	91.33
Sheep II., old, 1903, . . .	80.31	—	66.20	40.11	87.88	92.57
Sheep III., old, 1903, . . .	90.80	34.67	74.03	126.50	88.03	90.95
Average,	80.75	22.74	67.48	—	85.97	91.61
Sheep I., young, 1904, . . .	85.87	53.95	58.19	74.25	91.63	93.19
Sheep II., young, 1904, . . .	77.75	30.56	54.20	1.99	87.16	94.88
Sheep III., young, 1904, . . .	74.65	30.27	61.84	—	84.24	94.22
Average,	79.42	38.26	58.07	38.12	87.66	94.09
Average, both experiments,	80.08	30.50	62.77	—	86.81	92.85
Corn meal for comparison, . . .	89.00	—	70.00	—	94.00	91.60

In the first trial Sheep I. evidently had a somewhat weakened digestion. This condition has already been referred to, and this sheep was dropped during 1904. Sheep III. appeared to have digested the hominy quite thoroughly, while Sheep II. gave results midway between the other two. Just why the three sheep should have shown such variable results with a feed that is supposed to be easily digested, is not clear. In the second trial, with a different sample and with the young sheep, the results also vary more than one would expect. Sheep III. was unable to digest the starchy matter as well as the other two, but made better use of the protein. The percentage of fiber contained in the hominy is relatively small, and the results differ so noticeably that they must be considered worthless. Both lots of sheep utilized the starchy matter and fat to about the same degree; the young sheep failed to digest the protein, as well as the old sheep. The average results of the two experiments must be regarded as giving a fairly good idea of the digestibility of the several fodder groups. It has been assumed hitherto that hominy was as digestible as corn meal; but, in view of the results obtained, this opinion is no longer tenable. The total dry matter of the hominy seems to be about 9 per cent. less digestible than that of the corn. This deficiency apparently falls largely on the protein and extract

matter. Corn meal as found upon the market contains on an average 14 per cent. of water, or 1,720 pounds of dry matter to the ton; while hominy shows 9 per cent. of water, or 1,820 pounds of dry matter to the ton. Applying the digestion coefficients for dry matter obtained in both cases, hominy would yield 1,456 pounds and corn meal 1,531 to the ton, and would show the corn meal to be about 5 per cent. more valuable than the hominy. It is proposed to repeat the digestion test with still another sample, and also to compare the two feeds with milch cows. The fact must not be overlooked that different samples of both grains, more particularly the hominy, are likely to vary somewhat in nutritive value, hence too positive conclusions should not be drawn. On the basis of our present knowledge, it may be said that both feeds have similar nutritive values.

Eureka Silage Corn Fodder. — This was a cured sample of the variety previously described. In composition it differed somewhat from the green sample, by containing more ash, noticeably more fiber and less extract matter. Whether this change was the result of sampling, or whether it was brought about by the curing process, it is difficult to say. In case of the green corn, small lots were cut every two or three days during the experiment, each lot being carefully sampled and moisture determinations made immediately. At the end of the trial equal weights of each sample were mixed, and this mixture held to represent the corn fed during the entire experiment. To secure as fair a sample as possible of the material to be cured, a considerable quantity was cut about the middle of the digestion trial with the green corn, and placed in stooks in the field. The stooks were removed to the barn before snow came. In spite of the care taken, differences in the composition of the two lots would be likely to occur. At the time of feeding the cured material, in early March, it still contained 60 per cent. of water. It was finely cut before feeding, and, though somewhat mouldy on the outside, proved to be in fairly good condition. Because of the unexpected large water content, the sheep did not receive a sufficient amount daily, — 1,200 grams, — although the results show that they suffered no

great loss in live weight during the period. Sheep III. ate the ration clean, while Sheep II. refused a noticeable amount of the coarser portions. The following figures show the results with the dry fodder; for comparison, the results obtained with the green corn are also stated:—

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, dry fodder, .	63.88	39.66	57.72	71.09	64.14	62.72
Sheep III., old, dry fodder, .	63.80	41.02	56.36	72.02	63.50	62.14
Average,	63.84	40.34	57.04	71.56	63.82	62.43
Sheep I., old, green fodder, .	64.32	43.10	66.50	56.17	70.26	67.32
Sheep II., old, green fodder, .	68.57	41.76	66.85	63.65	74.34	65.68
Sheep III., old, green fodder, .	66.99	41.76	67.70	60.97	72.72	64.80
Average,	66.63	42.21	67.02	60.26	72.44	65.93

The coefficients obtained are concordant, and the experiment may be considered quite satisfactory. In comparing the results of the two experiments, it will be noticed that the dry fodder was not as well digested as the green material. This may be accounted for partly on the ground that the sheep received the green fodder in September, after having been at pasture all summer, while the dried material was fed in March, after they had been in similar experiments for six months; and partly because previous experiments have demonstrated that in case of very coarse fodders sheep digest the green substance a little more thoroughly than the cured. For some reason the fiber in the dry material was more fully digested than in the green substance. This may be due to the fact that in the cured fodder some of the extract matter had been converted into a hemi-cellulose, which resisted the action of the chemical solvents, but yielded to the influence of the digestive fluids. In general, it may be said that the results obtained with the Eureka corn compare very favorably with those obtained by other experimenters with the southern varieties at a similar stage of growth.

2. THE DIGESTIBILITY OF GALACTAN.

REPORTED BY J. B. LINDSEY.¹

Those carbohydrates that can be removed from plants and seeds by the action of dilute mineral acid and alkali, and that are soluble in F. Schulze's reagent, E. Schulze has termed hemi-celluloses. Under this heading he has brought the mother substances, — dextran, levulan, mannan, galactan, araban and xylan; which yield on inversion the sugars, — dextrose, levulose, mannose, galactose, arabinose and xylose. These hemi-celluloses are intermixed with the true celluloses in the cell walls of the plants and seeds. They have been frequently recognized as reserve material, being used by the embryo during the sprouting of the seed. The levulan and mannan have not been found generally distributed, while the araban and xylan (pentosans) constitute fully one-third of the extract matter of all hays and straws, are quite prominent in the hull and bran of most grain seeds, and are even found in the endosperm and cotyledons of many seeds.

Galactan was first extracted from lucerne seeds by Muntz,² and was converted into galactose by boiling with dilute acid. E. Schulze³ and his co-workers found considerable galactan in the seeds of the blue lupine, and as a result assumed that this hemi-cellulose might be very generally distributed in agricultural plants. Lindsey and Holland⁴ determined the

¹ This experiment was carried out by Mr. E. S. Fulton of the class of 1904 of the Massachusetts Agricultural College, who expressed a desire to undertake work of this character for a graduation thesis. The sheep and apparatus belonging to the department of foods and feeding were placed at his disposal. The digestibility of the hay used had already been determined. Mr. Fulton assumed charge of the sheep, and prepared the feces for analysis in the station laboratory. The analytical work was done at the college laboratory, under the supervision of Prof. C. Wellington. Mr. Fulton expresses his thanks to Professor Wellington and also to Dr. Lindsey and his co-workers for the many helps and suggestions received.

² *Bul. Soc. Chem.* (2), 37, p. 409.

³ *Zeitsch. f. physiol. Chem.* Bd. 14, Heft. 3, *Zeitsch. f. physiol. Chem.* Bd. 16, Hefts. 4 and 5.

⁴ Ninth report of the Hatch Experiment Station, pp. 92-96.

percentage of galactan in a large number of hays, straws and concentrated feeds. The results of their work showed the presence of quite small amounts of galactan in the non-leguminous plants and seeds. In the leguminous plants from 3 to 4 per cent. was found, while in leguminous seeds the amount varied from 1½ to 14 per cent.

The method¹ employed was the one proposed by Tollens and his pupils, and consisted in principle of oxidizing a given amount of the plant or seed with a solution of slightly diluted nitric acid, and collecting the resulting mucic acid, after further treatment for the removal of impurities, on a tared filter.

No experiments are on record relative to the digestibility of galactan, hence the undertaking of this trial. Alsike clover seed was selected because it contained a noticeable quantity of galactan. It was ground reasonably fine, and fed in connection with hay, the digestibility of which had been previously determined. The experiment was conducted in the usual way, three young Southdown wethers being employed, and passed off without any disturbances.

TABULATED DATA OF THE EXPERIMENT.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

FEEDS.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay, ²	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed,	8.07	5.88	34.29	13.12	41.42	5.29

Composition of Faeces (Per Cent.).

[Dry matter.]

Sheep.	FEEDS.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I., .	Hay and clover seed,	.99	11.57	11.97	29.27	44.43	2.76
II., .	Hay and clover seed,	.95	11.21	13.11	30.23	42.84	2.61
III., .	Hay and clover seed,	1.02	11.32	12.63	28.94	44.49	2.62
I., .	Hay, ² . . . . .	.86	11.16	7.86	32.51	45.75	2.72
II., .	Hay, . . . . .	.76	10.70	8.40	31.51	46.74	2.65
III., .	Hay,	1.07	10.92	7.97	32.20	46.40	2.51

¹ *Loco citato.*

² The figures for all constituents, excepting galactan, in hay and hay manures were determined in a previous experiment.

*Dry Matter Determinations made at the Time of weighing out the Foods,
and Dry Matter in Manure excreted, estimated from Air-dry Faeces
(Per Cent.).*

Sheep.	FEEDS.	Hay.	Clover Seed.	Manure.
I., . .	Hay and clover seed, . . .	88.85	91.53	94.05
II., . .	Hay and clover seed, . . .	-	-	93.70
III., . .	Hay and clover seed, . . .	-	-	94.07
I., . .	Hay,	-	-	93.36
II., . .	Hay,	-	-	93.27
III., . .	Hay,	-	-	93.25

Table showing Food fed, Water drunk daily, and Daily Amount of Manure excreted.

[Food consumed daily: 600 grams hay, 200 grams clover seed, 5 grams salt.]

DATE.	SHEEP I.				SHEEP II.			SHEEP III.		
	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drunk daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drunk daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drunk daily (Cubic Centimeters).	
March 20,	922.0	33.24	1,590.0	741.0	29.29	2,290.0	663.0	24.66	2,415.0	
" 21,	853.0	29.16	1,060.0	888.0	31.98	1,865.0	879.0	31.60	2,410.0	
" 22,	829.0	30.11	1,615.0	938.0	28.55	2,500.0	938.0	33.29	2,425.0	
" 23,	799.0	29.56	1,350.0	1,059.0	32.02	2,500.0	822.0	32.29	2,400.0	
" 24,	738.0	27.60	1,855.0	852.0	28.14	2,500.0	973.0	33.39	2,500.0	
" 25,	909.0	31.64	1,950.0	949.0	29.02	2,500.0	964.0	33.93	2,500.0	
" 26,	927.0	33.69	1,750.0	1,316.0	33.50	2,500.0	1,050.0	36.21	2,500.0	
Average,	853.9	30.71	1,555.7	963.3	30.36	2,379.3	878.4	32.19	2,450.0	

Pounds.

Weight of Sheep I, at beginning of period,
 Weight of Sheep II, at beginning of period,
 Weight of Sheep III, at beginning of period,
 Weight of Sheep I, at end of period,
 Weight of Sheep II, at end of period,
 Weight of Sheep III, at end of period,

96.25
 94.75
 91.50
 99.50
 94.00
 91.00

Sheep I.

	Dry Matter (Per Cent.).	Galactan (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per (Cent.).
600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
307.10 grams manure excreted,	288.83	2.86	33.42	34.57	84.54	128.33	7.97
Grams digested,	427.33	21.08	12.15	61.41	115.40	226.14	12.21
Minus hay digested, ¹	265.95	6.90	4.82	12.41	87.93	156.85	4.05
Clover seed digested,	161.38	14.18	7.33	49.00	27.47	69.29	8.16
Per cent. digested,	88.16	96.01	68.12	78.06	114.36	91.39	84.30

Sheep II.

600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
303.60 grams manure excreted,	284.47	2.70	34.03	37.29	86.00	121.87	7.42
Grams digested,	431.69	21.24	11.54	58.69	113.94	232.60	12.76
Minus hay digested, ²	289.69	7.28	7.87	12.53	98.25	166.55	4.64
Clover seed digested,	142.00	13.96	3.67	46.16	15.69	66.05	8.12
Per cent. digested,	77.57	94.52	34.11	73.54	65.32	87.11	83.88

Sheep III.

600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
321.90 grams manure excreted,	302.81	3.09	34.28	38.24	87.63	134.72	7.93
Grams digested, ³	413.35	20.85	11.29	57.74	112.31	219.75	12.25
Minus hay digested,	274.71	6.55	5.76	12.17	93.47	158.89	3.88
Clover seed digested,	138.64	14.30	5.53	45.57	18.84	60.86	8.37
Per cent. digested,	75.74	96.82	51.39	72.60	78.43	80.27	86.47

¹ Used average coefficient of Sheep I., Periods IV. and XII.² Used average coefficient of Sheep II., Periods IV. and XII.³ Used coefficients of Sheep III., Period IV.

SUMMARY OF THE RESULTS.

Composition of the Feeds (Per Cent.).

	Galactan. ¹	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay,	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed,	8.07	5.88	34.29	13.12	41.42	5.29

Digestibility of the Feeds (Per Cent.).

	Dry Matter.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay (all sheep), . . .	53.50	75.35	20.50	37.00	55.00	59.00	42.00
Clover seed, Sheep I.,	88.16	96.01	68.12	78.06	114.36	91.39	84.30
Clover seed, Sheep II.,	77.57	94.52	34.11	73.54	65.32	87.11	83.88
Clover seed, Sheep III.,	75.74	96.82	51.39	72.60	78.43	80.27	86.47
Average,	80.49	95.78	51.21	74.73	86.04	86.26	84.55

The analysis and digestibility of the hay were made in connection with a series of digestion experiments at the station. It appeared to contain rather more galactan than other samples examined.²

A previous complete analysis of alsike clover seed does not appear to be recorded. It contained a high percentage of protein and a normal amount of galactan.

The results of the digestion experiment with the three sheep show the *total dry matter* of the clover seed meal to have been fairly well digested, although the coefficients are noticeably lower than those on record for soy beans, peas, vetch and lupine (85 to 90 per cent.).

The galactan in the hay is shown to be 75 per cent. digestible. Because of the small quantity present, the results are of minor importance. All three sheep digested the galactan in the clover seed quite thoroughly. Such a result was to have been expected, for the reason that in the seed the galactan is supposed to be comparatively free from in-

¹ It may be assumed that the galactan belongs almost wholly to the nitrogen-free extract matter.

² Whether the substance obtained was pure galactan, or consisted partly of impurities that it was not possible to remove, it is difficult to say. Lindsey and Holland found a trifle less than 1 per cent. in another sample.

crusting substances, which have been shown by various investigators to seriously interfere with the digestibility of the several fodder groups.¹ Naturally, no positive conclusions should be drawn from the present single investigation. Knowing, however, the physiological and chemical character of the galactan, as well as the digestion coefficients obtained with starch and with the pentosans, — bodies of similar character, — it is reasonably safe to conclude that the results secured give a fairly correct idea of the ability of the animal to utilize the galactan group.

The pentosans, fifteenth report of the Hatch Experiment Station, p. 118.

3. THE FEEDING VALUE OF APPLE POMACE.

BY J. B. LINDSEY.

There is often considerable discussion in the agricultural press and among farmers concerning the value of apple pomace as a food for dairy and beef cattle; with a view to getting a little positive data, this station instituted a number of experiments, the results of which are here briefly stated.

(a) *Composition of Apple Pomace (Per Cent.).*

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sample I.,	81.40	.73	.94	3.00	13.03	.90
Sample II.,	80.20	.60	1.01	3.19	13.73	1.27
Corn silage for comparison,	80.00	1.10	1.70	5.40	11.10	.70

It will be seen from the above figures that apple pomace is a carbohydrate feed similar to corn silage. It contains about the same amount of water (four-fifths), rather less protein and fiber, and a larger proportion of extract matter. Whether the extract matter in the pomace is as valuable, pound for pound, as that contained in the corn, has not been thoroughly demonstrated.

(b) *Digestibility of Apple Pomace.*

The value of a feed cannot always be measured by its composition. A food is valuable as a source of nutrition only in so far as its various constituents can be digested and assimilated. This station has made two different experiments to ascertain the digestibility of the pomace, and the detailed results are to be found elsewhere in this report. The summary follows:—

Summary of Experiments (Per Cent.).

	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Apple pomace (first experiment), . . .	3	72.5	54.7	-	61.6	84.5	47.2
Apple pomace (second experiment), . . .	3	70.6	42.8	-	67.3	84.3	43.4
Average,	6	71.5	48.7	-	64.4	84.4	45.3
Dent corn silage (for comparison), . . .	17	64.0	-	52.0	62.0	69.6	85.0
Flint corn silage (small varieties), . . .	11	75.0	-	65.0	77.0	79.0	82.0

The results show the total dry matter in apple pomace to be about as digestible as in the best grades of silage. The protein content of the pomace is small, — about 1 per cent., — and it has not been possible by present methods to fix its digestibility. Judging from the composition and digestibility of the pomace, one would feel justified in assuming that, pound for pound, it should approach in feeding value an average quality of corn silage.

(c) Experiments with Dairy Animals.

While this station has not carried out any exhaustive comparative tests with pomace and other coarse feeds, it has fed the pomace a number of seasons to dairy animals. The material was drawn fresh from the mill, and placed in a large pile under cover. A noticeable quantity of juice gradually drained from it, but it kept in good condition for two months. The animals received from 15 to 30 pounds daily, ate it readily, and the results were quite satisfactory. In one case two cows were fed alternately four weeks at a time on grain and hay, and on grain, hay and pomace; 25 pounds of pomace were compared with 5 pounds of hay. During the pomace period the animals produced 1,153 pounds of milk, and gained 24 pounds in live weight; during the hay period, 1,138 pounds of milk, and lost 6 pounds in weight. On this basis, 5 pounds of pomace were more than equivalent to 1 pound of hay. Judging from this feeding test and from the composition and digestibility of the pomace, it seems probable that 4 pounds, when fed in

what is termed a "balanced ration," would be equal in feeding value to 1 pound of good cow hay.

The Vermont Experiment Station has fed apple pomace for four years, using in all twenty cows in the several trials. The pomace was shovelled into the silo, levelled off, and kept in good condition without further care. In some cases it was placed on top of the corn silage after the latter had settled. The quantity fed varied from 10 to 35 pounds daily, with no unfavorable effects. As a result of the several experiments, the Vermont station concludes that the pomace is equivalent in feeding value to an equal weight of average corn silage,¹ and that it is without injurious effect on the flavor of milk and butter.

Farmers are cautioned not to feed too large quantities at first, but to begin with 10 pounds daily, and to gradually increase the quantity to 30 pounds, taking a week or more in which to do it. In this way, danger of a sudden milk shrinkage, or of the animals getting "off feed," as is sometimes reported, may be avoided. Judging from all the data available, it is believed that farmers living in the vicinity of cider mills will find it good economy to utilize the pomace as a food for their dairy stock.

¹ There is doubt in the mind of the writer whether pomace would prove fully equal to well-preserved and well-cared corn silage; it certainly would approach it in feeding value, and ought to be fully utilized.

4. BLOMO FEED FOR HORSES.

J. B. LINDSEY AND P. H. SMITH.

Blomo feed¹ is a mixture of ground corn stalks, or similar material, with dried blood and refuse molasses. It is almost black in color, slightly sticky to handle, and of a bulky, fibrous nature. It has been extensively advertised as a satisfactory partial oat substitute for horses, and is guaranteed to contain 15 per cent. protein and 1.19 per cent. fat. Feeds of similar character have been in use for some time in Europe.

Composition of Blomo Feed (Per Cent.).

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed,	20.2	9.0	14.7	12.1	43.3	.7
Oats for comparison,	11.0	2.9	12.9	8.5	59.6	5.1
Corn for comparison,	11.0	1.4	10.8	1.9	70.2	4.7

It will be seen from the foregoing table that Blomo feed contains more protein and decidedly less fat and starchy matter than either oats or corn. Part of the extract matter consists of cane sugar derived from molasses. The ash content is considerably in excess of either oats or corn.

Digestibility of Blomo Feed.

A digestion experiment² was recently completed at this station, with the following results:—

Digestion Coefficients (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed,	66.7	31.4	62.7	61.4	76.0	15.3
Oats for comparison,	72.0	33.0	86.0	31.0	79.0	82.0
Corn (cracked) for comparison,	88.0	—	76.0	—	96.0	73.0

¹ Made by the Blomo Manufacturing Company, New York, N. Y.

² With sheep.

Digestible Nutrients in a Ton (Pounds).

	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Total Organic Nutrients.
Blomo feed,	184	149	658	2	993
Oats for comparison,	222	53	942	84	1,301
Corn meal for comparison, . .	164	-	1,348	69	1,581

It will be seen that the coefficients obtained from the Blomo are noticeably less than those from either corn or oats. The fat coefficient is of minor importance, because of the small quantity present. It is an established fact that horses digest less fiber than sheep, hence the digestion coefficient for the fiber in the Blomo feed, when applied to horses, is probably too high; a coefficient of 50 would be nearer correct.

Applying the digestion coefficients to the composition of the several feeds, and calculating the digestible organic nutrients in 1 ton, it becomes evident that the Blomo contains some 20 per cent. less digestible organic matter than oats, and some 35 per cent. less than corn. This is due to the comparatively undigestible character of the filler employed.

Cost of Digestible Matter in a Ton.

Allowing \$32.50 a ton for Blomo (\$1.30 an 80-pound bag), \$31 a ton for oats (50 cents a bushel of 32 pounds), and \$28 a ton for corn meal, the cost of a pound of digestible matter in each of the several feeds would be as follows:—

	Cents.
Blomo,	3.28
Oats,	2.40
Corn meal,	1.77

At the above prices, it will be seen that digestible matter costs nearly twice as much in the form of Blomo feed as when purchased in corn meal, and about one-third more than in the form of oats.

Feeding Trials with Horses.

Four horses belonging to the agricultural division of the station were employed for the purpose. These horses did hard farm work, which naturally varied somewhat in character and amount from time to time.

TRIAL I.

Object. — The object of the trial was to see if the horses would eat Blomo readily, maintain their weight, and keep in as good working condition as when fed their regular ration.

Rations fed. — The ordinary ration, previous to the beginning of the trial, consisted of 6 quarts of oats, 6 quarts of corn, and what hay the animals would eat clean. The trial ration consisted of 6 quarts of Blomo in place of 6 quarts of oats, 6 quarts of corn, and hay. The Blomo and oats should have been compared pound for pound, but through a misunderstanding they were fed quart for quart, so that 4.2 pounds of Blomo were fed against 6 pounds or more of oats.¹ The horses were gradually placed on the Blomo ration. Three ate it readily, while the fourth refused more or less of it at first, but eventually took the entire quantity without objection.

Duration of the Trial. — The trial began March 19 and lasted until July 5. During this time all four horses were kept constantly on the same ration, and in no case did they fail to take the full quantity of Blomo daily.

Weight and Condition of the Horses. — The horses were weighed two mornings weekly before being fed or watered.

Average Weight at Beginning and End of Trial (Pounds).

1904.	No. 1.	No. 2.	No. 3.	No. 4.
March 19,	1,248	1,288	1,368	1,195
July 5,	1,243	1,270	1,358	1,193

The weight varied slightly from week to week, but it is evident that the ration was sufficient to enable the animals to keep in good condition and do the work required.

¹ Unfortunately, this department did not have the direct care of the animals, hence could not closely supervise the details of the trial.

While the trial was in progress it was found that the Blomo feed, which had been obtained directly from the manufacturers, was several per cent. below its protein guarantee. They claimed that this was due to carelessness on the part of their chemist, and forwarded another lot, with the request that it be used in place of the first shipment.

TRIAL II.

In the second trial the same horses were used.

Object of the Trial. — The object of the trial was to compare the Blomo feed with oats as a partial grain substitute for work horses.

Plan and Duration of the Trial. — The four horses were divided into lots of two each. In the first half of the trial horses Nos. 1 and 4 received the Blomo ration, and horses Nos. 2 and 3 the oat ration. In the second half these conditions were reversed. Each half lasted six weeks, as follows: —

	Blomo Ration.	Oat Ration.	Length (in Weeks).
July 18 through August 28,	Horses Nos. 1 and 4,	Horses Nos. 2 and 3,	6
September 5 through October 17,	Horses Nos. 2 and 3,	Horses Nos. 1 and 4,	6

Character of Rations. — The rations were in all cases measured out by the regular feeder. The same misunderstanding existed as in the former trial regarding the relative weight of the Blomo and oats, the feeder giving equal measure instead of weight of each. This resulted in the comparison of approximately 4.2 pounds of Blomo with 6 pounds of oats, which was manifestly unfair to the Blomo.

Blomo Ration fed daily.

6 quarts Blomo feed.
6 quarts cracked corn.
Hay (judgment of feeder).

Oat Ration fed daily.

6 quarts oats.
6 quarts cracked corn.
Hay (judgment of feeder).

Weights of Horses (Pounds).

HORSES.	BLOMO.			OATS.		
	Beginning.	End.	Gain or Loss.	Beginning.	End.	Gain or Loss.
No. 1, . . .	1,230	1,245	15+	1,255	1,240	15-
No. 2, . . .	1,295	1,350	55+	1,265	1,290	25+
No. 3, . . .	1,390	1,370	20-	1,325	1,375	50+
No. 4, . . .	1,180	1,205	25+	1,200	1,195	5-
Totals, . . .	5,095	5,170	75+	5,045	5,100	55+

These horses made a slight gain in each case, indicating that both rations were rather more than sufficient to furnish the necessary nutrients for the work performed. Because of the uneven character of the work from day to day, it is not possible to say that one ration gave any better results than the other. It can simply be stated that the horses ate the Blomo ration readily, kept in good condition, and did satisfactory work during the trial.

Keeping Quality of Blomo.

The first lot, of 1 ton, obtained in March, contained 21.5 per cent. of moisture. It was fed gradually until late June, when 480 pounds, or about one-quarter, had spoiled. The second lot, of $\frac{1}{2}$ ton, contained 20 per cent. of water, and was fed from early July until late October, during which time 450 pounds, or nearly one-half, had become sour. This lot underwent a slight decomposition during the warm, muggy weather of August and September. It will be quite necessary for the manufacturers to reduce the moisture content to 12 or less per cent., in order to prevent such changes, especially during the warm season.

Conclusions.

1. Blomo feed was eaten readily, excepting that one of the horses objected to it during the first week of the trial.
2. Considerable of the Blomo spoiled on being kept during the warm weather, and it will be necessary for the manufacturers to reduce the moisture content, in order to overcome this difficulty.

3. It contained noticeably less digestible matter than corn or oats, and, at prices usually prevailing, the nutritive matter it contains must be regarded as decidedly expensive.

4. No injurious effect was noted from feeding a considerable quantity of Blomo as a component of the daily ration during a period of seven months. The horses kept in good condition and did satisfactory work.

5. Owing to a misunderstanding, whereby the Blomo and oats were fed measure for measure, instead of weight for weight, it was not possible to directly compare the feeding value of these two feeds.

6. No particular advantage is to be gained from the use of Blomo feed, other than securing a change from the regular corn and oat diet.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, RICHARD H. ROBERTSON,¹ EDWARD G. PROULX.

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 1904.

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 66; of these, 38 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 2 in Pennsylvania, 2 in Ohio, 1 in Rhode Island, 1 in Canada, 1 in New Jersey, 1 in Maryland and 1 in Arkansas.

Three hundred and twenty-nine brands of fertilizers and agricultural chemicals have been licensed in Massachusetts during the year. Five hundred and seventy-six samples of

¹ Died Sept. 10, 1904.

fertilizers have been collected up to the present time, in our general markets by experienced assistants in the station. Five hundred and twenty-five samples were analyzed at the beginning of December, 1904, representing 295 distinct brands of fertilizers. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 100, July, and No. 102, November, 1904. Other official samples not included in these two bulletins will be reserved for our next publication in March, 1905. By comparing the above statements with those of our previous annual reports, it will be seen that there is a gradual increase in the number of fertilizers that are licensed in the State of Massachusetts from year to year. This fact would tend to show an increased consumption of these articles, and would emphasize the importance of their annual inspection from a commercial agricultural standpoint. Twenty-three more brands of fertilizers have been licensed during the past season than in the previous year.

The following table gives in compact form an abstract of the results of analyses of official commercial fertilizers: —

	1903.	1904.
<i>(a)</i> 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,	19	32
Number with one element above the highest guarantee,	91	111
Number with three elements between the lowest and highest guarantee,	207	190
Number with two elements between the lowest and highest guarantee,	118	146
Number with one element between the lowest and highest guarantee,	42	48
Number with three elements below the lowest guarantee,	2	none
Number with two elements below the lowest guarantee,	24	12
Number with one element below the lowest guarantee,	100	103
<i>(b)</i> Where two essential elements of plant food were guaranteed:—		
Number with two elements above the highest guarantee,	2	8
Number with one element above the highest guarantee,	17	16
Number with two elements between the lowest and highest guarantee,	31	20
Number with one element between the lowest and highest guarantee,	13	19
Number with two elements below the lowest guarantee,	1	1
Number with one element below the lowest guarantee,	14	15
<i>(c)</i> Where one essential element of plant food was guaranteed:—		
Number above the highest guarantee,	11	16
Number between the lowest and highest guarantee,	13	24
Number below the lowest guarantee,	18	13

From the above table it will be seen that, on the whole, the quality of the fertilizers that have been licensed, collected and examined during the past year is higher than in the previous season of 1903.

*Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals,
1903 and 1904 (Cents per Pound).*

	1903.	1904.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	15.00	16.00
Organic nitrogen in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers.	17.00	17.50
Organic nitrogen in fine bone and tankage,	16.50	17.00
Organic nitrogen in medium bone and tankage,	12.00	12.50
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pumace 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 ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chloride),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the market costs of the different essential ingredients of plant food for 1904 with the previous year shows the following variation: nitrogen in the form of nitrates is a cent higher per pound; the higher grades of organic nitrogen, including nitrogen classed in high-grade mixed fertilizers, are half a cent higher in cost than for the year 1903; the cost of the different forms of phosphoric acid and potassium oxide remains the same as in the previous year.

As in the past, the above schedule of trade values 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, 1904, and is based upon the quotations in ton lots of the leading standard raw materials furnishing nitrogen, phosphoric acid and potash, and which go to make up the bulk of our commercial fertilizers. These quotations are taken from the fertilizer markets in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1904.

Table A, on the following page, gives the average analysis of officially collected fertilizers for 1904; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential ingredients of plant food found in the special crop fertilizers, so called, put out by the different manufacturers during the season of 1904.

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1904 (Per Cent.).*

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,	11.33	5.38	1.12	2.34	14.82	8.72	11.03	10.76	5.36	8.44	8.96	1.54	3.53
Fruit and vine fertilizer,	11.29	3.86	2.46	3.02	13.02	7.82	9.53	9.26	7.08	7.23	11.08	5.62	8.42
Grain fertilizer,	9.67	7.81	.84	2.65	11.06	8.12	9.77	9.01	4.37	6.58	10.40	.88	3.82
Grass fertilizer,	7.83	5.31	2.49	4.08	14.71	5.06	9.14	13.03	2.08	6.81	11.94	2.20	5.33
Market-garden fertilizer,	11.53	4.09	1.73	2.87	11.54	8.65	10.56	9.69	6.91	8.18	10.00	2.08	6.18
Potato fertilizer,	11.38	4.68	1.71	2.63	14.44	6.93	10.27	12.58	4.12	8.08	10.08	2.58	5.64
Tobacco fertilizer,	10.14	5.97	.66	4.04	14.96	5.50	10.20	11.42	1.76	6.59	15.06	.72	8.13
Onion fertilizer,	10.95	3.42	1.61	3.02	12.18	8.24	9.88	8.93	6.84	7.97	10.48	6.78	7.78

A study of Table B teaches the same lessons as in the past. It is a much safer plan to study our fertilizer bulletins, when selecting a supply of commercial fertilizers, than to depend upon mere trade names. Oftentimes the fertilizer costing the most per ton is the cheapest and most economical fertilizer to use if applied to the soil intelligently. Every farmer should know the requirements of his soil, in order to judiciously select his supply of fertilizers. No iron-clad rule can be laid down for selecting fertilizers, as conditions vary so widely on different soils; it is safe to say, however, that for general use those fertilizers should be purchased which furnish the greatest amount of the three essential elements of plant food 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, 1904, to May 1, 1905), and the Brands licensed by Each.

The American Agricultural Chemical Co.,
Boston, Mass.:—

Brightman's Fish and Potash.
Double Manure Salt.
Dissolved Bone-black.
Dried Blood.
Dry Ground Fish.
Fine-ground Bone.
Fine-ground Tankage.
Grass and Lawn Top-dressing.
Ground South Carolina Phosphate.
High-grade Fertilizer with Ten Per Cent. Potash.
High-grade Sulfate of Potash.
Kainit.
Muriate of Potash.
Nitrate of Soda.
Plain Superphosphate.
Tobacco Starter and Grower.

The American Agricultural Chemical Co.
(Bradley Fertilizer Co., branch), Boston, Mass.:—

Abattoir Bone Dust.
Bradley's Complete Manure for Corn and Grain.
Bradley's Complete Manure for Onions.
Bradley's Complete Manure for Potatoes and Vegetables.
Bradley's Complete Manure for Top-dressing Grass and Grain.
Bradley's Complete Manure with Ten Per Cent. Potash.
Bradley's Corn Phosphate.
Bradley's Eclipse Phosphate.

The American Agricultural Chemical Co.
(Bradley Fertilizer Co., branch), Boston, Mass.—*Con.*

Bradley's English Lawn Fertilizer.
Bradley's Niagara Phosphate.
Bradley's Potato Fertilizer.
Bradley's Potato Manure.
Bradley's Seeding-down Manure.
Bradley's X L Superphosphate.
Columbia Fish and Potash.
Church's Fish and Potash.

The American Agricultural Chemical Co.
(H. J. Baker & Bro., branch), New York, N. Y.:—

Baker's A A Ammoniated Phosphate.
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 King Philip Guano.
Clark's Cove Potato Fertilizer.
Clark's Cove Potato Manure.

The American Agricultural Chemical Co.
(Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.:—

Crocker's A A Complete Manure.
Crocker's Corn Phosphate.
Crocker's Potato, Hop and Tobacco Phosphate.

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

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 Farm Favorite.
Darling's General Fertilizer.
Darling's Potato and Root Crop
Manure.
Darling's Potato Manure.
Darling's Tobacco Grower.

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

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

The American Agricultural Chemical Co.
(Packers' Union Fertilizer Co., branch),
Rutland, Vt.:—
Animal Corn Fertilizer.
Gardener's Complete Manure.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co.
(Quinnipiac Co., branch), Boston,
Mass.:—
Quinnipiac Climax Phosphate.
Quinnipiac Corn Manure.
Quinnipiac Havana Tobacco Fertil-
izer.
Quinnipiac Market-garden Manure.
Quinnipiac Onion Manure.
Quinnipiac Phosphate.
Quinnipiac Potato Manure.
Quinnipiac Potato Phosphate.

The American Agricultural Chemical Co.
(Read Fertilizer Co., branch), New
York, N. Y.:—
Read's Farmers' Friend.
Read's High-grade Farmers' Friend.
Read's Practical Potato Special.
Read's Standard.
Read's Vegetable and Vine.

The American Agricultural Chemical Co.
(Standard Fertilizer Co., branch), Bos-
ton, Mass.:—
Standard Complete Manure.
Standard Fertilizer.
Standard Guano.
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 Americus Phos-
phate.
Williams & Clark's Corn Phosphate.
Williams & Clark's High-grade Spe-
cial.
Williams & Clark's Potato Manure.
Williams & Clark's Potato Phosphate.
Williams & Clark's Prolific Crop Pro-
ducer.
Williams & Clark's Royal Bone Phos-
phate.

The American Agricultural Chemical Co.
(M. E. Wheeler & Co., branch), Rut-
land, Vt.:—
Corn Fertilizer.
Bermuda Onion Grower.
Grass and Oats Fertilizer.
Havana Tobacco Fertilizer.
Potato Manure.

W. H. Abbott, Holyoke, Mass.:—
Animal Fertilizer.
Eagle Brand.
Tobacco Fertilizer.

The Abbott & Martin Rendering Co.,
Columbus, O.:—
Abbott's Tobacco and Potato Special.
Harvest King.
Ideal Grain Grower.

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.:—
All Soluble.
Ammoniated Bone with Potash.
Bone Meal.
Blood, Bone and Potash.
Grain Grower.
High-grade Potato.

- H. J. Baker and Bro., New York, N. Y.:—
Castor Pumace.
- Beach Soap Co., Lawrence, Mass.:—
Beach's Advance Brand.
Beach's Fertilizer Bone.
Beach's Reliance.
Beach's Universal.
- Berkshire Fertilizer Co., Bridgeport, Conn.:—
Berkshire Complete Fertilizer.
Berkshire Ammoniated Bone Phosphate.
Berkshire Potato and Vegetable Phosphate.
- Joseph Breck & Sons, Boston, Mass.:—
Breck's Lawn and Garden Dressing.
Breck's Market-garden Manure.
- Bowker Fertilizer Co., Boston, Mass.:—
Bone, Blood and Potash.
Bowker's Ammoniated Food for Flowers.
Bowker's Bone and Wood Ash Fertilizer.
Bowker's Complete Mixture.
Bowker's Double Manure Salts.
Bowker's Farm and Garden Phosphate.
Bowker's Fish and Potash (Square Brand).
Bowker's Ground Bone.
Bowker's High-grade Fertilizer.
Bowker's Hill and Drill Phosphate.
Bowker's Kainit.
Bowker's Lawn and Garden Dressing.
Bowker's Potato and Vegetable Fertilizer.
Bowker's Potash Bone.
Bowker's Market-garden Fertilizer.
Bowker's Potato and Vegetable Phosphate.
Bowker's Soluble Animal Fertilizer.
Bowker's Special Onion Manure.
Bowker's Superphosphate.
Bowker's Sure Crop Phosphate.
Bowker's Tankage.
Bowker's Ten Per Cent. Manure.
Bowker's Tobacco Ash Fertilizer.
Bowker's Tobacco Starter.
Bristol Fish and Potash.
Corn Phosphate.
Dissolved Bone-black.
Dried Blood.
Early Potato Manure.
Fine Dry Ground Fish.
Fish and Potash (D Brand).
Gloucester Fish and Potash.
Muriate of Potash.
Nitrate of Soda.
Stockbridge Special Manures.
Sulfate of Ammonia.
- Bowker Fertilizer Co., Boston, Mass.:—
Con.
Sulfate of Potash.
Tobacco Ash Elements.
Wood Ashes.
- T. H. Bunch, Little Rock, Ark.:—
Cotton-seed Meal.
- Charles M. Cox & Co., Boston, Mass.:—
Cotton-seed Meal.
- Chicopee Rendering Co., Springfield, Mass.:—
Pure Ground Bone.
Complete Animal Fertilizer.
Lawn and Garden Dressing.
Tankage.
- E. Frank Coe Co., New York, N. Y.:—
American Farmers' Ammoniated Bone.
American Farmers' Complete Manure.
American Farmers' Corn King.
American Farmers' Grass and Grain.
American Farmers' Market-garden Special.
Columbian Corn Fertilizer.
Columbian Potato Fertilizer.
E. Frank Coe's F P Fish and Potash.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's Nitrate of Soda.
E. Frank Coe's Tobacco and Onion Fertilizer.
Celebrated Special Potato.
Excelsior Potato Fertilizer.
New Englander Corn Fertilizer.
New Englander Potato Fertilizer.
Red Brand Excelsior Guano.
X X X Ground Bone.
- John C. Dow & Co., Boston, Mass.:—
Dow's Pure Ground Bone.
- Eastern Chemical Co., Boston, Mass.:—
Imperial Grass Fertilizer.
Imperial Plant Food.
- William E. Fyfe & Co., Clinton, Mass.:—
Canada Unleached Hard-wood Ashes.
- R. & J. Farquhar & Co., Boston, Mass.:—
Clay's London Fertilizer.
Thompson's Improved Vine, Plant and Vegetable Manure.
- Hargraves Soap Co., Fall River, Mass.:—
Ground Bone Fertilizer.
- The Hardy Packing Co., Columbus, O.:—
Hardy's Complete Manure.
Hardy's Tankage, Bone and Potash.
Hardy's Tobacco and Potato Special.

C. W. Hastings, Cambridgeport, Mass.:—
Ferti Flora.

Thomas Hersom & Co., New Bedford,
Mass.:—
Bone Meal.
Meat and Bone.

John Joynt, Lucknow, Can.:—
Pure Canada Unleached Hard-wood
Ashes.

Lister's Agricultural Chemical Works,
Newark, N. J.:—
Lister's Animal Bone and Potash.
Lister's High-grade Special.
Lister's Oneida Special.
Lister's Potato Manure.
Lister's Special Corn.
Lister's Special Potato.
Lister's Success Fertilizer.

Lowell Fertilizer Co., Boston, Mass.:—
Acid Phosphate.
Muriate of Potash.
Nitrate of Soda.
Swift's Lowell Animal Brand.
Swift's Lowell Bone Fertilizer.
Swift's Lowell Dissolved Bone and
Potash.
Swift's Lowell Dissolved Bone-black.
Swift's Lowell Empress Brand.
Swift's Lowell Ground Bone.
Swift's Lowell Lawn Dressing.
Swift's Lowell Market Garden.
Swift's Lowell Potato Manure.
Swift's Lowell Potato Phosphate.
Swift's Lowell Tankage.

George E. Marsh & Co., Lynn, Mass.:—
Pure Bone Meal.

Mapes Formula and Peruvian Guano Co.,
New York, N. Y.:—
Average Soil Complete Manure.
Cauliflower and Cabbage Manure.
Complete Manure (A Brand).
Complete Manure for General Use.
Complete Manure Ten Per Cent.
Potash.
Corn Manure.
Economical Potato Manure.
Fruit and Vine Manure.
Grass and Grain Spring Top-dressing.
Lawn Top-dressing.
Potato Manure.
Tobacco Ash Constituents.
Tobacco Manure Wrapper Brand.
Tobacco Starter Improved.
Top-dressing Improved, One-half
Strength.
Vegetable Manure or Complete Manure
for Light Soils.

D. M. Moulton, Monson, Mass.:—
Ground Bone.

National Fertilizer Co., Bridgeport,
Conn.:—
Chittenden's Ammoniated Bone.
Chittenden's Complete Fertilizer.
Chittenden's Fish and Potash.
Chittenden's High-grade Special.
Chittenden's Market Garden.
Chittenden's Potato Phosphate.
Chittenden's Tobacco Manure.

New England Fertilizer Co., Boston,
Mass.:—
Corn Phosphate.
Potato Fertilizer.
Superphosphate.

Olds & Whipple, Hartford, Conn.:—
Complete Tobacco Fertilizer.
Vegetable Potash.

R. T. Prentiss, Holyoke, Mass.:—
Complete Fertilizer.

Parmenter & Polsey Fertilizer Co., Pea-
body, Mass.:—
A A Brand.
Acid Phosphate.
Lawn Dressing.
Grain Grower.
Muriate of Potash.
Nitrate of Soda.
P. & P. Potato.
Plymouth Rock Brand.
Special Fertilizer for Strawberries.
Special Potato.
Sulfate of Potash.

Jacob Reese, Darby, Penn.:—
Odorless Slag Phosphate.

Rogers & Hubbard Co., Middletown,
Conn.:—
Hubbard's All Soils and All Crops
Fertilizer.
Hubbard's Corn Phosphate.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Oats and Top-dressing.
Hubbard's Potato Phosphate.
Hubbard's Pure Raw Knuckle Bone
Flour.
Hubbard's Soluble Corn.
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall,
Conn.:—
All Round Fertilizer.
Complete Corn and Onion.
Complete Fish and Potash.

Rogers Manufacturing Co., Rockfall,
Conn.—*Con.*

Complete Potato and Vegetable.
High-grade Grass and Grain.
High-grade Oats and Top-dressing.
High-grade Tobacco and Potato.
High-grade Soluble Tobacco.
Nitrate of Soda.
Pure Fine-ground Bone.

Ross Bros., Worcester, Mass.:—

Ross Brother's Lawn Dressing.

N. Roy & Son, South Attleborough,
Mass.:—

Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.:—

Essex Complete Manure for Corn,
Grain and Grass.
Essex Complete Manure for Potatoes,
Roots and Vegetables.
Essex Corn Fertilizer.
Essex Dry Ground Fish.
Essex A I Superphosphate.
Essex Market Garden and Potato
Manure.
Essex Odorless Lawn Dressing.
Essex Rhode Island Special for Pota-
toes and Roots.
Essex Special Tobacco Manure.
Essex Tobacco Starter.
Essex X X X Fish and Potash.
Muriate of Potash.
Nitrate of Soda.

Salisbury Cutlery Handle Co., Salisbury,
Conn.:—

Fine Bone.

M. L. Shoemaker & Co., Limited, Phila-
delphia, Penn.:—

Swift Sure Superphosphate for Gen-
eral Use.
Swift Sure Bone Meal.

Sanderson's Fertilizer and Chemical Co.,
New Haven, Conn.:—

Sanderson's Corn Superphosphate.
Sanderson's Fine-ground Fish.
Sanderson's Formula A.
Sanderson's Formula B.
Sanderson's Sulfate of Potash.
Sanderson's Potato Manure.
Sanderson's Special with Ten Per
Cent. Potash.
Sanderson's Top-dressing for Grass
and Grain.

Thomas L. Stetson, Randolph, Mass.:—

Bone Meal.

J. Stroup, Son & Co., Boston, Mass.:—

Canada Hard-wood Unleached Ashes.

A. L. Warren, Northborough, Mass.:—

Warren's Ground Bone.

The Whitman & Pratt Rendering Co.,
Lowell, Mass.:—

Whitman & Pratt's All Crops.
Whitman & Pratt's Corn Success.
Whitman & Pratt's Potato Plowman.
Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.:—

Complete Bone Superphosphate.
Dry Ground Fish.
Fish and Potash.
High-grade Tobacco Special.
Potato Fertilizer.
Potato, Onion and Vegetable.

Sanford Winter, Brockton, Mass.:—

Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield,
Mass.:—

Tankage.

A. H. Wood & Co., Framingham, Mass.:—

A A Brand.
B B Brand.
C C Brand.

PART II.—REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.
3. Notes on phosphatic slag and experiments with native phosphates.

1. ANALYSES OF MATERIALS FORWARDED FOR EXAMINATION.

This department of our work has been of the same general character as in past years. We have received during the season 283 samples of miscellaneous substances from farmers within our State for analysis; this is 48 more than was received during the season of 1903.

As far as time and facilities permit, we have devoted our attention to the examination of this class of materials, the substances being taken up for analysis in the order of their arrival at this office. During the season of the official inspection of commercial fertilizers, April 1 to November, our time is so completely occupied that work in this class of general materials, for the benefit of individual farmers, has to give place, in a measure, to the control work of inspection. For this reason we would urge those sending samples for free analysis to forward them, so far as possible, between November 1 and April 1, thus insuring more prompt reports in results of analysis.

As in the past, we have taken an active part in the technical work of the Association of Official Agricultural Chemists for the establishment of new methods of analysis. Many determinations were made on samples forwarded by the association to test the efficacy of several new methods of determining potash and the various forms of phosphoric acid.

Following is a list of materials forwarded by farmers and agricultural organizations during the season of 1904:—

Wood ashes,	50	Steamed bone,	2
Soils,	47	Wool dust,	2
Complete fertilizers,	32	Wool waste,	2
Lime ashes,	14	Dried blood,	2
Tankage,	10	Sewage,	2
Ground bone,	9	Pulp ashes,	1
Nitrate of soda,	8	Cotton compost,	1
Miscellaneous substances,	9	Carbonate of potash-magnesia,	1
Low-grade sulfate of potash,	7	Silicate of potash,	1
Muck,	7	High-grade sulfate of potash,	1
Meadow mud,	7	Nitrate of potash,	1
Cotton-seed meal,	6	Belgian phosphate,	1
Dry ground fish,	5	Raw bone,	1
Mill refuse,	5	Dissolved bone,	1
Manure,	5	Lime and nitrate of soda,	1
Acid phosphate,	4	Guinea pig manure,	1
Peat,	4	Liquid manure,	1
Cotton-hull ashes,	3	Sheep manure,	1
Muriate of potash,	3	Lime refuse from tannery,	1
Lime,	3	Waste lime,	1
Dissolved bone-black,	3	Granulated lime,	1
Cotton-seed droppings,	2	Plaster,	1
Cotton-seed dust,	2	Raw hide dust,	1
Sulfate of ammonia,	2	Cocoa shells,	1
Carbonate of potash,	2	Dandelion roots,	1
Phosphatic slag,	2	Clover roots,	1

2. NOTES ON WOOD ASHES AND LIME ASHES.

(a) *Wood Ashes.*—Seventeen and one-half per cent. of the materials forwarded for analysis during the season have been wood ashes, being about the same proportion as that for the year 1903. The following abstract of results of analysis shows their general chemical character, also a comparison in results of analysis with the previous year 1903:—

Analysis of Wood Ashes.

	NUMBER OF SAMPLES.	
	1903.	1904.
Moisture from 1 to 10 per cent.,	11	18
Moisture from 10 to 20 per cent.,	14	16
Moisture from 20 to 30 per cent.,	9	8
Moisture above 30 per cent.,	3	3
Potassium oxide above 8 per cent.,	2	2
Potassium oxide from 6 to 7 per cent.,	4	8
Potassium oxide from 5 to 6 per cent.,	8	6
Potassium oxide from 4 to 5 per cent.,	12	12
Potassium oxide from 3 to 4 per cent.,	8	10
Potassium oxide below 3 per cent.,	3	7
Phosphoric acid from 1 to 2 per cent.,	34	30
Phosphoric acid above 2 per cent.,	none	3
Phosphoric acid below 1 per cent.,	3	12
Average per cent. of calcium oxide (lime),	29.39	30.16
Insoluble matter below 10 per cent.,	7	6
Insoluble matter from 10 to 15 per cent.,	12	18
Insoluble matter above 15 per cent.,	17	20

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes for the Seasons of 1903 and 1904.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1903.	1904.	1903.	1904.	1903.	1904.
Moisture,	37.34	37.85	2.27	none	15.23	14.42
Potassium oxide,	8.15	11.04	1.68	.80	4.76	4.51
Phosphoric acid,	1.80	6.07	.46	.28	1.37	1.37
Calcium oxide,	35.75	42.86	22.33	19.73	29.39	30.16
Insoluble matter,	28.85	47.21	1.40	4.56	15.07	18.35

From the above tables it will be seen that the percentage of potassium oxide in the wood ashes received during the season is, on the average, somewhat less than for the previous season. The average of phosphoric acid is the same; while the average percentage of lime is somewhat higher than for 1903.

A study of these tables will emphasize the importance of buying this class of material on a statement of a guaranteed composition. We would urge all parties to ask for a positive guarantee of the amount of potassium oxide, phosphoric acid and calcium oxide (although our State law does not oblige the manufacturer to guarantee the latter element, it should be required when buying this class of fertilizers) said to be contained in this or similar classes of fertilizers. We would also advise all parties to patronize those dealers and importers who have complied with our State laws by securing a license for the sale of their article in Massachusetts. It is only in this way that protection by our State laws can be secured.

(b) *Lime Ashes.* — What has been said regarding wood ashes applies with equal force to lime ashes. They should always be bought on a statement of the guarantee of lime, potash and phosphoric acid which they contain, as they are more apt to vary widely in chemical composition than even wood ashes.

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes for the Seasons of 1903 and 1904.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1903.	1904.	1903.	1904.	1903.	1904.
Moisture,	23.16	36.62	10.47	none	15.66	10.88
Potassium oxide, . . .	3.32	2.46	.76	.06	1.86	1.54
Phosphoric acid, . . .	1.66	1.48	.03	trace	.63	.74
Calcium oxide,	55.44	55.24	32.42	21.92	41.15	42.93
Insoluble matter, . . .	26.50	25.47	1.10	2.76	6.46	8.11

From the above comparison it will be seen that the lime ashes during the present season analyzed a little higher in lime and a little lower in potash than in 1903.

3. NOTES ON PHOSPHATIC SLAG AND EXPERIMENTS WITH NATIVE PHOSPHATES.

In one of our previous annual reports (thirteenth annual report, 1901, of Hatch Experiment Station of Massachusetts Agricultural College, pp. 68–70) we have discussed in detail the history and timely appearance of the basic slag phosphate

in our general markets. In this article we pointed out the special modes of analysis that were in use in testing this material, also certain changes that have taken place in many localities in preparing the phosphatic slag by the addition of silica in a fusing process to change the free lime which is present in the slag to a silicate of lime, thus showing, it is claimed, a larger percentage of available phosphoric acid.

Samples of phosphatic slag have been collected in our general markets during the past year. This would indicate that this class of material was claiming the attention of agriculturists more than in the past. The extensive introduction of new methods of iron manufacture has largely increased the supply of phosphatic slag. Results of field experiments have shown the superior value of this material and demonstrated its fitness as a manurial matter. In view of the above facts, we have again taken this subject up for discussion.

The following table gives the results of analysis of samples of phosphatic slag made at the laboratory during 1904, in comparison with the average of analyses of slags made at the station in years past. Sample I. was imported from England in 1904; Sample II. was collected in our general markets during the spring of 1904; Sample III. was the average of all previous analyses made at the station.

Analysis of Samples (Per Cent.).

	Sample I.	Sample II.	Sample III.
Moisture, . . . . .	.15	none	.99
Total phosphoric acid,	18.61	20.52	20.61
Available phosphoric acid,	-	4.96	4.05
Insoluble phosphoric acid,	-	15.56	19.02
Calcium oxide,	50.58	46.78	50.32
Insoluble matter,	-	18.78	6.59

From the results of the above compilation of analyses it will be seen that the present phosphatic slag does not differ materially from that of the past. The two samples analyzed during the year showed the presence of free lime, which fact was recognized and the mode of analysis was so modified as to

counteract the action of the free lime before subjecting the samples to the usual treatment with neutral citrate of ammonia for the determination of the available phosphoric acid.

The attempt to imitate the phosphatic slag, by fusing apatite with soda ash at 600° to 800° C., was mentioned in our previous annual report. Observations have been extended along this line during recent years by fusing natural phosphates with carnallite and kieserite for ten to fifteen minutes, at a temperature of 650° to 800° C. This treatment gave a compound analyzing:—

	Per Cent.
Total phosphoric acid,	20.71
Phosphoric acid soluble in 2 per cent. citric acid solution,	15.23
Calcium oxide,	9.92
Magnesium oxide,	10.20
Potassium oxide,	6.85
Chlorine,	16.47

It was reported that the effect of this fertilizer on oats and peas was somewhat superior to phosphatic slag, as regards the yield of grain.

Another substitute for slag phosphate is described by Prof. P. Wagner: 100 parts of coarsely crushed phosphorite is fused with 70 parts of acid sodium sulfate; 20 parts of calcium carbonate, 22 parts of sand and 6 to 7 parts of coal; this gave a product testing 15.7 per cent. phosphoric acid, practically all of which was soluble in citric acid solution. Pot experiments were conducted on oats, grown on loam soil, by the aid of this mixture, alongside of similar experiments conducted with a superphosphate testing 17.7 per cent. water-soluble phosphoric acid and 18.9 per cent. total phosphoric acid and phosphatic slag, testing 18 per cent. citric acid soluble phosphoric and 19.9 per cent. total phosphoric acid. The fused mixture gave as quick-acting and effective results as the superphosphate, and also gave results superior to the basic slag phosphate.

During the winter of 1902 Mr. H. D. Haskins of this department made some interesting experiments in fusing Canadian apatite with a mixture of sodium and potassium carbonates. The apatite was a high-grade material, testing

31.22 per cent. phosphoric acid and 51.74 per cent. calcium oxide. His experiments were conducted as follows: 1 part of the apatite was fused with 4 parts of a mixture composed of 23 parts of sodium carbonate and 39 parts of potassium carbonate. The resulting mass was extracted with water, and showed a test of 3.68 per cent. water-soluble phosphoric acid. The residue, upon treatment with neutral citrate of ammonia, showed a test of 26.78 per cent. of reverted phosphoric acid, leaving only .76 per cent. of phosphoric acid in an insoluble form. In another experiment 1 part of the apatite was fused with 1.15 parts of the same fusing mixture, this amount of sodium and potassium carbonate being theoretically necessary to convert all of the phosphoric acid into phosphates of soda and potash. The resulting mass showed 2.56 per cent. of water-soluble phosphoric acid, 15.96 per cent. of reverted phosphoric acid and 12.70 per cent. of insoluble phosphoric acid. Mr. Haskins also made experiments to ascertain to what extent the phosphoric acid in apatite would become available if boiled with a solution of sodium and potassium carbonate. Several strengths of solution were used, but only traces of phosphoric acid were dissolved, the residue in no case showing over 1.98 per cent. available phosphoric acid. From the above observations it will appear that great fields are opened for a more extensive use of our natural phosphates when introduced in a suitable form by some fusing process.

In conclusion, we must say that the consumption of commercial fertilizers is ever on the increase, and it is a great satisfaction to feel that apparently the increased consumption of fertilizers is more than off-set by the prospective increase in natural supplies. The increased production of sulfate of ammonia from improved methods in the manufacture of coke from bituminous coal, the recent discoveries of new potash deposits in Saxony, Ger., as well as the recent reported discovery of nitrate of soda beds along the Pacific coast in the United States, all furnish pleasant reflections for the future of American agriculture.

REPORT OF THE ENTOMOLOGISTS.

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

A number of different lines of investigation have been begun or continued during the year 1904, in addition to what may be termed the routine work of the division.

Experiments to determine the best treatment for the San José scale, begun at this station in 1902, have been concluded, at least for the present, as they have resulted in so thoroughly freeing the college orchard from this pest as to leave no material for further experiment. It is true that the scale is not exterminated, but it is present in such small numbers that several years must elapse before the orchard will become so reinfested as to be of any value for experimental purposes. On the other hand, it is impossible under present conditions to attempt experimental work elsewhere, and therefore this line of research is at least temporarily suspended.

A number of private preparations claiming to be useful as insecticides have been tested during the year, with varying results; but none have thus far been found which appear to be of great value. Whether it is worth while to take the large amount of time necessary for these tests, when the results, if they should ever by any chance prove valuable, would practically only produce free advertising to those manufacturing them, is certainly questionable, particularly as scarcely any of these substances are made by residents of this State.

The codling moth is now treated by spraying during the egg-laying period of this insect. In the west there are several broods of this pest each year, but in Massachusetts there seems to be much uncertainty on this point. For two years observations have been conducted to determine the

number of broods of this insect, and the proper times at which to spray the trees in order to obtain the best results. The difference in seasons is of course a factor in the determination of these points, and renders it necessary that the work be continued for a term of years before final results can be obtained.

The oyster-shell scale can easily be controlled by mild sprays if these are applied at the right times, but two years ago no one in Massachusetts seemed to know just that time. In States but a short distance south this pest has two broods, and it has been doubtful whether there were not two here also. In order to determine these questions, careful observations have been made during the last two years, and must be continued for several more in order to obtain reliable results.

For nearly three months of the year all the spare time of the entomologists was devoted to the preparation of an exhibit for the Louisiana Purchase Exposition, taking time which could otherwise have been devoted to experimental work. The nature and scope of this exhibit has been presented elsewhere, and need not be given here.

During the colder months of the year experimental work is practically impossible, and this time is made use of in putting together the results of previous investigations, and drawing conclusions from them; in classifying and arranging the materials gathered and received during the summer; in solving the more complex problems connected with cases of injury difficult to reach and control by ordinary means; and in original investigations of various kinds.

The correspondence with residents of the State requires a large amount of time. In 1903 this was less than usual, the reasons for it being considered in the last report. This year it has resumed its normal quantity, about 1,500 inquiries having been received and answered by letter, or by sending printed information on the topics concerned.

Particular effort has been made to obtain samples of the injuries caused by insects, these being often markedly characteristic, and therefore of the greatest utility in a collection so constantly referred to.

The card catalogue has now been installed in a new case, capable of holding 90,000 cards, and is in constant use; in fact, it is probably the most useful single piece of apparatus in the possession of the division. Additional cards are constantly being added as new literature is published.

INSECTS OF THE YEAR.

The unusually cold weather during the winter of 1903-04, together with a few sudden and marked fluctuations of the temperature, was not without its effect upon insect life, as was shown last summer, though perhaps less than might have been expected.

The San José scale was destroyed in large numbers by the winter-killing of trees, and to some extent on those which survived the winter. This demonstrates that this insect is not entirely hardy during severe winters in this latitude. Unfortunately, enough succeeded in living to produce many young during the summer, so that this insect is now somewhat more abundant than it was a year ago. It is generally distributed over the State east of the western slopes of the Connecticut valley, but seems not to have penetrated the Berkshire hills to any great extent. Spraying with the lime-sulphur mixture for this pest has been made use of by many fruit growers and others, and has proved to be an excellent method for its control.

Plant lice and root maggots have been fairly abundant this year, due perhaps to their great increase during 1903 enabling them to have so many descendants that a larger number than usual succeeded in passing the winter.

The white fly (*Aleyrodes*) in greenhouses has apparently spread in all directions, complaints of the destruction it has caused having been received from all parts of the State.

The red spider (*Tetranychus*, spp.) has also been very abundant, both in greenhouses and outside, where a characteristic brownish tinge on the leaves of affected plants has often been very noticeable.

The usual amount of correspondence about the treatment for ants in houses and on lawns, about cut-worms, wire worms, the oyster-shell and scurfy scales and the various

soft scales, indicates that these pests have been as abundant as ever, and that many people are still entirely ignorant of the appearance of their commonest insect foes.

The brown-tail moth has continued to spread over the State, and has been found in Lunenburg, Clinton and Whitman, by the State nursery inspectors. This indicates that the insect is spreading westward rapidly, and that it will be present in all parts of Massachusetts within a very few years. During the middle of July, while the moths were flying, it was noticeable that they were attracted to light, many being destroyed by flying into open arc lights on the streets, in some cases falling to the ground below the lights in such numbers as to form heaps of noticeable size.

It has usually been believed that the amount of feeding done by these insects in the fall was so slight that it could be ignored. This year, however, the caterpillars, after hatching and even after forming their tents, fed so much that where they were abundant all the foliage was skeletonized and turned brown. This was very noticeable in parts of Belmont, Arlington, Winchester and elsewhere. After the pear and apple, oaks seemed to be a favorite food for this insect, and the browning of the foliage in places was so great that newspapers called attention to "an extra brood" of this pest, and in some cases discovered that it was "a new and hitherto unknown insect" which was causing the injury.

The gypsy moth is now generally distributed over its original territory, and in one or two places has spread beyond it. In the districts where it is most abundant, the destruction it formerly caused when unchecked is again seen, and the result if no means of repression or control are taken can easily be imagined by any one who has visited these places. Local organizations in the infested districts are taking action to destroy this and the brown-tail moth, and are doing splendid work; but this should be supplemented by work on broader lines and with more power than local organizations possess, if lasting results are to be hoped for.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANTS, F. R. CHURCH, S. B. HASKELL.

The work of the agricultural department of the experiment station during the past year has in the main followed the general lines of investigation which have recently engaged attention. These for the most part are connected with questions affecting the selection and use of manures and fertilizers. To give results of value, such experiments require numerous repetitions, because of variation in product due to seasons and to conditions which we cannot fully control. In the averages of a series of years the influence of such variations is in a measure eliminated, and deductions based upon such averages will serve as a basis in farm practice.

The work of the past season has involved the care of over 220 plots in the open field, 150 closed plots and 278 pots in vegetation experiments.

Our grass garden, which includes 48 species and 7 varieties, most of them occupying 1 square rod of land, has been cared for as usual. One-half of the area in each species has been kept constantly lawn-mown, with a view to studying the probable effects of grazing; and a considerable number of species which had become mixed have been renewed, after paring and burning the old turf for the destruction of seeds and roots of weeds and other grasses.

Numerous experiments with alfalfa, both on our own grounds and on the grounds of selected farmers, are in progress. The results of this work are to be given in a bulletin. It suffices for the present to say that we have nowhere attained results so satisfactory that the extensive sowing of this crop can be advised; it must still be regarded as in the experimental stage.

A few cultures of nitrogen-assimilating bacteria, sent out by the Department of Agriculture for use with legumes, have been tried, and, so far as can be judged, with disappointing results. A bulletin descriptive of this work and the results obtained will be prepared in due time.

We have increased the scope of our work with the new and promising varieties of timothy received from Prof. A. D. Hopkins of the West Virginia Experiment Station, five years ago. Several of these are distinct improvements upon the ordinary commercial timothy, and these are being increased as rapidly as possible, for the production of seed which will later be furnished to selected farmers for trial.

Variety work with wheat, oats and barley has engaged considerable attention. Seeds of 31 varieties which for a series of years had given remarkable crops in the Dominion of Canada were kindly donated for the purpose by Dr. William Saunders, director, Experimental Farms of Canada. It was hoped that these northern-grown grains might prove valuable, but the results were disappointing. Practically all varieties were affected by rust, and the yields of most were small. The range of variation in the crops obtained was as follows: for wheat, at the rate of from 6 to 15 bushels per acre; for barley, at the rate of from 6 to 26 bushels per acre; for oats, at the rate of from 40 to 55 bushels per acre. Among the varieties of oats, the Improved Ligowa, Bavarian, Thousand \$ and Wide Awake gave the best yields, — all in excess of 50 bushels. These varieties would seem to be worthy of further attention.

The work with poultry has been along the same lines as last year, the relations of food combinations to egg production being the subject under investigation.

The statement of results obtained, presented in detail in this report, does not cover all the experiments in progress.

The principal subjects of inquiry discussed, and the more important results, are as follows: —

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 was potatoes, and, on the basis of yield, the rank of the nitrogen-furnishing mate-

rials is as follows: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate ranks relatively lower this year than in any previous year of the experiment except last. On the basis of increases in all the crops grown since the experiment began, as compared with the no-nitrogen plots, the materials rank as follows: nitrate of soda, 100; barnyard manure, 83.6; dried blood, 66.9; sulfate of ammonia, 56.9. In this experiment we are also testing the stubble value to succeeding crops of legumes on the no-nitrogen plots. The results of this year indicate the soy bean crop stubble to have been of little value.

II. — To determine the relative value of muriate, as compared with high-grade sulfate of potash, for field crops. The results of this year indicate the sulfate to be considerably superior to the muriate both for rhubarb and for cabbages.

III. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainit, muriate, nitrate, carbonate and silicate. The crops of this year were cabbages, field corn and ensilage corn. The most striking results of the comparison are the relatively very low yield of the silicate of potash and the relatively high yields obtained on the nitrate and the carbonate.

IV. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was corn. The most striking result was the very inferior yield produced on the plot where Florida soft phosphate is used. This result, in exact agreement with results with different crops in earlier years, indicates a very low degree of availability for this phosphate.

V. — *A.* Soil test with corn. The crop of this year, the sixteenth during which the experiment has continued, was excellent on all plots to which potash has been annually applied. Where muriate of potash alone has been continuously used, the yield was at the rate of about 47 bushels per acre. Where muriate of potash and dissolved bone-black have been continuously used, the yield was at the rate of 53 bushels per acre, which is the best crop produced on any combination of fertilizers, and actually exceeds the yield

on the plot where manure has been annually applied at the rate of 5 cords per acre. The experiment strikingly shows the great importance of the liberal supply of potash in fertilizers for the corn crop. *B.* Soil test with grass and clover. The nitrate of soda, whether used alone or in combination, caused a large increase in the first crop. The use of potash without lime had little effect upon the crop. Where potash has been used continuously for fifteen years, with two heavy applications of lime (in 1899 and 1904), the effect on the proportion of clover and on total yield was very marked. The most profitable crop produced by any fertilizer combination was obtained upon the plot to which dissolved bone-black and muriate of potash have been continuously applied. On the limed portion of this plot the yield is at the rate of 6,100 pounds of hay. The annual cost of the fertilizers applied to this plot has been \$7.50.

VI. — To determine the relative value in crop production of a fertilizer mixture rich in potash, as compared with one representing the average of the special corn fertilizers purchasable in our markets. The result of this year is substantially equal crops under the two systems of manuring, at a cost of rather over \$5 per acre less for the combination of fertilizers richer in potash.

VII. — To determine the relative value in corn production of a moderate application of manure alone, as compared with a smaller application of manure used in combination with 160 pounds of high-grade sulfate of potash per acre. The result of this year was crops under the two systems equal in amount of stover, but an average at the rate of 5 bushels of grain per acre less on the combination of manure and potash than on the manure alone. The difference in crop is not sufficient to cover the excess in cost of the larger amount of manure alone, as compared with the lesser amount of manure and potash.

VIII. — To determine the economic result of using in rotation on grass lands, the first year, barnyard manure, 8,000 pounds per acre; the second year, wood ashes, 1 ton per acre; and the third year, bone meal, 600, and muriate of potash, 200, pounds per acre. The average yield of hay

during the past season, all three systems of manuring being represented on a total area of about 9 acres, is at the rate of 8,050 pounds of hay per acre. The average for the twelve years during which the experiment has continued (1893 to 1904, inclusive) is 6,718 pounds.

IX. — To determine which is better economy, — to spread manure as hauled from the stable during the winter, or to place in a large heap to be spread in spring. This experiment was repeated in five pairs of plots. The winter application gave the better yield in three cases, the spring application in two; but the difference in the value of the crop where the spring application gave the larger yield was not sufficient to cover the difference in the cost of the two systems of handling the manure, which amounts to \$4.80 per acre. The winter of 1903 and 1904 was exceptionally favorable to good results from application at that season, as conditions were such that there was no washing over the surface.

X. — To determine whether the application of nitrate of soda after the harvesting of the first crop will give a profitable increase in the rowen crop. The increases produced were considerable, but, possibly because of somewhat deficient rainfall, were not sufficient to make the application distinctly profitable.

XI. — The variety test of potatoes. Forty-nine varieties of potatoes were tested. The yield obtained from the different varieties ranged from 104 bushels of merchantable potatoes per acre for the Clinton to 319 bushels of merchantable potatoes per acre for Simmon's Model. Seven varieties gave a yield in excess of the rate of 260 bushels per acre, namely: Simmon's Model, Extra Early White Rose, Great Divide, Steuben, 1904, Mills' New Rose Beauty. These varieties are mentioned in the order of their productiveness.

XII. — Comparison of different foods and combinations of foods furnishing essential nutrients in different nutritive ratios for laying hens. The hens were supported, at a cost of about $\frac{1}{6}$ of a cent per hen daily, on mixtures of food rich in corn, as compared with a cost of about $\frac{1}{4}$ of a cent per hen daily, on mixtures of food rich in wheat. The food

cost per egg was lowest on the food mixtures containing a large proportion of corn. The combination of feeds including a considerable portion of rice and rice meal gave the most satisfactory egg yield of any combination tested, but the cost of rice is too great to make it an economical food for poultry.

I. — MANURES AND FERTILIZERS FURNISHING NITROGEN COMPARED. (FIELD A.)

The experiments in Field A have two principal objects in view: first, to compare the efficiency (as measured by crop production) of a few standard materials which may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a legume will render the application of nitrogen to a succeeding crop of another family unnecessary. The field includes eleven plots of one-tenth acre each. A full description of the plan followed will be found in the twelfth annual report of the Hatch Experiment Station. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. All the plots annually receive equal and liberal amounts of materials supplying phosphoric acid and potash. Three plots in the field have had no nitrogen applied to them since 1884; the materials under comparison on the other plots in the field are applied in such quantities as 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. The potash applied to these plots is supplied in the form of muriate to six plots, namely, 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, namely, 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, soy beans.

The crop of this year was potatoes. The variety was the Green Mountain. The seed, which was of fine quality, was grown in northern Maine. The land was plowed on May

3; manure and fertilizers were applied on the 7th, and the potatoes, which had been soaked in formalin solution for prevention of scab, were planted on May 11. The crop was thoroughly cared for throughout the season, although there was some injury from bugs, apparently due to the fact that the Paris green used for the first spraying on June 27 was impure. The vines were sprayed three times with Bordeaux mixture and Paris green: respectively, July 3, 18 and 30. There was apparently little injury from blight. The leaves on the plot to which manure was applied retained their green color considerably longer than those on the other plots. On September 10 they were estimated to be still about one-half green, while the proportion still remaining green on other plots was in general estimated to be about one-tenth to one-eighth. By September 22 the tops were dead, and the potatoes were dug between that date and the 29th. The rates of yield on the several plots and the source of nitrogen on each are shown in the following table:—

Yield of Potatoes per Acre (Bushels).

Plots.	NITROGEN FERTILIZERS USED.	Merchant-able.	Small.
0, . .	Barnyard manure,	236.67	41.67
1, . .	Nitrate of soda (muriate of potash),	190.33	36.00
2, . .	Nitrate of soda (sulfate of potash),	188.17	33.50
3, . .	Dried blood (muriate of potash),	141.33	36.00
4, . .	No nitrogen (sulfate of potash),	96.33	30.00
5, . .	Sulfate of ammonia (sulfate of potash),	157.50	19.17
6, . .	Sulfate of ammonia (muriate of potash),	102.50	13.33
7, . .	No nitrogen (muriate of potash),	104.33	11.50
8, . .	Sulfate of ammonia (muriate of potash),	113.50	32.50
9, . .	No nitrogen (muriate of potash),	141.67	36.17
10, . .	Dried blood (sulfate of potash),	232.33	24.17

The yield on the different plots varies widely, that on the plot receiving manure being the best in the field, and standing relatively much higher as compared with the plots receiving their nitrogen in the form of a fertilizer than in any previous year. It is believed that this result must be in large measure a consequence of the fact that the application of barnyard manure tends to maintain the stock of humus in the soil, and so keeps it in a condition more favorable to productive capacity. Neither the soy bean nor the potato leaves a residue which contributes materially to the humus content of the soil, and no other crops have been grown

during the past five years. Experiments in continuous potato culture without manures in the Cornell University Experiment Station have shown in a striking manner the dependence of this crop upon the presence of a suitable proportion of organic matter in the soil.¹ The common observation that potatoes thrive exceptionally well in virgin soils and upon sod land points in the same direction.

The superiority of the yield on Plot 10 also is striking. This, in the writer's opinion, is due to the fact that the potatoes on this plot were covered by hand, while those on the other plots were covered by the use of the plow. The potatoes on this plot came up much more quickly and more vigorously than those on the others, and showed decided superiority in growth from the start.

The average yields of this year on the several fertilizers are shown in the following table:—

FERTILIZERS USED.	Merchantable (Bushels).	Small (Bushels).
Average of the no-nitrogen plots (3),	114.11	25.89
Average of the nitrate of soda plots (2),	189.25	34.75
Average of the dried blood plots (2),	186.83	30.09
Average of the sulfate of ammonia plots (3),	124.50	21.67

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops in the following relative amounts:—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.00
Dried blood,	90.40
Sulfate of ammonia,	90.30
No nitrogen,	72.80

Similar averages for this year are as follows:—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	124.30
Dried blood,	96.80
Sulfate of ammonia,	65.30
No nitrogen,	62.50

As was the case last year, the nitrate of soda stands relatively lower than in experiments of previous years, although

¹ Bulletin No. 196, Cornell University Experiment Station, p. 52.

it still maintains its superiority as compared with the other fertilizers furnishing nitrogen. The barnyard manure produces a superior crop, not, it is believed, because of the superior availability of the nitrogen it contains, but, as has been suggested, because of the better physical condition of the soil produced by the humus it furnishes.

If we compare the different materials used as sources of nitrogen on the basis of increase in crop rather than on the basis of total product, they rank to date for the entire period of the experiment 1890 to 1904 as follows:—

Relative Increases in Yields (Average for the Fifteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	83.60
Dried blood,	66.90
Sulfate of ammonia,	59.90

These figures make the superiority of nitrate of soda as a source of fertilizer nitrogen very apparent. In view of the fact that at current prices it furnishes a pound of nitrogen at a lower cost than almost any other material, the advisability of depending chiefly upon the nitrate as a means of supplying the important element nitrogen becomes strikingly evident.

Effect of a Legume upon the Following Crop.

It is pointed out, in introducing what will be said under this topic, that the object in this experiment is not to test the effect of producing a legume which is plowed under, but simply the improvement, if any, derived from the roots and stubble the legume leaves behind when harvested. The results thus far indicate little improvement in the condition of the soil following the culture of the soy bean, with the exception of those obtained with the potato crop following soy beans in 1902. The introduction of the clover crop, on the other hand, was followed by marked improvement; and it would now appear possible that the good results with the potato crop in 1902 may have been in part at least a consequence of the unexhausted residue of the clover stubble and roots turned under in the spring of 1900. The following table, with the curve below it, makes the facts clear:—

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS (EACH ONE-TENTH ACRE).	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean.	Oats.
Nitrogen plots, . .	343	484	1,965	598	620	494	1,740	445
No-nitrogen plots, .	290	421	1,443	540	452	370	1,143	197

*Effect of Leguminous Crops upon the Following Crop (Pounds) —
Concluded.*

PLOTS (EACH ONE-TENTH ACRE).	1898.	1899.	1900.	1901.	1902.	1903.	1904.
	Oats.	Clover.	Potatoes.	Soy Bean.	Potatoes.	Soy Bean.	Potatoes.
Nitrogen plots, . .	254	413	1,316	442.21	1,053.6	2,726	1,199
No-nitrogen plots, .	158	367	1,254	398.31	1,046.0	1,907	840

1 Dry beans and straw.

*Curve showing Relation of Average No-nitrogen to Average Nitrogen
Plots, the Latter being considered in Each Year 100.*

[Per cent. average no-nitrogen to average nitrogen.]



It will be noticed that the crops following soy beans have as a rule showed little improvement which can be attributed to that crop. So long as the soy bean was the legume grown, the crops on the no-nitrogen plots continued in general to decline, as compared with the crops obtained upon the nitrogen plots. This is indicated by the fairly uniform and comparatively rapid fall in the line indicating the relative production. The introduction of clover causes a marked rise in the line indicating production, and this continues during the first three seasons following the plowing of the clover sod. The effect of the soy beans upon the crop of potatoes grown in 1902 appears to have been distinctly beneficial; but, as was stated in the fifteenth annual report, the fact that the potato crop in 1902 suffered from blight undoubtedly favored the plots where the growth was relatively feeble. In commenting upon the results obtained in 1902, I said:—

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.

In view, then, of the doubt as to whether the true relative capacity for product was shown in 1902, and the further fact that all other years show a general agreement in not indicating a decided benefit following the introduction of the soy bean as a crop, we seem to be justified in the conclusion that the residual fertility left behind by the soy bean is comparatively unimportant.

II.—THE RELATIVE VALUE OF MURIATE AND HIGH-GRADE SULFATE OF POTASH. (FIELD B.)

The object in view in this experiment is to test the relative value of muriate and high-grade sulfate of potash when used continuously upon the same soil. The experiment was begun in 1892. The potash salts were used for the period

from 1892 to 1899 inclusive, 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. The number of plots in the field at present is ten, five receiving muriate of potash, and alternating with the same number of plots which yearly receive sulfate of potash. 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. With few exceptions, good yields have been obtained. Among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done 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, while the quality of the potatoes and sugar beets when grown on sulfate of potash has been distinctly better than on muriate of potash. Three years ago, two of the plots in this field were set to small fruits, asparagus and rhubarb, — on each plot one row each of raspberries, blackberries, asparagus and rhubarb. Aside from the crops just named, those of the past year have been cabbages on two plots and three varieties of clover, namely, Mammoth Red, Medium Red and Alsike, each on two plots. The clover was sown in the spring, and the product of the plots was considerably mixed with weeds; for this reason, the weights were not taken. There was no readily distinguishable difference in the growth of either the Medium or the Mammoth clovers that could be attributed to the difference in potash manuring. The Alsike clover upon the plot manured with sulfate of potash has made a distinctly better start than that on the muriate. Neither the asparagus, raspberries nor blackberries have yet become sufficiently established to give a full crop, and the results will not be reported in detail. The yield of asparagus was substantially equal on the two potash salts. The yield of raspberries on the muriate of potash was considerably greater than on the sulfate. Observation of the growth of the berry bushes and asparagus since they were set indicates that the rate of manuring which has been the practice on this field does not

maintain the soil in sufficiently high fertility to produce satisfactory growth on either of the combinations of fertilizers employed. During the past season, therefore, we have used nitrate of soda at the rate of 200 pounds per acre, in connection with the customary amounts of bone meal and potash, on the plots occupied by these crops.

1. *Rhubarb (Sulfate v. Muriate of Potash).*

The rhubarb grown in this experiment is of the Monarch variety. The growth has been vigorous and healthy. The product of this year is shown in the following table:—

Muriate v. High-grade Sulfate of Potash (Rhubarb).— Yields per Acre (Pounds).

FERTILIZERS USED.	Stalks.	Leaves.
Muriate of potash,	8,421	11,957
Sulfate of potash,	8,559	14,286

The yield of stalks on the two plots is substantially equal, but the weight of the leaves accompanying the stalks produced on the sulfate of potash is materially greater than on the other potash salt. Whether this fact has any special significance is not at present known; but it is at least suggestive that on Field C, where, under conditions otherwise differing quite widely from those in Field B, the muriate is compared with the sulfate, a similar difference in weight of leaves as compared with stalks is found. It is, of course, evident that the results of this year do not throw any important light upon the question as to whether there is any important practical difference in the two potash salts for this crop.

2. *Cabbages (Sulfate v. Muriate of Potash).*

The variety of cabbages grown this year was Fottler's Brunswick Drumhead. The seed was planted in hills two feet apart and in rows three and one-half feet apart, on June 30. The plants were thinned first to two in a hill, and later, on August 16, to one. The summer and the autumn, especially the latter, averaged much below the normal temperature, and the cabbages were by no means matured on the approach of weather which compelled their harvesting. With a normal

season there is no doubt that nearly all the plants would have produced merchantable heads. Under existing conditions a very large proportion of the heads were regarded as too soft to be included in that class. The yields per acre are shown in the following table:—

Muriate v. High-grade Sulfate of Potash (Cabbages).— Yields per Acre (Pounds).

FERTILIZERS USED.	Hard Heads.	Soft Heads.
Muriate of potash,	872	22,791
Sulfate of potash,	2,071	24,319

It will be seen that the product on the sulfate of potash is considerably superior to that on the muriate. The yield of hard heads is nearly two and one-half times as great, while the yield of soft heads also somewhat exceeds that on the muriate. As this result is in general agreement with that usually obtained heretofore with the cabbage crop, it tends to still further confirm the conclusion that it is best that the potash used for this crop be in the form of sulfate rather than muriate.

III. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

Field G contains 40 plots, of about one-fortieth of an acre each. The experiments in progress have for their object the determination of the relative value for field crops of all the prominent potash salts when each is used continuously upon the same land throughout a long series of years. This experiment was begun in 1898. The plots are arranged in five series of eight each. In each series one plot has received no potash since the experiment began. The potash salts under trial are as follows: kainit, high-grade sulfate of potash, low-grade sulfate of potash, muriate of potash, nitrate of potash, carbonate of potash and silicate of potash. Each is always applied in such quantity as to furnish actual potash at the rate of 165 pounds per acre. All the plots in the field are yearly fertilized with materials supplying to each equal amounts of nitrogen and phosphoric acid. For

nitrogen, nitrate of soda is applied at the rate of 250 pounds per acre, except on the plots where nitrate of potash is the source of the potash applied; here a suitable reduction in the quantity of nitrate of soda is made, on account of the nitrate nitrogen furnished by the potash salt. The principal source of phosphoric acid on these plots is acid phosphate, applied at the rate of 360 pounds per acre to all. Tankage at the rate of 270 pounds per acre is applied to all plots as a source of less immediately available nitrogen and phosphoric acid. The crops grown in this experiment in the order of succession are as follows: 1898, Medium Green soy beans; 1899, Beauty of Hebron potatoes; 1900, Fottler's Brunswick cabbage, Medium Green soy beans, Black cow pea, Wonderful cow pea; 1901, Turkish Red wheat, Medium Red clover; Rural Thoroughbred, Leaming Field, Boston Market and Eureka corn; 1902, Medium Red clover; 1903, Medium Red clover.

During the past season the crops grown in the field were as follows: cabbages on sixteen plots, two series of eight each; Sibley's Pride of the North corn on sixteen plots, two series; and Leaming Field corn for ensilage on eight plots. The season was unfavorable to full maturity for the cabbage crop, for reasons which have been alluded to in discussing results on fields B and C. For the same reasons, and also because of the excessive rains at the season of planting, the season was highly unfavorable to the corn crop. Defective germination, owing to the excessive rains, produced an uneven stand of plants in the areas devoted to corn. For the reasons indicated, it does not seem worth while to publish the results in full detail, and averages only will be given. These for the cabbages are as follows:—

Cabbages. — Average Rates of Yield per Acre (Pounds).

POTASH SALT.	Hard Heads.	Soft Heads.
No potash (plots 1, 9),	10,850	22,850
Kainit (plots 2, 10),	11,100	26,150
High-grade sulfate (plots 3, 11),	10,600	25,500
Low-grade sulfate (plots 4, 12),	12,100	27,400
Muriate of potash (plots 5, 13),	11,900	26,600
Nitrate of potash (plots 6, 14),	14,800	23,100
Carbonate of potash (plots 7, 15),	16,500	23,400
Silicate of potash (plots 8, 16),	10,650	25,050

The most striking points brought out by these figures are : first, the high-grade sulfate of potash fails to show the superiority in yield to muriate which has generally been shown ; second, the nitrate and carbonate of potash have given yields very materially exceeding those obtained on any of the other potash salts ; third, the yield on the silicate of potash is one of the poorest in the field.

Field Corn. — Average Yields per Acre.

POTASH SALT.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
No potash (plots 17, 25),	15.00	17.78	3,740
Kainit (plots 18, 26),	20.25	14.00	4,300
High-grade sulfate (plots 19, 27),	19.50	13.45	4,340
Low-grade sulfate (plots 20, 28),	17.75	14.34	4,200
Muriate of potash (plots 21, 29),	20.50	14.44	4,660
Nitrate of potash (plots 22, 30),	17.00	13.45	4,020
Carbonate of potash (plots 23, 31),	17.00	15.78	4,420
Silicate of potash (plots 24, 32),	13.75	18.56	4,160

The most striking point brought out by these averages is the poor results where the silicate is the potash salt employed. Aside from this, the results with corn seem to be in general accord with those which have been usually obtained, which indicate that the different potash salts appear to have substantially similar effects upon this crop.

Ensilage Corn. — Average Yield per Acre (Pounds).

POTASH SALT.	Green Fodder.	POTASH SALT.	Green Fodder.
No potash (plot 33),	28,800	Muriate (plot 37),	36,800
Kainit (plot 34),	38,800	Nitrate (plot 38),	32,800
High-grade sulfate (plot 35),	34,600	Carbonate (plot 39),	30,000
Low-grade sulfate (plot 36),	36,600	Silicate (plot 40),	22,400

In the case of the ensilage, as well as field corn, the silicate of potash gives a yield much inferior to that produced by the other potash salts. That the silicate, whether with cabbages, field or ensilage corn in each of the five series of plots where it is employed, gives yields inferior to those obtained with the other potash salts, and that the yield does not in some cases equal even the yield obtained from the no-potash plot, is a fact which it seems desirable to point

out. Up to the present year the yields on silicate of potash with the different crops grown have not been markedly inferior to those obtained on other potash salts. It is impossible, in the light of our present knowledge of the conditions, to offer an explanation of the facts, although it is, of course, evident that the soil, which was originally in fair condition as regards its stock of available potash, has previous to this year been in condition to furnish a larger share of the potash needed by the crop than at present. With increasing exhaustion of natural stores of potash, the differences due to the several fertilizers used may naturally be expected to increase.

IV. — COMPARISON OF PHOSPHATES ON THE BASIS OF EQUAL APPLICATION OF PHOSPHORIC ACID.

The present is the eighth season of this experiment, which has for its object the determination as measured by crop production, of the relative availability of different materials which may be used as sources of phosphoric acid when used in such quantities as to furnish equal amounts of actual phosphoric acid to each plot, and in connection with materials which supply the other elements of plant food, especially the nitrogen and the potash, in abundance and in the same forms and in equal amounts on each of the plots. The field in which these experiments are carried on is divided into thirteen plots, of about one-eighth of an acre each. Three plots in the field, one at each end and one in the middle, have received no phosphoric acid since the experiment began. The phosphates which are employed on the other plots are as follows: apatite, South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone-black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. These phosphates are used in such quantities as to furnish actual phosphoric acid, at the rate of 96 pounds per acre. The nitrogen and potash fertilizers used supply nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some of the crops grown (onions and cabbages) a supplementary application of quick-acting nitrogen

fertilizers has been made to all plots alike. The crops which have been grown in the 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, onions, and cabbages. With the exception of the onions and cabbages, all the crops previously grown in the field have given good yields, even on the three no-phosphate plots. The soil of the different parts of the field was not even in fertility at the start. Plot 1 was somewhat more productive than any of the others, and in general the plots tended to decline in productiveness from 1 toward 13. The crop the past season was corn. The soil of the field inclines to be heavy, and the corn crop during the prevailing cool weather of the past season suffered from poor soil conditions and low temperature, especially on plots 8, 11, 12 and 13. Observation of the growth of the crop of the preceding year (cabbages), and study of the soil conditions throughout the preceding season, had led to the conclusion that the physical and chemical conditions of the soil in the field would be improved by a heavy application of lime. The field was plowed in the fall of 1903. Freshly slacked lime to the amount of 4,675 pounds (about 2,000 pounds per acre) was applied on May 10 and plowed in on May 15. The variety of corn grown was the Leaming Field. The seed was obtained of E. E. Chester & Son, Champaign, Ill., and was of excellent quality. The rainfall was so excessive, however, that there were a few blanks in some of the plots. The crop was cut on September 19 and immediately weighed and put into the silo. The rates of the yields on the several plots are shown in the following table: —

Plots.	FERTILIZERS USED.	Green Corn (Pounds per Acre).
1,	No phosphate,	41,000
2,	Apatite,	40,720
3,	South Carolina rock phosphate,	40,496
4,	Florida soft phosphate,	28,240
5,	Phosphatic slag,	36,440
6,	Tennessee phosphate,	32,120
7,	No phosphate,	32,344
8,	Dissolved bone-black,	30,080
9,	Raw bone,	45,800
10,	Dissolved bone meal,	41,840
11,	Steamed bone meal,	28,400
12,	Acid phosphate,	29,040
13,	No phosphate,	20,240

The point of principal significance in connection with the results appears to be the marked inferiority of the yield on the Florida soft phosphate. There was no difference in the physical conditions on this plot, as compared with those on either side, that can explain the wide difference in the amount of the product. The results of this year, then, additionally confirm the conclusions of previous years, — that this phosphate seems likely to give results which are distinctly disappointing, as compared with the claims of those interested in its production and sale. The low product on plots 8, 11 and 12 was undoubtedly in considerable measure due to the unfavorable conditions which have been referred to.

V.—SOIL TESTS.

In introducing what I have to say concerning soil tests, I cannot do better than to employ the language used in my last annual report, p. 244:—

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. 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, 800 pounds.

Manure, 5 cords.

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

This acre has been used in soil tests for sixteen years, beginning in 1889. The crops for 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, corn, and corn. Since 1889 this field has, therefore, borne eight corn crops, and during this time it has been four years in grass. The present is the third successive corn crop, these three crops following grass, which occupied the field in 1901. Last season was one of the most unfavorable for corn within the memory of our oldest men. The crop was exceedingly small, even on the land which had annually received an application of manure at the rate of 5 cords per acre. With only one exception, previous to last year, the corn crop wherever potash has been applied to the soil in this field has always been good. In 1898 the crop even where potash and other fertilizers had been used was small. This suggested the probable necessity of an addition of lime. The application of lime at the rate of 1 ton to the acre restored the productiveness of all the plots to which muriate of potash had been continuously applied. The small crop of last year, in connection with observations on the condition of the soil, led to the conclusion that lime might once more prove useful; the entire field, therefore, was given a dressing of freshly slacked lime, at the rate of 1 ton per acre. The marked increase in the crop of this year wherever potash was used indicates the correctness of the opinion that lime was needed. The plot where potash was used alone last year gave a yield at the rate of about 15.5 bushels of corn per acre; this year the product is almost three times that amount. Last year the plot to which nitrate of soda and muriate of potash are annually applied gave a yield at the rate of 16.5 bushels per acre; this year the yield is 47.8 bushels. The plot receiving dissolved bone-black and muriate of potash, which last year gave a crop of a little less than 19 bushels, this year gave a crop of rather over 53 bushels. These facts make it strikingly evident that, in connection

with fairly liberal amounts of muriate of potash, it is essential to use lime freely on many of our soils, if their productiveness is to be maintained. This field contains four plots, to which neither manure nor fertilizer of any kind has been applied during the sixteen years that the experiment has continued. These plots have now become very highly exhausted, producing crops which are practically valueless so far as the production of grain is concerned, although the nominal yield is at the rate of about 3.5 to 8 bushels per acre. The following table shows the fertilizers used on the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots:—

Corn. — South Acre Soil Test, 1904.

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,	7.11	1,200	2.78	330
2, .	Dissolved bone-black,	3.89	960	— .44	90
3, .	Nothing,	4.33	870	-	-
4, .	Muriate of potash,	46.89	3,760	42.86	2,933
5, .	Lime,	2.67	820	—1.07	—37
6, .	Nothing,	3.44	740	-	-
7, .	Manure,	50.00	4,000	46.56	3,260
8, .	Nitrate of soda and dissolved bone-black.	15.11	1,500	6.33	320
9, .	Nothing,	8.78	1,180	-	-
10, .	Nitrate of soda and muriate of potash.	47.67	3,560	39.71	2,440
11, .	Dissolved bone-black and muriate of potash.	53.11	3,940	45.96	2,880
12, .	Nothing,	6.33	1,000	-	-
13, .	Plaster,	7.44	1,100	1.11	100
14, .	Nitrate of soda, dissolved bone-black and muriate of potash.	47.78	3,700	41.45	2,600

It will at once be noticed that the potash is the element which determines the crop, almost to the exclusion of all others. Where potash has been used alone during sixteen years, the yield is almost as great as it is with potash and any of the other combinations. Nitrate of soda alone does

very little good. Dissolved bone-black alone gives a crop less than the average of the nothing plots. The combination of nitrate of soda and dissolved bone-black gives a very inferior crop, but wherever potash is used the crop is good. Particular attention is called, further, to the fact that the continuous use of lime alone is not beneficial; on the contrary, the yield on the plot where lime has been continuously used is the poorest in the field. Plaster used alone and continuously gives a slightly better crop, but not much in excess of the nothing plots. It may perhaps be urged that the soil of this field must be of very exceptional character; that, otherwise, the so long-continued use of one fertilizer element could not produce the results obtained. To a certain extent this criticism may be justified, and I do not call particular attention to the marked effect of the potash for the purpose of urging upon our farmers exclusive dependence upon this fertilizer, but to make more emphatic the point that our farmers in general should insist that fertilizers designed for use for the corn crop should be richer in potash than is usually the case. The results obtained in previous years on this field indicate not so much that this soil is deficient in potash, — for some crops, such as grass, for example, do well on the plots to which no potash has been applied since the beginning of the experiment, — as that the corn crop depends in a marked degree upon a liberal supply of readily available potash.

B. — Soil Test with Mixed Grass and Clover (North Acre).

The acre used in the north soil test has been kept in this experiment fifteen years, beginning in 1890. The fertilizers have been used in the same combinations and in general in the same amounts on the several plots as in the south soil test, except that during the years when onions have been grown the fertilizers have been used in double the usual quantities. Each fertilizer or combination of fertilizers has been used continuously upon the same plot. In this experiment the plots were divided transversely in 1899, and lime was applied at the rate of 1 ton to the acre to one-half of each plot. The lime was applied after plowing, and har-

rowed in. During the past season the same halves of all the plots have once more been limed, and at practically the same rate as before; but this year, as the land was in grass, the lime was applied as a top-dressing on the grass in spring. The date of application was May 13. The crops grown in this field, in the order of succession, beginning in 1890, 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, grass and clover, and grass and clover. The field was sown to grass and clover after the harvesting of potatoes in the autumn of 1902 (September 15). The rate of seeding per acre was: timothy, 18 pounds; red-top, 8 pounds; red clover, 5 pounds; and alsike clover, 4 pounds. The clover winter-killed, and accordingly additional clover seed (15 pounds) was sown on April 4, 1903.

On account of the deficiency in rainfall from the middle of April to about the 10th of June, 1903, the yields last year on all plots were very small. The yields during the past season have been much larger. They are shown in the following table:—

Grass and Clover. — North Acre Soil Test, 1904.

Plots.	FERTILIZERS USED.	YIELD PER ACRE, HAY.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing,	1,060	800	-	-
2, .	Nitrate of soda,	1,960	1,600	1,067	880
3, .	Dissolved bone-black,	1,000	680	273	40
4, .	Nothing,	560	560	-	-
5, .	Muriate of potash,	600	1,920	40	1,265
6, .	Nitrate of soda and dissolved bone-black.	2,120	2,320	1,560	1,570
7, .	Nitrate of soda and muriate of potash.	1,920	1,860	1,360	1,015
8, .	Nothing,	560	940	-	-
9, .	Dissolved bone-black and mu- riate of potash.	860	3,600	280	2,575
10, .	Nitrate of soda, dissolved bone- black and muriate of potash.	2,200	4,400	1,600	3,290
11, .	Plaster,	560	600	-60	-595
12, .	Nothing,	640	1,280	-	-

Grass and Clover.—North Acre Soil Test, 1904—Concluded.

Plots.	FERTILIZERS USED.	YIELD PER ACRE, ROWEN.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing,	140	80	-	-
2, .	Nitrate of soda,	60	90	-30	7
3, .	Dissolved bone-black,	60	120	30	7
4, .	Nothing,	30	130	-	-
5, .	Muriate of potash,	70	780	37	557
6, .	Nitrate of soda and dissolved bone-black.	210	810	175	495
7, .	Nitrate of soda and muriate of potash.	50	520	12	112
8, .	Nothing,	40	500	-	-
9, .	Dissolved bone-black and mu- riate of potash.	80	2,560	47	2,125
10, .	Nitrate of soda, dissolved bone- black and muriate of potash.	620	2,840	595	2,470
11, .	Plaster,	20	80	2	-225
12, .	Nothing,	10	240	-	-

The results of this year resemble those of last year in one particular, namely, the marked increase in the first crop which follows the application of nitrate of soda; but in one important particular the results this year differ from those of 1903 in a marked degree, namely, in the very large increase on the limed portion of those plots to which muriate of potash has been annually applied. In commenting upon the results of last year, I said:—

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.

The principal ground on which this statement was based was the comparative absence of clover, even on the limed portion of such plots as had been supplied annually with potash. This relative absence of clover last year was doubtless in part due to the unfavorable climatic conditions; but the widely different results of this year indicate that the lime applied this season proved distinctly and largely beneficial.

It is desired to call particular attention to the yield both of hay and of rowen on the limed portion of Plot 9. This

plot, it should be understood, has not received an application of anything furnishing nitrogen during the fifteen years that the experiment has continued; and yet on the limed portion of this plot we this year have a yield of hay at the rate of 3,600 pounds and a yield of rowen at the rate of 2,560 pounds per acre, — a total of rather over 3 tons, at a fertilizer cost at the rate of \$6.50 per acre. Allowing for an application of lime at the rate of a ton once in eight years, the annual cost of the materials applied to this plot amounts to about \$7.50 per acre. The yields obtained at this very low cost indicate in a most striking manner the possibilities in the production of clover hay on soils naturally suited to clovers, without the use of the expensive nitrogen manures or fertilizers.

It is of especial interest to compare the yields of Plot 10 with those on Plot 9. Plot 10 has annually received nitrate of soda, in addition to the same amounts of dissolved bone-black and muriate of potash as are used on Plot 9. The result is a fair hay crop, even on the part of the plot where lime has not been used. Here, however, as on Plot 9, the yield is greatly increased by the application of lime, and we have a total in the two crops of the year at the rate of 7,240 pounds per acre. This exceeds the yield of the two crops on Plot 9 at the rate of a little more than a thousand pounds per acre. This increase is produced as the result of an application at the rate of 160 pounds of nitrate of soda. Such an application would cost about \$4, and the increase is therefore produced at a moderate profit.

As in previous years, the relative proportion of the different species (red-top, timothy and clovers) on the several plots has been carefully studied. The most important points noted are as follows: first, the use of nitrate of soda increases the proportion of red-top; second, potash increases the proportion of clover in a marked degree, and this influence is enormously increased on the limed portion of the plots.

It will be seen, by reference to the table showing how the fertilizers are applied, that Plot 6, which receives an application of nitrate of soda and dissolved bone-black annually, lies between two plots (5 and 7) each of which annually receives an application of potash. During the past season,

and to some slight extent in previous seasons, it has been noticed that the growth of the crops on the edges of Plot 6, although it is separated from 5 and 7 by strips $3\frac{1}{2}$ feet in width which have not received any fertilizer since the experiment began, shows plainly the influence of the potash applied to the neighboring plots, which has apparently diffused through the intervening $3\frac{1}{2}$ feet strips, and is now beginning to affect the growth of the crops on Plot 6. During the past season there has been a little fringe of clover on each edge of Plot 6; this, however, has not been sufficient in amount to materially affect the yield on this plot, which, as will be seen, showed but little increase in the amount of rowen, which best measures the proportion of clover. The figures, however, for this plot are undoubtedly to some small degree misleading. The nitrate and the dissolved bone-black alone would produce little or no clover; they have, however, produced a fairly large crop of hay, about equally good on the unlimed and limed portions of the plot. This result is doubtless to be ascribed mainly to the effect of nitrate of soda in stimulating the growth of the grasses.

The relatively small increase on the limed portion of Plot 7, where nitrate of soda and muriate of potash are used together, appears to be due to the fact referred to in my last annual report, — that, where these two fertilizers are used together, soil effects very unfavorable to the growth of clover follow. It is believed that, to correct this unfavorable influence of these chemicals, lime must be used in very large amounts.

VI. — SPECIAL CORN FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

It may be remembered that on this acre we are endeavoring to throw light upon the question as to the proper composition of fertilizers used alone for the corn crop. This experiment began in 1891. The crop from 1891 to 1896 inclusive was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900 it was corn; in 1901 and 1902, grass and clover; in 1903 and 1904, corn. A statement of the results to date will be found in preceding an-

nual reports. The 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 grass and clover. The field used in the experiment contains one acre, and is divided into four equal plots. 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 of the composition of the average of the special corn fertilizers analyzed at this station. This average has changed but little during recent years, and in 1899, since which date we have made 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 various fertilizers offered in 1899 differed widely in composition. The extent of the variation is shown in the following table:—

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

The fertilizers used on plots 2 and 4 are substantially the same in kind and amount as recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference in composition between the fertilizer mixtures under comparison is that that used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. 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
Muriate of potash,	37.5	62.5

The crop of the past two seasons has been corn, the crop of 1903 being the first to follow mixed grass and clover, which occupied the land in 1901 and 1902. The season of 1904, while too low in average temperature for the best growth of corn, was distinctly more favorable to the crop than 1903. The following tables show the yields on the several plots and the averages for the two systems of manuring:—

Yields of Corn, 1904.

PLOTS.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plot 1 (lesser potash),	59.25	7.78	10,640
Plot 2 (richer in potash),	57.50	9.33	9,208
Plot 3 (lesser potash),	57.75	7.79	8,280
Plot 4 (richer in potash),	55.25	13.56	9,660

Average Yields per Acre.

PLOTS.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	58.50	7.78	9,460
Plots 2 and 4 (richer in potash),	56.37	11.45	9,434

It will be seen that the yields under the two systems of fertilization were substantially equal, although the grain on plots 1 and 3 was better ripened than on the other plots. During the early part of the season the growth of the corn on plots 1 and 3 was materially better than on plots 2 and 4; the plants showed a better color and were of larger size. This difference showed itself very early in the season. On July 6, it was judged that the plants on plots 1 and 3 averaged one and one-half times the height of the plants on the other plots, and the difference in the growth on that date was judged to be considerably less than at an earlier period. As the season advanced, the corn on plots 2 and 4 steadily gained in condition and size, as compared with that on plots 1 and 3; and by the end of the season, as the harvest showed, the initial superiority on plots 1 and 3 had entirely disappeared. At present we are not in a position to state

to what cause the superior growth on plots 1 and 3 early in the season was due; but it appears probable that the cause was the stimulative effect of the excess of phosphoric acid, which, as has been repeatedly shown, when used in liberal amounts exercises a marked effect in hastening maturity.

At present prices for fertilizer materials, the fertilizers used on plots 1 and 3 cost, laid down in Amherst, at the rate of \$19.25 per acre; those used on plots 2 and 4 cost at the rate of \$14.20 per acre. The fertilizer combination richer in potash, therefore, costs a little more than \$5 per acre less than the combination representing average corn fertilizers. It is significant that at this lower cost we have a corn crop equal to that produced at the higher figure. Last year, when the corn crop on all plots was very poor, the yield on plots 1 and 3 was distinctly better than on plots 2 and 4; but, with that exception, the average results to date show corn crops substantially equal on the two fertilizer combinations, while whenever the land is put into mixed grass and clover, the fertilizer combination richer in potash gives crops materially larger and of better quality than the combination richer in phosphoric acid. The advantage to date, therefore, is most decidedly in favor of the fertilizer combination containing the more potash; and fertilizer manufacturers are urged to increase the proportion of this element in corn fertilizers, and farmers on their part should insist on such increase.

VII. — MANURE ALONE *v.* MANURE AND POTASH.

These experiments, which have for their object to show the relative value as indicated by crop production of an average application of manure used alone, as compared with a smaller application of manure used in connection with a potash salt, were begun in 1890. The field used is level, and the soil of comparatively even quality. It is divided into four quarter-acre plots. The crop grown during the years 1890 to 1896, 1899 and 1900, 1903 and during the past season, has been corn. In 1897 and 1898, and again in 1901 and 1902, the crop was mixed grass and clover. Where manure is used alone, it is applied at the rate of 6

cords per acre. Where manure is used with potash, the rates of application are: manure, 4 cords; high-grade sulfate of potash, 160 pounds per acre. Manure alone is applied to plots 1 and 3; the lesser quantity of manure and high-grade sulfate of potash to plots 2 and 4. Estimating the manure alone as costing \$5 per cord, applied to the land, the money difference in the cost of materials applied is at the rate of \$5.30 per acre, the manure and potash costing that amount less than the larger quantity of manure alone. The tables show the rates of yield on the several plots, and the averages, under the two systems of manuring.

Yield of Corn, 1904.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	68.25	5,840
Plot 2 (manure and potash),	66.25	5,280
Plot 3 (manure alone),	66.50	4,280
Plot 4 (manure and potash),	58.25	4,840

Average Yields per Acre.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	67.37	5,060
Plots 2 and 4 (manure and potash),	62.25	5,060

The averages made show an equal amount of stover produced under the two systems of manuring, and slightly more than 5 bushels of corn per acre less on the combination of manure and potash than on the larger quantity of manure alone. This difference in yield is not sufficient to pay the added cost of the larger quantity of manure applied to plots 1 and 3; but, since manure is an article of home production on most farms where corn is grown, not much importance would be attached to this point by the average farmer. The corn crops produced under the two systems of manuring previous to this year have been substantially equal. The inferiority in yield this year is of consequence only on Plot 4; and it is suspected that accidental variation in conditions determined the smaller product on this plot, rather than the

difference in the system of manuring. We know that the plants in the field, on account of imperfect germination due to the unfavorable weather which preceded and followed planting, were not as thick as is desirable. The fact, however, that the yield of stover on Plot 4 is greater than that on Plot 3, renders it exceedingly doubtful whether the cause of the relatively small yield of corn on Plot 4 was the greater proportion of unoccupied space.

VIII. — EXPERIMENT IN MANURING GRASS LAND.

The report which is to be made concerning results in this experiment is best introduced by quoting from my sixteenth annual report : —

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 equal 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.

The past season was exceptionally favorable for the production of a heavy yield of hay, but a relative deficiency in rainfall during the period occupied by the growth of the rowen crop was doubtless the principal reason for the falling off in the yield of rowen, as compared with that produced in the season of 1903. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre : —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	7,068	2,147	9,215
Bone and potash,	6,024	2,030	8,054
Wood ashes,	4,866	2,064	6,930

The average total yield of the entire area for this year is 8,050 pounds. The average for the entire period during which the experiment has continued (1893 to 1903 inclusive) is 6,597 pounds. The average to date is 6,718 pounds. The average yield when top-dressed with manure has been 7,026 pounds; when top-dressed with wood ashes, 6,304 pounds; when top-dressed with bone and potash, 6,686 pounds. The yields for the past year, it will be noticed, are considerably above the averages for the entire period.

Different Seed Mixtures compared.

In my last annual report¹ will be found a description of the variation in the seed mixtures used on different portions of two plots in this field (1 and 2). In one of these seed mixtures timothy is the most prominent species; in the other, meadow and tall Fescue are prominent; and these different mixtures may be spoken of respectively as the timothy mixture and the Fescue mixture. The timothy mixture is substantially the same as that in general use among farmers, including timothy, red-top, common red clover and alsike clover. The other mixture includes small quantities of all of these species, and in addition Kentucky blue-grass and the two Fescues named. In my last report the statement is made that it is believed that the Fescues will hold the ground more tenaciously than the timothy. The yields last year were materially greater on the portions of the plots occupied by the timothy mixture. The rates of yield on the two mixtures for the past season are as follows:—

	YIELD PER ACRE (POUNDS).	
	Hay.	Rowen.
Plot 1, Timothy mixture,	6,229	2,101
Plot 1, Fescue mixture,	5,769	2,121
Plot 2, Timothy mixture,	5,541	2,129
Plot 2, Fescue mixture,	5,896	2,597

The differences this year are materially less than last, and on Plot 2 the Fescue mixture has given the larger yield.

¹ Sixteenth annual report, Hatch Experiment Station, pp. 145, 146.

The timothy has not yet been displaced by other species to any noticeable extent, but the poorer showing of the mixture in which it is prominent this year as compared with last possibly indicates that the belief that the Fescue mixture would ultimately prove the better of the two will be justified by the results obtained.

IX. — EXPERIMENT IN THE APPLICATION OF MANURE.

This experiment is designed to ascertain whether it is economically good policy to spread manure during the late fall and winter, and allow it to remain on the surface until spring before plowing under. This system in our experiment is compared with the plan of hauling manure to the field during the winter, and putting it into large heaps. To insure even quality of the manure used in the two systems, it is our practice to manure two plots at one time, putting the loads of manure as hauled to the field alternately upon the two, in the one case spreading, but in the other putting a sufficient number of loads to provide for the entire plot into one large heap. We are using in this experiment five large plots, each of which is subdivided into two subplots. For one of these subplots the manure is spread when hauled out, for the other it is put into a large heap. The area of these subplots is about one quarter of an acre, and to each the amount of manure applied is 11,096 pounds. The manure from well-fed milch cows is used upon eight subplots, and horse manure on two. The manure used in this experiment is applied at different dates during the winter, our practice being to allow the manure to accumulate in the pits from which it is taken until there is a sufficient quantity for at least two subplots. The condition of the soil at the time of application and the nature of the weather which follows must necessarily differ in the different experiments; and these differences, together with the difference in the dates of application above referred to, no doubt in a measure account for the variation in the results of the two systems noticed on the different plots.

The crop in this field last year was soy beans. After the beans were harvested, winter rye was sown as a cover crop.

The date of sowing was necessarily late, and the rye went into the winter very small. There was no injury, however, from winter-killing, and at the date of plowing last spring, May 14, this crop had made considerable growth. The crop of the past season was a mixed growth of Sibley's Pride of the North corn and Medium Green soy beans for ensilage. The corn, on account of seasonal peculiarities several times alluded to in this report, germinated somewhat imperfectly, and there was some damage due to pulling of the young plants by crows. The proportion of corn to beans, therefore, was somewhat lower than is desirable. The date of planting was June 13 and 14, the work having been impossible earlier, on account of the wet condition of the soil. Taking into consideration the condition of the soil at the time of planting and the relatively low temperature of the summer, the crop was fairly satisfactory; but it was undoubtedly unfavorably affected in places because of faulty soil conditions. It was judged that these conditions most seriously affected the several pairs of plots directly compared in the following table as follows: in Plot 1, on the south half; in Plot 2, on the north half; in Plot 3, on the south half; in Plot 4, on the south half; and in Plot 5, on the south half. These facts should be kept in mind in interpreting the results. The rates of yield per acre and the relative standing of the several plots are shown in the following table:—

Actual and Relative Yields of Green Forage.—Corn and Soy Beans.

PLOTS.	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.
Plot 1,	26,622	24,549	100	92.2
Plot 2,	20,548	22,062	100	107.4
Plot 3,	15,375	20,007	100	130.1
Plot 4,	22,167	20,595	100	92.9
Plot 5,	22,959	22,325	100	97.2

Attention is called to the fact that the differences this year, with one exception, are not very large, and that with

the single exception alluded to it is the half-plot on which the soil conditions were least favorable which gives the smaller yield. The winter of 1903 and 1904 must be regarded as having been on the whole favorable to winter application. The ground, it is true, was deeply frozen before the coming of snow, but the winter was severely and continuously cold. There was a noticeable absence of winter rains and thaws, during which water washes in large quantities over the surface. In estimating the significance of the result, it must be kept in mind that it costs more to put manure first into a large heap and then in spring to take it from this heap and spread it, than it does to spread during the winter at the time the manure is hauled from the stable. The money difference in the cost of handling manure in the two ways, as shown by our experience, amounts to about \$4.80 per acre. The difference in the value of the crops in favor of spring application is scarcely sufficient to cover this added cost, even on Plot 3, where such difference was greatest; and, although the unfavorable soil conditions above referred to doubtless lowered the product on that special plot where the manure was applied in the spring in three instances, plots 1, 4 and 5, it seems highly improbable that, even with equality of conditions, the gain from spring application on these plots would have given a degree of superiority sufficient to cover the added cost.

Previous reports have tended to show spring application to be advisable on this field, which has a considerable slope; and so I still believe it will in the long run prove to be. The exceptional character of the winter of 1903 and 1904 is a sufficient explanation of the difference in average results.

X. — NITRATE OF SODA FOR ROWEN.

This experiment is an effort to determine whether an application of nitrate of soda after the harvesting of the first crop will give an increase in rowen sufficient to cover the cost. The field where the experiment has been a number of times repeated is a mixed timothy and clover sod. It is divided into eight plots of like area, these plots being numbered 1 to 8 and each including about three-eighths of

an acre. Nitrate of soda at the rate of 150 pounds per acre is applied to plots 2 and 4, while the application on Plot 6 is 200 pounds, and on Plot 8 250 pounds. To the remaining plots no nitrate is applied. The first crop of hay in this field was housed on July 14. The rate of yield was 6,314 pounds per acre. When this experiment has been tried in previous years, it has been found a matter of considerable difficulty to spread the relatively small amounts of nitrate of soda used evenly; and, as a means of obviating this difficulty, the nitrate used on each plot during the past season was mixed with basic slag meal. The amount of slag meal applied was 137½ pounds per plot, and the slag meal was applied to the plots receiving no nitrate as well as to the others, and on all in equal amounts. The mixture of slag and nitrate remained dry, and its even application was relatively easy. At the rates used, the nitrate and slag were mixed in proportions varying from about one nitrate to three slag to about one nitrate to two slag. Even with the higher proportions of nitrate to slag, the mixture remained dry and in convenient form for application. The rates of yields on the several plots are shown in the following table:—

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

[Basic slag meal at the rate of 137½ pounds per plot.]

Plots.	NITRATE USED (RATES PER ACRE).	Yield.
Plot 1, . . .	No nitrate,	716
Plot 2, . . .	Nitrate of soda, 150 pounds,	1,341
Plot 3, . . .	No nitrate,	990
Plot 4, . . .	Nitrate of soda, 150 pounds,	1,432
Plot 5, . . .	No nitrate,	853
Plot 6, . . .	Nitrate of soda, 200 pounds,	1,234
Plot 7, . . .	No nitrate,	1,021
Plot 8, . . .	Nitrate of soda, 250 pounds,	1,932

In the effort to determine whether the application of nitrate is profitable, the yield wherever it has been applied has been compared either with the yield of the nearest plot, or, in cases where it is possible, with the average yield of

the two plots between which the plot under consideration lies to which no nitrate was applied. On this basis, the average increase due to application of 150 pounds of nitrate of soda was 499 pounds; the use of 200 pounds of nitrate of soda gave an apparent increase of 297 pounds; while the application of 250 pounds of nitrate of soda gave an apparent increase of 911 pounds. The weather during the period of growth of the rowen crop was too dry for the best results. At the rates of increase shown, the application would be hardly profitable.

XI. — VARIETY TEST, POTATOES.

During the past season we have carried out the second year's trial of forty-nine different varieties of potatoes, including practically all of those of recent origin advertised in prominent seed catalogues up to the spring of 1903, as well as two or three old standard sorts for comparison. The seed used this year was grown from the original stock of each of the varieties on our own grounds in the season of 1903. The seed of all varieties was carefully preserved during the winter under precisely similar conditions. In preparation for planting, the tubers were treated with formalin for prevention of scab, in the customary manner. After removal from the formalin solution, they were spread in a thin layer in an airy room April 30, where they were allowed to lie until the 17th of May, when the tubers were cut into pieces of about two or three eyes each, and planted. The soil used in this experiment is a medium loam. It produced a corn crop in the season of 1903, and mixed grass and clover seeds were sown in the standing corn. Neither grass nor clover had made much growth when the field was plowed on May 3 in preparation for the potatoes. The field received an application of barnyard manure at the rate of $4\frac{1}{2}$ cords per acre, and fertilizers at the following rates:—

	Pounds.
Nitrate of soda,	175
Dried blood,	225
Acid phosphate,	625
Dry ground fish,	400
High-grade sulfate of potash,	350

Both manure and fertilizers were spread evenly after plowing, and harrowed in. The varieties grown and the rate of yield of each are shown in the following table:—

Variety Test Potatoes.—Rates of Yield per Acre.

VARIETY.	Merchantable (Bushels).	Small (Bushels).
Admiral Foote,	208	25
Beauty of Hebron (home grown),	204	35
Beauty of Hebron (Maine seed),	167	21
Clinton,	104	10
Crine's Lightning,	210	7
Daughter of Early Rose,	221	8
Daybreak,	167	29
Early May,	161	33
Early Nancy,	225	27
Early Norwood,	215	40
Early Rose,	256	29
Ensign Bagley,	192	38
Eureka Extra Early,	196	38
Extra Early Pioneer,	204	42
Extra Early White Rose,	294	6
Gem of Aroostook,	248	42
Governor Yates,	259	29
Great Divide,	273	31
Hamilton's Early,	225	8
I. X. L.,	256	38
John Bull,	217	8
Junior Pride,	171	38
Kaiser Krone,	154	50
King of Michigan,	197	60
King of Ohio,	125	29
Market Prize,	256	8
Maxima,	263	31
Million Dollar,	225	13
Mills' New Rose Beauty,	263	15
Milwaukee,	165	25
New Early Wisconsin,	183	33
New Surprise,	204	29
1904,	263	27
Nome,	204	13
Nott's Peachblow,	192	14

Variety Test Potatoes. — Rates of Yield per Acre — Concluded.

VARIETY.	Merchantable (Bushels).	Small (Bushels).
Pat's Choice,	217	11
Peck's Early,	223	10
Prince Henry,	206	17
Red River Triumph,	208	14
Red River White Ohio,	156	31
Sensation,	248	14
Simmon's Model,	319	25
Snowflake, Jr.,	252	8
Steuben,	268	38
Sweet Home,	140	48
Van Ornam's Earliest,	197	17
Vornehm,	185	33
White Ohio,	146	27

The growth of practically all varieties was normal and healthy. The vines were sprayed twice with Bordeaux mixture for prevention of blight and rot. The treatment was successful, and the yield of most varieties was good. One variety, Simmon's Model, gave a yield exceeding 300 bushels per acre. The smallest yield is that given by the Clinton, — 104 bushels of merchantable tubers per acre. Six varieties, mentioned in the order of their productiveness, gave yields of merchantable tubers at rates between 260 and 300 bushels per acre, viz.: Extra Early White Rose, Great Divide, Steuben, Maxima, 1904, Mills' New Rose Beauty. The Beauty of Hebron, which in previous variety tests has given yields almost as large as any under trial, takes a lower rank as the result of the test of last season.

XII. — POULTRY EXPERIMENTS.

The poultry experiments of the past season have followed along precisely similar lines to those followed last year. We are making an effort to throw light on the question as to the proper selection of feeds for laying fowls.

1. In the experiment comparing wheat with corn, animal meal being the source of the animal food used, the following

results were obtained: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .4333 per hen day; the corn ration at the rate of .3837 per hen day; in other words, 100 hens would have laid per day on the wheat ration $43\frac{1}{3}$ eggs, and on the corn ration practically $38\frac{1}{3}$ eggs per day. For the second period, May 17 to September 30, the wheat ration produced an average of .1911 eggs per hen day, the corn ration .2067 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration about $19\frac{1}{10}$ eggs and on the corn ration $20\frac{2}{3}$ eggs per day. The average food cost per egg produced was for the wheat ration .611 cents, for the corn ration .505 cents for the first period; while for the second period the cost per egg on the wheat ration was 1.657 cents, and on the corn ration 1.315 cents. The gross cost of the food on the wheat ration varied from about .24 to .30 cents per day for each fowl, while on the corn ration the cost varied from about $.17\frac{1}{2}$ to about .26 cents per day. The yield of eggs during the second period was very small. The small average product is to be attributed largely to the fact that the period was continued beyond the date when the hens began to molt. The 20 hens on the wheat ration laid only 82 eggs during the last two months of the experiment, while those on the corn ration laid only 158 eggs during the same time.

2. In the experiment comparing wheat with corn, with milk albumin as the source of animal food and with corn oil added as a source of fat, the egg product was as follows: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .463 eggs per hen day, the corn ration .4324 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration practically $46\frac{1}{3}$ eggs per day, and on the corn ration $43\frac{1}{4}$ eggs per day. For the second period the wheat ration gave an average of .3109 eggs per hen day, the corn ration .3017 eggs per hen day; or, in other words, respectively for the wheat ration an average of 31 eggs per 100 hens daily, and for the corn an average of $30\frac{1}{6}$ eggs. The food cost of the eggs in this experiment was as follows: for the wheat ration during the

first period .5471 cents per egg, for the second period 1.3406 cents; for the corn ration the figures were for the first period .3932 cents per egg, and for the second .918 cents. The cost of feeding the hens was: for the wheat ration during the first period at the rate of .227 cents per day, for the second period, .39 cents; for the corn ration the cost of food for the first period was .155 cents per hen daily, for the second period .263 cents. The egg yield in this as in the other experiment is very low for the second period. The causes are similar to those which have been pointed out under 1.

3. In the experiment comparing wheat with rice, and with milk albumin as the source of animal food, the results have been as follows: for the first period the egg production was: for the wheat ration .3813 per hen day, for the rice ration .4077; or, in other words, from 100 hens daily respectively about $38\frac{1}{8}$ and $40\frac{3}{4}$ eggs per day. For the second period the averages were on the wheat ration .2244 eggs per hen day, and on the rice ration .3018 eggs per hen day; or from 100 hens daily respectively nearly $22\frac{1}{2}$ and a little more than $30\frac{1}{6}$ eggs per day. The food cost of the eggs has been as follows: for the wheat ration for the first period .6976 cents, for the second period 1.59 cents; for the rice ration for the first period 1.1863 cents, for the second period 2.379 cents. The cost of keeping the hens has been as follows: for the wheat ration during the first period .2414 cents per hen daily, for the second period .34 cents; for the rice ration for the first period .4442 cents per hen daily, and for the second period .7003 cents.

The ration including rice this year as last has given one of the most satisfactory egg products obtained. The high cost of this food at the present time seems to preclude its becoming a question of much practical importance whether rice is well or ill suited as a food for egg production. We have introduced it in our experiments as a means of testing the question as to whether fat is an important constituent in the food for laying hens, rice being lower in fat than any other grain we can obtain. The large egg product where rice is prominent among the foods used seems to indicate

that fat is less important than has been judged as the result of some of our earlier experiments. Among the various grains, cleaned rice, as put upon our markets, contains least fiber, and rice is known to be the most digestible of all the grains. It is perhaps these peculiarities of this grain which account for its apparent good effect on the egg product.

The nutritive ratios in the food combinations used in the different experiments of the past year have been as follows :—

For the rations where wheat is compared with corn with animal meal as the source of animal food : for the wheat ration, 1 : 4.46 ; for the corn ration, 1 : 6.42.

For the experiment in which wheat is compared with corn, milk albumin being the source of animal food : for the wheat ration, 1 : 4.43 ; for the corn ration, 1 : 6.18.

In the experiment in which wheat and rice have been compared : for the wheat ration, 1 : 4.35 ; for the rice ration, 1 : 6.2.

Our experiments throw relatively little light upon the question as to the proper nutritive ratio in feeding for eggs. The factors affecting the egg yield must be numerous, and others than the question of the nutritive ratio in the foods given to the fowls must often determine the results. The fact that we have the most satisfactory egg yield obtained during the past year on the rice ration, with a nutritive ratio of 1 : 6.20, does not at least seem to support the opinion that the nutritive ratio in feeding for eggs should be narrow.

REPORT OF THE HORTICULTURISTS.

F. A. WAUGH; GEO. O. GREENE, ASSISTANT.

The work of this division has followed the plans outlined in the reports of 1902 and 1903. The following subjects are ready for discussion, and reports are made herewith:—

- I. Report on plums.
- II. Experiments in pruning peach trees.
- III. Growing chrysanthemums for a retail trade.

REPORT ON PLUMS.

The horticultural department has a fairly large collection of plums. A number of these are represented by several trees each, enough to determine their commercial quality. The plum crop of 1904 was unusually good; it was abundant in quantity, and generally of good quality. This was true of all classes of plums, practically every variety on the grounds bearing a normal crop. This furnished an excellent opportunity for making observations on the different varieties. The notes follow below. It has been thought best to omit any extended description of these varieties for the present. This form of report is justified by the fact that nearly all the varieties mentioned are old and well-known sorts. The notes this year are valuable chiefly in showing the behavior of these well-known varieties in this particular locality. The problem of local adaption of varieties is nowadays considered to be one of the most important in horticulture, and in no class of fruits or vegetables are these local adaptations more complicated than with plums. The varieties below are classified as nearly as possible into the more commonly accepted pomological groups.

DOMESTICAS.

Agen (Prune d' Agen). — Tree unhealthy and a poor grower, moderately productive, an irregular cropper; fruit very good, but not so bright nor large as in some localities.

Bradshaw. — This is one of the best plums of its class, and, indeed, one of the best market and home-use plums of any class on our grounds. We have about twenty young trees in bearing which gave a good crop in 1904. The tree is a strong somewhat upright grower, does not come early into bearing, but bears well after reaching an age of eight to ten years. The fruit buds do not seem to be tender here, as they are in some localities. The fruit is large, smooth, bright and of excellent quality.

Bryanstone. — Tree an irregular and slow grower, late and irregular in bearing; not reliable. Fruit small to medium in size; of good quality.

Clyman. — Represented only by a single specimen, which bears sparsely and does not seem to be of any value.

Dame Aubert (Yellow Egg, Magnum Bonum). — Tree rather upright in growth, fairly strong and hardy, but does not bear heavily. Fruit large and fine, but very subject to rot.

Damsons. — Several varieties of Damsons are included in our collection, among which the French Damson seems to be the best; this bears fairly well, but by no means as abundantly as in some sections.

Diamond. — A fairly strong, healthy tree, coming late into bearing, and yielding uncertain crops here.

Englebert (Prince Englebert). — Tree upright, strong and hardy; does not come early into bearing, but yields good crops after reaching ten years of age. Fruit of medium size and fair quality.

Fellenburg (Italian Prune). — Tree round-topped, bushy, with spreading irregular branches; does not bear until eight or ten years of age, and then not very heavily. Fruit of good quality. This variety does not rank so highly as a market plum as in western New York or Michigan.

Field. — Tree seems to be not very strong and healthy, but bears fairly well. Fruit of excellent quality. This is a promising, medium early plum.

Giant Prune. — Our trees are young and poor, and have borne only a few samples. The fruit is large and attractive. This variety is worthy of further test.

Gueii.—Tree rather a bushy grower; fairly productive. Fruit small, sour; not of the best quality.

Hand.—Tree a large, strong grower; shapely; notably unproductive. Fruit large, fine, showy. This variety is certainly not worth planting, the objection being its unproductive character.

Lincoln.—Tree not very strong or sound, and fruit not of very good quality. Not to be recommended, on the basis of our experience.

McLaughlin.—Tree unhealthy and a poor grower; not bearing very heavily. Fruit not so smooth and highly colored as in some sections, but still of very fine quality. In spite of its imperfections of tree, this variety is worth growing on account of its high quality; it would not be profitable in a market orchard.

Moore's Arctic.—Tree vigorous, upright, strong, hardy; productive, and coming fairly early into bearing. Fruit small; rather poor quality.

Peter's Yellow Gage.—Tree not very vigorous or hardy; a slow grower. Fruit small, and not very good for this variety.

Pond.—Tree large, strong grower; fairly productive. Fruit large and excellent, but very much subject to rot, and unprofitable on that account.

Quackenbos.—A very good, medium-sized tree, fairly productive. Fruit medium size; clean and fair quality for one of the small blue plums. This is probably the best of the so-called blue plums, with possibly the exception of Englebort.

Reine Claude.—Tree an irregular grower; not very vigorous, and only moderately productive. Fruit medium size and quality for this variety; considerably subject to rot. This takes the place of the old-fashioned Green Gage, being a larger, better and later variety. It is a very fine plum for canning, but could not be profitably grown for the market in this locality.

Saratoga.—Our single tree of this variety is small, and not very productive; unpromising.

Smith's Orleans.—Tree moderate size, somewhat irregular in growth; moderately productive. Fruit not so large or fine as it should be in this variety.

Tragedy.—We have only one tree of this variety, just coming into bearing; promising.

Victoria.—Tree moderately large; irregular in growth; moderately productive. Fruit of medium size and excellent quality; somewhat subject to rot.

Washington.—In almost all respects like Hand, which see.

JAPANESE VARIETIES.

Abundance. — Tree upright, early bearing; very much subject to disease. This is probably one of the poorest trees to be found amongst the Japanese plums. Fruit of good size and good quality; somewhat subject to rot; very apt to be eaten by birds. We would entirely discard this variety as a commercial plum, on the basis of our experience, and could not recommend it highly for planting for home use. This experience we are aware is different from that of some other plum growers in New England.

Burbank. — Tree vigorous, spreading, hardy; comes early into bearing, and is very productive. Fruit medium to large, good quality; less subject to rot than most plums. This is the most profitable and productive market plum on our grounds.

Chabot. — Tree upright, vase form; hardy, prolific. Fruit medium size, round red; fair quality. This is an excellent market plum, medium to late in season.

Georgeson. — Tree spreading, rather large growing, vigorous and hardy; fairly prolific. Fruit large, yellow; good quality. This is an excellent canning plum, and worth growing in this section, although it does not sell well in the markets on account of its yellow color.

Hale. — Tree upright, very vigorous grower; somewhat subject to winter-killing; coming rather late into bearing, never bearing abundantly. Fruit medium size, round; excellent quality. According to our experience, this variety is not worth planting in this section.

October Purple. — Tree vigorous, upright, and very strong grower; somewhat subject to winter-killing; coming late into bearing, but giving moderate crops after reaching an age of seven or eight years. Fruit medium size, rather dull color; good quality. The variety does not seem to be of any special value in this section.

Paragon. — Somewhat like Chabot, but of no special value.

Red June. — Tree spreading, vase form; vigorous and relatively hardy. The fruit buds on this variety are less hardy than on Burbank, however, sometimes being killed while Burbank survives. Trees bear early and abundantly. The fruit is one of the first to come into the market, and, though of second quality, usually brings a fair price. This is proved to be a profitable plum with us.

Satsuma. — Tree upright, spreading, moderate grower; not very hardy, bearing rather sparsely. Fruit usually small with us; of indifferent quality. Although this variety succeeds in other localities in the Connecticut valley, it is of no value here.

HYBRID VARIETIES.

Apple. — Tree very vigorous, sprawling grower; hardy, coming fairly early into bearing. Fruit medium large, round; dark red with red flesh. On our grounds this variety promises to take the place of *Satsuma*, to which it seems to be superior in most respects.

Compass Cherry. — An interesting hybrid curiosity, but of no value.

Doris (doubtfully placed among hybrids). — Tree spreading, vigorous, hardy. Fruit small, watery; of no value.

Duke. — Tree medium strong, upright; fruited this year for the first time; of doubtful promise.

Gold (of Stark Brothers). — Tree small, spreading, irregular in growth; hardy, bearing early, but never abundantly on our grounds. Fruit round oblate, medium size, yellow, watery; poor quality, ripening very unevenly; much subject to rot. This variety is of no value with us, and our trees have been mostly grafted to other sorts.

Juicy. — Tree strong and hardy. Fruit small, yellow; of no value.

Wickson. — Tree upright, strong grower; rather tardy in coming into bearing, and never bearing heavy crops; fruit buds tender, apt to be frozen. Fruit of medium size, variable in quality; ripening very irregularly. This variety is not to be recommended here.

NATIVE VARIETIES.

There are on the grounds several native varieties, mostly Americanas, Hortulanas and Chickasaws. Some of these do fairly well, but none of them have conspicuous merit as grown in this section.

Marketing Plums.

The very excellent crop of 1904 gave us an opportunity to study the manner in which plums can be sent to market. For the most part the crop from the department of horticulture of the Massachusetts Agricultural College was marketed in three-pound baskets, such as are used for grapes;

when these were shipped by freight or express, they were packed in crates holding approximately one bushel. This style of package proved generally satisfactory; it furnishes about the quantity of fruit desired by most purchasers.

In making local sales, especially of plums for canning purposes, a larger package was usually more satisfactory. The so-called Jersey peach basket, holding sixteen quarts (one-half bushel), is the cheapest and most convenient.

In some cases, where fancy plums are designed for the fruit stand trade, they may be put up in quart baskets, such as are used for strawberries. We find these also satisfactory.

This whole matter may be summarized by saying that most markets are not fastidious with respect to the form of package used for plums. Any small, neat basket or box will answer, if the fruit is of good quality and well packed.

EXPERIMENTS IN PRUNING PEACH TREES.

The department of horticulture has under way a series of experiments and special studies in pruning fruit trees. Reports on various phases of this work will be made from time to time as results are reached. At the present time we are able to make a report of progress in the experiments in pruning peach trees.

1. The Results of No Pruning.

One row of trees in the principal peach orchard has been left entirely without pruning from the first. This row runs crosswise of the variety rows, and therefore contains trees of all the varieties in the orchard, as follows: Oldmixon, Triumph, Mountain Rose, Elberta, Early Crawford, Late Crawford, Crosby. The trees are nine years old.

These trees, left unpruned for nine years, are plainly different from adjacent trees of the same varieties which have been pruned. Surprising as it may appear on first statement, they are more open-headed. They have generally assumed a vase form. The interior wood has died out, leaving the centres open, and at the same time leaving the lower part of the main branches bare. The fruiting wood is sparse, weak and high up in the trees. The trees are very

much less thrifty and vigorous than the pruned trees of the same varieties. This lack of vigor is so marked that some of the weak trees succumbed more or less completely to the severe freezing of last winter.

The trees next the unpruned specimens have been headed back two or three times. They were all headed back mod-



MAP OF EXPERIMENTAL ORCHARD.—A shows apple trees 40 feet apart; the circles show peach trees unpruned; the half-circles show those slightly headed back; the squares indicate trees severely headed in; the triangles show trees cut back to stubs; the blackened figures represent trees which died in 1904.

erately in the spring of 1902 and again in the spring of 1903, and some of them were headed back again in the spring of 1904. The trees so treated are thick-topped, with a good deal of weak, sappy growth on the inside,—a condition which is manifestly objectionable. On the other hand, the

annual growth has been much more vigorous, and the health of the trees has been much better. More and stronger fruit buds have been formed, but unfortunately the successive freezes of the last two winters have killed the buds, and made a comparison of fruit crops impossible. The main branches of the headed-back trees are shorter and stronger than those of the unpruned trees, and are obviously better able to support a large crop of fruit.

This experiment, which was begun by Prof. S. T. Maynard, and which has been continued through several years, has shown conclusively that the best form of peach tree cannot be secured and maintained without pruning.

2. *The Effect of Heading Back.*

Each spring, in the years 1902, 1903 and 1904, a number of trees in the college peach orchards were headed back. This shortening-in of the branches varied in amount: sometimes only one-third of the previous year's growth was cut away, sometimes one-half the year's growth was taken off, sometimes two-thirds was removed; in a few cases the trees were pruned clear back into two or three year old wood; in the majority of cases the heading-in amounted to about two-thirds of the previous year's growth. The cutting back in 1903 and in 1904 was more severe than it would have been had not the prospective fruit crop been wiped out by freezing.

In nearly all cases it was possible to compare trees thus headed in with other trees of the same varieties not so treated. The results were uniform and unequivocal. The trees headed back always made a more healthy and vigorous annual growth than the trees not so treated. In many cases the difference was remarkable, the growth of the pruned trees being from two to ten times as much as the unpruned trees. More and larger fruit buds formed on the pruned trees, and the shorter, stockier branches seemed better prepared to support a possible fruit crop. The foliage on the pruned trees was notably larger, more abundant and darker green. There was some tendency to the formation of weak shoots on the shaded interior branches.

The conclusion which we have reached from this experiment, continued through three years, is that the heading back of peach trees in early spring is good practice, and in all cases advisable. In this pruning from one-third to two-thirds of the wood of the previous year should be removed. In determining the exact amount to be cut away, the judgment of the fruit grower will be influenced largely by the number of living fruit buds in the one-year-old wood. If there is a crop in prospect, he will leave enough fruit buds to set the desired quantity of fruit. In years when, from one cause or another, there are no living fruit buds, he will take advantage of the circumstances to cut back with comparative severity. Only in extraordinary instances, however, will he remove all the previous year's wood, cutting back into two or three year old branches.

3. *Summer Pruning.*

It has been noted above that trees which were headed back in the early spring pruning showed a tendency toward the formation of many weak and useless shoots on the interior of the head. Experiments in summer pruning were begun with a view to the correction of this tendency, and also with a view to stopping the really inordinate extension of the main annual shoots of the current year. The two problems, however, were met in different ways.

The formation of weak sprouts on the interior of the tree is due chiefly to the exclusion of light. The external foliage of the tree top becomes so dense that the interior is shut off from the light and from much of the air. To improve the situation in this respect we have gone through the orchard once or twice between the middle of June and the middle of July, removing a considerable quantity of the new leafy shoots on the outside of the tree. A quantity of the outside shoots and foliage was thus removed sufficient to admit a reasonable amount of light to the inside of the tree top. The work was done with a pair of hand pruning shears, or, when the branches were soft, they were simply torn out with the bare hands. The latter method is preferable, because more expeditious.

In no case were the results of this treatment convincing. The formation of strong shoots with fruit buds on the interior branches was never visibly promoted. The outside branches which were allowed to remain seemed to profit somewhat by the removal of their crowding neighbors, and this was apparently the chief benefit derived from the work. On the whole, it does not seem to us that this practice is to be greatly recommended.

To correct the over-growth of outside branches, the plan was tried of cutting back the young growth. The tips were pinched or the shoots were pruned with hand pruning shears. Sometimes a foot or so of new growth was removed. The pruning was done at various seasons, usually some time in July.

In all cases this treatment was unsatisfactory. The stopping of the growing shoots is often — almost as a rule — followed by the pushing of side buds, and the shoots thus formed are nearly always too weak to set fruit buds, yet in putting out they ruin what might otherwise become strong, sound fruit buds.

4. *Pruning to renew Frozen Trees.*

As the spring of 1903 drew on, it was plain that more or less injury had been suffered by the trees in our peach orchards. In the spring of 1904 the damage was still more obvious and widespread. In both years some experiments were made to learn the best manner of handling a winter-injured tree.

The damage in the spring of 1903 proved to be small, and measures designed to have a corrective effect therefore showed meager results. All the trees came off about equally well, no matter how treated. Some were lightly headed in, some were severely headed in, while a few were cut back nearly to the main trunk, leaving only the stubs of the main branches. In every case not otherwise to be accounted for the tree recovered and made excellent growth.

In the spring of 1904 the trees were seriously weakened by freezing, and some were killed outright, so as to be beyond the reach of any remedial treatment. It should be said, however, that the damage proved to be less sweeping

than was feared at the time the year's experiments were outlined. It was decided to lay off the orchard where this experiment was to be made into four blocks, to be given different kinds of treatment, as follows: (1) the first block was to be left entirely without pruning; (2) the second block was to be pruned in midsummer, after the trees had started; (3) the third block was to be cut back, from two-thirds to three-fourths of the previous year's growth being removed; (4) the fourth block was to be headed back near to the trunks, only the stubs of the main branches being left.

A certain percentage of these trees died during the year of 1904. The general result can be seen in the following table:—

Statistical Summary.

	Total Number pruned.	Living, Autumn of 1904.	Dead, Autumn of 1904.	Per Cent. Living.
Trees unpruned,	121	113	8	93
Moderately cut back,	48	47½	½	99
Severely cut back,	68	55	13	81
"Dehorned,"	46	24	22	52

It will be seen that the trees cut back to the trunks ("dehorned") suffered the worst; those severely cut back lost a larger percentage than those unpruned. A careful examination of the orchard itself makes it seem that the difference between blocks 2 and 3 in this respect is considerably exaggerated by the statistics. Some of the deaths in block 3 were apparently due to other causes, and should not be charged up against the pruning. Moreover, the growth made by the headed-in trees which lived was decidedly better than that made by the unpruned trees. The judgment of all those who saw the orchard and examined it carefully during the latter part of the summer of 1904 was that the trees moderately cut back showed the best growth and were in the best condition.

It at least seems clear that the trees seriously weakened by freezing should not be cut back close to the main trunks.

GROWING CHRYSANTHEMUMS FOR A RETAIL TRADE.

BY FRANCIS CANNING.

The work in the college greenhouses has to a certain extent been carried along on the lines and in many respects similar to that of a country florist's establishment, having a local trade. The many problems which present themselves under such conditions have been the subject of considerable experiment.

A florist's establishment in a country town is managed on a very different basis from that which obtains in growing cut flowers for the wholesale market, where two or three varieties of flowers are grown in quantity.

To meet the demands of a local trade requires the handling of a large variety of cut flowers and plants, not necessarily large in quantity, yet sufficient to meet the demand when any particular variety is in season.

One of the principal crops a florist grows under such conditions is the chrysanthemum, and it necessarily follows that he must be familiar with the earliest and latest flowering varieties, so as to prolong the season as far as possible. He must also ascertain which varieties are the best adapted for pot plants, also the colors which suit his trade.

The chrysanthemum having a short season, it follows that considerable forethought is necessary in the arrangement of space devoted to it; it frequently means the crowding of some other crops until that occupied by the chrysanthemum becomes available. To the uninitiated the transformation at the close of the chrysanthemum season, from beds filled with blooming plants to those occupied with other material, seems remarkable; yet the florist has long prearranged this matter in his mind. At this stage the saving of the necessary stock plants is done. In this connection a weeding out of undesirable varieties, or varieties that do not reach the standard in the grower's judgment, is accomplished. Various methods of saving the stock plants are practised; but we have found the use of boxes five or six inches in depth, with provision for drainage, to be a good method. It is better, however, not to mix several varieties in one box, for even though

placed separately, the creeping stems will invade each other's territory, and result in mixing the varieties when the cuttings are taken. The boxes should be afforded a reasonably good place in a cool greenhouse, where the sun may reach them, so they do not have a soft, spindly growth, a condition exceedingly detrimental to future success.

Propagating commences in February, or much earlier when any special variety is to be considerably increased. After two batches of cuttings have been rooted, the boxes containing the stock plants may be thrown away, depending upon the newly propagated plants for future cuttings. From the earlier-rooted cuttings the varieties suitable for pot plants are selected, and are potted on as their needs demand. For the general stock for benching, or, in other words, for the cut flowers, the best time to propagate is from April 15 to May 1; thus suitable provision is made to have strong plants in two and one-half or three inch pots by the time the season arrives for planting. No specific date in this connection is observed, some florists commencing to plant in May and others late in July; but when the propagating has taken place at the previously mentioned date, the plants will be in good condition from the 15th to the end of June.

The question as to the advantages of solid beds or benches is of some interest. Our experience has been in favor of solid beds. We are, however, favored with a soil of a porous character, and gravelly subsoil, which for solid beds insures a good drainage, — a necessity for this crop. Wherever one may secure similar conditions, it would seem advisable to adopt this method, and thus avoid the expense of building benches and keeping them in repair.

The young plants are planted in rows eight inches apart each way, allowing two or three shoots to form, and thus secure the same number of blooms from each plant.

The soil used for benches and pot plants is a good, turfy loam, and is composted the previous fall or in the early spring of the same year. To three parts of soil is added one part of well-rotted manure, with bone meal to the amount of one quart to the barrowful of compost. To avoid fungous diseases, keeping the plants in good health by careful culture

is the best preventative. For disposing of the ever-present aphid, or black fly, fumigation with tobacco has proved the surest and cheapest remedy. Throughout the year chrysanthemums should be subjected to a weekly fumigation, the prevention of insects being especially desirable in their successful management.

About forty varieties of chrysanthemums are grown in the college greenhouses, many of them represented by a few plants only, to ascertain their merits for such a trade as ours. This method of becoming acquainted with newer varieties should be adopted by all progressive florists. The fact remains, however, that many older varieties have not yet been superseded. Not infrequently the size of bloom has been the principal point in favor of the newer introductions, sacrificing in some instances their purity of color.

The following varieties have proved themselves well adapted for a local trade, being easily grown and naturally vigorous. In their order of flowering they are: white, — Polly Rose, Ivory, Alice Byron, Queen, Timothy Eaton, W. H. Chadwick, Merry Christmas; pink, — Glory of the Pacific, Pink Ivory, George Carpenter, Mrs. Perrin, Mrs. C. F. Berwind, Mrs. S. T. Murdock, Maud Dean; yellow, — Sinclair, Robert Halliday, Colonel Appleton, Major Bonaffon, W. H. Lincoln, W. H. Reiman; bronze, — Brutus, Sunrise, Petaluma; red, — Gettysburg, Malcome Lamond, Cullingfordii. The varieties that do well as pot plants are: Ivory, Alice Byron, Pink Ivory, Mrs. Perrin, Mrs. S. T. Murdock, Mrs. C. F. Berwind, Sinclair, Major Bonaffon, W. H. Lincoln, Brutus, Sunrise, Cullingfordii.

The singles and pompons should not be overlooked. They may be grown in pots with very little disbudding. They have a wide range of colors, and make salable pot plants; the white ones afford good material for designs, etc. Among the best may be mentioned Snowdrop, President, Julia Lagravere, Queen of England, Mizpah, Buttercup.

A great aid in the matter of testing the qualifications of varieties is the use of the "scale for judging" adopted by the Chrysanthemum Society of America. In scaling a variety a searching investigation is made, and many defects are

apparent not ordinarily observed. In the work of the class in floriculture in the Massachusetts Agricultural College special emphasis has been placed upon judging chrysanthemums. Some practice will soon develop a rapid and correct estimate of the merits of varieties, and should prove valuable to the average florist.

The commercial scale is as follows:—

Color,	20	Substance,	15
Form,	15	Size,	10
Fullness,	10		
Stem,	15	Total,	100
Foliage,	15		

The score upon a number of varieties follows:—

<i>Major Bonaffon.</i>		<i>The Queen.</i>	
Color,	18	Color,	15
Form,	12	Form,	10
Fullness,	10	Fullness,	6
Stem,	15	Stem,	15
Foliage,	15	Foliage,	10
Substance,	12	Substance,	8
Size,	10	Size,	10
Total,	92	Total,	74
<i>Black Hawk.</i>		<i>Colonel Appleton.</i>	
Color,	20	Color,	20
Form,	7	Form,	12
Fullness,	10	Fullness,	8
Stem,	7	Stem,	13
Foliage,	12	Foliage,	10
Substance,	8	Substance,	12
Size,	8	Size,	10
Total,	72	Total,	85

These scores may vary from those awarded the same varieties by the Chrysanthemum Society of America. Our conditions may be accountable for the variation.

Some varieties present features especially desirable for a retail trade, — good keeping qualities, oddities in shape or color, etc. Those presenting desirable features, from two or three years' tests, follow:—

Baer, Mrs. G. F. — Known as Yellow Jerome Jones, and presents many of the fine characteristics of this fine variety.

Berwind, Mrs. C. F. — Dark pink, with silvery reverse; good keeper; a desirable kind.

Black Hawk. — Dark crimson; one of the handsomest of this color, and should be grown where there is any demand for this color.

Brutus. — Orange red; very dwarf in character; makes good pot plant and cut flowers; a desirable color, and satisfactory.

Byron, Miss Alice. — One of the best whites; makes a fine pot plant, and good for cut flowers.

Carpenter, George. — Medium early, dark pink flower; there is a demand for this variety when well grown.

Childs, G. H. — One of the best dark reds for cut flowers.

Dean, Maud. — One of the best pinks; large flower, good shape; fine for Thanksgiving trade.

Golden Trophy. — A desirable kind for pot plants.

Idavan. — Fine solid pink flower, shading to cream; a few are desirable.

Intensity. — Red; a good pot plant.

Jones, Mrs. Jerome. — One of the best whites.

Liberty. — A good late yellow; grown cool, will last till Christmas.

Merry Christmas. — A correspondingly late white variety.

Millbrook. — An odd salmon pink; a few pot plants may be serviceable.

Murlock, Mrs. S. T. — A desirable kind for cut flowers and plants; shell pink in color.

Mutual Friend. — A good white variety.

Petaluma. — An odd quilled-petalled variety; bronze or brown in color; good keeper.

Philadelphia. — Lemon yellow; globular flower; good for fancy trade.

Pitcher, Miss Georgiana. — A good old robust yellow variety, easily grown.

Reiman, W. H. — Yellow globular; late, good for Thanksgiving and later.

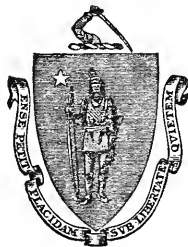
Rose, Polly. — An indispensable early variety.

Sunderbruch, H. L. — An early yellow; fine large flowers; good for pots.

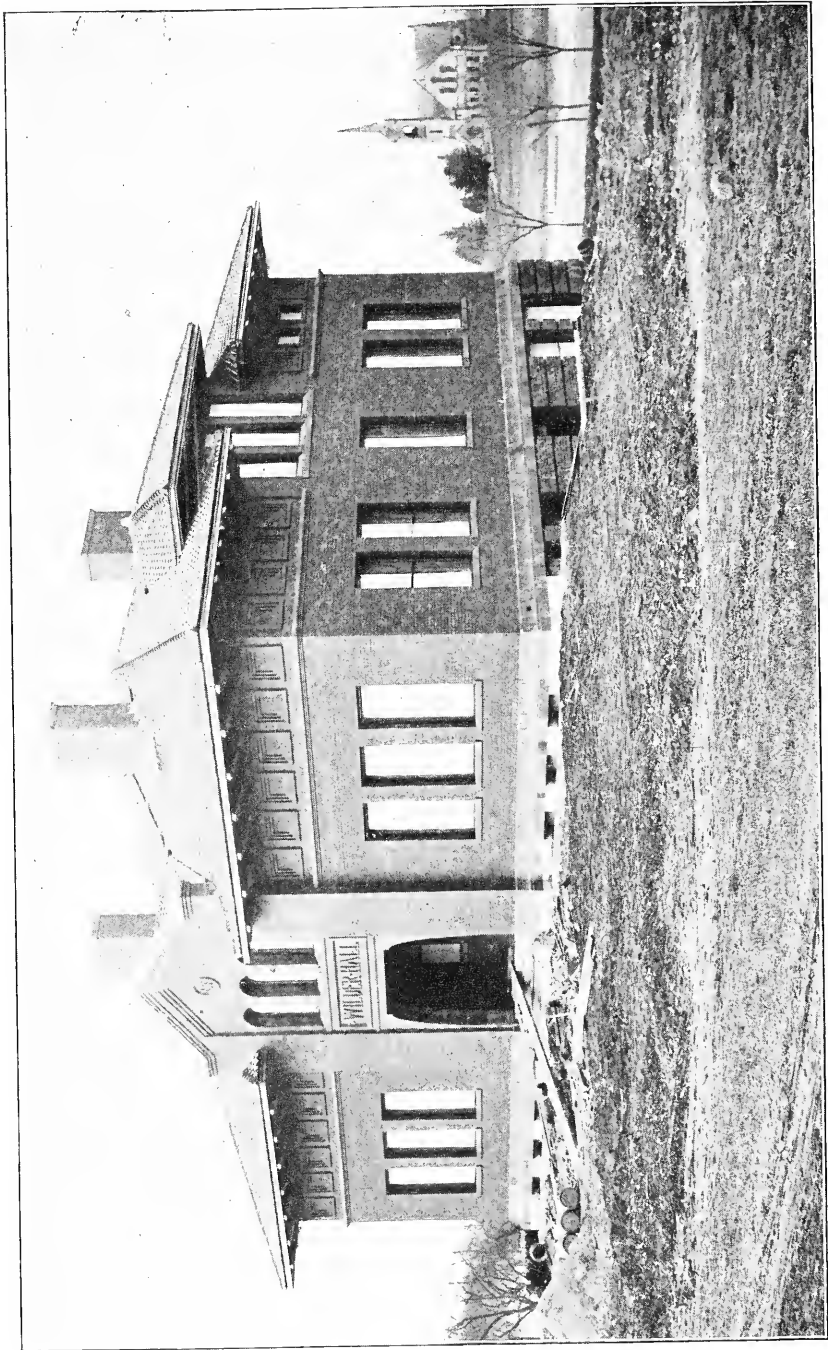
Many other prominent varieties are being tested, a second year being desirable, to determine their value.

FORTY-THIRD ANNUAL REPORT
OF THE
MASSACHUSETTS
AGRICULTURAL COLLEGE.

JANUARY, 1906.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1906.



WILDER HALL (DECEMBER, 1905.)

FORTY-THIRD ANNUAL REPORT

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APPROVED BY
THE STATE BOARD OF PUBLICATION.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 2, 1906.

To His Excellency WILLIAM L. DOUGLAS.

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

I am, very respectfully, your obedient servant,

WM. P. BROOKS,
Acting President.

CONTENTS.

	PAGE
Calendar,	7
Report of trustees,	9
Catalogue of officers and students,	27
Graduate courses,	41
Four-years courses,	45
Admission,	45
Entrance examinations,	47
Synopsis of courses,	50
Short courses,	69
Equipment,	70
Expenses,	78
Scholarships,	79
Labor funds,	81
Prizes,	81
Reports,	85
Treasurer,	87
Gifts,	94
Farm,	97
Military department,	101
To Secretary of Agriculture,	108
Annual Report of Hatch Experiment Station,	111
Director,	114
Treasurer,	120
Meteorologist,	122
Agriculturists,	124
Horticulturist,	156
Chemist (fertilizers),	159
Chemist (foods),	174
Botanist,	224
Entomologists,	258
Appendix, compilation of analyses,	263

CALENDAR FOR 1906-1907.

- Jan. 3, 1906, Wednesday, fall semester resumed, at 8 A.M.
February 7, Wednesday, fall semester ends.
February 8, Thursday, spring semester begins, at 8 A.M.
March 28, Wednesday, }
to } spring recess.
April 3, Tuesday, }
April 3, Tuesday, spring semester resumed, at 8 A.M.
June 16, Saturday, Grinnell prize examination of the senior class in
agriculture.
June 17, Sunday, Baccalaureate sermon.
June 18, Monday, { Burnham prize speaking.
Flint prize oratorical contest.
June 19, Tuesday, { Class-day exercises.
Meeting of the alumni.
Reception by the president and trustees.
June 20, Wednesday, commencement exercises.
June 21, 22, Thursday and Friday, examinations for admission, at 9 A.M.,
Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston Univer-
sity, 12 Somerset Street, Boston; at Pittsfield; and at Horticultural
Hall, Worcester.
September 18, 19, Tuesday and Wednesday, examinations for admission,
at 9 A.M., Botanic Museum.
September 20, Thursday, fall semester begins, at 8 A.M.
December 19, Wednesday, }
to } winter recess.
Jan. 2, 1907, Wednesday, }
January 2, Wednesday, fall semester resumed, at 8 A.M.
February 6, Wednesday, fall semester ends.
February 7, Thursday, spring semester begins, at 8 A.M.
March 27, Wednesday, }
to } spring recess.
April 3, Wednesday, }
April 3, Wednesday, spring semester resumed, at 8 A.M.
June 19, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

In beginning the preparation of the annual report, the mind irresistibly recalls the one who prepared the last. Even then suffering intensely, that dauntless soul, with courage and determination which were the surprise and admiration of all, with devotion to duty so absolute that self seemed to be entirely forgotten, still guided and impelled until the immediate, and therefore to him imperative, task was done. Then, and only then, could he be brought to relinquish the helm, to seek rest and hoped-for restoration to health. Again, as we write, comes vividly to mind that April morning when the telegraph and the telephone brought the sad news of his death. By that death on April 23, 1905, was brought to an end a period of almost thirty-eight years of most devoted service to this college.

Henry Hill Goodell, at that time twenty-eight years of age, and with an honorable and enviable record as college student, soldier and teacher, entered the service of the Massachusetts Agricultural College with its first class in the fall of 1867. Originally engaged as professor of modern languages and English literature, Mr. Goodell, during the formative period of the college, when its resources were small, and again when in the late seventies and early eighties the institution passed through its darkest days and its need was great, seems to have stepped into every breach where service was called for; and he filled at different times the position of instructor in such varied branches as gymnastics, military tactics, entomology, zoölogy, anatomy and physiology, rhetoric, elocution and his-

tory. The most striking tribute to the qualities of the man as an educator is found in the fact that in all this wide range of subjects he was an able, inspiring and most highly successful teacher. As a teacher I believe he will be longest remembered. Who that has sat under him as a pupil can ever forget his energy, his enthusiasm for his subject, his absolute mastery of the matter in hand, his hearty and appreciative recognition of good work, — nay, even of faithful effort unaccompanied with marked success, his quick perception of anything which even suggested an attempt to deceive, and the consequent instantly flashing scorn? The pupil under Mr. Goodell felt that he must do good work, and became imbued with a most earnest desire to win a word of appreciation from the teacher whom he so ardently admired. Who shall attempt to define the limits of the influence of such a teacher?

In connection with all his teaching and administrative duties, this professor and president found time for the duties of secretary of the faculty from 1882 to 1886, and served as librarian from 1885 to 1899. In a very real sense he was the creator of the library, which numbered but a few hundred volumes when he began his work, and had grown into one of the most complete of its class at the time of his death, when it numbered rather over 26,000 volumes.

On the death of President Paul A. Chadbourne, in 1883, Professor Goodell was made acting president, and served from February to September of that year. In 1886 he was elected president, and in 1888 director of the Hatch Experiment Station. President Goodell brought to the discharge of the duties of president and director executive abilities of a high order; and, as was to be expected of a man of his ability, singleness of purpose, energy and devotion to duty, his work was attended with distinguished success. During the years of his presidency of the college, 1886 to 1905, the faculty of the institution was doubled, the students in attendance increased in about the same proportion, and the appropriations for the support of the college, both by State and national governments, were more than doubled. Indeed, in 1886 the State made no fixed annual appropriation for

the support of the college; at the time of President Goodell's death such appropriations totalled \$40,000 annually.

President Goodell early took a leading position in the Association of American Agricultural Colleges and Experiment Stations, in the organization of which he was one of the most influential. For many years he was the chairman of its executive committee, in which position, as always wherever placed, he won in remarkable degree the admiration, love and respect of his associates. During the formative period of this association he played a most important part in shaping its organization and its policy, and in influencing national legislation. During these years the Hatch act and the second Morrill act were passed. The first established and provided for the support of one agricultural experiment station in each State and Territory in the Union, and the second appropriated to each agricultural and mechanical college the sum of \$25,000 annually. These acts have had the most far-reaching consequences for good. In pressing them upon the attention of congress and securing their consideration there, President Goodell, by his tact, energy and enthusiasm, was able to exercise great influence.

Any reference to the life of Professor and President Goodell, — "Prof. Henry" and "Prexy," as the boys liked to call him, — which should fail to call attention to his personal character and influence, would be incomplete and inadequate. The students felt always that in him they had a friend and sympathizer and a safe and wise counsellor; and the beauty of his life, reflected it may be indeed but faintly, will live in the lives and characters of his students.

Another of the very early instructors at the college has died during the year. Maj. Henry E. Alvord, who served his country in the volunteer forces engaged in the civil war with distinction, was the first military instructor in the Massachusetts Agricultural College. Coming to the college in that capacity in 1869, Major Alvord organized the military department and brought it to a high state of efficiency, relinquishing the position when he resigned from the army in 1871, after two years of service.

It was at about this time that Major Alvord, apparently

from pure love of the subject, took up the study of dairying, in which within a few years he became a recognized authority. He was later for some years at the head of the experimental farm belonging to the late Lawson W. Valentine of New York. On the retirement of Dr. Manley Miles from the chair of agriculture, in 1886, Major Alvord was elected to succeed him, but, receiving an offer of the directorship of the Maryland Agricultural Experiment Station, he resigned to accept that position early in 1888. It will be remembered that Major Alvord a few years later became chief of the Dairy Bureau of the United States Department of Agriculture, which position he filled with marked success until his death. It is a pleasure here to record the fact that Major Alvord always retained his interest in and love for the Massachusetts Agricultural College, as shown by the fact, elsewhere recorded in this report, that he made it a beneficiary under his will.

COURSES OF STUDY.

During the past year there has been but one change in the courses of study offered by the college, — the two-years course in horticulture for women has been withdrawn. The principal reasons for its withdrawal are the facts: First, that it does not seem to be in demand; during the four years that it has been offered, it has been taken by only two students. Second, it is well-nigh impossible for the college, with its present resources, to carry on the course. Third, it has not been found satisfactory by those students who have taken it. The time devoted to it is evidently too short for a thorough course, which alone is likely to satisfy. This change in no way affects the attitude of the college towards co-education. Women will still be welcomed for all regular courses, and a course in horticulture for women will be given whenever Simmons College, with which we have an agreement in relation thereto, is ready to send up a class.

A minor change in the conditions under which graduate study for the degree of Master of Science may be carried on should be noted. Graduates of our own college or of other approved institutions employed in the college or experiment station may in connection with the work for which they are

employed pursue graduate studies for the degree, and any work done in discharging the regular duties of the position held which has a recognized value in fitting the man for the degree may be counted as a part of the work for the degree.

CHANGES IN FACULTY.

The past year has brought a number of changes in the teaching staff of the college. The illness of President Goodell during the early part of the year and his subsequent death made it necessary to provide for teaching history to the freshman class, which President Goodell himself had always done. This work was taken for the balance of the year by Maj. John Anderson. The resignation of Major Anderson taking effect the first of September, the college was fortunate in completing arrangements with Professor Gallinger, associate professor of history in Amherst College, for taking charge of the work during the present college year. Professor Gallinger is a graduate of Amherst College, and received a doctor's degree in Germany for post-graduate work in history. He is notably successful in his work as a teacher.

The resignation of Maj. John Anderson, who had acceptably filled the chair of professor of military science and tactics for five and a half years, to take effect the first of September, was received in June. This early notice gave ample opportunity to look up the qualifications of candidates for the position, and the place has been acceptably filled by the detail of Capt. George C. Martin, Eighteenth Infantry, who reported for duty early in September.

Dr. Charles S. Walker, who, in addition to serving as college chaplain, has for nineteen years filled the chair of political science, has been granted a year's leave of absence, dating from July 1 last. His work in the department of political science has been taken by George N. Holcomb, A.B., a graduate of Trinity College, who has had the advantage of two years' post-graduate work in American constitutional and political history and in economic and industrial history in the University of Pennsylvania and in Harvard University. Mr. Holcomb has also had successful experience as a teacher.

Mr. Henry J. Franklin, who during the past year served

as instructor in botany, resigned the first of July to continue post-graduate studies. His place was filled by the appointment of A. Vincent Osmun, M.S. Mr. Osmun is a graduate of the Massachusetts Agricultural College, from which institution in June last he also took the Master's degree. The unexpectedly large size of the freshman class rendered it impossible for Mr. Osmun to do all the work required, and he is now assisted by Mr. Franklin, who gives up a part of the time which he proposed to devote to his graduate work.

The introduction of laboratory work in the department of agriculture rendered the employment of additional assistance necessary; and Sidney B. Haskell, a graduate of the college in 1904, has been appointed instructor in agriculture. The resignation of William E. Tottingham, instructor in chemistry, to accept a better position elsewhere, made necessary the appointment of an instructor in chemistry; and Charles G. Barnum, A.B., a graduate of Middlebury College, Vt., has been appointed.

George O. Greene, who for two years had served as instructor in horticulture, resigned during the summer vacation to accept a position in Kansas, and his place has been filled by the appointment of Maurice A. Blake, a graduate of the college in the class of 1904, who during his first year out of college served acceptably as an instructor in the Rhode Island College of Agriculture and Mechanic Arts.

THE YEAR.

On the night of November 16 the large college barn and the dairy school wing attached thereto, with the greater part of the contents, were destroyed by fire, which seems without doubt to have been incendiary in its origin. The fire was not discovered until it had made great headway, and in spite of the courageous, cool and level-headed work of the farm superintendent and a large number of students, there was some loss of live stock. Seventy of the most valuable cows were saved, but a number of young cattle, two or three valuable cows which were in box stalls, and the bulls, were lost. The sheep, with the exception of the buck at the head of the flock, were saved; but the swine, kept in the basement,

with the exception of two or three animals, were destroyed. Fortunately the greater part of the breeding swine was in outlying buildings, which were not endangered by the fire. The barn contained a very large quantity of hay, roots, beets, celery and a great deal of farm machinery; no part of these could be saved. The dairy wing of the building was the last to burn, and a few of the valuable machines which it contained were safely taken out.

As the stock of forage depended upon to feed the cattle, with the exception of the silage, was destroyed by fire, it was deemed best to sell most of the animals. These were disposed of at public auction, and brought good prices. Sixteen of the best cows were saved, and these are temporarily accommodated in one of the barns of the Hatch Experiment Station. The sheep which were retained are also temporarily accommodated in one of the buildings of the experiment station.

The year just passed, in spite of the great losses which have been referred to, must be characterized as one of prosperity and growth. The college has admitted to its present freshman class the largest number ever enrolled in an entering class, — 86. The sophomore class, now numbering 61 men, is also, it is believed, the largest sophomore class in our history. The total enrollment in the regular four-year courses at the present time is 213 men, and we have 8 post-graduate students. We have, therefore, a larger number of men in college at the present time taking regular and post-graduate courses than ever before in its history.

The short course in dairy farming offered last winter was successful. Forty-one men were admitted to the class, and about one-half as many more were refused admission, as it was impossible to suitably provide for practical work for a larger number. The short course in bee farming which has been offered for the past two years did not fill; but the work was offered to members of the senior class, and was taken by 9 of these men, which is about as large a number as under present arrangements can be provided for. It is believed that the policy of offering this work to the members of the senior class should be continued.

PRIZES.

A number of new prizes have been offered during the past year.

The Western Alumni Association at their last annual banquet in February voted to offer for three years an annual prize of \$25, to be awarded at the end of each college year to that member of the sophomore class who during his two years in college has shown greatest improvement in scholarship, character and example. This prize was awarded for the first time in June last. The offer of this prize is peculiarly welcome, not by any means solely because of its probable direct influence upon the men in college during their first two years here, though this is important, but rather because such an offer from a body of alumni makes evident to our students in a practical way the fact that men who have been here as students and who have gone out in the world are still interested in their Alma Mater; that they think of it with interest, and are willing to make sacrifices for its welfare. Such an offer, therefore, is likely to add enormously to the *esprit de corps* and enthusiasm of the whole student body.

The Bay State Agricultural Society at its last annual meeting voted to offer for one year a prize in forestry, to be known as the J. D. W. French prize, in honor of the late J. D. W. French, a former trustee of the college, and one of the very foremost in New England to work in the cause of improved forestry management. The amount of this prize is \$25, and it is to be awarded to that member of the senior class submitting the best essay on forestry.

An anonymous friend offers two prizes of \$15 and \$10, open to competition by members of the senior and junior classes. The basis of the award is to be an essay on the management of a farm wood lot.

Another gift to the college which should be mentioned in this connection is the bequest of the late Maj. H. E. Alvord, whose services to the college have been elsewhere referred to. Major Alvord's will left to the college the greater part of his books, pamphlets, periodicals and museum material, the

whole constituting an exceedingly valuable collection. Major Alvord's will also bequeathed to the college the sum of \$5,000 (to become available upon the death of Mrs. Alvord), to constitute a fund to promote advanced study of problems connected with dairying.

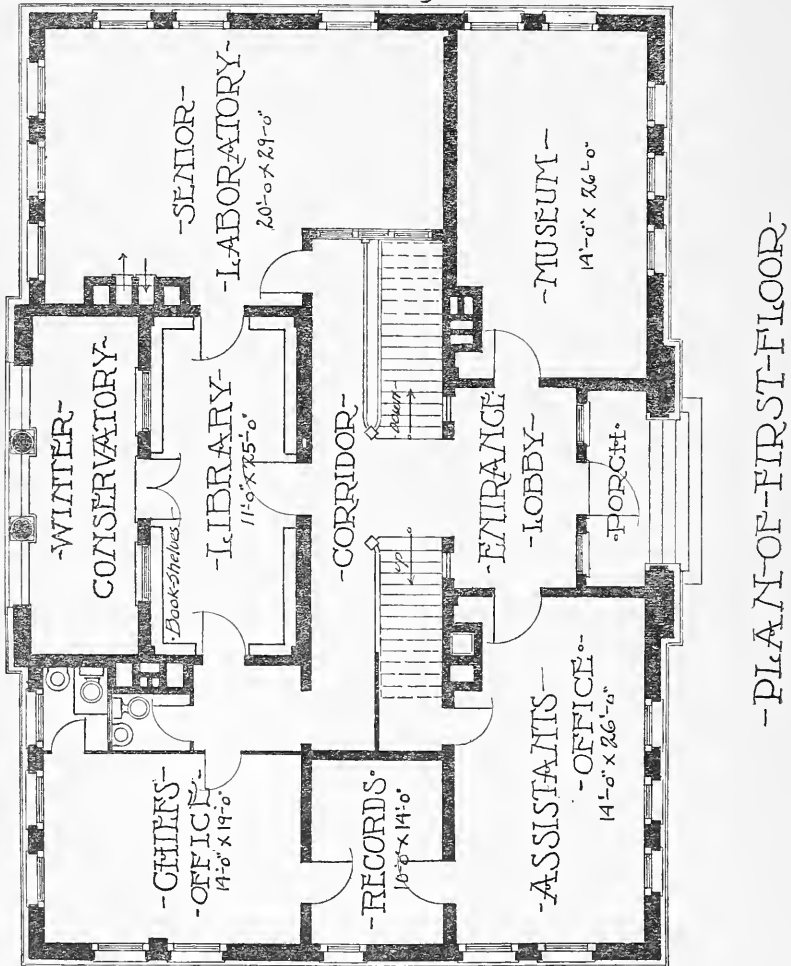
ENDOWED LABOR FUND.

In this connection attention is called to the fact, not heretofore publicly announced, that a generous friend of the college some five years since placed at its disposal as a fund for the assistance of needy and deserving students the sum of \$5,000. This friend modestly desires that his name shall not be published. The sum of money thus donated has been invested, and the income will be used to pay for the labor of deserving students needing the opportunity for self-help.

The improvements provided for by the last Legislature have all of them been entirely completed or well advanced toward completion. The addition to the entomological laboratory and the construction of a new plant house for the entomological department have been completed within the appropriation, and both are eminently satisfactory. The central heating system has been extended in accordance with plans to the new horticultural building, to the botanic museum and to the east experiment station building. The work has been very thoroughly done under the direct charge of the college engineer within the appropriation, and it is believed the new lines will prove more thoroughly insulated and more satisfactory in every way than any portion of the lines previously put in. The large barn and the dairy school wing, recently destroyed by fire, and the horse stable, had been put into thorough repair and well painted, at an expense leaving a balance of about \$92 of the appropriation made for these purposes. The new horticultural building is completed with the exception of the finish. A view of the building, which by vote of the trustees will be called Wilder Hall in honor of the late Marshall P. Wilder, as it stood December 1 constitutes the frontispiece in this report, and a description of it, with floor plans furnished by Professor Waugh, follows:—

HORTICULTURAL BUILDING.

The General Court of 1905 appropriated the sum of \$39,950 "to build, furnish and equip" a building for the department of horticulture and landscape gardening at the Massachusetts Agricultural College. This building is now nearly completed, and

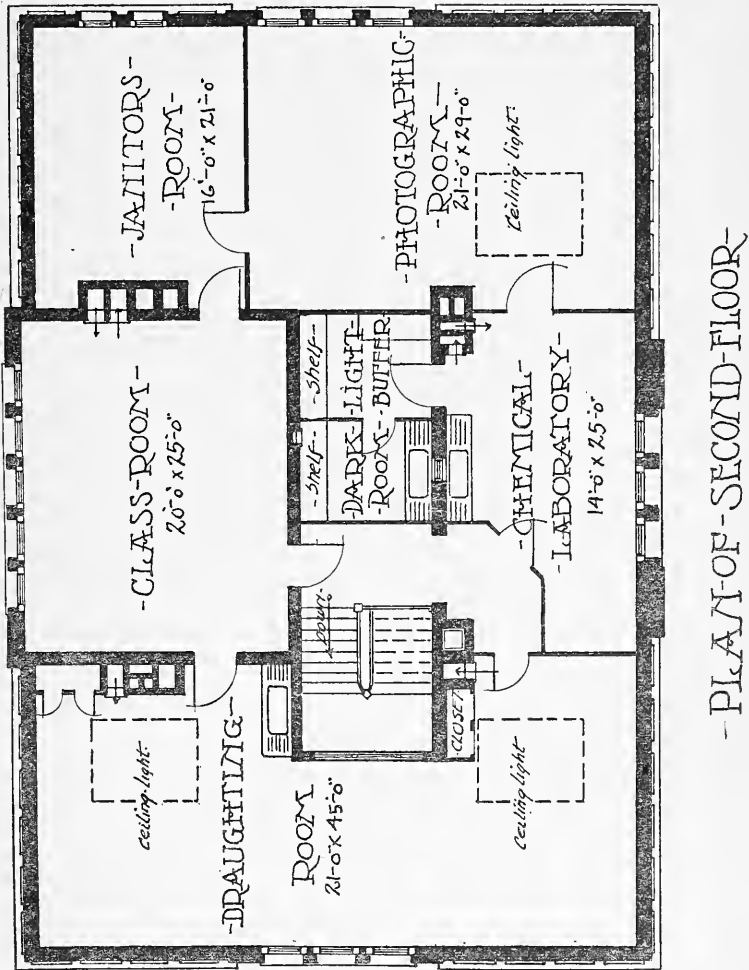


will doubtless be finished during January, 1906. It was designed by Mr. W. R. B. Wilcox, a successful architect of public buildings. It was built by Blodgett and Bosworth of Amherst.

The building is approximately 50 by 70 feet in size, and has three floors, the entire floor space being available. The construction is practically fireproof, being of red brick, trimmed with terra

cotta, floored with fireproof tile and roofed with tile. It is heated by steam furnished by the central heating plant of the college.

The basement floor contains two class rooms, two laboratories, a storeroom, instrument room, lavatory, etc. The first floor con-



tains two offices, records room, library, museum and a large student laboratory. The second floor contains a large drafting room for landscape gardening, a class room, two laboratories, and a living room for the care taker. The building will accommodate the recitations, lectures and laboratory work in horticulture, floriculture, landscape gardening and forestry.

NEEDS OF THE COLLEGE.

It will be remembered that we asked the Legislature last year for an appropriation for what would have constituted practically a new building for the botanical department, but that this appropriation was not granted. The loss of the dairy rooms and the increasing numbers in the college make the pressure for additional rooms yet greater than it was last year, and this will be true even after the completion of the horticultural building. The large size of the freshman class made necessary its division into three sections for laboratory work in botany. It has been found a matter of much difficulty to schedule the work on this basis. We found it impossible to provide for it, as is elsewhere pointed out, save through the appointment of an additional teacher; but the subdivision of the class into three sections for a part of its work and not for the work in other subjects creates much confusion; and, further, subdivision for other subjects, although it would be desirable from the standpoint of efficiency of the work, is not deemed practicable on account of the large increase in teaching force which would be necessary to provide for it. The freshman class for most of the branches of its work is divided into two sections, but even such subdivision is impossible in all subjects; and the only room in the college sufficiently large to provide for meeting the entire class, as is desirable for certain lectures, is the main audience room in the college chapel. This room is very ill suited to work of this description, as it is far too large and too high. Moreover, it is impossible to use this room, with such furniture as is appropriate to its use as a chapel, for making the demonstrations which should accompany lectures in certain scientific subjects.

The sophomore class also is so large that it must be subdivided into two sections for work in a portion of its studies. Such subdivision is necessary to the attainment of satisfactory results, and, as will be at once seen, it necessarily greatly increases the work imposed upon our teaching force. It is imperative that the pressure upon the teaching force be reduced as far as possible; and it must, therefore, be regarded as a matter of the highest importance that rooms of sufficient

size to accommodate such a class for lectures, which can as well be given to the entire number as to a smaller number, should be provided at as early a day as possible. At the present time one of our instructors meets a class of 61 men in a room whose dimensions are 32 by 18 $\frac{3}{4}$ feet, — a room with no provision for ventilation except by means of the windows, and not well fitted for more than half the number of students now meeting in it. In another subject the same class meets in a room 24 by 27 feet, designed to accommodate only two-thirds the number. It is deemed important at this time to point out, further, that many of the other rooms which we are now using are quite unfit for the purposes to which they are put. They are located in buildings some of them put up forty years ago, and are altogether unworthy of the State of Massachusetts, and far below the standard maintained not alone in colleges and universities, but even in cities and towns of the State for educational purposes. Thus, for example, the city of Springfield has spent more money in the erection of two high school buildings than the State of Massachusetts has spent for all the buildings used for educational purposes in this institution. It is well known that to do good work along scientific lines requires ample provision of room and equipment; and the State should realize that in the near future a very considerable expenditure will be required to bring the equipment of this institution into a condition even reasonably satisfactory.

The college imperatively needs at the present time the following provisions for additional room for instructional purposes, and for doing the work for which it exists: —

1. A new building for the botanical department. The inconveniences under which this department now works have been set forth. We asked last year for a sum sufficient to enlarge an existing building and to provide equipment. The location of the existing building which it was proposed to enlarge is not such as to render it the most convenient for the uses to which it will be put, and since the amount saved by enlarging the old building rather than putting up an entirely new structure is relatively small, it has been thought best this year to ask for an entirely new building, located

near the new horticultural building and the insectary. This building is to include lecture rooms and laboratories of greatly increased size. The principal lecture room will accommodate 150 students; the principal laboratory will accommodate 60 students. The building provides smaller rooms and laboratories for advanced students and for the head of the department, and it provides further the needed quarters for the experimental work of the department. For this building and the plant house, which is a necessary part of it, we need the following amounts:—

For the main building,	\$60,500
For the hothouse,	5,500
For introduction of heat from the central heating system,	2,000
For equipment,	7,000
	<hr/>
Total,	\$75,000

2. The college needs new greenhouses for the horticultural department. The hothouse products of the State have increased rapidly during the last few years, and have now attained a total annual valuation considerably in excess of \$2,000,000. The college aims to teach hothouse management as an industrial proposition. The only houses which it possesses are those built from twenty to forty years ago. The plan of construction is radically different from that of the present day, and it is a practical impossibility to teach modern industrial horticulture while using such houses. For new houses we need the sum of \$20,000.

3. The college last year asked the Legislature for an appropriation of \$5,000 for the installment of duplicate engine and generator for our lighting plant. With the growth of the institution the capacity of the present machinery is practically reached; further growth, which is sure to come, means that the machinery will be overtaxed. We have had several breakdowns, involving great inconvenience and interruption to the work of the college in the past; with the machinery taxed more heavily, such breakdowns will become increasingly probable. We imperatively need, and in the immediate future, a new generator and dynamo of increased capacity,

and for this purpose an appropriation of \$5,000 will be needed.

4. When last year in asking for a new horticultural building an item for maintenance was included, the representatives of the college were told that it was against the policy of the State to grant annual appropriations for maintenance in that way; that the State policy was that each institution should annually ask for such sums as should be actually necessary for maintenance of its various buildings and its property. With a view to carrying out this suggestion, a careful examination of the different buildings, roads, bridges, etc., belonging to the college has been made, and it has been found that the following amounts will be needed for maintenance during the next ensuing year:—

For slating the roof of the drill hall and general repairs thereto,	\$650
For repairs and improvements in roads and walks (total length about 4 miles),	150
For repairing and painting the president's house,	350
For new water main for the president's house,	100
For repairs on south dormitory, and painting and glazing windows,	150
For repairs on north dormitory, and painting and glazing windows,	150
For installation of steam heating to replace worn-out furnace in farmhouse,	100
For repairs and painting Professor Hasbrouck's house,	100
For steel-truss flag staff,	350
For increase in water rate, due to introduction of the meter system,	1,000
For painting and repairing of experiment station barns, seed house, fertilizer house and dwelling house,	400
For apparatus and chemicals,	1,000
Total,	<u>\$4,500</u>

5. It was for many years the policy of the college to keep its buildings and property fully covered by insurance. The State some years since refused further appropriations to pay insurance premiums, on the ground that it is not the policy of the State to insure in private companies, but rather to run its own risks or insure its own property. The loss of the farm barns and dairy building and the greater part of their con-

tents has been referred to. The aggregate money loss allowed by the insurance companies on buildings and contents was \$55,408.38. There were in existence at the time of the fire a few blanket policies the term of which had not expired. On these policies the college recovered the sum of \$17,229.39. Of this sum it has been found necessary, in order to meet the emergencies due to the fire, viz., to provide temporary accommodations for stock, to prepare and equip new rooms for instruction in dairying, and to purchase necessary farm implements and machines, to expend some \$5,000. It is deemed best, in rebuilding stables, dairy buildings and silos, to adopt fireproof construction. Because of this change in plan and the great increase in the cost of building during the last few years, it is found that we shall require \$63,000 in addition to the balance of insurance money to erect new barn, stables, piggery, silos and farm dairy building.

6. The horticultural building having now been completed, it is found necessary to ask for the appropriation of \$1,000 annually for maintenance thereof.

Briefly summarizing our needs, we require for:—

New building and plant house for the botanical department, .	\$75,000
New greenhouse for the horticultural department,	20,000
Duplicate engine and generator for lighting plant,	5,000
Maintenance,	4,500
Barn, stables, piggery, silos and farm dairy building,	63,000
For maintenance of the horticultural building, annually, . .	1,000
	<hr/>
Total,	\$168,500

Plans for the erection of new farm buildings are under consideration. Such buildings will be a necessity, and at an early date during this session it will be necessary for the college to appeal to the Legislature for such sum in addition to insurance money as may be required to put up new buildings, to install a new equipment of farm machinery and implements and to purchase new live stock.

The recommendations in the report of Captain Martin, herewith transmitted, are especially worthy of attention. What he has to say concerning the benefits which would follow an annual encampment and improved facilities for and meth-

ods of target practice are particularly commended to your attention. Equally important is his suggestion that an effort be made to secure modification of the rules now governing the War Department in the selection of the men to be recommended for appointment as second lieutenants in the regular army. Captain Martin's points appear to be well taken. It is believed that assigning to the agricultural colleges a certain proportion of the available appointments, to be competed for by these colleges alone, would do much to increase the interest in the military training in these institutions, and thus add greatly to its value for all.

THE STUDENT BODY.

The last annual report showed the towns and cities in the Commonwealth from which the students then in college came. It will be of interest to note the proportion coming respectively from cities and from rural communities. The total number of undergraduate students in college in December, 1905, was 213; of these, 24 came from other States in the Union and 5 from foreign countries. The total number of undergraduate students claiming residence in Massachusetts was 184; of these, 68 came from cities and 116 from towns. Nearly two-fifths of these students, therefore, come from cities. There are 33 cities in the Commonwealth; of these, 20 are represented in our student body. There are 320 towns in the Commonwealth; of these, only 69 are represented in the student body. It is apparent that the towns are not making use of the advantages offered by the college to the same extent as the cities. It must be recognized, however, in noting this fact, that the urban population is greater than the rural population, and the proportion of students to total rural population is greater than the proportion of students to total urban population.

In this connection it will be of interest to note the occupations followed by the parents of our students. A careful investigation to determine these occupations was made one year ago. The proportion of parents in the different occupations would doubtless be substantially the same at the present time.

In December, 1904, there were 179 undergraduate students in the college; the occupations of the fathers were reported as follows:—

OCCUPATIONS OF FATHERS.	Number.	Per Cent.
Business (merchants, dealers, etc.),	56	32.2
Professional:—		
Lawyers,	4	} 9.0
Physicians,	—	
Clergymen,	4	
Other,	8	
Government officials,	2	1.2
Farmers,	60	34.0
Wage earners,	38	21.3
Retired,	4	2.3
	176	
Unheard from,	5	

These figures disclose the fact that only about one-third of our students come from the farm.

In this connection it is of interest to note the studies elected by the students during junior and senior years. There are in college at the present time 54 men in the two upper classes; of these, 38 have elected either agriculture, horticulture or landscape gardening. It will thus be seen that, with only one-third of our students coming from the farm, we have practically two-thirds of those in junior and senior years electing agriculture. An investigation recently made shows that 25 per cent. of the men graduated from the college in the last ten years are actually on the farm; about 35 per cent. more are engaged in occupations directly connected with agriculture, such, for example, as teaching in agricultural colleges and schools, agricultural chemistry, economic entomology and experiment station investigation.

These facts are a sufficient answer to the criticism sometimes heard, that the agricultural college turns students from the farm.

Respectfully submitted, by order of the trustees,

WM. P. BROOKS,

Acting President.

THE CORPORATION.

	TERM EXPIRES
J. HOWE DEMOND of NORTHAMPTON,	1907
ELMER D. HOWE of MARLBOROUGH,	1907
NATHANIEL I. BOWDITCH of FRAMINGHAM,	1908
WILLIAM WHEELER of CONCORD,	1908
ARTHUR G. POLLARD of LOWELL,	1909
CHARLES A. GLEASON of NEW BRAINTREE,	1909
JAMES DRAPER of WORCESTER,	1910
SAMUEL C. DAMON of LANCASTER,	1910
MERRITT I. WHEELER of GREAT BARRINGTON,	1911
CHARLES H. PRESTON of DANVERS,	1911
CARROLL D. WRIGHT of WORCESTER,	1912
M. FAYETTE DICKINSON of BOSTON,	1912
WILLIAM H. BOWKER of BOSTON,	1913
GEORGE H. ELLIS of BOSTON,	1913

Members ex Officio.

HIS EXCELLENCY GOVERNOR WILLIAM L. DOUGLAS,
President of the Corporation.

WILLIAM P. BROOKS, *Acting President of the College.*

GEORGE H. MARTIN, *Secretary of the Board of Education.*

J. LEWIS ELLSWORTH, *Secretary of Board of Agriculture.*

CHARLES A. GLEASON of NEW BRAINTREE.

Vice-President of the Corporation.

J. LEWIS ELLSWORTH of WORCESTER, *Secretary.*

GEORGE F. MILLS of AMHERST, *Treasurer.*

CHARLES A. GLEASON of NEW BRAINTREE, *Auditor.*

Committee on Finance.

GEORGE H. ELLIS, J. HOWE DEMOND,
 ARTHUR G. POLLARD, CHARLES H. PRESTON,
 CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.

WILLIAM H. BOWKER, ELMER D. HOWE,
 M. FAYETTE DICKINSON, CARROLL D. WRIGHT,
 WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticulture.*Farm Division.*

GEORGE H. ELLIS, CHARLES A. GLEASON,
 MERRITT I. WHEELER, N. I. BOWDITCH, *Chairman.*

Horticultural Division.

JAMES DRAPER, ELMER D. HOWE,
 J. LEWIS ELLSWORTH, *Chairman.*

Committee on Experiment Department.

J. LEWIS ELLSWORTH, JAMES DRAPER,
 WILLIAM H. BOWKER, SAMUEL C. DAMON,
 CHARLES H. PRESTON, *Chairman.*

Committee on Buildings and Arrangement of Grounds.

WILLIAM WHEELER, WM. H. BOWKER,
 M. FAYETTE DICKINSON, N. I. BOWDITCH,
 JAMES DRAPER, *Chairman.*

Examining Committee of Overseers.

JOHN BURSLEY (*Chairman*), . . . of WEST BARNSTABLE.
 W. C. JEWETT, of WORCESTER.
 CHARLES H. SHAYLOR, . . . of LEE.
 ISAAC DAMON, of WAYLAND.
 A. H. NYE, of BLANDFORD.

The Faculty.

HENRY H. GOODELL,¹ LL.D., *President.*

WILLIAM P. BROOKS, PH.D., *Acting President,*
Professor of Agriculture.

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,² PH.D.,
Professor of Mental and Political Science.

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.

GEORGE C. MARTIN, Captain, Eighteenth U. S. I. N. F.,
Professor of Military Science and Tactics.

RICHARD S. LULL, PH.D.,
Associate Professor of Zoölogy.

¹ Died April 23, 1905.

² On leave of absence.

PHILIP B. HASBROUCK, B.S.,
Associate Professor of Mathematics.
Adjunct Professor of Physics.

HERMAN BABSON, M.A.,
Assistant Professor of English and Instructor in German.

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

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

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

ALFRED AKERMAN, M.F.,
Lecturer on Forestry.

LOUIS R. HERRICK, B.Sc.,
Instructor in French and Spanish.

FRANCIS CANNING,
Instructor in Floriculture.

HERBERT P. GALLINGER, PH.D., *Associate Professor of*
History in Amherst College,
Instructor in History.

GEORGE N. HOLCOMB, A.B.,
Instructor in Political Science.

A. VINCENT OSMUN, M.Sc.,
Instructor in Botany.

SIDNEY B. HASKELL, B.Sc.,
Instructor in Agriculture.

CHARLES G. BARNUM, A.B.,
Instructor in Chemistry.

MAURICE A. BLAKE, B.Sc.,
Instructor in Horticulture.

HENRY J. FRANKLIN, B.Sc.,
Instructor in Botany.

NATHAN J. HUNTING, B.Sc.,
Instructor in Dairying.

FREDERICK R. CHURCH, B.Sc.,
Instructor in Babcock Test.

CHARLES W. FRYHOFER,
Instructor in Butter Making.

WALTER B. HATCH, B.Sc.,
Instructor in Drawing.

E. FRANCES HALL,
Librarian.

PHILIP B. HASBROUCK, B.S.,
Registrar.

ELWIN H. FORRISTALL, M.Sc.,
Farm Superintendent.

Graduates of 1905.¹

Master of Science.

Osmun, Albert Vincent, . . . Brooklyn, N. Y.
Smith, Elizabeth Hight, . . . Amherst.

Bachelor of Science.

Adams, Richard Laban (Boston Univ.), Jamaica Plain.
Allen, George Howard (Boston Univ.), West Somerville.
Barnes, Hugh Lester (Boston Univ.), Stockbridge.
Bartlett, Francis Alonzo (Boston
Univ.), . . . Belchertown.

¹ 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 1905.

Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles (Boston Univ.),	Amherst.
Gardner, John Joseph,	Milford.
Gay, Ralph Preston,	Stoughton.
Hatch, Walter Bowerman,	Falmouth.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Weston.
Ingham, Norman Day,	Granby.
Kelton, James Richard (Boston Univ.),	Orange.
Ladd, Edward Thorndike (Boston Univ.),	Winchester.
Lewis, Clarence Waterman (Boston Univ.),	Melrose.
Lyman, John Franklin (Boston Univ.),	Amherst.
Munson, Willard Anson (Boston Univ.),	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
Patch, George Willard (Boston Univ.),	Arlington Heights.
Sanborn, Monica Lillian (Boston Univ.),	Salem.
Sears, William Marshall,	Brockton.
Swain, Allen Newman (Boston Univ.),	Dorchester.
Taylor, Albert Davis (Boston Univ.),	Westford.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth (Boston Univ.),	Natick.
Whitaker, Chester Leland,	Somerville.
Williams, Percy Frederic (Boston Univ.),	Natick.
Willis, Grenville Norcott (Boston Univ.),	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	32

Senior Class.

Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.

Craighead, William Hunlie,	Boston.
Filer, Harry Burton,	Palmer.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Hall, Jr., Arthur William,	North Amherst.
Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hood, Clarence Ellsworth,	Millis.
Kennedy, Frank Henry,	Ashmont.
Martin, James Edward,	Brockton.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civile,	Natick.
Rogers, Stanley Sawyer,	Brookline.
Russell, Henry Merwin,	Bridgeport, Conn.
Scott, Edwin Hobart,	Cambridge.
Sleeper, George Warren,	Swampscott.
Strain, Benjamin,	Mt. Carmel, Conn.
Suhlke, Herman Augustus,	Leominster.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tirrell, Charles Almon,	Plainfield.
Wellington, Richard,	Waltham.
Wholley, Francis Dallas,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Total,	30

Junior Class.

Alley, Harold Edward,	Gloucester.
Armstrong, Arthur Huguenin,	Hyde Park.
Barlow, Waldo Darius,	Amherst.
Bartlett, Earle Goodman,	Chicago, Ill.
Caruthers, John Thomas,	Columbia, Tenn.
Chace, Wayland Fairbanks,	Middleborough.
Chadwick, Clifton Harland,	Cochituate.
Chapman, Joseph Otis,	East Brewster.
Clark, Jr., Milford Henry,	Sunderland.
Cutter, Frederick Augustus,	Lawrence.
Dickinson, Walter Ebenezer,	North Amherst.
Eastman, Jasper Fay,	Townsend.

Green, Herbert Henry,	Spencer.
Hartford, Archie Augustus,	Westford.
Higgins, Arthur William,	Westfield.
Jones, Arthur Merrick,	Ludlow.
King, Clinton,	Dorchester.
Larned, Joseph Adelbert,	Amherst.
Lincoln, Ernest Avery,	Fall River.
Livers, Susie Dearing,	Boston.
Parker, Charles Morton,	Newtonville.
Peters, Frederick Charles,	Lenox.
Pierce, Henry Tyler,	West Millbury.
Shaw, Edward Houghton,	Belmont.
Summers, John Nicholas,	Brockton.
Thompson, Clifford Briggs,	Halifax.
Walker, James Hervey,	Greenwich Village.
Watkins, Fred Alexander,	West Springfield.
Watts, Ralph Jerome,	Littleton.
Whitney, John Frank,	Dana.
Wood, Herbert Poland,	Hopedale.
Total, . . . . .	. . . . .

31

Sophomore Class.

Allen, Charles Francis,	Worcester.
Anderson, Albert John,	North Brookfield.
Anderson, Kenneth French,	Roslindale.
Austin, Frank Lee,	Potsdam, N. Y.
Bailey, Ernest Winfield,	Worcester.
Bangs, Bradley Wheelock,	Amherst.
Barry, Thomas Addis,	Amherst.
Bartlett, Louis Warren,	Amherst.
Bates, Carleton,	Salem.
Bennett, Ernest Victor,	Malden.
Browne, Marcus Metcalf,	Malden.
Brydon, Robert Parker,	Lancaster.
Chapman, Lloyd Warren,	Pepperell.
Chase, Henry Clinton,	Swampscott.
Clark, Orton Loring,	Malden.
Cobb, George Robert,	Amherst.
Coleman, William John,	Natick.
Cowles, Edward Russell,	Deerfield.
Cummings, Winthrop Atherton,	Auburn, Cal.

Curtis, Jesse Gerry,	South Framingham.
Cutting, Roy Edward,	Amherst.
Daniel, John,	Osterville.
Davenport, Stearnes Lothrop,	North Grafton.
Davis, Paul Augustin,	Lowell.
Dolan, Clifford,	Hudson.
Draper, James Edwin,	Worcester.
Eastman, Perley Monroe,	Townsend.
Edwards, Frank Laurence,	Somerville.
Farley, Arthur James,	Waltham.
Farrar, Allan Dana,	Amherst.
Farrar, Parke Warren,	Springfield.
Flint, Clifton Leroy,	Amesbury.
Gillett, Chester Socrates,	Southwick.
Gillett, Kenneth Edward,	Southwick.
Gold, Frank Lyman,	Amherst.
Gowdey, Carlton Cragg,	St. Michael, Barbados.
Hall, Jr., Walton,	Marshfield.
Hayes, Herbert Kendall,	North Granby, Conn.
Howe, William Llewellyn,	Marlborough.
Hyslop, James Augustus,	Rutherford, N. J.
Ingalls, Dorsey Fisher,	Cheshire.
Jackson, Raymond Hobart,	Amherst.
Jennison, Harry Milliken,	Millbury.
Johnson, Frederick Andrew,	Westford.
Jones, Thomas Henry,	Easton.
Larsen, David,	Bridgeport, Conn.
Liang, Lai-Kwei,	Tientsin, China.
Miller, Danforth Parker,	Worcester.
Pagliery, Joseph Cecilio,	New York, N. Y.
Parker, John Robert,	Poquonock, Conn.
Philbrick, Edwin Daniels,	Somerville.
Reed, Horace Bigelow,	Worcester.
Regan, William Swift,	Northampton.
Sawyer, William Francis,	Sterling.
Shattuck, Leroy Altus,	Pepperell.
Thurston, Frank Eugene,	Worcester.
Turner, Olive May,	Amherst.
Turner, William Franklin,	Reading.
Verbeck, Roland Hale,	Malden.
Warner, Theoren Levi,	Sunderland.
Waugh, Thomas Francis,	Worcester.
Wellington, Joseph Worcester,	Waltham.

Wheeldon, Albert James, . . .	Worcester.
Wheeler, Hermon Temple, . . .	Lincoln.
White, Herbert Linwood, . . .	Maynard.
Whiting, Albert Lemuel, . . .	Stoughton.
Whitmarsh, Raymond Dean, . . .	Taunton.
Wright, Samuel Judd, . . .	South Sudbury.
Total,	68

Freshman Class.

Adams, William Everett, . . .	Chelmsford.
Alger, Paul Edgar, . . .	Somerville.
Bardwell, Frank Raymond, . . .	North Brookfield.
Barnes, Jr., Benjamin Franklin, . . .	Haverhill.
Bartholomew, Persis, . . .	Melrose Highlands.
Bartlett, Oscar Christopher, . . .	Westhampton.
Bean, Thomas Webster, . . .	South Hadley Falls.
Beebe, John Cleaveland, . . .	Hampden.
Bent, George Franklin, . . .	Milton.
Blake, Rodman Ruggles, . . .	East Pepperell.
Briggs, Orwell Burlton, . . .	Egremont.
Brown, Eben Hermon, . . .	Bridgewater.
Brown, Jr., George Murray, . . .	Cambridge.
Burke, Edward Joseph, . . .	Holyoke.
Caffrey, Donald John, . . .	Gardner.
Cardin, Patricio Penarredonda, . . .	Artemisa, Cuba.
Chase, Edward Irving, . . .	Somerville.
Codding, George Melvin, . . .	Taunton.
Coleman, Leon Nelson, . . .	Gardner.
Cook, Walter Arthur, . . .	Milton.
Corbett, Lamert Seymour, . . .	Jamaica Plain.
Cox, Jr., Alfred Elmer, . . .	Malden.
Cox, Leon Clark, . . .	Boston.
Cronyn, Theodore Reid, . . .	Bernardston.
Crosby, Harold Parsons, . . .	Lenox.
Crossman, Samuel Sutton, . . .	Needham.
Curran, David Aloysius, . . .	Marlborough.
Cutler, Homer, . . .	Westborough.
Eddy, Roger Sherman, . . .	Dorchester.
French, Horace Wells, . . .	Pawtucket, R. I.
Fulton, Gordon Russell, . . .	Lynn.
Geer, Myron Francis, . . .	Springfield.

Geer, Wayne Emory,	Springfield.
Handy, Leroy Marshall,	Worcester.
Hathaway, Elmer Francis,	Cambridge.
Hayward, Warren Willis,	Millbury.
Hibbard, Myron James,	North Hadley.
Hillman, Arthur Joseph,	Hardwick.
Hubbard, Arthur Ward,	Sunderland.
Ide, Warren Leroy,	Dudley.
Jen, Huan,	Tientsin, China.
Kenney, Walter James,	Lowell.
Knight, Harry Orrison,	Gardner.
Lambert, Marjorie Willard,	West Brighton, N. Y.
Learned, Wilfred Hill,	Florence.
Lindblad, Rockwood Chester,	North Grafton.
Lull, Robert Delano,	Windsor, Vt.
Lyman, Arthur Densmore,	Springfield.
MacGown, Guy Ernestus,	South Britain, Conn.
Maps, Charles Hulick,	Long Branch, N. J.
Martin, Jr., Nelson Lansing,	Sharon.
Monahan, James Valentine,	South Framingham.
Neale, Harold Johnson,	Worcester.
Noble, Harold Gordon,	Springfield.
Noyes, John,	Roslindale.
O'Donnell, John Francis,	Worcester.
O'Grady, James Raphael,	Holliston.
Oliver, Joseph Thomas,	Dorchester.
Paddock, Harold Charles,	West Claremont, N. H.
Parsons, Egbert Rockwell,	Lenox.
Pearce, Ernest Edwin,	Worcester.
Phelps, Harold Dwight,	West Springfield.
Potter, John Sherman,	Concord.
Potter, Richard,	Concord.
Putnam, Charles Sumner,	Princeton.
Randolph, Lucy Amelia,	Belchertown.
Richardson, George Tewksbury,	Middleborough.
Sexton, George Francis,	Worcester.
Shamiae, George Mansoor,	Damascus, Syria.
Smith, Alexander Halliday,	Nyack, N. Y.
Smulyan, Marcus Thomas,	New York, N. Y.
Stewart, Eri Shepardson,	Royalston.
Strong, Anson Loomis,	Colchester, Conn.
Sweet, Charles Rochford,	Worcester.
Thompson, Myron Wood,	Halifax.

Thomson, Jared Brewer, . . .	Monterey.
Trainor, Owen Francis, . . .	Worcester.
Treat, Carlton Eddy, . . .	Chelsea.
Tucker, Horace Northrop, . . .	Waterbury, Conn.
Turner, Henry William, . . .	Trinidad, Cuba.
Turner, LeRoy Henry, . . .	Pittsburg, Penn.
Wadsworth, Ralph Emerson, . . .	Northborough.
Warner, Frederick Chester, . . .	Sunderland.
Webb, Charles Russell, . . .	Worcester.
Whaley, James Sidney, . . .	East Orange, N. J.
Whelpley, Walter Merton, . . .	Winthrop.
White, Charles Howard, . . .	Providence, R. I.
Willis, Luther George, . . .	Melrose Highlands.
Wilson, Jr., Frank Herbert, . . .	Nahant.
Total,	89

Short Winter Course, Dairy Farming.

Barnes, Charles White, . . .	Haverhill.
Carruth, Charles Mason, . . .	Barre.
Carter, Harry Rufus, . . .	Millbury.
Chase, Edward Irving, . . .	Somerville.
Daniels, Francis Newell, . . .	Foxborough.
Davis, Warren Henry, . . .	Great Barrington.
Dearborn, Carr Alvah, . . .	Amherst.
Devlin, James Francis, . . .	Whitinsville.
Dunnell, David Lawson, . . .	Greenfield.
Eames, William Ovid, . . .	Becket.
Fabian, Benedict Sebastian, . . .	Worcester.
Filer, Charles Humphrey, . . .	West Brimfield.
Gaskill, Roy Frank, . . .	Hopedale.
Gates, Oliver Horace, . . .	Ashburnham.
Geer, Raymond, . . .	Wapping, Conn.
Greenhalgh, Cecil Norman Victor, . . .	Plymouth.
Guiel, Arthur Daniel, . . .	Amherst.
Haynes, Jay Freeman, . . .	North Hero, Vt.
Hollquist, Andrew Gustaf, . . .	Worcester.
James, Arthur Eugene, . . .	North Ferrisburg, Vt.
Kimball, Edward Bartlett, . . .	Methuen.
Lincoln, James Keyes, . . .	Barre.
Lucia, Jr., John Baptiste, . . .	Middlebury, Vt.
Mann, Walter Samuel, . . .	Foxborough.
May, Basil Morris, . . .	South Egremont.

McCrone, Henry Richmond,	Amesbury.
Moore, Edwin Allyn,	Westfield.
Packard, Henry Wakefield,	Goshen.
Pomeroy, Robert Edgar,	Northampton.
Ranney, William Henry,	South Ashfield.
Rayercraft, Jr., Frank,	Caldwell, N. J.
Salmon, William Everett,	Boston.
Schmitz, Eugen Alfons Richard,	Shirley.
Sheridan, Walter Peter,	Charlton.
Smith, David French,	Plymouth, N. H.
Smith, Morey Ambios,	Berlin, N. Y.
Taylor, Arthur Francis,	North Amherst.
Thompson, Oscar Raymond,	Heath.
True, Arthur Ray,	Amesbury.
Twitchell, Julian Phelps,	Cambridge.
Watley, Frank Crandall,	Davenport, N. Y.
Whitney, Harvey Horace,	Shrewsbury.
Total,	42

Graduate Students.

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

Back (B.Sc., M. A. C., '04), Ernest Adna,	Florence.
Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.
Kibbey (A.B., Harvard, '04), Richards Carroll,	Marshalltown, Ia.
Ladd (B.Sc., M. A. C., '05), Edward Thorndike,	Winchester.
Lancaster (A.B., Harvard, '84; M.D., Harvard, '89), Walter Brackett,	Boston.
Monahan (B.Sc., M. A. C., '03), Neil Francis,	Amherst.
Osmun (B.Sc., M. A. C., '03), Albert Vincent,	Danbury, Conn.
Smith (B.Sc., M. A. C., '97), Philip Henry,	Amherst.
Staples (B.Sc., M. A. C., '04), Parkman Fisher,	Westborough.

Tottingham (B.Sc., M. A. C., '03), William Edward,	Bernardston.	
Tower (B.Sc., M. A. C., '03), Winthrop Vose,	Roxbury.	
Whipple (B.Sc., Kansas Agr'l College, '04), Orville Blaine,	Olivet, Kan.	
Total,		13

Special Students.

Dacey, Alice Evelyn,	Boston.	
Foster, Elsie Addie,	Worcester.	
French, Vida Rachel,	Amherst.	
Locke, Ada Elsie,	La Junta, Col.	
Total,		4

Summary.

Graduate course:—		
For degrees of M.S. and Ph.D.,		13
Four-years course:—		
Graduates of 1905,		32
Senior class,		30
Junior class,		31
Sophomore class,		68
Freshman class,		89
Winter courses,		42
Special students,		4
Total,	—	309
Entered twice,		3
Total,		306

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, oecology, 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 phy-

biological 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.

Ecology: 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.

Zoölogy. — This course is offered as a minor subject for candidates for the degree of Doctor of Philosophy.

General and comparative anatomy, both gross and microscopic; ontogeny and phylogeny; life cycles, metamorphosis and metagenesis; animal associations, colonial, commensal and parasitic, and symbiotic associations of animals and plants; adaptation, adaptive radiation and parallelisms.

Geologic, geographic and bathymetric distribution of animals.

Systematic zoölogy, including palæozoölogy; museum and field technique.

Economic zoölogy.

History and development of zoölogical science.

Weekly seminars and journal club meetings are held, in which all advanced students of zoölogy take an active part.

Collateral reading and a general knowledge of current zoölogical literature are required.

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 1906 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." For the examination in 1907 and 1908 the books are: Shakespeare's "The Merchant of Venice;" Irving's "Life of Goldsmith;" Coleridge's "The Ancient Mariner;" Scott's "Ivanhoe" and "The Lady of the Lake;" Tennyson's "The Passing of Arthur;" 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 1906 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 21 and 22, and on Tuesday and Wednesday, September 18 and 19, as follows: —

<i>First Day.</i>	<i>Second Day.</i>
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 the convenience of the examiners, at other times in the year, but not during the summer vacation.

ENTRANCE EXAMINATION PAPERS USED IN 1905.

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

ALGEBRA.

1. Factor $\frac{a^2}{b^2} + \frac{b^2}{a^2} - 2$.

Factor $6x^2 - 7xy - 3y^2$.

2. Expand by binomial theorem $(a^{1/2} + 2b^2x^{-1})^4$.

3. Find the square root of $x^4 - x^3 + \frac{x^2}{4} + 4x - 2 + \frac{4}{x^2}$.

4. Find sum of $\sqrt{\frac{3}{4}} + \sqrt{\frac{1}{3}} + \frac{1}{6}\sqrt{9}$.

5. Solve $\frac{ax - 1}{\sqrt{ax + 1}} = 4 + \frac{\sqrt{ax - 1}}{2}$.

6. Solve $\begin{cases} \frac{a^2}{x^2} + \frac{b^2}{y^2} = 10. \\ \frac{ab}{xy} = 3. \end{cases}$

7. Solve $\begin{cases} x^2 + y^2 + x + y = 32. \\ xy = 12. \end{cases}$

Solve $\begin{cases} x^2 + xy = 15. \\ xy - y^2 = 2. \end{cases}$

GEOMETRY.

1. (a) What is a scalene triangle? (b) What is an inscribed angle? (c) What is a segment of a circle? (d) Give theorem of limits. (e) What is a sector of a circle?

2. Find the area of a segment of a circle having for its chord a side of a regular inscribed hexagon, if the radius of the circle is 10; take $\pi = 3.1416$.

3. The medians of a triangle intersect at a common point, which lies two-thirds the way from each vertex to the middle point of the opposite side. Prove.

4. Draw the exterior and interior common tangents to two given circles which do not intersect. Explain constructions fully.

5. Find the area of a triangle whose sides are 8, 13, and 15.

PHYSICAL GEOGRAPHY.

1. Describe the continent of South America, its form, boundaries, elevation, drainage, and the relation of the mountain systems to the continent form.

2. What is glacial erosion? What evidence have we of the former existence of an ice sheet in this region? What is an esker? A drumlin? A terminal moraine?

3. What are corals? Under what conditions do they live? What is a barrier reef? A fringing reef? An atoll? How is each formed?

4. What are ocean currents? Describe and explain the gulf stream. What is its influence on mankind? What is the Sargasso Sea? Where is it?

5. Describe the physical features and climate of Massachusetts (or your home State). What influence do these have on its agriculture, manufactures and other industries?

CIVIL GOVERNMENT.

1. Name the characteristic features of the following forms of government in this country:—

- (a) Provincial.
- (b) Proprietary.
- (c) Charter.
- (d) Revolutionary, 1776–1781.
- (e) Confederate, 1781–1789.
- (f) Constitutional, 1789–1905.

2. Give the year, month and day of the month when the United States began its existence as a nation. What act signalized this beginning?

3. State three qualifications for the office of President of the United States. Name the vice-presidents who have succeeded to the presidency by the death of the president.

4. Name the principal courts of the United States. Give five kinds of cases that can be brought before the United States courts.

5. Write upon the following subjects, developing them as fully as you can:—

- (a) The Massachusetts Legislature.
- (b) Municipal government.
- (c) The regulation of railroad rates.

PHYSIOLOGY.

1. Compare carefully the skeleton of the arm and leg with the hip and shoulder girdle, naming and describing the corresponding bones in each, and giving their positions.

2. Describe the digestive system, and tell of each process and where it occurs in the digestion of a meal consisting of beefsteak, potatoes, and bread and butter.

3. Describe carefully the process of respiration. How the air is inhaled. How it is exhaled. What changes have occurred in the air thus breathed? What in the blood?

4. What is the difference between a cold and a warm blooded animal? How is the temperature kept up in the latter? Are there any waste products arising from this production of heat? If so, what becomes of them?

5. What is a nervous impulse? What is reflex action? Give an example of the latter, explaining in full.

GENERAL HISTORY.

1-4. Write a general account of the old civilization of the following three countries, Egypt, Greece and Rome, discussing: (*a*) classes of people in each; (*b*) occupations of the common people; (*c*) art, as shown in buildings, statuary and literature; (*d*) war-like characteristics.

5. What is meant by "The fall of the Roman Empire," which took place in 476 A.D., and why is this date considered the dividing line between ancient and mediæval history?

6. What was the effect of the spread of Christianity over the northern countries of Europe? What were some of the actual results of this, so far as the following are concerned? (*a*) Buildings; (*b*) Crusading; (*c*) Literary work.

7. Name the events in connection with the history of England that were directly instrumental in laying the foundations of the present English language.

8. What was the great service rendered to their country and to their subjects by the following rulers? (*a*) Charlemagne; (*b*) Peter the Great; (*c*) Frederick the Great; (*d*) Cromwell.

9. Name four different events in the history of our own country which you think had a great influence on the history of the nineteenth century.

10. What was the age of compromise in the history of the United States? In what way did this "age" really bring on the civil war?

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 three hundred words in length.

- (a) Shakespeare's first acquaintance with the theatre.
- (b) The bright and the dark side of Oliver Goldsmith.
- (c) Walter Scott's fight against bankruptcy.
- (d) Lowell's boyhood and college days.
- (e) Tennyson's love for retirement.
- (f) The life of George Eliot.

2. Choose any three of the following, and write a few paragraphs on each subject chosen. Give title in each case.

- (a) Was Shylock's demand for justice unreasonable?
- (b) Home life as depicted in the "Vicar of Wakefield."
- (c) What we learn of Robin Hood from "Ivanhoe."
- (d) The abiding lesson of Tennyson's "Princess."
- (e) Sir Launfal before and after the "Vision."
- (f) The two brothers in "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 semester, four exercises a week for eight 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 uses 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 subdivision 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. BLAKE.

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-book, lectures, laboratory and field exercises. — Mr. BLAKE.

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, lectures and field exercises. — Mr. BLAKE.

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. BLAKE and Mr. CANNING.

A seminar, made up of all students electing advanced work in horticulture or landscape gardening, meets weekly 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, first and second semesters, four hours a week. Elements of landscape design: the fundamental principles under-

lying the artistic development of parks, estates, gardens and other areas, together with some of the simpler applications to practical conditions. — Professor WAUGH and Mr. HATCH.

2. Junior year, first semester, three periods weekly. Arboriculture: trees, shrubs and other ornamental plants; their propagation, planting and care. Field and laboratory exercises and lectures. — Professor WAUGH, Mr. CANNING and Mr. HATCH.

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.

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, second semester, six 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, twelve weeks, three hours a week. Structural, dynamical, physiographical and historical, based upon Scott's "Introduction to Geology." The course aims to give a review of the physical condition of the earth; the various dynamic agencies, and the results of their activities; the origin and structure of the rocks; and, finally, the geological history of the globe, and the appearance in time and the development of the principal races of animals and plants. The museum, lantern slides and the classic Connecticut valley afford ample means for illustration. — Professor LULL.

ZOOLOGY.

1. Anatomy and physiology, freshman year, one-half of the second semester, four hours a week. Lectures based upon Martin's "The Human Body," advanced course, illustrated by demonstrations from the charts and models and from microscopic and other preparations. The fact that the subject is required for entrance makes it possible in a comparatively brief period to review the main features of human anatomy, the generally accepted views concerning the physiology of the various organs,

and the more essential laws of health; and, aside from the practical value of the last, the knowledge of the human system thus gained aids greatly in the zoölogical work to come. — Professor LULL.

2. Zoölogy, sophomore year, first semester, two periods a week. This is mainly a laboratory course, the aim being to familiarize the student with the structure of a number of typical forms, representative of the chief phyla of the animal kingdom, to train him to more precise habits of observation, and to lay the foundation for a more thorough understanding of laboratory technique. Lectures, amply illustrated by specimens, charts and lantern slides, supplement and render orderly the knowledge gained in the laboratory. — Professor LULL.

3. Zoölogy, elective, junior year, four periods a week. A course in comparative morphology and systematic zoölogy, based upon Parker and Haswell's "Text-book of Zoölogy." Opportunity is given for the careful dissection of each of the typical forms or its equivalent, described in the text, with a further series of animals for comparative study. Special attention is paid to individual and racial development, adaptation, relationship of animals to one another and to plants, geological and geographical distribution of animals, and the economic importance of the different groups, except the insects, both living and extinct. The lectures are illustrated by the very complete museum collection. — Professor LULL.

ECONOMICS AND GOVERNMENT.

The aim of this department is to introduce the student to such studies as may enable him to deal with economic problems and to fulfill his social and political duties. In all work of the department the text-book and lecture systems are combined.

1. Economics, junior year, first semester, four hours a week. Ely's "Outlines of Economics" and Taylor's "Introduction to Agricultural Economics" are used as text-books. The lectures on general economics are intended to supplement Ely's book, with emphasis on present-day problems. The lectures on agricultural economics treat of the history of the agricultural industry, and existing agricultural economic conditions and tendencies in the United States. Such subjects as the resources of the various geographical divisions of our country in land and labor, the application of division of labor to agriculture, specialized and diversified farming, the large and small farm

systems, tenure of farm lands, the transportation of farm products, tendencies toward agricultural co-operation, and those characteristics of agriculture which make it especially attractive to the liberally educated mind, are briefly treated. Special papers on subjects selected by the individual students from an assigned list are read and discussed in the class room.

2. Government, senior year, four hours a week, during the last half of the first semester and the whole of the second. Woodburn's "The American Republic" is used as a text-book, supplemented by assigned readings in Hart's "Actual Government" and Buchanon's "Massachusetts Town Officers." The lectures treat of general sociology, the theory and forms of the State, the origin and history of American political institutions, political parties and movements in the United States, and eminent political leaders and interpreters of the Constitution. Special attention is given to the United States Department of Agriculture, State Board of Agriculture, agricultural education and the organization of the New England country town. — Mr. HOLCOMB.

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 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. — Assistant Professor BABSON.

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. — Professor MILLS and Assistant Professor BABSON.

3. *Literature.* — American literature is studied in the first semester of sophomore year, three 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. — Assistant Professor BABSON.

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.

BACTERIOLOGY.

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 antitoxin used to counteract their action.

Senior year, first 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., and of their functions and chemical and physical properties. This course extends into the next semester.—Mr. OSMUN.

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. OSMUN.

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, and is necessary for a comprehension of the following courses.—Mr. OSMUN.

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 method 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. Both courses are optional. These courses are 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 OSTRANDER and Professor HASBROUCK.

Second semester, two hours a week. Solid geometry. Wells' "Solid Geometry." — Professor HASBROUCK.

Plane trigonometry, two hours a week. Lyman and Goddard's "Trigonometry." — Professor OSTRANDER.

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. Nichols' "Analytic Geometry." — Professor HASBROUCK.

Second semester, four hours a week. Differential and integral calculus. Osborne's "Calculus." — Professor HASBROUCK.

Physics.

Sophomore year, first semester, four hours a week. Elementary mechanics of solids, liquids and gases, heat and sound. Merri- man's "Elements of 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. Text-book and lectures. — 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 for 1906–07 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 1907–08 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, the measurement of earth work, 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; free-hand 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. — Professor H. T. FERNALD.

Senior year, elective, open to those who have taken the junior entomology, first and second semesters, three laboratory exercises of two hours each, and one lecture, 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.: required, four hours a week for both semesters of the freshman year. The special aim of this course is to enable the student to lay the foundation of an ability to read modern French fluently, special reference being had to scientific journals and treatises. The object of the grammar drill is to give not only instruction in the broader and more general topics, but also a thorough drill in the idiomatic peculiarities of the language, a thorough comprehension of which is held to be absolutely necessary to a correct and accurate translation. Great stress is laid upon the acquisition of a good vocabulary, and absolute accuracy in translation is insisted upon. The course is further strengthened by drill in pronunciation, exercises and composition, and, in general, in whatever tends to increase interest, facility and ability in translation.

Course II. is given, upon demand, as a supplement to Course I., and is an elective requiring four hours a week for both semesters of senior year. Its aim is, primarily, to furnish by an additional year's training a greater practical efficiency in translation than can be attained merely by the completion of Course I.; and, secondarily, to equip the student with a general knowledge of scientific French literature. Constant advanced

drill is furnished along the general lines of Course I., with the object of attaining such mastery of the language that it may be easily used as a tool in scientific pursuits and investigations of any nature. Students who have not attained a good rank in Course I. are not encouraged to elect Course II.

Though the main object of both courses is practical, a general attempt is constantly made, by the comparison of French and English and by occasional lectures on French life and customs, to interest the student in the study and better comprehension of the genesis of his own language, and to encourage a desire for a broad and general culture.

Spanish.— Given at present as an elective for four hours a week during both semesters of the year. This course is open as a regular study to seniors, and to freshmen who upon entering college have passed off French or German (Course I.), and also as an extra to any student in good and regular standing. It is offered in response to the recognized demand in Spanish-speaking countries for graduates of agricultural colleges who have made a specialty of agriculture, entomology, horticulture, engineering, etc. Students planning future fields of work in such countries are thus enabled to acquire sufficient facility in reading, writing and speaking the Spanish language to start them to the best advantage. The earlier work is based upon some such grammar as Marion and Garennes' "*Introducción á la Lengua Castellana.*" The course is strengthened by writing from dictation, and by the reading of books characteristic of Spanish life and customs.

German.— Course I.: required for both semesters of sophomore year, three hours a week first semester, three hours a week second semester. An understanding of the rudiments of grammar, facility in translation and an ability to pronounce the language and to understand simple spoken German are the main objects in view.— Assistant Professor BABSON.

Course II.: elective for both semesters of senior year, four hours a week. Special attention is given to the reading of German, particularly to German of a scientific nature. Work is also required in prose composition throughout the year. Accuracy in pronunciation, the ability to understand German as spoken in the class room, and to converse within reasonable limits, are also features of this course. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein.— Assistant Professor BABSON.

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 a resident 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. 101, dated Washington, D. C., June 29, 1905, 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 Secretary of War,

ADNA R. CHAFFEE,
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.

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, "Infantry Drill Regulations," "Manual of Guard Duty and Firing Regulations for Small Arms;" "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," "Field Service Regulations." — Captain MARTIN.

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,	. . . . .	1
		French,	. . . . .	4
Mathematics,	{	Algebra,	. . . . .	5
		Agriculture,	. . . . .	4
Science,	{	Botany, 2+1,	. . . . .	3
		Tactics,	. . . . .	1
Military,				
History,				2
				— 20

Second Semester.

Language,	{	English,	. . . . .	4
		French,	. . . . .	4
Mathematics,	{	Geometry and trigonometry,	. . . . .	4
		Anatomy and physiology, half semester,	. . . . .	4
Science,	{	Chemistry, half semester,	
		Botany, 1+1,	. . . . .	2
History,				2
				— 20

SOPHOMORE YEAR.

First Semester.

Language,	{	English,	. . . . .	3
		German,	. . . . .	4
Physics,				4
Science,	{	Agriculture,	. . . . .	4
		Chemistry,	. . . . .	3
		Zoölogy, 1+1,	. . . . .	2
				— 20

Second Semester.

Language,	{	English,	. . . . .	4
		German,	. . . . .	3
Physics,	.	. . . . .	. . . . .	4
Surveying,	.	. . . . .	. . . . .	2
Science,	{	Agriculture, 2+1,	. . . . .	3
		Chemistry, 2+1,	. . . . .	3
		Horticulture,	. . . . .	3
				— 22

JUNIOR YEAR.

First Semester.

Course in agriculture,	{	Agriculture, 3+1,	. . . . .	4
		Botany, 2+1,	. . . . .	3
		Chemistry,	. . . . .	3
		Economics,	. . . . .	4
		Horticulture,	. . . . .	3
		English,	. . . . .	4
				— 21
Course in horticulture,	{	Horticulture,	. . . . .	4
		Horticulture, 1+3,	. . . . .	4
		Botany, 2+1,	. . . . .	3
		Chemistry,	. . . . .	3
		Economics,	. . . . .	4
		English,	. . . . .	4
				— 22
Course in biology,	{	Zoölogy, 3+1,	. . . . .	4
		Botany, 2+1,	. . . . .	3
		Chemistry,	. . . . .	3
		Economics,	. . . . .	4
		Horticulture,	. . . . .	3
		English,	. . . . .	4
				— 21
Course in chemistry,	{	Chemistry,	. . . . .	4
		Agriculture, 3+1,	. . . . .	4
		Mathematics,	. . . . .	4
		Economics,	. . . . .	4
		English,	. . . . .	4
		Special subject,	. . . . .	2
				— 22
Course in mathematics,	{	Analytical geometry,	. . . . .	4
		Engineering, 1+3,	. . . . .	4
		Free-hand drawing,	. . . . .	2
		Landscape gardening,	. . . . .	4
		Economics,	. . . . .	4
		English,	. . . . .	4
				— 22

Course in landscape gardening,	{	Landscape gardening,	4
		Agriculture, 2+1,	3
		Botany, 2+1,	3
		Free-hand drawing,	2
		Horticulture,	3
		Economics,	4
		English,	4
			— 23
<i>Second Semester.</i>			
Course in agriculture	{	Agriculture, 2+1,	3
		Botany, 2+1,	3
		Chemistry,	4
		Horticulture,	2
		Entomology,	4
		Geology,	3
			— 19
Course in horticulture,	{	Horticulture,	4
		Botany, 2+1,	3
		Chemistry,	4
		Landscape gardening,	2
		Entomology,	4
		Geology,	3
			— 20
Course in biology,	{	Entomology,	4
		Zoölogy,	3
		Botany, 2+1,	3
		Chemistry,	4
		Horticulture,	2
		Geology,	3
			— 19
Course in chemistry,	{	Chemistry,	5
		Agriculture, 2+1,	3
		Mathematics,	4
		Geology,	3
		Special subject,	5
			— 20
Course in mathematics,	{	Engineering,	4
		Mathematics,	4
		Mechanical drawing,	2
		Landscape gardening,	4
		Geology,	3
			— 17
Course in landscape gardening,	{	Landscape gardening,	4
		Botany, 2+1,	3
		Mechanical drawing,	2
		Engineering,	5
		Entomology,	4
		Geology,	3
			— 21

SENIOR YEAR.

First Semester.

The following subjects are required in all courses:—

Bacteriology, half semester, 4, . . . . .	}	. . . . .	4
Constitution of the United States, 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 courses, closely correlated with his junior year course; only one course in language may be elected:—

Agriculture,	4	Physics,	4
Horticulture, 3+1,	4	Engineering,	4
Veterinary,	4	English,	4
Botany, 3+1,	4	French,	4
Landscape gardening, 3+1,	4	German,	4
Entomology, 3+1,	4	Spanish,	4
Chemistry, 3+1,	4	Latin,	4
Floriculture, 3+1,	4		

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

	Hours per Week.
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, trans- planting, 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. BEE CULTURE.

	Total Hours.
The structure of bees, with special reference to their work (Prof. H. T. Fernald),	3
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 con-
tinues 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 destroyed by fire in November, 1905, were stocked with the best breeds of horses, cattle, sheep and swine, and will be replaced by new buildings at as early a date as possible. 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. The department has assigned to its use one lecture room with museum attached, and five rooms for laboratory and dairy purposes.

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.

The work in horticulture, floriculture and landscape gardening is now much better provided for than in the past, through the completion of the new Wilder Hall. This contains three class rooms, three student laboratories, a large drafting room and a library, besides offices, a museum and private laboratories. It is a substantial structure, three stories high, containing all the most modern appliances, and exemplifying the best ideas in college laboratory building. It is practically fireproof, being constructed of red brick, terra cotta and tile. The floors and the roof are of tile.

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.

ZOOLOGY.

Zoölogical Laboratory. — A large, well-lighted room, situated in the old chapel building, is amply supplied with the best apparatus obtainable. The equipment includes compound and simple microscopes, dissecting instruments and trays, an incubator, paraffin bath, microtomes, etc., also a reference library, containing the current zoölogical journals and a good series of mounted slides for the microscope.

Zoölogical Lecture Room. — The lecture room is in south college, adjacent to the museum; its equipment includes, besides the museum specimens, the Leuckart series of charts, and many specially made charts as well; the Auzoux models, illustrative of human and comparative anatomy; and an electric stereopticon.

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 glassware. 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 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 in accordance with the latest ideas regarding 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 workshop. The hospital stable contains a pharmacy, operating hall, post-mortem and dis-

infecting 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, paraffin 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; 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 micro-

scopes. 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 Wheatstone 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 west 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 26,665. 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, and the horticultural building and botanic museum on the east side. 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, to be paid in advance, 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 one period of two hours 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,	12 00	12 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
Miscellaneous,	41 00	45 00
	\$220 50	\$300 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 STATE LABOR FUND.

The object of this fund, five thousand dollars appropriated annually by the State, is to assist those Massachusetts 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.

ENDOWED LABOR FUND.

There is available also the income of five thousand dollars, the gift of a generous friend of the college, which will be used in payment for labor of deserving students needing assistance.

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 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.

Notwithstanding the death of Mr. Flint, these prizes will be continued under the name of the Flint prizes.

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; ten dollars for the best collection of Massachusetts trees and shrubs; and ten dollars for the best collection of Massachusetts woods.

J. D. W. FRENCH PRIZE.

Offered by the Bay State Agricultural Society to the members of the senior class for the best essay on forestry. Twenty-five dollars, to be called the J. D. W. French prize, in honor of the late J. D. W. French, formerly a trustee of the college, and one of the very earliest movers in favor of improved forestry management in New England.

WESTERN ALUMNI PRIZE.

Twenty-five dollars, to be awarded at the end of sophomore year to that member of the sophomore class who during his two years in college has shown the greatest improvement in scholarship, character and example. Offered by the Western Alumni Association.

FORESTRY PRIZE.

Two prizes, fifteen and ten dollars, offered to those members of the senior and junior classes who prepare the best essays on the management of the farm woodlot. Given by an anonymous friend.

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, 1905.

Grinnell Agricultural Prizes (Senior). — First prize, Bertram Tupper; second prize, Harold Foss Tompson.

Hills Botanical Prizes (Senior). — Best herbarium, Esther Cowles Cushman; best collection of Massachusetts trees and shrubs, Esther Cowles Cushman; best collection of Massachusetts woods, Chester Leland Whitaker.

Flint Oratorical Prizes (Junior). — First and second prizes equally divided between Ralph Ware Peakes and William Hunlie Craighead.

Burnham Essay Prizes (Sophomore). — First prize, Waldo Darius Barlow; second prize, Clinton King; third prize, Joseph Otis Chapman.

Burnham Declamation Prizes (Freshman). — First prize, Thomas Francis Waugh; second prize, Allan Dana Farrar.

Western Alumni Improvement Prize (Sophomore). — Henry Tyler Pierce.

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: George Howard Allen, Edwin White Newhall, Jr., Frederick Loring Yeaw.

Dairy Prizes (Winter Course Students). — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, William Everett Salmon; second prize, Charles Mason Carruth; third prize, Eugen Alfons Richard Schmitz.

Massachusetts Society for Promoting Agriculture: for highest scoring butter, first prize, Cecil Norman Victor Greenhalgh; second prize, John Baptiste Lucia, Jr.; third prize, Harry Rufus Carter.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, Morey Ambios Smith; second prize, Charles Mason Carruth; third prize, William Henry Ranney; fourth prize, Robert Edgar Pomeroy.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one-half ton Stockbridge fertilizer, Eugen Alfons Richard Schmitz.

Special prize, given by B. von Herff of New York, for best knowledge of the use of fertilizers on grass lands, Oliver Horace Gates.

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.

RECEIPTS AND DISBURSEMENTS FOR YEAR, DEC. 21, 1904, TO
DEC. 20, 1905.

RECEIPTS.

State Treasurer, Morrill fund,	\$16,666 66
Endowment fund:—	
United States grant,	7,300 00
State grant,	2,697 02
Maintenance appropriation,	5,000 00
Instruction appropriation,	13,000 00
Scholarship appropriation,	15,000 00
Labor appropriation,	5,000 00
Insurance, special appropriation,	150 00
Heating and lighting maintenance,	500 00
Dining hall maintenance,	500 00
Veterinary laboratory maintenance,	1,250 00
Library fund, income:—	
Amherst Savings Bank,	319 44
Bonds,	200 00
Burnham emergency fund, income:—	
Northampton Institute for Savings,	70 00
Massachusetts Agricultural College, in- terests,	75 00
Botanical laboratory fees,	342 96
Chemical laboratory fees,	563 03
Entomological laboratory fees,	98 22
Landscape gardening fees,	81 47
Zoölogical laboratory fees,	154 30
Agricultural department (including dairy school),	1,055 73
Farm department (produce, live stock, etc.),	11,041 22
Horticultural department (market garden- ing, nursery, etc.),	6,073 04
Rents, interest and sundries,	1,172 61
Tuition, room rents and text-books,	3,464 53
Heat and light,	2,107 08
<i>Amount carried forward,</i>	
	\$93,882 31

<i>Amount brought forward,</i>		\$93,882 31
Furniture sold,		4 50
Tools and lumber account,		2 41
Funds as reported Jan. 1, 1904,		42 00
Dining hall (board),		10,527 11
Insurance,		17,229 36
		<hr/>
		\$121,687 69

DISBURSEMENTS.

Labor appropriation,		\$4,569 97
Library, books, binding, etc.,		1,894 47
Burnham emergency prizes,		135 00
Agricultural laboratory,		29 06
Botanical laboratory, supplies, etc.,		396 75
Chemical laboratory, supplies, etc.,		260 73
Entomological laboratory, supplies, etc.,		36 12
Landscape gardening, supplies, etc.,		75 58
Veterinary laboratory, supplies, etc.,		1,251 32
Zoölogical laboratory, supplies, etc.,		197 68
Band, instruments,		109 15
Advertising,		698 90
Agricultural department,		2,574 15
Farm department,		17,593 83
Horticultural department,		9,333 94
Expense, labor, repairs, water and sundries,		6,490 48
Text-books,		1,677 40
Heating and lighting,		9,640 97
Furniture,		197 09
Tools and lumber account,		18 73
Extra instruction,		316 00
Salaries,		33,833 39
Funds, as reported due Jan. 1, 1904,		900 36
Insurance,		34 25
Dining hall, labor and provisions,		13,506 96
		<hr/>
		\$105,772 28
Total receipts,		\$121,687 69
Total disbursements,		105,772 28
Excess of receipts over disbursements,		<hr/>
		\$15,915 41

CASH ACCOUNT.

Dr.

Cash on hand Dec. 21, 1904,		\$6,498 21
Excess of receipts over disbursements, Dec.		
20, 1905,		15,915 41
		<hr/>
		\$22,413 62

Cr.

Cash on hand Dec. 20, 1905,		\$22,413 62
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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	
		<hr/> \$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 and insectary,	6,000 00	
Veterinary laboratory and stable,	22,500 00	
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	- ¹	
Graves house and barn,	1,500 00	
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Horticultural building,	37,000 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	
		<hr/> 252,775 00
		<hr/> \$297,125 00

EQUIPMENT.

Botanical department,	\$4,310 00
Horticultural department,	11,706 70
Farm,	12,931 78
Chemical laboratory,	1,515 00
Botanical laboratory,	3,641 53
Entomological laboratory,	15,450 00
Zoölogical laboratory,	3,286 00
Zoölogical museum,	6,103 00
	<hr/>
<i>Amount carried forward,</i>	\$58,944 01

¹ Burned Nov. 16, 1905.

<i>Amount brought forward,</i>		\$58,944 01	
Veterinary laboratory,		6,000 00	
Physics and mathematics,		3,848 60	
Agricultural department,		2,500 00	
Agricultural laboratory,		1,600 00	
Library,		27,000 00	
Fire apparatus,		350 00	
Band,		450 00	
Furniture,		1,500 00	
Text-books,		400 00	
Tools, lumber and supplies,		280 00	
Heating and lighting,		61,500 00	
Dining hall,		5,000 00	
		<hr/>	\$169,372 ⁷ / ₆₁

BALANCE SHEET DEC. 20, 1905.

Assets.

Real estate,		\$297,125 00	
Equipment,		169,372 61	
		<hr/>	\$466,497 61

Quick Assets.

Amount due farm,		\$602 33	
Amount due horticultural,		200 00	
Amount due for heat and light,		516 00	
Amount due for rent and text-books,		367 58	
Amount due for laboratory fees,		396 50	
Amount due for board,		600 00	
		<hr/>	\$2,682 41
Notes,		155 00	
Cash,		22,413 62	
		<hr/>	25,251 03
			<hr/>
			\$491,748 64

Liabilities.

Amount due from farm,		\$684 00	
Amount due from expense,		25 78	
Amount due from heating and lighting,		792 97	
Amount due from term bill,		68 70	
Amount due from agricultural,		73 23	
Amount due from laboratories,		89 79	
		<hr/>	\$1,734 47
Burnham emergency fund note,		3,000 00	
		<hr/>	\$4,734 47
Balance,			487,014 17
			<hr/>
			\$491,748 64

FUNDS.

Endowment Fund.

United States grant,	\$219,000 00	
Commonwealth grant,	142,000 00	
	<hr/>	\$361,000 00

This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same (for amount of income, see statement of receipts).

Burnham Emergency Fund.

Northampton Institution for Savings,	\$2,000 00	
Massachusetts Agricultural College note,	3,000 00	
	<hr/>	\$5,000 00

(For amount of income, see statement of receipts.)

Library Fund.

Amherst Savings Bank,	\$5,426 12	
Three bonds Lake Shore & Michigan Southern 4s,	3,000 00	
Two bonds New York Central debenture 4s,	2,000 00	
	<hr/>	\$10,426 12

FUNDS DESIGNED FOR SPECIAL PURPOSES.

Endowed Labor Fund (the Gift of a Friend of the College).

	Amount.	Income.
Two bonds American Telephone and Telegraph 4s,	\$2,000 00	\$80 00
One bond New York Central debenture 4s,	1,000 00	40 00
Two bonds Lake Shore & Michigan Southern 4s,	2,000 00	40 00
	<hr/>	<hr/>
	\$5,000 00	\$160 00
Interest from Hampden Trust Company,		26 88
Cash from Massachusetts Agricultural College, due as reported Dec. 21, 1904,		349 72
		<hr/>
		\$536 60
Paid for labor,	\$330 72	
Paid premium on bonds,	30 17	
	<hr/>	360 89
Balance of income,		<hr/>
		\$175 71
<i>Amount carried forward,</i>		<hr/>
		\$175 71

Amount brought forward, \$175 71

Hills Fund.

	Amount.	Income.
Northampton Institution for Savings,	\$2,180 00	\$76 30
One bond American Telephone and Telegraph Company 4s,	1,000 00	40 00
Three American Telephone notes, 5 per cent.,	3,000 00	150 00
One bond New York Central debenture 4s,	1,000 00	40 00
One bond New York Central & Lake Shore 3½s,	1,000 00	35 00
Boston & Albany Railroad stock,	362 00	31 68
	<hr/> \$8,542 00	<hr/> \$372 98
Cash from Massachusetts Agricultural College, due as reported Dec. 21, 1904,		462 40
		<hr/> \$835 38
Paid botanical and horticultural departments,		149 27
Balance of income,		<hr/> 686 11

Mary Robinson Scholarship Fund.

	Amount.	Income.
Northampton Institution for Savings,	\$820 00	\$28 70
Boston & Albany Railroad stock,	38 00	3 32
	<hr/> \$858 00	<hr/> \$32 02
Paid Massachusetts Agricultural College, due as reported Dec. 21, 1904,		36 76
Deficit,		<hr/> \$4 74

Whiting Street Scholarship Fund.

	Amount.	Income.
One bond New York Central debenture 4s,	\$1,000 00	\$40 00
Amherst Savings Bank,	260 00	10 40
	<hr/> \$1,260 00	<hr/> \$50 40
Paid scholarship,	\$28 00	
Paid Massachusetts Agricultural College, due as reported Dec. 21, 1904,	5 24	
	<hr/> 33 24	
Balance of income,		<hr/> 17 16
<i>Amount carried forward,</i>		<hr/> \$878 98

Amount brought forward, \$878 98

Gassett Scholarship Fund.

	Amount.	Income.	
One bond New York Central de- benture 4s,	\$1,000 00	\$40 00	
Cash from Massachusetts Agricultural Col- lege, due as reported Dec. 21, 1904,		22 00	
		<hr/> \$62 00	
Paid scholarship,		42 00	
Balance of income,		<hr/>	20 00

Grinnell Prize Fund.

	Amount.	Income.	
Ten shares New York Central & Hudson River Railroad stock,	\$1,000 00	\$50 00	
Cash from Massachusetts Agricultural Col- lege, due as reported Dec. 21, 1904,		66 24	
		<hr/> \$116 24	
Paid prizes,		50 00	
Balance of income,		<hr/>	66 24

Massachusetts Agricultural College.

	Amount.	Income.	
One share New York Central & Hudson River Railroad stock,	\$100 00	\$5 00	
Balance of income,		<hr/>	5 00
			<hr/> \$970 22
Deficit in Mary Robinson scholarship fund,			4 74
			<hr/>
Cash on hand of income,			\$965 48

Uninvested Balances of Funds.

Endowed labor,	\$143 39	
Hills,	72 75	
Whiting Street,	11 64	
Gassett,	11 64	
Library,	22 90	
	<hr/>	262 32
		<hr/>
Total cash on hand of funds,		\$1,227 80

I hereby certify that I have this day examined the accounts as reported by the treasurer, George F. Mills, for the year ending Dec. 20, 1905. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

AMHERST, Dec. 29, 1905.

CHAS. A. GLEASON,
Auditor.

GIFTS.

- From W. H. BOWKER (M. A. C., '71), Boston, one-half ton Stockbridge fertilizer, for prize in dairy school.
- MASSACHUSETTS SOCIETY FOR THE PROMOTION OF AGRICULTURE, one hundred and seventy-five dollars in prizes for dairy school.
- B. VON HERFF, New York, one ton of kainite, for prize in dairy school.
- S. C. KEITH, Jr., Charlestown, butter cultures for ten weeks.
- O. DOUGLASS, Boston, butter cultures for ten weeks.
- STODDARD MANUFACTURING COMPANY, Rutland, Vt., cover frame for Victor churn.
- Dr. MADISON BUNKER, Newton, Jersey bull calf.
- CYPHERS INCUBATOR COMPANY, Buffalo, N. Y., 1905 pattern standard incubator, 1906 pattern standard incubator, and egg-turning rack.
- CHAS. A. CYPHERS, Buffalo, N. Y., two model colony brooders.
- SYRACUSE CHILLED PLOW COMPANY, Syracuse, N. Y., three cultivators.
- CHILEAN NITRATE WORKS, New York, two and one-half tons nitrate of soda.
- GERMAN KALI WORKS, New York, six barrels "Torfmull," one ton sulfate of potash and one ton muriate of potash.
- AMERICAN STEEL AND WIRE COMPANY, New York, one thousand pounds sulfate of iron.
- E. MORTIMER & Co., New York, one-half ton Chincha guano.
- EXPERIMENT STATION, Orono, Me., one ton sand.
- VERMONT SOIL INOCULATION AND SEED COMPANY, Burlington, Vt., two half-acre packages of culture for clover; one acre package each of culture for alfalfa and soy beans.

From NATIONAL NITRO-CULTURE COMPANY, West Chester, Penn., one acre package Nitro-culture for red clover, one and one-half acre packages Nitro-culture for soy beans, two acre packages Nitro-culture for alfalfa.

DARLING & Co., Chicago, Ill., one thousand pounds beef scraps.

F. W. BIRD & SON, East Walpole, Mass., paroid roofing for henhouse.

F. ROSEBORO, Brooklyn, N. Y., fifty pounds Weedkiller.

W. ATLEE BURPEE & Co., Philadelphia, Penn., two pounds Uncle Gideon's Quick Lunch potatoes; two pounds Vermont Gold Coin potatoes.

HENRY FIELD, Shenandoah, Ia., two pounds Banner potatoes.

JOHN HENRY SMITH, Hartford, Conn., Monster squash seeds.

MASSACHUSETTS SOCIETY FOR THE PROMOTION OF AGRICULTURE, set "American Jersey Cattle Club Herd Registry."

Miss JULIA A. BRECKINRIDGE, Ware, Mass., annual reports of the secretary of the Massachusetts Board of Agriculture for 1856, '57, '61, '63, '78, '87, and '88; returns of the agricultural societies of Massachusetts for 1856; the statistical returns from the cities and towns of Massachusetts for 1855.

THE AMERICAN JERSEY CATTLE CLUB, New York, picture including portraits of all Jersey cows which took part in the dairy cow demonstration at the St. Louis Purchase Exposition, with their official records.

E. MORTIMER & Co., five large photographs.

H. T. FERNALD, Amherst, forty-four sets of eggs, many with nests.

LAWRENCE DICKINSON, Amherst, nest and eggs of bobwhite.

W. V. TOWER (M. A. C., '03), Roxbury, and E. A. BACK (M. A. C., '04), Florence, nest and eggs of broadwing hawk.

DAVID MACHIE, Boston, skull of black bear.

A. W. MORRILL (M. A. C., '00), Dallas, Tex., two horned toads.

From THE PUBLISHERS, subscriptions to —

The Southern Fancier, Atlanta, Ga.

Farm, Field and Fireside, Chicago, Ill.

The Furrow, Moline, Ill.

Swine Breeders' Journal, Indianapolis, Ind.

American Sheep Breeder, Chicago, Ill.

Dairy News, Philadelphia, Penn.

Southern Farm Magazine, Baltimore, Md.

The Breeder's Gazette, Chicago, Ill.

Vick's Family Magazine, Rochester, N. Y.

American Chemical Journal, Baltimore, Md.

Farm Implement News, Chicago, Ill.

The Journal of Biological Chemistry, New York.

The Country Gentleman, Albany, N. Y.

The Southern Planter, Richmond, Va.

Forestry Quarterly, Ithaca, N. Y.

The Journal of Agriculture and Horticulture, Montreal, Can.

The Southern Cultivator, Atlanta, Ga.

The Louisiana Planter, New Orleans, La.

LOANS.

DE LAVAL SEPARATOR COMPANY, three separators, pulley and crank piece, New York.

P. M. SHARPLES, three separators, West Chester, Penn.

STAR MILK COOLER COMPANY, star milk cooler, with anti-pressure standpipe, Haddonfield, N. J.

EMPIRE CREAM SEPARATOR COMPANY, one separator, Bloomfield, N. J.

A. H. REID CREAMERY AND DAIRY SUPPLY COMPANY, one separator, Philadelphia, Penn.

FARM REPORT.

The farm operations for the past year have been about the same as in years before. The principal crops have been hay, potatoes, corn and celery, with small lots of carrots and mangels.

The spring season was very dry, enabling us to work our land very early. The oats and peas were sown April 18, and potatoes were planted by April 26. Both crops came up nicely and looked well throughout the season.

Spraying the potatoes was begun June 3, followed by sprayings June 9 and 24, July 3 and 7, leaving two rows through the middle of the piece unsprayed for a check. The tops on these rows stood up equally as well as those sprayed, and not until after we began to dig the potatoes did we see the benefits of our spraying. A sprayed row gave on the average one-sixth more potatoes than one unsprayed. The formula used was the 6, 4, 50.

The continued dry weather gave us a chance to keep at work on our corn ground, so that we were able to finish planting by May 20. This early planting did not prove very successful, as much of the corn failed to germinate, and second planting had to be resorted to.

Three varieties of corn were received from the Department of Agriculture at Washington, namely, Selection 78, Hybrid 68 and Department of Agriculture Leaming. These varieties were the last to be planted, and were given the very best of culture. The first two failed to make any stand, and the ground had to be harrowed and planted over; the third had to be planted over by hand, but proved a little better than the others.

Twenty-one acres of corn land were seeded down this year.

College Farm Crops.

CROPS.	Acres.	TOTAL PRODUCT.		COST.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure and Fertilizers.	Labor and Seed.			
Celery,	1	200 doz. bunches.	-	\$17 58	\$94 60	\$250 00	\$147 82	-
Carrots,	$\frac{1}{2}$	263	-	17 03	32 16	157 80	108 67	-
Mangels,	$\frac{1}{6}$	-	8 $\frac{1}{2}$	3 82	16 08	45 00	26 10	-
Oats and peas,	1	-	14 $\frac{1}{2}$	-	20 20	66 00	45 70	-
Hay,	71	-	193 $\frac{1}{4}$	-	-	2,319 00	-	-
Rowen,	-	-	60	-	-	1,024 00	-	-
Grass cut for green feed,	-	-	11	-	501 43	44 00	2,800 19	-
Rowen pastured,	-	-	10	-	-	50 00	-	-
Potatoes,	6	-	-	112 11	268 91	815 00	423 88	-
Field corn,	13	{ 1,000 } { 250 }	Stover 50	391 86	830 60	2,377 00	1,144 54	-
Ensilage corn,	18	-	270	-	-	-	-	-
Pop corn and squash,	$\frac{2}{4}$	{ 55 } { - }	Stover 3,000 } 3 }	13 62	21 00	{ 72 50 } { 60 00 }	97 88	-
Winter rye,	1	-	9	-	14 00	27 00	13 00	-
Rape,	2	-	-	22 68	21 75	50 00	5 57	-

Manures and Fertilizers for the Several Crops per Acre.

	Rape, Two Acres.	Corn, Campus, Two Acres.	Corn, Ensilage, Twelve Acres.	Corn, Ensilage, Seven Acres.	Corn, Field, Thirteen Acres.	Mangels, One-sixth Acre.	Carrots, One-half Acre.	Potatoes, Four Acres.	Potatoes, Two Acres.	Celery, One Acre.	Pop Corn and Squash, Three-fourths Acre.
Manure (cords),	2	4	-	3	4	4	4	3	-	5	3
Nitrate of soda (pounds),	100	100	100	100	100	200	200	100	100	150	150
High-grade sulfate of potash (pounds),	100	150	150	125	150	-	-	250	250	200	200
Phosphatic slag (pounds),	600	400	500	400	500	600	600	-	-	500	600
Lime (pounds),	2,000	-	2,000	-	-	-	-	-	-	-	-
Muriate of potash (pounds),	-	-	-	-	-	350	350	150	150	-	-
Dried blood (pounds),	-	-	-	-	-	-	-	250	250	-	-
Tankage (pounds),	-	-	-	-	-	-	-	400	400	-	-

LIVE STOCK.

The kinds and numbers of the several classes of live stock are shown below:—

Horses.—French Coach, 1 stallion, 3 mares, 2 fillies; Percheron, 1 stallion; German Coach, 1 mare; French Coach, half-blood, 2 colts; Percheron, three-fourths blood, 2 mares, 1 colt; work horses, 5.

Neat Cattle.—Jersey, 2 calves, 2 cows; Ayrshire, 3 calves; 7 cows; Holstein-Friesian, 1 bull, 7 cows; total, 22 head.

Sheep.—Southdown, 7 breeding bucks, 48 ewes, 7 lambs; total, 62 head.

Swine.—Berkshire, 1 boar, 4 sows; Yorkshire, 1 boar, 11 sows; total, 17 head.

The stock is all making very satisfactory progress. Owing to the loss by fire of two months' milk records, we are unable to give a yearly statement of the milk product, but suffice it to say the herd has done better than last year.

THE FARM FINANCES.

The cash receipts for the year are \$10,757.04, and there is due on account of sales made during the year over and above bills payable the sum of \$194.65. This added to the cash receipts makes a total of \$10,951.69,—an increase of \$4,191.37 over last year. The inventory at the present time is \$12,931.18; to this add the inventory of loss by fire, \$10,645.23, making a total of \$23,576.41,—an increase of \$5,663.83 over last year's inventory. This increase of \$5,663.83 added to cash receipts makes a total of \$16,615.52; from this deduct the total expenses for the year, or \$16,390.98, and we have a balance of \$224.54 to credit to the farm.

The cash received during the year has been derived from the following sources: for milk and cream, \$4,492.22; cattle, \$2,019.30; horses, including fees for the use of stallions, \$435.95; swine, \$937; sheep, \$261.36; hay, \$38.90; potatoes, \$372.81; celery, \$139.83; labor, \$1,402.58; sundries, \$657.09.

E. H. FORRISTALL,

Superintendent.

MILITARY DEPARTMENT.

Acting President WM. P. BROOKS, *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, 1905.

I have been in charge of the department of military science and tactics since September, 1905, under Special Order, No. 195, War Department, dated Washington, D. C., Aug. 23, 1905. 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. 101, War Department, 1905, this instruction is graded, in respect to the military course, as of the second class, "B," requiring the following minimum of exercises, viz.:—

At every institution of Class B, at which a professor of military science and tactics is detailed, it shall be provided in its regular schedule of studies that at least three hours per week for two years, or the equivalent thereof, shall be assigned for instruction in the military department, not less than two-thirds of the total time to be devoted to practical drill, including guard mounting and other military ceremonies, and the remainder to theoretical instruction.

The character of instruction will vary according to the nature of the institutions and the facilities afforded; but instruction of classes A, B, and C shall include practical instruction in the following subjects:—

Infantry drill regulations.

Field service regulations.

Manual of guard duty.

Firing regulations for small arms.

Theoretical instruction shall include the portions of the above subjects covered by the practical instruction, and may be supplemented by lectures.

The above requirements of the War Department have been strictly complied with since the college opened in September, and additional drills have been given in "Butts' Manual of

Physical Drills," and in artillery drill. Lectures, though not now required, have been given on military subjects. Only seniors and freshmen have been required to take theoretical instruction, each class once per week.

Up to June 29, 1905, General Order, No. 65, War Department, dated April 6, 1904, governed in this department, and required the following:—

(a) Practical:—

Infantry drill regulations, through the school of the battalion in close and extended order.

Advance and rear guards and outposts.

Marches.

The ceremonies of battalion review, inspection, parades, guard mounting and escort of the colors.

Infantry target practice.

Instruction in first aid to the injured.

Weather permitting, there shall be not less than one parade and five guard mounts during each week of the school term, and one battalion inspection and review each month.

In no case shall target practice, to the extent permitted by the allowance of ammunition, be omitted during the school year except on authority given in each case by the Secretary of War.

(b) 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, requisition and property returns; (6) lectures: one on the organization of the United States Army, one on patrols and outposts, one on camps and camp hygiene, three on lines and basis of operations, two on attack and defence of advance and rear guards, outposts and convoys.

Records of this department show above order to have been complied with except as to number of guard mounts and target practice, it being necessary to reduce guard mounts to four per week, and to limit the number of students taking target practice.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.:—

Monday, recitation of seniors, 5 P.M.; drill, 3.45 P.M.

Tuesdays, the same practical instruction as for Mondays.

Thursdays, drill at 3.45 P.M.; recitation of freshmen, 2.30 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 the companies, after which the exercises include all movements in company and battalion drill.

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 "Butts' Manual of Physical Drill," the latter in the drill hall during the winter months, and when the weather is too inclement to drill out of doors.

One hundred and twenty-four 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 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 which only a few students can take part, is of little or no benefit. To become a good marksman requires a careful study of the mechanism of the rifle; frequent practice upon the rifle range under various conditions of weather, and daily practice for a few minutes each day in the sighting; pointing and aiming drills for at least a month before going to the range; also gallery practice.

If target practice is to be continued, I strongly recommend that at least two more targets be erected; and, if it is possible, that some provision be made by the State whereby tentage and camp equipage be provided which would enable the whole student body to go into camp for one week in each college year, the time to be given to instruction in guard and outpost duty, target practice, construction of shelter trenches, etc. If this cannot be done, I would suggest the erection of one more target, and restrict target practice to the junior and sophomore classes. As conducted at present, target practice is of little value, and is not much more than a waste of time and ammunition.

The band, under the leadership of Stanley Sawyer Rogers, member of the senior class, is doing good work, and merits all the encouragement that has been given it in the way of appropriations. During the winter it will play for the drills in "Butts' Manual."

All the buildings under my supervision are in good condition, except that the drill hall is greatly in need of 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. It was with difficulty that the drill hall was saved during the recent burning of the college barn, owing to its shingled roof.

Under the provisions of General Orders, No. 65, War Department, 1904, the following-named students of the class of 1905 were reported to the Military Secretary of the Army and the Adjutant-General of the Commonwealth as having shown special aptitude in military exercises, viz.: George H. Allen, Frederick L. Yeaw, Edwin W. Newhall.

During a recent wind storm the college flagstaff was blown down and rendered unfit for further use. I would recommend that a new one of steel be erected, similar to the one in the town of Amherst.

Under the provisions of General Orders, No. 101, War Department, dated June 29, 1905, I quote the following:—

The reports of the regular inspection of the colleges and schools to which officers of the army are detailed as professors of military science and tactics will hereafter be submitted annually to the general staff for its critical examinations; and the chief of staff shall report to the Secretary of War from the institutions which have maintained a high standard the six whose students have exhibited the greatest application and proficiency in military training and knowledge.

The President of the United States authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded annually to an honor graduate of each of the six institutions thus designated, provided that sufficient vacancies exist after the appointment of graduates of the Military Academy at West Point and the successful competitors in the annual examination of enlisted men. By the term honor graduate is understood a graduate whose attainments in scholarship have been so marked as to receive the approbation of the president of the school or college, and whose proficiency in military training and knowledge and intelligent attention to duty have merited the approbation of the professor of military science and tactics.

This has been the rule for the past two years, but up to date no Agricultural College, Class B, has received such an appoint-

ment. I believe this to be due entirely to the limited amount of time that can be given to the military department at institutions of Class B. Thus far all appointments provided for in above order have gone to institutions of Class A and Class C, schools that are essentially military schools, and where a great amount of time is devoted to the military department. I do not believe Class B institutions can compete with those of Class A and Class C in the military department.

Inasmuch as there are 45 Class B institutions and only 40 of Class A and Class C that are affected by above order, it would seem to me a better arrangement if at least two of the above appointments could go to Class B institutions, and thus create competition among them in military work. This, in my opinion, is a prize of great value, well worth striving for, and should inspire the ambition of every student. I make the above suggestion, hoping it may bear fruit by way of recommendation to War Department, which will lead to giving Class B institutions the above suggested two appointments.

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, radical, 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.
- 100 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. Two hundred and seventeen 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 1905.

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. GEORGE CHIPMAN MARTIN, . . . Eighteenth U. S. Infantry.

Staff.

Cadet Adjutant, . . . CLARENCE ELLSWORTH HOOD.
 Cadet Quartermaster, . . . ADDISON TYLER HASTINGS, Jr.
 Cadet Sergeant Major, . . . GEORGE WARREN SLEEPER.
 Cadet Ordnance Sergeant, . . . JOHN NICHOLAS SUMMERS.
 Cadet Color Sergeant, . . . CHARLES ALMON TIRRELL.
 Cadet Color Sergeant, . . . HENRY MERWIN RUSSELL.

Company A.

Cadet Captain, . . . HERMAN AUGUSTUS SUILKE.
 Cadet First Lieutenant, . . . FRY CIVILLE PRAY.
 Cadet Second Lieutenant, . . . BENJAMIN STRAIN.
 Cadet First Sergeant, . . . WILLIAM OTIS TAFT.
 Cadet Sergeant, . . . WALTER EBENEZER DICKINSON.
 Cadet Sergeant, . . . FRANCIS DALLAS WHOLLEY.
 Cadet Sergeant, . . . EDWIN DANIELS PHILBRICK.
 Cadet Sergeant, . . . CLIFTON HARLAND CHADWICK.
 Cadet Corporal, . . . HENRY TYLER PIERCE.
 Cadet Corporal, . . . HAROLD EDWARD ALLEY.
 Cadet Corporal, . . . HARRY BURTON FILER
 Cadet Corporal, . . . WILLIAM HUNLIE CRAIGHEAD.
 Cadet Corporal, . . . HERBERT POLAND WOOD.
 Cadet Corporal, . . . RAYMOND DEAN WHITMARSH.
 Cadet Corporal, . . . MARCUS METCALF BROWNE.
 Cadet Corporal, . . . CHESTER SOCRATES GILLETTE.

Privates, 62; aggregate, 78.

Company B.

Cadet Captain, . . . GEORGE TALBOT FRENCH.
 Cadet First Lieutenant, . . . DANIEL HENRY CAREY.
 Cadet Second Lieutenant, . . . ALEXANDER HENRY MOORE WOOD
 Cadet First Sergeant, . . . ARTHUR WILLIAM HALL, Jr.
 Cadet Sergeant, . . . FRÉDERICK CHARLES PETERS.
 Cadet Sergeant, . . . WAYLAND FAIRBANKS CHACE.
 Cadet Sergeant, . . . EDWIN FRANCIS GASKILL.
 Cadet Sergeant, . . . RICHARD WELLINGTON.
 Cadet Corporal, . . . EDWIN HOBART SCOTT.

Cadet Corporal,	JOHN THOMAS CARUTHERS.
Cadet Corporal,	JAMES HENRY WALKER.
Cadet Corporal,	CLIFFORD BRIGGS THOMPSON.
Cadet Corporal,	JOSEPH OTIS CHAPMAN.
Cadet Corporal,	CLINTON KING.
Cadet Corporal,	RALPH JEROME WATTS.
Cadet Corporal,	THOMAS ADDIS BARRY.

Privates, 62; aggregate, 78.

Band.

Cadet First Lieutenant, . . .	STANLEY SAWYER ROGERS.
Cadet First Sergeant, . . .	RALPH WARE PEAKES.
Cadet Sergeant,	LOUIS HALE MOSELEY.
Cadet Corporal,	EVERETT PIKE MUDGE.
Cadet Corporal,	FRANK HENRY KENNEDY.

Privates, 17; aggregate, 22.

Total in military department: 2 captains, 5 first lieutenants, 2 second lieutenants, 1 sergeant major, 1 ordnance sergeant, 2 color sergeants, 3 first sergeants, 9 sergeants, 18 corporals, 141 privates, aggregate 184.

Respectfully submitted,

GEORGE CHIPMAN MARTIN,
Captain, Eighteenth United States Infantry, 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. Value of Additions to Equipment during the Year ended June 30, 1905.

1. Permanent endowment,	\$424 65
2. Library,	1,000 00
3. Apparatus,	2,272 71
4. Dining hall,	5,000 00
	<hr/>
Total,	\$8,697 36

II. Receipts for and during the Year ended June 30, 1905.

1. State aid :—	
(a) Income from endowment,	\$4,407 27
(b) Appropriation for current expenses,	43,650 00
(c) Appropriations for buildings or for other special purposes,	3,500 00
2. Federal aid :—	
(a) Income from land grant, act of July 2, 1862,	10,410 21
(b) Additional endowment, act of Aug. 30, 1890,	16,666 66
3. Fees and all other sources,	3,782 24
	<hr/>
Total,	\$82,416 38
4. Federal appropriation for experiment stations, act of March 2, 1887,	\$15,000 00

III. Property, Year ended June 30, 1905.

Value of buildings,	\$246,775 00
Value of other equipment,	167,543 06
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60

Value of farm and grounds,	\$44,350 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,	142,000 00
Number of bound volumes in library June 30, 1905,	26,503

IV. Faculty during the Year ended June 30, 1905.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	28
2. Number of staff of experiment station,	25

V. Students during the Year ended June 30, 1905.

1. College of Agriculture and Mechanic Arts, collegiate and special courses,	232
2. Graduate courses,	8
	<hr/>
Total, counting none twice,	240

EIGHTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1906.

HATCH EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

JAMES DRAPER, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
CHARLES H. PRESTON.

SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio.*

Station Staff.

CHARLES A. GOESSMANN, PH.D., LL.D., *Honorary Director and Chemist (fertilizers).*
WILLIAM P. BROOKS, PH.D., . . . *Director and Agriculturist.*
GEORGE E. STONE, PH.D., . . . *Botanist.*
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.*
FREDERICK R. CHURCH, B.SC., . . . *Assistant Agriculturist.*
NEIL F. MONAHAN, B.SC., . . . *Assistant Botanist.*
HENRI D. HASKINS, B.SC., . . . *First Assistant Chemist (fertilizers).*
EDWARD G. PROULX, B.SC., . . . *Second Assistant Chemist (fertilizers).*
E. THORNDIKE LADD, D.SC., . . . *Third Assistant Chemist (fertilizers).*
EDWARD B. HOLLAND, M.S., . . . *First Chemist (foods and feeding).*
PHILIP H. SMITH, B.SC., . . . *Assistant Chemist (foods and feeding).*
ARTHUR C. WHITTIER, B.SC., . . . *Assistant Chemist (foods and feeding).*
FRANK G. HELYAR, B.SC., . . . *Inspector (foods and feeding).*
SUMNER R. PARKER, B.SC., . . . *Dairy Tester (foods and feeding).*
ROY F. GASKILL, . . . *Assistant in Foods and Feeding.*
WALTER B. HATCH, B.SC., . . . *Assistant Horticulturist.*
CLIFTON H. CHADWICK, . . . *Observer.*

REPORT OF THE DIRECTOR.

WILLIAM P. BROOKS, DIRECTOR.

The work of the Hatch Experiment Station during the past year has progressed under favorable conditions. The only changes in the station staff have been a few affecting minor positions, which are elsewhere referred to. There has accordingly been no interruption in the lines of investigation which have been in progress.

Besides the monthly meteorological bulletins, during the past year four other bulletins have been issued: Nos. 103 and 104 on the subject of fertilizers and the results of analyses thereof; No. 105 on tomatoes under glass and methods of pruning tomatoes; and No. 106 on condimental stock and poultry foods.

The work of the section of our division of chemistry having to do with fertilizers shows that the conditions of the fertilizer trade in the State are substantially the same as during recent years. The manufacturers and dealers still offer an enormous number of different brands of so-called complete and special fertilizers in the markets. The number of samples analyzed during the past year is 511, representing 313 distinct brands. There can be no doubt that the business of manufacturing and selling fertilizers might easily be greatly simplified; that a great reduction in the number of brands offered, without loss in any direction, is possible; and that the result of such simplification and reduction in the number of brands would be that fertilizers sufficiently varied for every purpose could be furnished to the farmers at lower prices than those at present prevailing.

The fertilizer section of our division of chemistry has during the past year analyzed the usual number of samples

of miscellaneous materials, wood ashes, lime ashes, soils, etc. Such samples as are sent in by the farmers are usually analyzed and the results reported without charge.

The bulletin on tomatoes under glass is an important contribution to knowledge on the best methods of handling this crop, which is coming to be one of much importance in this State. Bulletin No. 106, on condimental stock and poultry foods, presents analyses of a large number of foods coming under these classes. It discusses the utility of such foods, and their cost as compared with the more common food stuffs. It is clearly shown that their cost is in excess of what appears to be a perfectly fair estimate of their value. The bulletin presents a brief résumé of the results of experiments in the use of stock and poultry foods, which tends to show that the claims made for these foods are not justified by facts. The results of an experiment in the department of foods and feeding are presented and discussed, the conclusion being that the food under trial (Pratt's) did not appear to be superior in any way to a like mixture of corn meal and wheat middlings, while the cost was considerably greater.

In the division of foods and feeding, under Dr. J. B. Lindsey, a number of other important lines of investigation have been followed during the year. A somewhat full statement of the results in a number of these will be found in Dr. Lindsey's report, which is transmitted herewith. Among the more important results of these investigations are the following points: Bibby's dairy cake, a food which has been persistently urged upon the attention of our milk producers, has been carefully tested, but has been found to be less satisfactory from an economical point of view than some of the ordinary food stuffs.

Eureka corn has been carefully compared with Sibley's Pride of the North corn, from the standpoint both of production and of food value. It is found that, although the Eureka gives a much heavier yield, the excess in weight is made up almost exclusively of water. The food value of the product of an acre of Eureka corn is not equal to the food value of the much smaller acre product of Sibley's Pride of the North.

Wheat bran has been compared with corn silage, in connection in both cases with some of the more nitrogenous concentrates, as food for milch cows. The results indicate that silage is equally as satisfactory as the bran, and that by substitution of silage for the bran the necessary outlay for purchased foods in milk production can be greatly reduced.

This division has carried out an interesting investigation into the conditions prevailing in milk production in Amherst and neighboring towns. It is found that the conditions are often quite unsanitary; that bacteria are frequently exceedingly numerous in the milk, indicating improper methods of handling; and that in general there is urgent need of improvement. In the judgment of Dr. Lindsey, the results of this investigation indicate the desirability of the establishment of some regular system of inspecting dairies. It is believed that this is something which consumers in increasing numbers will be likely to insist upon in the near future.

In the horticultural division the only investigation sufficiently advanced to justify report is that undertaken, and in part reported upon in our last annual report, on methods of pruning peach trees injured by winter-killing. It will be remembered that four systems were under trial: no pruning, light pruning, moderate pruning, and severe pruning. Severe pruning consisted in removing nearly all the branches of the injured tree. The observations of another year lead to the conclusion that this system cannot be recommended. A more moderate pruning, consisting of the removal of from one-third to one-half of the growth of the previous year, seems to have given results which are on the whole most satisfactory; and such pruning is recommended in all cases when the wood has been injured by winter-killing. If only the fruit buds have been destroyed by the winter, it is recommended to prune back the previous season's growth severely, leaving only two or three buds.

In the entomological division, experiments are in progress with a view to determining the definite strength of hydrocyanic acid gas which can be used with safety on plants in greenhouses under varying conditions of growth.

In the report of the division of botany and vegetable pathology will be found a discussion of the general conditions as affecting plant diseases during the past year; references to the somewhat unusual attack of the potato rot fungus (*Phytophthora infestans*) on the tomato; and a discussion of the causes of sun scald and the browning of the foliage of conifers and other evergreens.

The report of the vegetable pathologist, Dr. George E. Stone, includes also a suggestive discussion on winter-killing as affecting trees and shrubs, as a result of the exceptionally cold winters 1902-03 and 1903-04.

The great importance of suitable aeration of the soil for perfect germination of certain seeds is brought out by another paper. The effects of sterilization of soils respectively rich and low in organic matter on germination and the growth of plants have been investigated. It has been found that, if the soil is rich in organic matter, sterilization is favorable both to germination and subsequent growth; but if the soil contains little organic matter, such treatment is unfavorable.

The influence of treating seeds in soil decoctions of varying strengths has been carefully studied, and it is shown that such decoctions from sterilized soil when highly diluted exercise a favorable effect on germination. The report of Dr. Stone includes also the presentation and discussion of results of various methods of seed selection. The conclusion is that, for seeds adapted to that method of handling, the use of sieves of suitable mesh as a means of separating the small and inferior seeds is strongly to be recommended. The use of other methods of separation in the case of seeds which cannot be successfully handled by sifting is urged, as being of much importance.

The work of the agricultural division during the past year has followed the usual lines, and is elsewhere briefly summarized.

Among the different bulletins and reports which have been issued by the station, the following are still in stock and can be furnished on demand:—

- No. 3. Tuberculosis.
- No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
- No. 33. Glossary of fodder terms.
- No. 41. On the use of tuberculin (translated from Dr. Bang).
- No. 64. Analyses of concentrated feed stuffs.
- No. 67. Grass thrips; treatment for thrips in greenhouses.
- No. 75. Fertilizer analyses.
- No. 76. The imported elm-leaf beetle.
- No. 77. Fertilizer analyses.
- 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. 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. 92. Fertilizer analyses.
- No. 95. Fertilizer analyses; notes on barnyard manure; trade values of fertilizing ingredients.
- No. 96. Fungicides; insecticides; spraying calendar.
- No. 97. A farm wood lot.
- No. 98. Inspection of concentrates.
- No. 99. Dried molasses beet pulp; the nutrition of horses.
- No. 100. Fertilizer analyses; market values of fertilizing ingredients.
- No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.
- No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufactures, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.
- No. 104. Analyses of manurial substances and licensed fertilizers; market values of fertilizing ingredients.
- No. 105. Tomatoes under glass; methods of pruning tomatoes.

No. 109. Condimental stock and poultry foods.

Special bulletin, — The coccid genera *Chionaspis* and *Hemichionaspis*.

Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.

Technical bulletin, No. 2, — The graft union.

Index, 1888–95.

Annual reports, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906.

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

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

ANNUAL REPORT

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

For the Year ending June 30, 1905.

Cash received from United States Treasurer, . . .	\$15,000	00
Cash paid for salaries,	\$6,992	42
for labor,	1,788	14
for publications,	782	84
for postage and stationery,	367	35
for freight and express,	221	78
for heat, light, water and power,	544	60
for chemical supplies,	106	39
for seeds, plants and sundry supplies,	410	48
for fertilizers,	738	11
for feeding stuffs,	379	78
for library,	78	36
for tools, implements and machinery,	398	37
for furniture and fixtures,	162	26
for scientific apparatus,	586	31
for live stock,	127	05
for travelling expenses,	158	46
for contingent expenses,	25	00
for building and repairs,	1,132	30
	\$15,000	00
Cash received from State Treasurer,	\$13,625	00
from fertilizer fees,	4,365	00
from farm products,	1,512	95
from miscellaneous sources,	3,463	70
Balance June 30, 1904,	3,383	55
	\$26,350	20

Cash paid for salaries,	\$13,678 34	
for labor,	2,337 59	
for publications,	651 50	
for postage and stationery,	308 52	
for freight and express,	136 62	
for heat, light, water and power,	1,021 32	
for chemical supplies,	615 56	
for seeds, plants and sundry sup- plies,	451 51	
for fertilizers,	7 39	
for feeding stuffs,	613 28	
for library,	92 08	
for tools, implements and machin- ery	17 33	
for furniture and fixtures,	174 11	
for scientific apparatus,	735 74	
for live stock,	172 00	
for travelling expenses,	1,400 79	
for buildings and repairs,	198 86	
Balance,	3,737 66	\$26,350 20

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1905; that I have found the same well kept and classified as above; 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 of the \$15,000; and that \$3,737.66 are left of the State appropriation and of funds received from miscellaneous sources.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 7, 1905.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The attention of this division during the year has been largely confined to the work of making the usual observations of the various weather phenomena and a proper tabulation of these records, together with such computations as are found necessary for the purpose of comparison. The installation of some new apparatus has required some changes in the manner of tabulation, but the only effect on the results is to render them more accurate.

At the beginning of each month the usual bulletin of four pages has been issued, giving the more important daily records and monthly means, together with a summary of the results. The annual summary will be issued as a part of the December bulletin. In addition to issuing the bulletins, a considerable number of letters have been required to answer specific inquiries regarding rainfall, temperature and other features of the weather.

This station, being one of the voluntary observers' stations of the United States Weather Bureau, has furnished the section director at Boston with the usual monthly reports, and has also agreed to furnish the weekly snow reports during the winter. A phenological record has also been made, and a copy furnished the section director at his request.

The local forecast official at Boston has furnished this station with the local weather predictions daily except Sundays, and the proper signals have been displayed from the flagstaff on the tower. It was found necessary to shorten the flagstaff a few feet, but this has not resulted in making the signals less noticeable.

Owing to the unsatisfactory records made by some of the Draper self-recording instruments in the tower, it was decided to secure some of other make whose records would be more precise. Accordingly, a triple electric register for recording sunshine, rainfall and wind velocity was purchased from Julien P. Friez, and during the summer vacation the wiring was done to put it in working order. The sunshine recorder was mounted on top of the tower and connected by wires to the register in the tower. Two Edison primary batteries furnish the current required to operate the register at intervals of one minute while the sun is shining. A tipping-bucket rain gauge on the campus is connected to the register in the tower by more than a thousand feet of wire, and each one-hundredth of an inch of rainfall is registered. This furnishes a record of the rate of precipitation during a storm, as well as the total amount. The record is also checked by measurement in a standard rain gauge. A small anemometer of the Weather Bureau pattern was mounted on top of the tower in place of the Draper rain gauge, which was taken down, and each mile of wind travelled is recorded on the register below. As the drum on which all the above-mentioned records are made travels at a rate of nearly three miles per hour, the records are very distinct, and variations in rate of wind movement, as well as in the rainfall, are easily noted. A set of maximum and minimum thermometers of the Weather Bureau pattern was purchased during the year, to replace others that were greatly worn.

The assistant observer, Mr. C. H. Chadwick, was advanced to the position of observer in June, succeeding Mr. G. W. Patch.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANTS, F. R. CHURCH, S. B. HASKELL.

The work of the agricultural department for the past year has closely followed the lines of recent years. The leading object of our work is, by long-continued comparative experiments, to throw light upon some of the many problems connected with the use of manures and fertilizers. The results of a single year may be of value as a guide to practice, but it is important to know concerning any given system, not alone the immediate effect upon the crop, but the ultimate effect upon the soil as well. This is made manifest only by continued manuring along definite lines. Thus, by long-continued comparison of different materials which may be used respectively as sources of any given plant food element, we may hope to determine their real and average relative value, and, by suitable rotation of crops, their relative suitability also for different plants. By continued experiment along definite lines in successive years we may hope, moreover, to discover the relation of season to the fertilizer efficiency of the different fertilizer materials under comparison. With definite knowledge concerning immediate effect upon the crop, ultimate effect upon the soil and differences in effect due to variations in seasons, we shall be in a position to give advice of value both to the farmer seeking to produce crops at lowest cost and to the fertilizer manufacturer. The work carried on in the department during the past season has involved the care of 244 field plots in our various fertilizer and variety tests, 150 closed plots and 245 pots in vegetation experiments. The work in the closed plots and the vegetation experiments serve as valuable checks upon the accuracy of field work, and enable us to

extend the scope of our investigations. Besides the care for all this work, we have a grass garden including 48 species and 7 varieties, most of which occupy one square rod each. Our work with poultry has followed the general lines of investigation of earlier years, the principal subject under investigation being the relations of different foods and food combinations to egg production. A detailed report of results obtained will be at this time presented for but a small number of the experiments in progress.

The principal subjects of inquiry discussed, and the more important results, very briefly stated, are as follows:—

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 was mixed oats and peas for hay; and, on the basis of yield, the nitrogen-furnishing materials rank in the following order: nitrate of soda, dried blood, sulfate of ammonia, and barnyard manure. On the basis of increase, as compared with no-nitrogen plots, taking into account all the crops grown since the experiment began, the materials rank as follows: nitrate of soda, 100 per cent.; dried blood, 68.72 per cent.; sulfate of ammonia, 60.78 per cent.; barnyard manure, 80.58 per cent.

II. — To determine the relative value of muriate as compared with high-grade sulfate of potash for field crops. The results of this year indicate the sulfate to be superior to the muriate for clover, for rhubarb, and for blackberries.

III. — 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 soy beans. The different potash salts rank in the following order: carbonate, high-grade sulfate, silicate, nitrate, muriate, low-grade sulfate, and kainite. The crop where the latter salt was used was by far the poorest in the field, being much lower than the crop of the plots to which no potash has been applied for the past eight years.

IV. — To determine the relative value in crop production of a fertilizer mixture rich in potash, as compared with one

representing the average of special corn fertilizers purchasable in our markets. The crop of this year was hay, — mixed timothy, red-top and clovers. The crops were substantially equal; but, as the cost of fertilizers is lower where the fertilizer richer in potash is used, the advantage is with that combination of materials.

V. — To determine the relative value in corn and hay production of a moderate application of manure alone, as compared with a smaller application of manure used in combination with 160 pounds of high-grade sulfate of potash per acre. The crop of this year was hay, — mixed timothy, red-top and clovers. The larger average yield was produced on the combination of manure and potash; and, as this combination costs \$6.40 less per acre than the larger quantity of manure alone, the advantage in favor of the combination is decisive.

VI. — To determine which is better economy, to spread manure as hauled from the stable during the winter, or to place in a large heap to be spread in spring. This experiment occupies five pairs of plots. The spring application gave the better yield in all cases, but the difference was not sufficiently large to cover the larger cost of the extra handling involved in the case of the manure spread in the spring. The winter of 1904–05, however, was exceptionally favorable to good results from application at that season, as there was little or no wash over the surface.

VII. — To determine the economic result of using in rotation on grass lands: the first year, barnyard manure, 8,000 pounds per acre; the second year, wood ashes, 1 ton per acre; and the third year, bone meal, 600, and muriate of potash, 200, pounds per acre. The average yield of hay during the past season, all three systems of manuring being represented, on a total area of about 9 acres, is at the rate of about 4,840 pounds of hay per acre. The average for the thirteen years during which the experiment has continued, 1893–1905, inclusive, is 6,479 pounds.

VIII. — To determine whether the application of nitrate of soda after the harvesting of the first crop will give a profitable increase in the rowen crop. The increases produced

in the four pairs of plots under comparison were relatively small except in one instance. Nitrate applied at the rate of 250 pounds per acre gave an apparent increase of nearly 1 ton of rowen, which is considerably more than sufficient to cover the cost of the nitrate.

IX.—To test the relative value for the production of garden crops of fertilizers supplying respectively nitrogen and potash, when used with manure. The nitrogen fertilizers compared are dried blood, nitrate of soda and sulfate of ammonia. The use of the nitrate is attended with the greatest profit. On the basis of total crops produced, the relative standing of the different nitrogen fertilizers is: for the early crops, nitrate of soda, 100 per cent.; dried blood, 95.67 per cent.; sulfate of ammonia, 63.08 per cent.; for the late crops, nitrate of soda, 100 per cent.; dried blood, 98.77 per cent.; sulfate of ammonia, 79.52 per cent.

The potash salts under comparison are high-grade sulfate and muriate. For the fifteen years the relative standing of these fertilizers is: for the early crops, sulfate of potash, 100 per cent.; muriate of potash, 94.66 per cent.; for the late crops, sulfate of potash, 97.9 per cent.; muriate of potash, 100 per cent.

X.—To determine whether alfalfa is a profitable crop in Massachusetts. A large number of experiments tried during the past eight or ten years indicates that it is quite doubtful whether alfalfa can be successfully grown under our climatic conditions.

XI.—Comparison of different feeds and feed combinations furnishing the essential nutrients in varying proportions for laying hens. The results indicate corn to have superior merit among the different grains for the production of eggs, considered from the standpoint both of total number and economy of production. Rice is somewhat superior in number of eggs produced to corn, but the cost is so great as to render its use inexpedient.

I. — MANURES AND FERTILIZERS FURNISHING NITROGEN COMPARED. (FIELD A.)

To make clear the plan of the experiment, which is continuous, I quote from the seventeenth annual report:—

The experiments in Field A have two principal objects in view: first, to compare the efficiency (as measured by crop production) of a few standard materials which may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a legume will render the application of nitrogen to a succeeding crop of another family unnecessary. The field includes eleven plots of one-tenth acre each. A full description of the plan followed will be found in the twelfth annual report of the Hatch Experiment Station. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. All the plots annually receive equal and liberal amounts of materials supplying phosphoric acid and potash. Three plots in the field have had no nitrogen applied to them since 1884; the materials under comparison on the other plots in the field are applied in such quantities as 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. The potash applied to these plots is supplied in the form of muriate to six plots, namely, 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, namely, 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, soy beans, potatoes.

The condition of the soil of this field during the last year or two had indicated quite clearly that it would be benefited by liming. Freshly water-slaked lime was used. It was applied by the use of Kemp's manure spreader, adjusted with a view to applying lime as closely as possible at the rate of 1 ton to the acre. The amount actually applied to

$1\frac{1}{10}$ acre was 2,395 pounds, so that the lime was used in slightly greater quantity than intended. The work of the spreader in applying lime is quite satisfactory. There is no difficulty in adjusting it to apply any desired amount with substantial accuracy. Any chance that the amounts applied to the different plots in such experiments as those in progress on Field A will differ is avoided by driving the spreader in applying the lime the full length of the field across the plots.

The crop of this year was oats and peas. The lime was applied on April 26, and plowed in, and Canada peas at the rate of $1\frac{1}{2}$ bushels per acre were sown on April 28, and deeply harrowed in. On April 29 the fertilizers were applied, and harrowed in. The oats were of the Clydesdale variety. They were sown at the rate of 1 bushel to the acre on May 1, and harrowed in. No accidental conditions likely to interfere with the experiment were noted, although the rank growth on the plots receiving nitrogen in the most highly available form (nitrate of soda and sulfate of ammonia) resulted in considerable lodging, which no doubt decreased the yield on those plots.

The rates of yield on the several plots and the source of nitrogen on each are shown in the following table:—

Yield of Oats and Peas per Acre.

Plots.	NITROGEN FERTILIZERS USED.	Hay (Pounds).
0, . .	Barnyard manure,	4,950
1, . .	Nitrate of soda (muriate of potash),	6,900
2, . .	Nitrate of soda (sulfate of potash),	7,000
3, . .	Dried blood (muriate of potash),	6,700
4, . .	No nitrogen (sulfate of potash),	4,350
5, . .	Sulfate of ammonia (sulfate of potash),	5,650
6, . .	Sulfate of ammonia (muriate of potash),	6,600
7, . .	No nitrogen (muriate of potash),	4,800
8, . .	Sulfate of ammonia (muriate of potash),	6,900
9, . .	No nitrogen (muriate of potash),	3,900
10, . .	Dried blood (sulfate of potash),	6,500

It will be noticed that the yield on the three no-nitrogen plots (4,7,9) is much below the yield obtained on any of the plots where fertilizers supplying nitrogen were used. There was a fair proportion of peas in the crop, but, in spite of the fact that peas are usually able to take a considerable proportion of their nitrogen from the air, it is very clear that it will be unwise, in the case of a mixed crop including a legume and a non-legume, to depend to any great extent upon this atmospheric source of supply. The average yield of the three no-nitrogen plots was at the rate of 4,350 pounds of hay per acre. The average yield of the nitrogen plots was at the rate of 6,400 pounds per acre. Here is a difference of a little more than 1 ton per acre, which is far more than sufficient to cover the cost, \$7.85, of the amounts in which such fertilizer was used. It will be noticed, further, that the yield on the plot to which barnyard manure is annually applied is much below that on even the poorest plot to which a nitrogen fertilizer was applied. The manure in question was put on at the time of preparing the soil in the spring, and evidently the nitrogen it contained did not become in large degree available in season to benefit crops making their growth so early in the growing season as oats and peas. The average yields of this year on the several fertilizers are shown in the following table:—

FERTILIZERS USED.	Hay (Pounds).
Average of the no-nitrogen plots (4, 7, 9),	4,350
Average of the nitrate of soda plots (1, 2),	6,950
Average of the dried-blood plots (3, 10),	6,600
Average of the sulfate of ammonia plots (5, 6, 8),	6,383

As the result of experiments previous to this year, it has been found that the materials furnishing nitrogen have produced crops in the following relative amounts:—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.02
Dried blood,	90.83
Sulfate of ammonia,	88.62
No nitrogen,	72.11

Similar averages for this year are as follows :—

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	94.96
Sulfate of ammonia,	91.84
Barnyard manure,	71.22
No nitrogen,	62.60

Combining the results showing relative standing in 1905 with similar figures for all the years previous to 1905, the relative standing is as follows :—

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.47
Dried blood,	91.09
Sulfate of ammonia,	88.83
No nitrogen,	71.52

The figures showing relative standing of the different materials furnishing nitrogen as compared with the no-nitrogen plots so far given are based upon the total yield. If we compare the different materials used as sources of nitrogen on the basis of increase in crop rather than on the basis of total product, they rank to date for the entire period of the experiment, 1890 to 1905, inclusive, as follows :—

Relative Increases in Yields (Average for the Sixteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	80.58
Dried blood,	68.72
Sulfate of ammonia,	60.78

Whatever the method of comparison, the superiority of the results obtained from the use of nitrate of soda is very apparent. In estimating the significance of the figures, the fact must not be lost sight of that the four different materials, nitrate, dried blood, sulfate of ammonia and barnyard manure, are applied in this experiment in amounts furnishing precisely equal quantities of nitrogen to each plot where they are used. At current prices, a pound of nitrogen can be purchased at lower cost in nitrate of soda than in almost any other material; and the advisability, therefore, of depending largely upon the nitrate as a means of supplying the important element nitrogen, becomes strikingly evident.

II. — THE RELATIVE VALUE OF MURIATE AND HIGH-GRADE SULFATE OF POTASH. (FIELD B.)

This experiment, which has been in progress since 1892, was designed to test the relative value of muriate and high-grade sulfate of potash used continuously upon the same soil. These salts since 1900 have been annually applied at the rate of 250 pounds each per acre. There are ten plots in the field, each containing about $\frac{1}{7}$ of an acre. Five of these receive muriate of potash, and these plots alternate with the same number of plots which are yearly manured with sulfate of potash. Each plot in the field is manured annually with fine-ground bone at the rate of 600 pounds per acre. The crops grown in this field this year have included soy beans, celery, asparagus, rhubarb, raspberries, blackberries and clovers. The yields of the three crops, asparagus, raspberries and blackberries, have been small, and the differences in the results on the different potash salts did not appear to be sufficient to be of much significance. There was, however, a very marked difference in the extent to which the blackberry bushes on the two potash salts winter-killed. Those on the plot which has annually received an application of sulfate of potash were killed back much less seriously than the bushes on the muriate of potash plot. There was a marked difference in the growth of the celery on the two potash salts, that on the muriate being much better than that on the sulfate. This fact is reported at this time without comment, as it seems to the writer probable that some accidental cause, not connected directly with the system of manuring, unfavorably influenced the growth on the poorer plot. Six plots in the field have been in clover during the past year. All of these plots were sown to clover in the late summer of 1904, one pair of plots each (muriate and sulfate) with Alsike, Medium and Mammoth clovers. The clover on all plots germinated well, but early showed a very unhealthy condition on the plots occupied both by the Medium and Mammoth red clovers. The young plants early turned yellow and gradually disappeared. So poor was the condition of these varieties of clover this

spring that it was decided to plow them up. The unhealthy condition is thought to have been connected with a deficiency of lime in the soil, and these plots accordingly received an application of freshly slaked lime at the rate of about 1 ton to the acre. They were then plowed and reseeded to the same varieties of clover. The crops were cut on August 11, but, being much mixed with weeds, as was to be expected in the case of spring-sown clover, the product was not weighed. The Alsike clover upon the plots sown in the summer of 1904 gave one fair crop.

The yield on the muriate was at the rate of 3,986 pounds per acre; on the sulfate, 4,000 pounds. These figures do not accurately indicate the relative condition of the clover, for the growth on both plots was somewhat mixed with other grasses, which were much more abundant on the muriate of potash than on the sulfate, where the clover was very clearly much superior to that on the other plot. The rhubarb on both potash salts gave a heavy growth. The rates of yield per acre were as follows:—

Muriate v. High-grade Sulfate of Potash (Rhubarb). — Yields per Acre (Pounds).

FERTILIZERS USED.	Stalks.	Leaves.
Muriate of potash,	23,148	19,249
Sulfate of potash,	23,729	20,344

These yields are much heavier than last year, as the rhubarb is now more fully established, and the difference in favor of the sulfate of potash is still greater than previously.

III. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

This 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.¹

The crops grown in this experiment since 1898 in order of succession up to the present year have been : —

- 1898. Medium Green soy beans.
- 1899. Potatoes.
- 1900. Plots 1-8, cabbage; 9-24, Medium Green soy beans; 25-40, cow peas.
- 1901. 1-8, wheat; 9-40, corn.
- 1902. Clover.
- 1903. Clover.
- 1904. 1-16, cabbage; 17-40, corn.
- 1905. Soy beans.

The results with the crops of last year, cabbages and corn, were rather indecisive, and were not reported in detail. The most striking observation in connection with the results of last year was the relatively low yields on the silicate of potash and the relatively high yields on the nitrate and carbonate. The crop in 1905 was the Medium Green soy bean. The season was favorable to the crop, which, with one exception, to be presently noted, appeared to be affected by no disturbing accidental conditions. A circular area, extending entirely across Plot 10 and a short distance into both plots 9 and 11, was early affected by some unknown cause, which within a relatively short time resulted in the death of the plants growing there. It is estimated that the total number of plants in Plot 10 thus destroyed was from one-quarter to one-third of the total number of plants in the plot. The proportion of plants destroyed in plots 9 and 11 was relatively small.

At a period very early in the growth of the crop it was noticed that the leaves on all the plots to which kainite is applied as a fertilizer were abnormal. Practically all the

¹ Sixteenth annual report, Hatch Experiment Station.

leaves on plants on these plots early became very much crinkled. They were smaller than normal leaves, and there were numerous areas near the margins of some of the leaves where the tissues died. This appearance was repeated with such perfect regularity on each one of the plots (2, 10, 18, 26, 34) to which kainite was applied that it is impossible to doubt that the effect was due to constituents found in this fertilizer. It was clearly physiological in its origin. Whether due to the large amounts of chlorides contained in the kainite applied to these plots we are not at present certain; but, in view of the fact that potassium chloride has in a number of instances been shown to be distinctly inferior as a source of potash for soy beans in comparison with other salts in our experiments, it seems probable that such was the case. The potash salts used on the different plots and the rates of yield of beans per acre are shown in the following table:—

Yields per Acre.

Plots.	POTASH SALT.	Beans (Bushels).	Straw (Pounds).
1, . . .	No potash,	24.14	2,120
2, . . .	Kainite,	18.62	1,210
3, . . .	High-grade sulfate,	26.90	2,000
4, . . .	Low-grade sulfate,	25.17	1,800
5, . . .	Muriate,	22.41	1,640
6, . . .	Nitrate,	24.14	1,960
7, . . .	Carbonate,	32.41	2,280
8, . . .	Silicate,	22.07	1,540
9, . . .	No potash,	18.79	1,400
10, . . .	Kainite,	11.38	1,600
11, . . .	High-grade sulfate,	21.04	2,080
12, . . .	Low-grade sulfate,	22.42	2,280
13, . . .	Muriate,	22.07	2,240
14, . . .	Nitrate,	25.87	2,800
15, . . .	Carbonate,	28.28	2,700
16, . . .	Silicate,	26.90	2,740
17, . . .	No potash,	24.83	2,380
18, . . .	Kainite,	17.24	1,540
19, . . .	High-grade sulfate,	25.52	1,940
20, . . .	Low-grade sulfate,	24.14	1,760

Yields per Acre — Concluded.

Plots.	POTASH SALT.	Beans (Bushels).	Straw (Pounds).
21, . . .	Muriate,	30.69	1,820
22, . . .	Nitrate,	26.21	2,160
23, . . .	Carbonate,	26.90	2,260
24, . . .	Silicate,	26.21	2,080
25, . . .	No potash,	22.41	1,780
26, . . .	Kainite,	19 31	1,240
27, . . .	High-grade sulfate,	31 72	2,080
28, . . .	Low-grade sulfate,	25.57	1,760
29, . . .	Muriate,	24.48	1,900
30, . . .	Nitrate,	15.86	1,240
31, . . .	Carbonate,	26.55	1,960
32, . . .	Silicate,	23.19	1,600
33, . . .	No potash,	23.45	1,800
34, . . .	Kainite,	18.26	1,160
35, . . .	High-grade sulfate,	24.14	1,820
36, . . .	Low-grade sulfate,	16.21	960
37, . . .	Muriate,	15.52	1,040
38, . . .	Nitrate,	24.83	2,020
39, . . .	Carbonate,	24.14	2,240
40, . . .	Silicate,	28.62	2,160

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 : —

Soy Beans. — Average Yield per Acre.

POTASH SALT.	Beans (Bushels).	Straw (Pounds).
No potash (plots 1, 9, 17, 25, 33),	22.72	1,896
Kainite (plots 2, 10, 18, 26, 34),	16.96	1,350
High-grade sulfate (plots 3, 11, 19, 27, 35),	25.86	1,984
Low-grade sulfate (plots 4, 12, 20, 28, 36),	22.76	1,712
Muriate (plots 5, 13, 21, 29, 37),	23.03	1,728
Nitrate (plots 6, 14, 22, 30, 38),	23.38	2,036
Carbonate (plots 7, 15, 23, 31, 39),	27.86	2,288
Silicate (plots 8, 16, 24, 32, 40),	25.40	2,024

It will be noticed that the average rate of yield on all plots to which potash salts are applied, with the exception of those where kainite is the source of potash, is greater than on the no-potash plots. The average yield on the kainite, on the other hand, is much below the average on the no-potash plots. Examination of the longer table shows that this inferiority of kainite was constant for each of the five plots. Such examination also shows that the variation in relative standing of the plots where each of the different potash salts was used is fairly constant for each. The most marked exception to this rule is found in the case of plots 30, 36 and 37, where the yields are lower than on other plots receiving the same potash salts. This inferiority on these plots appears to have been due to the fact that the stand of plants in them was too thin. A count indicates that the average number of plants in a row in this field is about 120; in Plot 30 it was about 95; in plots 36 and 37 about 45. The potash salt giving the highest yield in this experiment is the carbonate, followed closely by the high-grade sulfate and silicate. The potash salts, other than kainite, containing chlorine (low-grade sulfate and muriate), give yields considerably lower. As neither the carbonate nor the silicate of potash is commonly found in our markets, these having been manufactured in the first instance as fertilizers for tobacco, the practical lesson to be drawn from the experiment is that for the soy bean it is much safer to depend upon the high-grade sulfate as a source of the needed potash than to use any of the potash salts containing chlorine. Neither the carbonate nor the silicate, even if available, would be preferable to the high-grade sulfate, as the cost per unit of potash is much greater than with sulfate. The result of the past season is in agreement with results obtained with this crop in a considerable number of earlier experiments, and it seems impossible to doubt the validity of the conclusion above stated. The advice, therefore, is most strongly given, that, on all soils at least with good retentive qualities and moisture, the sulfate of potash should generally be preferred to muriate or kainite, not only for soy beans, but for clovers and with little doubt for all other legumes as well.

IV. — SPECIAL FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

This experiment has been in progress since 1891. It occupies an acre of ground, divided into four equal plots. The crop from 1891 to 1896, inclusive, was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900 it was corn; in 1901 and 1902, grass and clover; in 1903 and 1904, corn. The land was seeded in the corn in late summer, 1904. The crop harvested this year is hay, — mixed timothy, red-top and clover. The object in this experiment is to test the question whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production in rotation of corn and mixed hay. The plots are numbered from 1 to 4. Plots 1 and 3 yearly receive an application of fertilizers furnishing the same amount 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 has changed but little during recent years, and in 1899, since which date we have made 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 used on plots 2 and 4 are substantially the same in amount and kind as recommended in Bulletin No. 58 of this station for corn on soils poor in organic matter. The essential difference in composition between the fertilizer mixtures under comparison is that the mixture used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. 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
Muriate of potash,	37.5	62.5

The following tables show rates of yields per acre of both hay and rowen on the several plots, and the averages for the two systems of manuring:—

Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (lesser potash),	3,960	240
Plot 2 (richer in potash),	3,900	360
Plot 3 (lesser potash),	3,720	400
Plot 4 (richer in potash),	3,720	300

Average Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 and 3 (lesser potash),	3,840	320
Plots 2 and 4 (richer in potash),	3,810	330

It will be noticed that the yields under the two systems of manuring, both in hay and rowen, are substantially equal. At current prices, the cost per acre of the fertilizers used on plots 2 and 4 is about \$5 less than the cost of the materials used on plots 1 and 3. As we have secured equal crops at a materially lower price, the advantage is clearly with the fertilizer combination richer in potash.

V. — MANURE ALONE *v.* MANURE AND POTASH.

By way of description of this experiment, I cannot do better than to quote from the seventeenth annual report:—

These experiments, which have for their object to show the relative value as indicated by crop production of an average

application of manure used alone, as compared with a smaller application of manure used in connection with a potash salt, were begun in 1890. The field used is level, and the soil of comparatively even quality. It is divided into four quarter-acre plots. The crop grown during the years 1890 to 1896, 1899 and 1900, 1903 and 1904, has been corn. In 1897 and 1898, and again in 1901 and 1902, the crop was mixed grass and clover. Where manure is used alone, it is applied at the rate of 6 cords per acre. Where manure is used with potash, the rates of application are: manure, 4 cords; high-grade sulfate of potash, 160 pounds per acre. Manure alone is applied to plots 1 and 3; the lesser quantity of manure and high-grade sulfate of potash to plots 2 and 4. Estimating the manure alone as costing \$5 per cord, applied to the land, the money difference in the cost of the materials applied is at the rate of \$6.40 per acre, the manure and potash costing that amount less than the larger quantity of manure alone.

Mixed timothy, red-top and clover was sown in late summer in the standing corn of last year. The following tables show the rates of yield on the several plots and the averages under the two systems of manuring:—

Yields per Acre, 1905 (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (manure alone),	6,720	1,840
Plot 2 (manure and potash),	5,820	1,200
Plot 3 (manure alone),	6,120	1,720
Plot 4 (manure and potash),	8,580	1,640

Average Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3 (manure alone),	6,420	1,780
Plots 2 and 4 (manure and potash),	7,200	1,420

It will be noticed that the average yield on the two plots receiving the smaller quantity of manure and potash is somewhat greater than on the other two plots. Since this com-

bination (4 cords of manure and 160 pounds muriate of potash) costs \$6.40 per acre less than the 6 cords of manure, the advantage is decisively in favor of the combination.

VI. — EXPERIMENT IN THE APPLICATION OF MANURE.

This experiment was begun in 1899, and is to be continued for a series of years. It is designed to throw light upon the question as to whether it is economically good policy to spread manure during the late fall and winter and allow it to remain on the surface until spring before plowing under. This method of application is compared with the plan of hauling manure from the stable to the field during the winter and putting it into large compact heaps, from which it is hauled and spread just before plowing in spring. The field in which this experiment is tried slopes moderately to the west. In further description I quote from the seventeenth annual report:—

To insure even quality of the manure used in the two systems, it is our practice to manure two plots at one time, putting the loads of manure as hauled to the field alternately upon the two, in the one case spreading, but in the other putting a sufficient number of loads to provide for the entire plot into one large heap. We are using in this experiment five large plots, each of which is subdivided into two subplots. For one of these subplots the manure is spread when hauled out, for the other it is put into a large heap. The area of these subplots is about one-quarter of an acre, and to each the amount of manure applied is 11,096 pounds. The manure from well-fed milch cows is used upon eight subplots, and horse manure on two. The manure used in this experiment is applied at different dates during the winter, our practice being to allow the manure to accumulate in the pits from which it is taken until there is a sufficient quantity for at least two subplots. The condition of the soil at the time of application and the nature of the weather which follows must necessarily differ in the different experiments; and these differences, together with the difference in the dates of application above referred to, no doubt in a measure account for the variation in the results of the two systems noticed on the different plots.

The crop raised in this field last year was mixed corn and soy beans for ensilage. After the harvest of this crop the field was well harrowed and sown to rye. This crop, which was intended for cover, germinated but poorly and made only a feeble growth. The crop of 1905 was corn,—a number of different varieties received for comparison from the United States Department of Agriculture, and Sibley's Pride of the North of our own growing. These varieties were so arranged that each plot and subplot had equal areas of each. The soil was thoroughly prepared by plowing and harrowing, and the seed was sown on May 19. Soil and seasonal conditions were favorable, and the growth was uninfluenced, so far as could be recognized, by accidental conditions. A number of varieties sown showed relatively low productive capacity, and the final yield was lower than is usual in this section on well-manured land of similar quality. The rates of yield per acre and the relative standing of the several plots are shown in the following tables:—

Corn and Stover. — Actual Yields (Rates per Acre).

PLOTS.	NORTH HALF, WINTER APPLICATION.			SOUTH HALF, SPRING APPLICATION.		
	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).
1, . . .	7,347	31.51	3.21	7,862	32.16	2.45
2, . . .	7,150	25.96	2.99	7,763	32.08	4.00
3, . . .	6,806	22.13	4.36	7,713	27.25	3.53
4, . . .	7,447	24.44	3.06	8,309	29.20	2.85
5, . . .	7,637	30.46	2.34	8,026	32.48	2.31

Corn and Stover. — Relative Yields (Per Cent.).

PLOTS.	NORTH HALF, WINTER APPLICATION.		SOUTH HALF, SPRING APPLICATION.	
	Stover.	Hard Corn.	Stover.	Hard Corn.
1,	100	100	107.0	102.1
2,	100	100	108.6	123.6
3,	100	100	113.3	123.1
4,	100	100	111.6	119.5
5,	100	100	105.1	106.4

It will be noticed that in every instance spring manuring has given a larger yield both of stover and of hard corn than winter application. This result is in general agreement with those of earlier years, but the differences as indicated by the relative yields are comparatively small. The winter of 1904 and 1905 was characterized by uniform temperatures, fairly deep and continuous snow cover and absence of thaws. Such conditions are of course favorable to winter application, and the above-mentioned peculiarities of season perhaps account for the smaller relative differences in yield this year.

The system of manuring designated as spring application involves, as will have been noticed by the reader, twice handling, while in winter application the manure is handled but once. Spring application, therefore, costs more than winter application. As the result of our experience, we estimate the money difference to amount to \$4.80 per acre. The average difference in the value of crops this year in favor of spring application, estimating stover to be worth \$5 per ton and the corn as husked 50 cents per bushel, amounts to only \$3.49 per acre,—a sum insufficient to cover the increased cost of spring application. Even on Plot 3, where the difference in favor of spring application is greatest, the money difference in value of the crops on the same basis as before is only \$4.81, which barely covers the increased cost of application. The results for this season, therefore, economically considered, indicate that spreading the manure as taken from the stable in the fall or winter is to be preferred.

VII. — EXPERIMENT IN MANURING GRASS LAND.

The plan of this experiment, which has continued now for thirteen years, will be made clear by quoting from the sixteenth annual report:—

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 9 acres. It is divided into three approximately equal 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.

The past season has been rather unfavorable for the production of large yields of hay, as there was a considerable deficiency in both spring and summer rainfall. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	3,738	1,210	4,948
Bone and potash,	3,326	1,249	4,575
Wood ashes,	3,816	1,047	4,863

The average yield of the entire area this year was 4,840 pounds per acre. The average yield of the entire area from 1893 to 1904, inclusive, has been 6,718 pounds per acre. The average yield from 1893 to 1905, inclusive, has been 6,479 pounds per acre. The average yields under the different systems of top-dressing have been as follows: —

	Pounds per Acre.
When top-dressed with manure,	6,866
When top-dressed with wood ashes,	6,193
When top-dressed with bone and potash,	6,524

It will be noticed that the average yields of the entire area for this year are much below similar averages for the period.

VIII. — NITRATE OF SODA FOR ROWEN.

For the past five years we have been experimenting in one of our fields for the purpose of determining whether nitrate of soda applied soon after the first crop is cut will

give a profitable increase in the rowen crop. The field where this experiment has been tried was seeded to pure timothy in the fall of 1897. The growth is now considerably mixed with clover, which has been gradually coming in. The whole field is uniformly fertilized for the first crop. The materials applied are usually put on in early spring at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds. This application usually gives us a good crop. The area of the field is a little more than 3 acres. The rate of yield in the first crop this year was 4,471 pounds of well-cured hay per acre. In this field eight equal plots, containing almost exactly $\frac{1}{3}$ acre each, have been laid out. Alternate plots in the series of eight receive annually a top-dressing of nitrate of soda. For the past two years, in order that the nitrate may be more uniformly spread, we have mixed the quantity to be applied to each plot with sufficient basic slag meal to constitute an application at the rate of 400 pounds per acre. To equalize conditions on the alternate plots to which no nitrate is applied, the basic slag meal is applied to all of these at the same rate. The rates of application for the fertilizers on the several plots per acre and the yields are shown in the table:—

Nitrate of Soda for Rowen.

Plots.	FERTILIZERS USED (RATES PER ACRE).	Yield (Pounds).	Increase per Acre (Pounds).
1, . . .	Slag meal, 400 pounds,	975	-
2, . . .	Slag meal, 400 pounds; nitrate of soda, 150 pounds.	1,127	228
3, . . .	Slag meal, 400 pounds,	822	-
4, . . .	Slag meal, 400 pounds; nitrate of soda, 150 pounds.	1,036	305
5, . . .	Slag meal, 400 pounds,	640	-
6, . . .	Slag meal, 400 pounds; nitrate of soda, 200 pounds.	1,340	486
7, . . .	Slag meal, 400 pounds,	1,067	-
8, . . .	Slag meal, 400 pounds; nitrate of soda, 250 pounds.	3,009	1,942

It will be noticed that the nitrate of soda wherever applied has given an increase in the crop. This increase is relatively small in all the plots except Plot 8, where it is at the rate of

nearly 1 ton per acre. During all the years that this experiment has been tried on this land it has been found that the yield on Plot 8 has been much the largest in the fall. True, this receives the heaviest application of nitrate, but it is not believed that the superiority in yield is entirely due to this difference. The moisture conditions are more favorable to growth during the late summer in this plot than in the others. During the five years that this experiment in the use of nitrate of soda for the rowen crop has been tried on this field, it has seemed to give increases sufficient to make the application profitable only in two trials; and, on the whole, the results of our experiments are not favorable to the conclusion that it will usually be found profitable to use nitrate of soda for the rowen crop. The soil in this field is a strong and retentive loam. It is, of course, quite possible that on soils of different character the results of the use of nitrate for rowen will be more favorable.

IX. — FERTILIZERS FOR GARDEN CROPS. (FIELD C.)

In this experiment the principal object in view is to study the effect of some of the standard fertilizing materials upon the yield and quality of garden crops. During the earlier years of the experiment, 1891 to 1897 inclusive, fertilizers alone were applied to the land. It was then decided that, since market gardeners as a rule employ large quantities of manure, the value of the experiment to those engaged in that branch of agriculture would be increased by applying manure equally to all the plots, while still continuing the application of fertilizers. During the earlier years of the experiment there were but six plots, on all of which fertilizers were used. With the change in system alluded to a seventh plot was introduced, and to all of the seven plots stable manure at the rate of 30 tons per acre has since been annually applied. It is intended that the seventh plot, on which manure alone is applied, shall serve as a basis of comparison with the others, in order that we may learn whether, and, if so, to what extent, any fertilizers prove beneficial. The seventh plot immediately adjoins the others, but previous to its inclusion in this experiment it

had been manured somewhat differently. For the first few years the product on manure alone on this plot exceeded the product with equal manure and fertilizers on the other plots. This initial superiority is gradually disappearing, and the product of most of the crops where the fertilizers as well as manure are used now exceeds that upon the seventh plot, where manure only is used. It is possible that the seventh plot does not even yet serve as a fair basis for comparison; but the following crops on most of the plots, where fertilizers in addition to manure are used, have given yields sufficiently greater than those produced where manure alone is used to much more than pay for the cost of the fertilizers, viz.: asparagus, rhubarb, peas, squashes, tomatoes and table beets. It should be pointed out, however, that such increase was in most cases very small where sulfate of ammonia is one of the fertilizer materials used. Indeed, with asparagus the combination of manure and fertilizers containing sulfate of ammonia gave a smaller yield than manure alone. With tomatoes the increased yield was mainly confined to green fruit. The fertilizers did not materially increase the yield of ripe fruit as compared with the yield obtained on manure alone. Some crops showed no increase at all on the plots where fertilizers were added to the manure. Among these were celery and turnips, while cabbages gave either no increase at all or one which was insignificant.

Practically all important out-door garden crops have been grown in rotation upon each plot, and each crop during several years. The crops so far grown are as follows: spinach, lettuce, onions, garden peas, table beets, early and late cabbages, potatoes, tomatoes, squashes, cucumbers, turnips, sweet corn, celery and strawberries. One row each of asparagus and rhubarb was set in each plot in 1902. The first cuttings were made last year.

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 under consideration have from the first been applied in such amounts as to furnish nitrogen at the rate of 60 pounds per acre to each plot. Each fertilizer is always applied to the same plot. To furnish 60 pounds of nitrogen, the application of the fertilizers at about the following rates per acre is required:—

	Pounds.
Nitrate of soda,	375
Sulfate of ammonia,	300
Dried blood,	650

Each of these fertilizers is used on two plots, on one of which the source of the potash is the sulfate, on the other the muriate, in both cases in such quantities as to furnish equal actual potash. In addition to the nitrogen and potash fertilizers, dissolved boneblack is applied at the rate of 320 pounds per acre to all plots. The amount of actual potash applied is at the rate of 120 pounds per acre; the amount of actual phosphoric acid at the rate of 50.4 pounds per acre. The source of the potash used affects the results on some of the crops in a marked degree. This is especially the case where sulfate of ammonia is the source of nitrogen.

The results obtained previous to this year may be summarized as follows:—

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.¹

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 for the early crops:—

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.64
Sulfate of ammonia,	60.95

¹ Sixteenth annual report, Hatch Experiment Station, p. 124.

For the late crops, including late cabbages, celery, tomatoes, turnips and squashes : —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	98.88
Sulfate of ammonia,	78.74

The relative average standing of the sulfate and muriate of potash, as indicated by the total yield of all crops grown in Field C 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	98.32
Muriate of potash,	94.04	100.00

For the past year the relative standing of the nitrogen fertilizers for the early crops, including asparagus, rhubarb, strawberries, peas and table beets, is as follows : —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	96.11
Sulfate of ammonia,	92.83

For the late crops, including cabbages, celery, tomatoes, turnips and squashes, the relative standing is : —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	97.22
Sulfate of ammonia,	90.51

Combining the results for 1905 with the fourteen previous years, the relative standing of the nitrogen fertilizers is : —

For the early crops : —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.67
Sulfate of ammonia,	63.08

For the late crops : —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	98.77
Sulfate of ammonia,	79.52

The relative standing of the potash salts for the present year is : —

For the early crops : —

	Per Cent.
Sulfate of potash,	96.52
Muriate of potash,	100.00

For the late crops : —

	Per Cent.
Sulfate of potash,	92.08
Muriate of potash,	100.00

Combining the relative standing of the potash salts for 1905 with the figures indicating relative standing for the fourteen previous years, the relative standing is : —

For the early crops : —

	Per Cent.
Sulfate of potash,	100.00
Muriate of potash,	94.66

For the late crops : —

	Per Cent.
Sulfate of potash,	97.90
Muriate of potash,	100.00

The results of the experiments for this year will not be reported in detail. The following points are worthy of mention : —

1. Nitrate of soda appears to be the best source of nitrogen for asparagus, table beets, cabbages and squashes.
2. Dried blood as the source of nitrogen has given the largest crops in the case of strawberries, peas, tomatoes and celery.
3. Sulfate of potash as the source of potash seems to be superior for asparagus, peas, beets and cabbages.
4. Muriate of potash gives results superior to those obtained with the sulfate for rhubarb, strawberries, squashes, tomatoes and celery.
5. Sulfate of ammonia for practically all crops appears to have been the poorest material used as a source of nitrogen.

X. — ALFALFA.

Our experiments with alfalfa have been continued both upon our own grounds and those of a few selected farms in different parts of the State. We are bringing to bear upon these experiments information in regard to successful methods from every possible source. We find in all cases a distinct benefit from a heavy initial application of lime. We have used from 2,000 to 3,000 pounds per acre. We are enriching soils already naturally good by heavy applications both of manures and fertilizers, using materials which experience has proved best. We are also giving the soil a most thorough preparatory tillage. It has usually been fall-plowed, and in addition it is plowed in the spring, and repeatedly harrowed to destroy weeds which start in the early part of the season. We have tried inoculating the soil both with earth obtained from a field in New York, where alfalfa is successfully grown, and with the cultures sent out by the Department of Agriculture and prepared by private firms. We have not attained such degree of success as justifies us in recommending the crop. We have occasionally got a fair stand of alfalfa, but in all cases the winters prove more or less injurious. In the course of a few years the alfalfa is mostly crowded out by grasses and clovers. The alfalfa almost every year suffers from leaf spot, which tends to cut down the yield.

We have found a very distinct benefit from the inoculation with earth from the New York alfalfa field. We have not found an equally distinct benefit to follow inoculation with any of the cultures; and, although we are not as yet ready to make a final report, it should be here remarked that the most careful experiments on the use of these cultures in sterilized soils, under conditions calculated to give accurate results, indicate that they have little if any value.

In our various experiments alfalfa has been tried on a wide variety of soils. We have had a quarter of an acre field upon a coarse-textured soil upon a farm in this neighborhood where there is never any standing water within 50 to 60 feet of the surface. Even on this soil the alfalfa,

although it did fairly well for a year, has been injured by successive winters, until it is at the present time almost ruined.

In this connection I call attention further to the fact that Mr. D. S. Bliss of the Department of Agriculture, who has been making special efforts to promote the introduction of alfalfa into New England, and who has travelled extensively for the purpose of studying the results obtained, now speaks very discouragingly as to the outlook in general.

In conclusion, while we are not inclined to discourage experiments with alfalfa, we do wish most emphatically to caution against engaging in these experiments upon an extended scale, for we feel that disappointment is almost inevitable.

XI. — POULTRY EXPERIMENTS.

Our work with poultry during the past year has had the same general purpose in view as in former years, namely, to throw light on the question of the proper selection of feeds for laying fowls. The fowls used in the experiments were pullets of our own raising, and matched flocks have been kept, as in former years, each in a house by itself, all the houses being of precisely similar dimensions and construction.

1. The two flocks in houses Nos. 1 and 2 have been fed on rations characterized by high content both of ash and fat and low fiber. The deficiency of wheat in fat as compared with corn is made up in the ration fed to the fowls in House No. 1 by the use of corn oil, the total amount of fat in the foods used being substantially the same for the two rations. This experiment, therefore, in a general way affords opportunity to test the relative value for egg production of wheat and corn. The ration fed the fowls in House No. 1 contains a relatively high percentage of protein, and has a narrow nutritive ratio. The ration used in House No. 2 contains a relatively low percentage of protein, and has a wide nutritive ratio. The animal food used in both these rations was beef scraps. The following results were obtained: for the first period, March 2 to May 12, inclusive, the wheat ration produced eggs at the average rate of .39 per hen day, the

corn ration at the rate of .45 per hen day; in other words, 100 hens would have laid 39 eggs per day on the wheat ration and 45 eggs per day on the corn ration. For the second period, May 13 to September 23, inclusive, the wheat ration produced an average of .31 eggs per hen day, the corn ration at the rate of .41 eggs per hen day; in other words, during the summer period 100 hens would have laid 31 eggs per day on the wheat ration and 41 eggs per day on the corn ration. The average food cost per egg produced was: for the wheat ration 1.036 cents, for the corn ration .749 cents, for the first period; while for the second period the cost per egg on the wheat ration was .895 cents and for the corn ration .703. The gross cost of the food on the wheat ration varied from about .26 cents to .37 cents per day for each fowl; while on the corn ration the cost varied from .27 cents to .30 cents per day. The number of eggs on the corn ration was considerably greater than on the other, and the cost per egg was much smaller. This result is in agreement with the results of most of the similar experiments which we have tried in earlier years. We are certainly justified in the conclusion that corn has superior merits for egg production as compared with wheat.

2. The rations fed to the fowls in pens Nos. 3 and 4 were characterized by relatively high ash and low fiber content. Milk albumen was used as the source of animal food on account of the low percentage of fat it contains; and the rations fed to the fowls in both of these pens were characterized by much lower fat content than the rations fed to the fowls in pens Nos. 1 and 2. As in the first set of comparisons, the fat content of the two rations used in pens Nos. 3 and 4 was equalized by the addition of corn oil to the one naturally lower in fat. In this experiment, as in the first, wheat was the leading whole grain in the ration fed to the fowls in one house (No. 3); corn the leading whole grain used in the other house (No. 4). The results with the fowls in these houses, like the results obtained in houses Nos. 1 and 2, afford a basis for estimating the relative value of wheat and corn, but with a relatively low percentage of fat in both. The egg product in this experiment was as fol-

lows: for the first period, March 3 to May 12, inclusive, the wheat ration produced eggs at the average rate of .41 per hen day, the corn ration .39 per hen day; or, in other words, 100 hens would have laid on the wheat ration 41 eggs, on the corn ration 39 eggs, per day. For the second period, May 13 to September 23, inclusive, the wheat ration gave an average of .35 eggs per hen day, the corn ration .31; or, in other words, respectively for the wheat ration, an average of 35 eggs per hundred hens daily, and for the corn an average of 31 eggs. The food cost of the eggs in this experiment was as follows: for the wheat ration during the summer period, .845 cents per egg; for the spring period, 1 cent per egg. For the corn ration, the food cost per egg was .871 cents for the summer period; .942 cents for the spring period. The cost of food per hen daily on the wheat ration varied from .273 to .372 cents; for the corn ration, from .248 to .333 cents. In this experiment the wheat ration gave a somewhat better egg yield than corn, but at a higher average cost per egg. The experiment indicates, therefore, that, unless the fat content of the ration is relatively high, the more starchy foods are not sufficient to produce a satisfactory egg yield, and the product falls below that obtained from feeding a ration higher in protein.

3. The fowls in houses Nos. 5 and 6 were fed rations in both cases characterized by low protein, high ash and high fat content, the deficiency of fat in the grains selected being made up by the use of corn oil. The fowls in Pen No. 5 were fed grains, including oats and oat feed, characterized by a high proportion of fiber. Those in Pen No. 6 were fed grains among which rice was prominent, characterized by a low percentage of fiber. The experiment in these houses, then, was calculated to throw light upon the influence of fiber on egg production, the nutritive ratio in the two houses being substantially the same, — about 1 to 6.5. In these houses beef scraps was the animal food used. The results were as follows: For the period March 2 to May 12, inclusive, the egg production was: for the oat ration (high fiber) .40 eggs per hen day, for the rice ration (low fiber) .42 eggs per hen day; or, in other words, from 100 hens

daily respectively 40 and 42 eggs. For the second period, May 13 to September 23, inclusive, the averages were: on the oat ration .38 eggs per hen day, on the rice ration .46 eggs per hen day; or, from 100 hens daily respectively 38 and 46 eggs. The food cost of the eggs has been as follows: for the oat ration during the first period 1.019 cents, for the second period .935 cents; for the rice ration for the first period 1.103 cents, for the second period 1.048 cents. The cost of food per hen per day has varied for the oat ration from .32 to .40 cents; for the rice ration from .412 cents to .423 cents per day. The rice ration, as last year, has given a very satisfactory yield of eggs, but, as was then stated, its high price at the present time renders it poor economy to use it. We are employing it in these experiments because it contains less fiber than any other grain, and we are trying to throw light upon the influence of fiber in egg production. The indication this year, as last, is very clear that this influence is unfavorable.

The nutritive ratios in the food combinations used in the different experiments of the past year have been as follows: for the rations where wheat is compared with corn with beef scraps for animal food and high fat content, — for the wheat ration, between 1 to 4.57 and 4.26; for the corn ration, between 1 to 6.69 and 5.81; for the experiment in which wheat is compared with corn with milk albumen and beef scraps for animal food, — for the wheat ration, between 1 to 4.03 and 4.54; for the corn ration, 1 to 5.63 and 5.84; in the experiment in which oats and rice have been compared with high fat content, — for the oats, between 1 to 5.88 and 6.49; for the rice, between 1 to 5.84 and 6.53.

Our experiments clearly do not support the view that a narrow nutritive ratio is essential to good egg production.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

The work of the division of horticulture for the past year has followed the lines announced in previous reports. It has been concerned chiefly with the propagation of plants, more especially dwarf fruit trees, with problems in pruning, and with the systematic study of varieties. During the year some interesting experiments in the growing of mushrooms have been under way. There follows herewith a report of progress in the experiments in pruning peach trees of bearing age.

PRUNING PEACH TREES.

A year ago this department made a report on experiments in pruning peach trees.¹ Another year has thrown new evidence on the problems involved, so it seems best to take up the subject again. In the mean time the trees have borne a considerable crop of fruit, and their behavior under this load has been particularly interesting.

Last year's report dealt with various problems, one of which was the practice of pruning frozen peach trees to help their recovery. Briefly stated, the experiment comprised four methods of treatment, as follows: (*a*) no pruning; (*b*) moderate pruning; (*c*) severe heading back; (*d*) cutting back to stubs, or "dehorning." The results of these various methods of pruning, as developed up to the time of making last year's report (December, 1904), showed that moderate pruning was to be preferred. It may be said at once that this general conclusion stands without much modification, though the severely pruned trees made a relatively better showing under the stress of a good crop of fruit.

¹ Hatch Experiment Station, seventeenth annual report, p. 162 (1905).

Perhaps the fact most obviously developed by the year's experience is that the trees were more severely injured by the freezes of 1902-03 and 1903-04 than had been supposed. From week to week one tree after another broke down or split down or lost large branches, through the stress of winds or growing fruit crop. As each successive tree broke down, it was plainly to be seen that the wood had been seriously injured by freezing, and that it had not recovered. Though the tree kept on growing, adding fresh and healthy outer layers of wood, the interior was dead and decaying. In many cases this decay was serious, and had extended through considerable areas of tissue. Many fungi (mostly saprophytes such as feed on dead wood) had gained a foothold, and seemed to be out-thriving the peach trees.

These evidences of decay, especially the larger fungi (polypori, etc.), were most conspicuous on the "dehorned" trees. A few of these trees have finally succumbed during the summer of 1905, and it is now plainer than it was a year ago that this method of treating severely frozen peach trees is not to be recommended. An additional drawback lay in the fact that the trees bore little or no fruit in 1905, while all the other trees in the experiment bore a good crop.

Perhaps a word of explanation should be added to this statement of the case. This method of pruning peach trees back to mere stubs has its uses, as in renewing the head when a tree is to be rebudded to a new variety. It can be successfully carried out, but only on vigorous and comparatively young trees. Trees weakened by freezing are precisely the ones which cannot respond to such vigorous treatment.

Coming next to the trees severely headed back (from which practically all the one-year-old wood was removed in the spring of 1905), we find conditions much better. There are some manifest evidences of the injury received during the freezes of two and three winters ago, some broken limbs and some growth of saprophytic fungi; but the trees show strong, sturdy tops, with a very satisfactory annual growth for 1905. The trees bore a good crop of fruit in 1905, and are in the best condition of any in the orchard for carrying

another crop in 1906. While trees severely headed back recovered less readily from the effects of freezing, those which finally bore the crop made distinctly better growth for the pruning.

The trees lightly pruned were cut back only a part of the previous year's annual growth, — from one-third to one-half. The largest percentage of recovery was shown by these trees, and they bore slightly larger crops of fruit in 1905 than any of the others. On the other hand, there appeared to be more breakage of large branches, the heads are left in less satisfactory form than on trees severely headed back, and the prospect for carrying a good crop in 1906 seems to be slightly less.

The trees left without pruning are now distinctly the poorest in the orchard, with the exception only of those that were "dehorned." The percentage of loss was high, the crop of 1905 was inferior to that on the pruned trees, and the present condition of these trees is unsatisfactory.

As the result of this experiment, the following practice would seem to be indicated: —

1. Prune peach trees moderately, removing not more than one-third to one-half the previous year's annual growth, when the wood has been injured by freezing.

2. When only the fruit buds are killed, the wood being uninjured and the trees in good condition, prune severely, cutting back the annual growth to two or three buds. It may be expedient to cut some branches back even into two or three year old wood.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.¹

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, EDWARD G. PROULX, E. T. LADD.

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 1905.

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, 36 have offices for the general distribution of their goods in Massachusetts, 9 in New York, 6 in Connecticut, 3 in Vermont, 2 in Ohio, 1 in Rhode Island, 1 in Maryland, 1 in Tennessee, 1 in Arkansas, 1 in Missouri, 1 in Canada, 1 in New Jersey and 1 in Pennsylvania.

¹ See also tables in Appendix.

Three hundred and twenty-six brands of fertilizers and agricultural chemicals have been licensed in Massachusetts during the year. Five hundred and seventy-four samples of fertilizers have been collected up to the present time, in our general markets, by experienced assistants in the station. Five hundred and eleven samples had been analyzed at the beginning of December, 1905, representing 313 distinct brands of fertilizers. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 104, July; No. 107, November, 1905. The analyses of other officially collected samples of fertilizers not included in these two bulletins will be published in our next bulletin, in March, 1906. About the same number of fertilizers were licensed in Massachusetts during the year as in 1904. The results of our inspection work show 18 more samples analyzed during the season than for the previous year.

The following table gives a brief abstract of the results of analyses of the official commercial fertilizers in comparison with the year previous:—

	1904.	1905.
<i>(a)</i> Where three essential elements of plant food were guaranteed:—		
Number with three elements equal to or above the highest guarantee,	7	3
Number with two elements above the highest guarantee,	32	16
Number with one element above the highest guarantee,	111	83
Number with three elements between the lowest and highest guarantee,	190	203
Number with two elements between the lowest and highest guarantee,	146	138
Number with one element between the lowest and highest guarantee,	48	38
Number with three elements below the lowest guarantee,	none	1
Number with two elements below the lowest guarantee,	12	25
Number with one element below the lowest guarantee,	103	92
<i>(b)</i> Where two essential elements of plant food were guaranteed:—		
Number with two elements above the highest guarantee,	8	3
Number with one element above the highest guarantee,	16	29
Number with two elements between the lowest and highest guarantee,	20	13
Number with one element between the lowest and highest guarantee,	19	23
Number with two elements below the lowest guarantee,	1	5
Number with one element below the lowest guarantee,	15	21
<i>(c)</i> Where one essential element of plant food was guaranteed:—		
Number above the highest guarantee,	16	4
Number between the lowest and highest guarantee,	24	25
Number below the lowest guarantee,	13	19

From the above table it will be seen that the quality of the licensed fertilizers during the past year has not been up to the usual standard.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1904 and 1905 (Cents per Pound).

	1904.	1905.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	16.00	17.00
Organic nitrogen in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers,	17.50	18.50
Organic nitrogen in fine bone and tankage,	17.00	18.00
Organic nitrogen in coarse bone and tankage,	12.50	13.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	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 neutral citrate of ammonia) in mixed fertilizers,	2.00	2.00
Potash as sulfate, free from chlorides,	5.00	5.00
Potash as muriate (chloride),	4.25	4.25
Potash as carbonate,	-	8.00

A comparison of the market cost of the three essential elements of plant food for 1905 with the previous year shows the only variation to be in the various forms of nitrogen compounds: nitrogen in the form of nitrates, and the higher grades of organic nitrogen, including nitrogen in high-grade mixed fertilizers, is a cent higher per pound; while the medium and lower grades of organic nitrogen also show an increased cost of one-half cent per pound. All nitrogen compounds, with the exception of ammoniates, show somewhat of an increase in cost as compared with 1904.

The above schedule of trade values 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, 1905, and is based upon quotations in the fertilizer market in centers of distribution in New England, New York and New Jersey during the six months preceding March, 1905, and refers to the current market prices, in ton lots, of the leading standard raw materials furnishing nitrogen, phosphoric acid and potassium oxide, and which go to make up our commercial fertilizers.

Table A, on the following page, gives the average composition of licensed fertilizers for 1905; Table B gives a compilation of analyses showing the average percentages, as well as the maximum and minimum percentages, of the three essential elements of plant food found in the so-called special crop fertilizers put out by the different manufacturers. This latter table shows how unsafe it is to be guided wholly by trade name when selecting a fertilizer for any special crop. Out of the several hundred fertilizers that are annually offered for sale in the general markets in Massachusetts, it becomes no easy matter for the farmer to select to meet his requirements in cases of the ready factory-mixed goods. No infallible rule can be laid down, as soil conditions vary so widely, and so much depends upon crop rotation. It is safe to say, however, that the higher-grade fertilizers are the most economical ones to buy. Those fertilizers should be purchased which furnish the most nitrogen, potash and phosphoric acid in a suitable and available form for the same money.

TABLE A. — Average Analysis of Officially Collected Fertilizers for 1905 (Per Cent.).

NATURE OF MATERIAL.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.						POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
	Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	TOTAL.		AVAILABLE.		Found.	Guaranteed.
						Found.	Guaranteed.	Found.	Guaranteed.		
Complete fertilizer,	10.79	2.66	4.24	3.63	2.42	10.24	9.13	7.87	7.07	5.11	4.81
Ground bone,	4.39	2.98	.15	10.47	14.75	25.16	26.80	10.62	6.00	—	—
Tankage,	9.91	5.54	.45	9.17	6.49	16.11	12.72	9.62	—	—	—
Dry ground fish,	9.13	8.21	—	5.14	3.15	6.32	7.43	5.14	—	—	—
Dissolved bone-black,	9.06	—	7.65	6.94	2.71	17.30	16.00	14.59	15.00	—	—
Dissolved bone,	10.56	3.00	1.02	9.12	6.02	16.16	18.00	10.14	13.00	—	—
Acid phosphate,	9.78	—	8.41	4.17	1.47	14.08	8.50	12.58	9.00	—	—
Wood ashes,	5.27	—	—	—	—	—	—	—	—	—	—
Cotton-seed meal,	6.06	7.64	—	—	—	1.51	1.00	—	—	5.33	4.40
Flax meal,	7.25	5.32	—	—	—	—	—	—	—	—	—
Sulfate of soda,	2.38	15.75	—	—	—	—	—	—	—	—	—
Sulfate of ammonia,	1.25	15.75	—	—	—	—	—	—	—	—	—
High-grade sulfate of potash,	3.06	19.50	—	—	—	—	—	—	—	49.66	49.42
Muriate of potash,	1.96	—	—	—	—	—	—	—	—	50.26	50.13
Dried blood,	9.20	9.50	—	—	—	1.66	—	—	—	—	—
Kainit,	1.62	—	—	—	—	—	—	—	—	12.79	12.00
Caster pomace,	8.26	4.74	—	—	—	—	—	—	—	—	—
Carbonate potash,	1.35	—	—	—	—	—	—	—	—	64.00	64.71
Vegetable potash,	2.85	—	—	—	—	—	—	—	—	23.96	25.00
Sulfate potash-magnesia,	1.25	—	—	—	—	—	—	—	—	20.56	26.00
Ground South Carolina phosphate, . . . . .	.85	—	—	2.94	25.84	28.78	26.56	2.94	—	—	—

TABLE B. — *Compilation of Analyses of Commercial Fertilizers, Special Crop Brands, for the Year 1905 (Per Cent.)*.

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,	11.11	3.87	1.02	2.63	16.24	8.32	11.17	12.92	4.70	8.58	12.27	1.74	4.06
Fruit and vine fertilizer,	11.69	3.00	2.16	2.48	10.88	7.60	9.39	9.78	4.68	7.32	11.68	6.20	8.08
Grass fertilizer,	7.57	8.86	1.33	4.19	16.24	4.76	8.94	10.74	2.58	6.54	12.27	1.74	5.72
Market-garden fertilizer,	9.97	4.85	1.84	3.19	13.22	5.04	9.93	10.74	2.58	7.59	12.50	2.02	6.51
Onion fertilizer,	11.11	3.87	1.02	2.63	16.24	8.32	11.17	12.92	4.70	8.58	12.27	1.74	4.06
Potato fertilizer,	10.77	4.98	1.02	2.59	15.00	6.02	10.45	9.86	5.08	8.07	10.18	2.20	5.67
Tobacco fertilizer,	10.70	5.77	.53	3.33	13.30	5.86	10.05	11.10	1.60	7.34	14.84	2.20	7.38
Root crop fertilizer,	8.14	3.76	3.01	3.31	12.06	9.98	10.64	9.66	7.72	8.59	10.04	7.04	8.05

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1905, to May 1, 1906), 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.
 Fine-ground 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.
 Dried Blood.
 Fine-ground Tankage.
 Ground South Carolina Phosphate.
- 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.
 Bradley's Complete Manure for Top-dressing 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.
 Bradley's Columbia Fish and Potash.
 Bradley's Abattoir Bone Dust.
 Church's Fish and Potash.
- The 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.
 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.
- 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 Potato and Root Crop Manure.
 Darling's General Favorite.
- The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.:—
 Great Eastern Garden Special.
 Great Eastern Vegetable, Vine and Tobacco.
 Great Eastern Northern Corn Special.
 Great Eastern General Fertilizer.
 Great Eastern Grass and Oats 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.:—
 Packers' Union Universal Fertilizer.
 Packers' Union Potato Manure.
 Packers' Union Animal Corn Fertilizer.
 Packers' Union Gardener's Complete Manure.
 Packers' Union 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.
 Quinnipiac Climax Phosphate.
 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. (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.
 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.:—
 Wheeler's Bermuda Onion Grower.
 Wheeler's Potato Manure.
 Wheeler's Havana Tobacco Grower.
 Wheeler's Corn Fertilizer.
 Wheeler's Grass and Oats Fertilizer.
- W. H. Abbott, Holyoke, Mass.:—
 Abbott's Animal Fertilizer.
 Abbott's Eagle Brand.
 Abbott's Tobacco Fertilizer.
- 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.:—
 Armour's Grain Grower.
 Armour's Blood, Bone and Potash.
 Armour's High-grade Potato.
 Armour's All Soluble.
 Armour's Ammoniated Bone with Potash.
 Armour's Bone Meal.
 Armour's Complete Potato.
 Armour's Corn King.
 Armour's Market-garden Fertilizer.
- H. J. Baker & Bro., New York, N. Y.:—
 Castor Pomace.
- Beach Soap Co., Lawrence, Mass.:—
 Beach's Advance Fertilizer.
 Beach's Reliance Fertilizer.
- Berkshire Fertilizer Co., Bridgeport, Conn.:—
 Complete Fertilizer.
 Potato and Vegetable Phosphate.
 Ammoniated Bone Phosphate.
- 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 Fertilizer.
 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 Blood, Bone and Potash.
 Bowker's Early Potato Manure.
 Bowker's Bristol Fish and Potash.
 Bowker's Fine-ground Dry Fish.

Bowker Fertilizer Co., Boston, Mass. —

Con.

Bowker's Tobacco Ash Elements.
 Bowker's Wood Ashes.
 Bowker's Ground Bone.
 Bowker's Superphosphate.
 Sulfate of Ammonia.
 Nitrate of Soda.
 Dissolved Bone-black.
 Muriate of Potash.
 Sulfate of Potash.
 Dried Blood.
 Bowker's Soluble Animal Fertilizer.
 Bowker's Tobacco Starter.
 Bowker's Tobacco Ash Fertilizer.
 Bowker's Market-garden Fertilizer.
 Bowker's Potash Bone.
 Bowker's Ten Per Cent. Manure.
 Kainit.
 Bowker's Complete Mixture.
 Bowker's Ammoniated Food for Flowers.
 Double Manure Salt.
 Bowker's Tankage.
 Bowker's Clover Brand Bone and Wood Ash.
 Bowker's Flour of Bone.
 Bowker's Market Bone.
 Bowker's Ground Phosphate Rock.
 Bowker's Ammoniated Dissolved Bone.
 Bowker's Square Brand Bone and Potash.
 Bowker's Potash or Staple Phosphate.
 Bowker's Special Fertilizer for Seeding Down.

F. W. Brode & Co., Memphis, Tenn. :—
 Owl Brand Pure Cotton-seed Meal.

T. H. Bunch, Little Rock, Ark. :—
 Cotton-seed Meal.

Charles M. Cox & Co., Boston, Mass. :—
 Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass. :—
 Lawn and Garden Dressing
 Vegetable and Potato Fertilizer.

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 Excelsior Potato Fertilizer.
 E. Frank Coe's Tobacco and Onion Fertilizer.
 E. Frank Coe's Columbian Corn Fertilizer.

E. Frank Coe Co., New York, N. Y. —
Con.

E. Frank Coe's Columbian Potato Fertilizer.
 E. Frank Coe's New Englander Potato Fertilizer.
 E. Frank Coe's New Englander Corn Fertilizer.
 E. Frank Coe's X X X Pure Ground Bone.
 E. Frank Coe's F. P. Fish and Potash.
 E. Frank Coe's Red Brand Excelsior Guano.
 E. Frank Coe's Celebrated Special Potato.
 E. Frank Coe's Grass and Grain Special.
 E. Frank Coe's X X X Ammoniated Bone Phosphate.
 E. Frank Coe's Muriate of Potash.
 E. Frank Coe's Nitrate of Soda.

John C. Dow & Co., Boston, Mass. :—
 Dow's Pure Ground Bone.

The Eureka Liquid Fertilizer Co., Boston, Mass. :—
 Eureka Liquid Fertilizer.

William E. Fyfe & Co., Clinton, Mass. :—
 Hard Wood Canada Ashes.

R. & J. Farquhar & Co., Boston, Mass. :—
 Clay's London Fertilizer.

C. W. Hastings, Ashmont, Mass. :—
 Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass. :—
 Bone Meal.
 Meat and Bone.

Hunter Brothers Milling Co., St. Louis, Mo. :—
 Prime Cotton-seed Meal.

John Joynt, Lucknow, Ont., Can. :—
 Joynt Brand Hard-wood Ashes.

A. Klipstein & Co., New York, N. Y. :—
 Carbonate of Potash.

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 Oneida Special.
 Lister's Animal Bone and Potash.

Swift's Lowell Fertilizer Co., Boston, Mass.:—

Swift's Lowell Bone Fertilizer.
 Swift's Lowell Potato Phosphate.
 Swift's Lowell Dissolved Bone and Potash.
 Swift's Lowell Animal Brand.
 Swift's Lowell Market-garden Manure.
 Swift's Lowell Potato Manure.
 Swift's Lowell Empress Brand.
 Swift's Lowell Superior Fertilizer.
 Swift's Lowell Special Grass Mixture.
 Swift's Lowell Lawn Dressing.
 Swift's Lowell Perfect Tobacco Grower.
 Swift's Lowell Ground Bone.
 Swift's Lowell Special Vegetable Manure.
 Acid Phosphate.
 Nitrate of Soda.
 Muriate of Potash.
 Tankage.

George E. Marsh & Co., Lynn, Mass.:—
 Pure Bone Meal.

D. M. Moulton, Monson, Mass.:
 Ground Bone.

Mapes Formula and Peruvian Guano Co., New York, N. Y.:—

Mapes' Potato Manure.
 Mapes' Tobacco Starter Improved.
 Mapes' Tobacco Manure (Wrapper Brand).
 Mapes' Economical Potato Manure.
 Mapes' Average Soil Complete Manure.
 Mapes' Vegetable Manure or Complete Manure for Light Soils.
 Mapes' Corn Manure.
 Mapes' Complete Manure ("A" Brand).
 Mapes' Cereal Brand.
 Mapes' Complete Manure Ten Per Cent. Potash.
 Mapes' Top-dresser Improved, Half Strength.
 Mapes' Tobacco Ash Constituents.
 Mapes' Grass and Grain Spring Top-dressing.
 Mapes' Fruit and Vine Manure.
 Mapes' Cauliflower and Cabbage Manure.

National Fertilizer Co., Bridgeport, Conn.:—

Chittenden's Complete Fertilizer.
 Chittenden's High-grade Special Tobacco.
 Chittenden's Market Garden.
 Chittenden's Potato Phosphate.

National Fertilizer Co., Bridgeport, Conn.—*Con.*

Chittenden's Ammoniated Bone.
 Chittenden's Fish and Potash.
 Chittenden's X X X Fish and Potash.
 Chittenden's Formula "A."

New England Fertilizer Co., Boston, Mass.:—

New England Corn Phosphate.
 New England Potato Fertilizer.
 New England Superphosphate.
 New England High-grade Potato Fertilizer.

Olds & Whipple, Hartford, Conn.:—

Complete Tobacco Fertilizer.
 Vegetable Potash.

R. T. Prentiss, Holyoke, Mass.:—

Prentiss Complete Fertilizers.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.:—

Plymouth Rock Brand.
 Special Fertilizer for Strawberries.
 Special Potato Fertilizer.
 Nitrate of Soda.
 A. A. Brand Fertilizer.
 P. & P. Potato Fertilizer.
 Pure Ground Bone.
 Lawn Dressing.
 P. & P. Grain Grower.
 Star Brand Superphosphate.

Rogers & Hubbard Co., Middletown, Conn.:—

Hubbard's Oats and Top-dressing.
 Hubbard's Grass and Grain.
 Hubbard's Soluble Corn.
 Hubbard's Soluble Potato.
 Hubbard's Soluble Tobacco.
 Hubbard's All Soils and All Crops.
 Hubbard's Corn Phosphate.
 Hubbard's Potato Phosphate.
 Hubbard's Market-garden Phosphate.
 Hubbard's Raw Knuckle Bone Flour.
 Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.:—

All Round Fertilizer.
 Complete Potato and Vegetable Fertilizer.
 High-grade Complete Corn and Onion. Fish and Potash.
 High-grade Tobacco and Potato.
 High-grade Oats and Top-dressing.
 High-grade Grass and Grain.
 High-grade Soluble Tobacco.
 Pure Knuckle Bone.

Ross Bros., Worcester, Mass.:—

Ross Brothers' Lawn Dressing.

N. Roy & Son, South Attleborough,
Mass.:—

Complete Animal Fertilizer.

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.

Essex Grass and Top-dressing.

Essex Nitrate of Soda.

Sanderson's Fertilizer and Chemical Co.,
New Haven, Conn.:—

Sanderson's Formula "A".

Sanderson's Formula "B".

Sanderson's Potato Manure.

Sanderson's Corn Superphosphate.

Sanderson's Fine-ground Fish.

Sanderson's Sulfate of Potash.

Walker's Complete Phosphate.

Walker's Complete Fertilizer.

Walker's High-grade Fertilizer.

Niantic Bone, Fish and Potash.

Old Reliable Superphosphate.

The Smith Agricultural Chemical Co.,
Columbus, O. (Abbott & Martin Ren-
dering Co., branch):—

Harvest King.

Tobacco and Potato Special.

The Smith Agricultural Chemical Co.,
Columbus, O. (Hardy Packing Co.,
branch):—

Tankage Bone and Potash.

Tobacco and Potato Special.

M. L. Shoemaker & Co., Limited, Phil-
adelphia, Pa.:—

Swift Sure Superphosphate.

Swift Sure Bone Meal.

Thomas L. Stetson, Randolph, Mass.:—

Bone Meal.

A. L. Warren, Northborough, Mass.:—

Warren's Ground Bone.

The Whitman & Pratt Rendering Co.,
Lowell, Mass.:—

Whitman & Pratt's All Crops.

Whitman & Pratt's Corn Success.

Whitman & Pratt's Vegetable Grower.

Whitman & Pratt's Potash Special.

Whitman & Pratt's Pure Ground
Bone.

Whitman & Pratt's Potato Plowman.

Wilcox Fertilizer Works, Mystic, Conn.:—

Wilcox Potato, Onion and Tobacco
Manure.

Wilcox Potato Fertilizer.

Wilcox Complete Bone Superphos-
phate.

Wilcox Fish and Potash.

Wilcox High-grade Tobacco Special.

Wilcox Dry Ground Fish.

Sanford Winter, Brockton, Mass.:—

Pure Fine-ground Bone.

J. M. Woodward & Bro., Greenfield,
Mass.:—

Tankage.

PART II. — REPORT ON GENERAL WORK IN THE
CHEMICAL LABORATORY.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.

1. ANALYSES OF MATERIALS FORWARDED FOR
EXAMINATION.

We have received 257 samples of miscellaneous substances, during the season, from farmers within our State. As far as circumstances and time permit we have taken up these materials for analysis, and as a general thing have reported results in the order of their arrival at this office. As in the past, we have been obliged to neglect this class of work until a lull occurred in the official inspection of commercial fertilizers. From December to April we have most time to devote to the investigation of general material, and for this reason would prefer to have the samples forwarded whenever possible, so they may be taken up during these months. This would insure more prompt reports of the results of analyses.

We have taken the usual active part in the technical chemical work of the Association of Official Agricultural Chemists for the establishment of new methods of chemical analysis, more particularly in regard to fertilizer work and the analysis of insecticides. We have also been in cooperation with the American Chemical Society and the United States Geological Survey in regard to technical details in the chemical analysis of argillaceous limestone. The results of these analyses were sent to the respective parties in Washington.

Following is a list of materials forwarded by farmers during the year:—

Soils,	54	Factory waste,	2
Wood ashes,	47	Ashes from leather scraps,	2
Complete fertilizers,	32	Insecticides,	2
Cotton-seed meal,	24	Oyster shells,	1
Lime ashes,	8	Sulfate of ammonia,	1
Miscellaneous materials,	7	Blood,	1
Nitrate of soda,	6	Wool waste ashes,	1
Manure,	6	Chicken grit,	1
Muck,	5	Tobacco dust,	1
Tankage,	4	Argillaceous limestone,	1
Superphosphate,	4	Burned bone,	1
Cotton-hull ashes,	4	Low-grade sulfate of potash,	1
High-grade sulfate of potash,	3	River mud,	1
Ground bone,	3	Cob ashes,	1
Bone and meat,	3	Castor pomace,	1
Sheep manure,	3	Linseed meal,	1
Peruvian guano,	3	Mud from seaweed,	1
Peat,	3	Cotton-seed compost,	1
Dry ground fish,	2	Damaged cocoa,	1
Dissolved bone-black,	2	Prepared bone,	1
Wood charcoal,	2	Vegetable potash,	1
Muriate of potash,	2	Rotten cotton waste,	1
Carbonate of potash,	2		

2. NOTES ON WOOD ASHES AND LIME ASHES.

(a) *Wood Ashes.*

Eighteen and one-half per cent. of the materials forwarded by farmers during the year have been wood ashes. The following table shows their chemical composition as compared with the previous year:—

Analysis of Wood Ashes.

	NUMBER OF SAMPLES.	
	1904.	1905.
Moisture from 1 to 10 per cent.,	18	15
Moisture from 10 to 20 per cent.,	16	20
Moisture from 20 to 30 per cent.,	8	7
Moisture above 30 per cent.,	3	1
Potassium oxide above 8 per cent.,	2	4
Potassium oxide from 6 to 7 per cent.,	8	4
Potassium oxide from 5 to 6 per cent.,	6	12
Potassium oxide from 4 to 5 per cent.,	12	13
Potassium oxide from 3 to 4 per cent.,	10	7
Potassium oxide below 3 per cent.,	7	3
Phosphoric acid above 2 per cent.,	3	7
Phosphoric acid from 1 to 2 per cent.,	30	32
Phosphoric acid below 1 per cent.,	12	4
Average per cent. of calcium oxide (lime),	30.16	32.30
Insoluble matter below 10 per cent.,	6	9
Insoluble matter from 10 to 15 per cent.,	18	14
Insoluble matter above 15 per cent.,	20	20

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes, 1904 and 1905.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1904.	1905.	1904.	1905.	1904.	1905.
Moisture at 100° C.,	37.85	32.05	none.	.02	14.42	13.45
Potassium oxide,	11.04	8.68	.80	2.32	4.51	5.09
Phosphoric acid,	6.07	4.74	.28	.38	1.37	1.67
Calcium oxide,	42.86	49.24	19.73	21.17	30.16	32.30
Insoluble matter,	47.21	33.32	4.56	4.15	18.35	15.49

From the above comparison it will be seen that the ashes analyzed during the year are of much better quality than for the year 1904. We wish to urge parties who buy wood ashes to patronize those importers and dealers who have secured a license for the sale of ashes in Massachusetts, for

it is only in this way that they can secure protection by our State laws. Wood ashes should always be bought on a statement of guarantee of potash, phosphoric acid and lime.

(b) *Lime Ashes.*

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes, 1904 and 1905.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1904.	1905.	1904.	1905.	1904.	1905.
Moisture,	36.62	19.35	none.	.05	10.88	11.18
Potassium oxide, . . .	2.46	4.80	.06	1.02	1.54	2.47
Phosphoric acid, . . .	1.48	1.58	trace.	.18	.74	.97
Calcium oxide,	55.24	63.44	21.92	37.56	42.93	49.34
Insoluble matter, . . .	25.47	28.93	2.76	3.21	8.11	8.99

It will be seen from the above comparison that the average composition of lime ashes for the past year is superior to that of 1904. The only safe way to buy lime ashes is to insist upon a guarantee of potash, phosphoric acid and lime which they are said to contain.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.¹

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH, E. S. FULTON,² A. C. WHITTIER.

Inspector of Feeds and Babcock Machines: A. PARSONS,³ F. G. HELYAR.

Dairy Tester: S. R. PARKER.

In Charge of Feeding Experiments: J. G. COOK,⁴ R. F. GASKILL.

Stenographer: MABEL C. SMITH.

PART I. — THE WORK OF THE YEAR.

1. Correspondence.
2. Summary of laboratory work.
3. Water analysis.
4. Dairy products and cattle feeds.
5. Special chemical work.
6. Feed control.
7. Act for protection of dairymen.
8. The testing of pure-bred cows.
9. Work completed.
10. Work in progress.
11. Changes in staff.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. Bibby's dairy cake.
2. Eureka silage corn.
3. Concerning wheat bran.

¹ See also tables in Appendix.

² Resigned Sept. 15, 1905.

³ Resigned July 1, 1905.

⁴ Resigned Aug. 1, 1905.

PART I.—THE WORK OF THE YEAR.

J. B. LINDSEY.

1. CORRESPONDENCE.

The answering of inquiries relative to feeding and dairy problems has continued to be a feature of the correspondence of this department. Grain dealers appear desirous of being well posted on the various feed stuffs in the market, and are constantly writing for information. The total number of letters of all kinds sent out during the year was approximately 3,600.

2. SUMMARY OF LABORATORY WORK.

The usual variety of chemical work has been carried out during the year.

There have been sent in for examination 102 samples of water, 792 of milk, 1,717 of cream, 5 of butter, 191 of feed stuffs and 6 miscellaneous. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 236 samples of milk and cream and 142 of fodders and feed stuffs. This makes a total of 4,042 substances analyzed during the year, as against 4,261 last year and 3,897 in the previous year. Work on the determination of sulphur in organic bodies, and nitrogen compounds in cheese, 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, and 1,665 pieces of glassware have been tested for accuracy, of which 197 pieces, or 11.83 per cent., were condemned.

3. WATER ANALYSIS.

The experiment station has made a feature of sanitary water analysis since its establishment in 1882. Within a few years a charge of \$3 a sample has been placed upon this

work, in order to hold in check many who have seemingly abused the privilege of free analysis. Instructions for securing an analysis are issued in circular form, as follows:—

Those wishing to secure a sanitary analysis of water must first make application, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return express 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.

Address

Dr. J. B. LINDSEY,

Hatch Experiment Station, Amherst, Mass.

The results of the analysis are forwarded on especially prepared blanks, with such additional remarks concerning the condition of the water, and its possible improvement, as is warranted in each case. This station does not make mineral analysis of water, excepting at rare intervals by special arrangement.

4. DAIRY PRODUCTS AND CATTLE FEEDS.

This department makes free analyses of milk, cream and cattle feeds for farmers and others, in so far as its resources permit. About the usual number have been received during the year. Many farmers and dairymen desire to know the percentage of fat and total solids in the milk produced by their herd and by individual animals, and send samples to the station for analysis. They are thus enabled to determine the quality of the product placed upon the market, and also the value of the cow for profitable milk production. The quality of the milk shipped to Boston is carefully scrutinized by the several contractors, and producers frequently send samples to the station, to ascertain whether their product is conforming to the legal requirements. Parties who have been warned by the contractors, or have had their milk refused, likewise forward samples, with requests for information as to methods of betterment. The station tries to be as helpful as possible in all such cases. One creamery sends

its samples regularly, and others send occasional lots, when not in condition to satisfactorily perform the work, or when desiring to check their own results. A charge is made in such cases sufficient to cover the cost of the work.

Farmers and grain dealers are constantly sending samples of feeds for examination, to determine their value and whether they are as represented. This work takes considerable time, but it is worthy of encouragement. It must not be understood, however, that the station furnishes a free chemical laboratory for jobbers and manufacturers who wish to ascertain the composition of their feeds for commercial purposes. The station does not solicit work of this character, but is willing to undertake a limited amount for a reasonable compensation.

5. SPECIAL CHEMICAL WORK.

During the year the department has undertaken co-operative work on chemical methods in connection with the Association of Official Agricultural Chemists, and has studied particularly methods for the determination of sulphur in organic substances, and of nitrogenous compounds in cheese. The department has also co-operated with the department of botany in ascertaining the amount of starch and sugars in cucumber leaves, grown under definite conditions.

6. FEED CONTROL (ACTS OF 1903, CHAPTER 202).

The several provisions of this act have been executed as heretofore. Bulletin No. 101, containing the analyses of 306 samples of feeds collected the previous autumn, was distributed early in January of 1905. This bulletin also contained many remarks and suggestions on the nutritive and commercial values of concentrates. Bulletin No. 106, sent out in October, 1905, gave the chemical and microscopic analyses of 65 samples of condimental stock and poultry foods, and the results of an experiment with Pratt's food. During the months of January, February, March and April, the inspector twice visited the most important cities and towns in the State, and collected 481 samples of feeds. The entire collection was tested during the late spring and early

summer. For financial reasons, it was not possible to publish the results in bulletin form. Those that were considered at all suspicious were examined by both the chemist and the microscopist, and the attention of retail dealers, jobbers and manufacturers called to any irregularities. Brief notes regarding this collection were published in Bulletin No. 106. The inspector canvassed the entire State in September and October, and the 365 samples collected are now being examined, and the results will be ready for publication in December.

The large majority of manufacturers, jobbers and retailers willingly conform to the requirements of the law. Considerable difficulty is frequently experienced in obtaining a statement in full, many omitting the weight of the package, and a few stating the protein and fat guarantees together. Some manufacturers and jobbers have been lax in attaching any guarantee whatever, and retailers have frequently offered unguaranteed goods for sale. The station has endeavored to be very patient with offenders, giving them full opportunity to conform to the statute requirements. The writer recognizes the diversity of conditions governing the purchase and sale of the great variety of concentrated feeds, and has been willing to condone many technical violations of the law, when it appeared that no intentional offence was intended. Some parties seem inclined to take advantage of this seeming leniency, and such it may be necessary to call to a sharp account.

The value of an intelligent and tactful inspector cannot be too strongly emphasized. He is in position to impart much valuable information to the dealer, and to smooth out many difficulties that may arise. The station finds it difficult to retain the services of a satisfactory person for any length of time, because of the small salary paid.

The great bulk of feed now offered is free from intentional adulteration, and is as represented. Buyers, as a rule, have only themselves to blame if they are defrauded. Much cotton-seed meal is being guaranteed several per cent. lower in protein than formerly, manufacturers claiming that it does not pay them to completely remove the hulls. It is

also stated that this lower-grade meal is shipped from other territory than that formerly supplying the Massachusetts markets.

Gluten feed and wheat by-products tested low in protein during 1905, owing to the inferior character of the 1904 corn and wheat.

Porto Rico molasses and a considerable variety of molasses feeds are being freely offered. The station is making a special study of these products, and hopes to publish the results in bulletin form within the next few months.

Rice by-products in considerable quantity are being sold in the southwest, but as yet they have not been offered in local markets. Detailed information concerning the composition and value of concentrates may be obtained by consulting the special bulletins on the subject.

7. AN ACT FOR THE PROTECTION OF DAIRYMEN (ACTS OF 1901, CHAPTER 202).

This act makes it obligatory for all creameries and milk depots within the State, employing the Babcock test or any other test for determining the value of milk or cream, to have all graduated glassware used in making such determinations tested for accuracy by this station. It further requires that all parties intending to operate such machines must first be examined for competency by the proper official of the station. Once each year the station is obliged to send a competent party to each creamery and milk depot within the State where such machines are in use, to duly inspect said machines and pronounce upon their fitness for the work. This department has endeavored to carry out the several provisions of this law with the same care as formerly. The following is a brief report of the work for 1905:—

Inspection of Glassware. — All glassware found to be correctly graduated has been marked "Mass Ex St." There were 1,665 pieces examined, of which 197, or 11.83 per cent., were condemned. The inaccurate bottles were largely of the bulb type (Bartlett). Until last year these bottles have been passed on accuracy of total graduation, as the usual charge of 5 cents a piece would not permit of additional

testing. Because of the difficulty in securing a correct graduation, it has been necessary to test the three distinct portions of the scale at a corresponding increase in cost. The use of this type of bottle is not to be encouraged.

Examination of Candidates. — A few less candidates than usual were examined, and 13 certificates of competency issued. Many candidates showed poor manipulation, and lacked a thorough understanding of the method. In case of failure, applicants are obliged to wait a month before a second examination will be given.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Frank G. Helyar, who makes the following report: —

The annual inspection of Babcock machines was made in November and December. Fifty-two places were either visited or heard from, of which number only 36 were amenable to the inspection. Those creameries or milk depots that did not come under the inspection were exempt for two reasons: some of them do not possess a machine, but have their samples regularly tested by city inspectors; while others have machines, but from all that can be learned they neither buy nor sell milk or cream on the results of their own tests. In suspicious cases they carry samples to the city inspector. There are three creameries paying by the space and one by the churn test.

Of the total number, 34 were creameries and 18 were milk depots. Of the 34 creameries, 19 were situated west of the Connecticut River, and, as a rule, in the back-hill towns, away from good transportation facilities. The rest of the creameries were scattered throughout the eastern part of the State. The milk depots, on the other hand, are situated nearer the large cities. Twenty of the milk depots and creameries were co-operative, while the rest were either proprietary or stock companies. The number of co-operative creameries is steadily decreasing.

As a whole, the machines were found to be in very good condition, none being condemned, and only 3 needing repairs. The cast-iron machine is being used in every place visited but 4. The Facile is used in 19 places, the Agos in 9 and the Wizard in 3.

Most of the owners of the Babcock machines have recognized

the value of a substantial foundation as a factor in keeping their machines in good repair. Still, there are a few machines that are being used on rather insecure and shaky supports. As a result, these machines are always a little out of level, and run with more or less unnecessary vibration. Some machines, even with repairs suggested in previous inspections, still overheat the samples. The operators of these machines counteract this by allowing the machine to run a few moments at the end of the test with the cover lifted. No machine was found that insufficiently heated the samples. The steam gauges, with only one or two exceptions, were found to be in good order. In those cases where they were not in good order, speed indicators are used to check up the speed of the machines.

Only in one place was untested glassware found. In some cases it was not as clean as it ought to be, but, on the whole, may be said to be in very good condition.

In addition to the regular work of the inspection, 4 city milk inspectors were visited. Only 1 desired an examination. His machine, an electrical Wizard, was given a certificate.

The above law is not as comprehensive as one could wish. It makes no financial provision for the purpose of carrying out the provisions of section 3 (inspection of machines), but requires the director of the station, or his agent, to make the inspection, and to assess the cost upon the several creameries inspected. The station is obliged to advance the expense out of its treasury, and collect 35 or 40 small bills resulting. Most creameries pay with a reasonable degree of promptness, but a few parties are obstinate and slow.

After the station has issued a certificate of competency to the operator of a Babcock machine, it has no further control over said party, even though he may prove careless, and even dishonest in his future operations. The law could be improved, and thus give a fuller measure of protection to dairymen, by a small annual State appropriation, together with the necessary authority to make a semi-annual inspection of all Babcock or similar machines, and of all glassware used in connection therewith, and by empowering the director of the experiment station, or some other competent party, to rescind the license of all operators who do not appear to be satisfactorily performing their duties.

8. THE TESTING OF PURE-BRED COWS.

Breeders of pure-bred Jersey, Guernsey and Holstein cattle are making tests of the weekly and yearly yields of milk and butter fat produced by their cows, under the rules and regulations of the several national cattle clubs. The rules require that these tests be made under the strict supervision of an officer of the Agricultural College or Experiment Station. This department has undertaken the work for Massachusetts breeders. Considerable more testing has been required during 1905 than heretofore, necessitating the temporary employment of 5 different inspectors at one time. It is frequently quite difficult and time-consuming for the regular employees to be required to meet the sudden demands of breeders for men to do work of this character, although thus far all calls for men and apparatus have been met promptly. Breeders ought to give the station at least ten days' notice. The cost of this work is paid by the parties for whom it is done, and includes tester's time at \$2 to \$2.50 a day, board, travelling expenses and breakage. There are at present 44 Jerseys and 29 Guernseys under yearly tests, belonging to F. L. Ames, North Easton, N. I. Bowditch, Framingham, W. L. Cutting, Pittsfield, C. H. Jones, Wellesley Farms, A. H. Sagendorph, Spencer, Storrs Agricultural College, Storrs, Conn., C. I. Hood, Lowell, A. F. Pierce, Winchester, N. H., and R. A. Sibley, Spencer. Eight seven-day milk and butter fat tests have been made for the Jersey Cattle Club, and 37 for the Holstein-Friesian Association, and the yearly tests of 32 Jerseys and 12 Guernseys have been completed.

9. WORK COMPLETED.

Eureka Silage Corn. — A two-years experiment, to study the composition, digestibility and economic value of this corn, a coarse southern dent, as compared with a medium dent that will mature its seed in our latitude, has been completed, and the details and conclusions reported in Part II. of the present report.

The Value of Wheat Bran. — The results of a study of the

cost of digestible protein and total digestible matter in wheat bran, as well as the use of bran in the farm economy, are presented quite fully in Part II.

Bibby's Dairy Cake. — Digestion tests and an experiment with dairy cows have been completed with this feed. The details of the experiment, and the conclusions, will be found as a portion of Part II.

Market Milk, its Production and Composition. — This department has investigated the conditions governing the production of milk in the territory supplying Amherst and Northampton, as well as the chemical and bacteriological composition of the milk. It is believed that the methods of production and the quality of the product are much the same as in other sections of the State. In general, it may be said that: —

1. The sanitary conditions on the whole were unsatisfactory.

2. The majority of producers were not familiar with, or did not apply, the teachings of modern dairy principles.

3. The chemical composition of most of the milk was above the Massachusetts standard.

4. A great deal of the milk contains an excess of bacteria, and indicated unsanitary methods of handling.

5. The milk was practically all retailed at 6 cents a quart, — a price too low to enable the producer to profitably produce an article under satisfactory sanitary conditions.

It is believed that producers supplying milk for human consumption should be subject to a system of regular, competent inspection, and that no one should receive a license who does not conform to reasonable sanitary conditions. The public needs to be educated relative to the great food value of milk, and ought to be willing to pay a fair price for an approved article. It is hoped to soon publish the detailed results of this investigation in bulletin form.

Digestion Experiments with Sheep. — There have been completed digestion experiments with soy bean fodder, Eureka corn fodder and Eureka corn stover, Pride of the North corn stover, Blomo feed for horses, malt sprouts, Sucrene, Holstein and Macon sugar feeds, hominy feed,

buckwheat and oat middlings. The results have been incorporated in the tables of digestion coefficients, in the Appendix. The details of these experiments and a discussion of the results are reserved for a future publication.

Sorghum and Other Forage Crops. — Trials of a variety of green crops for summer soiling are conducted each year. Sorghum has been given particular attention for the last two years. A very complete analysis of this crop has been made at different stages of growth, and, likewise, digestion trials with sheep, the results of which are not as yet completed. The seed¹ was sown broadcast at the rate of 1 bushel per acre, the 25th of May. Cutting was begun as soon as the heads appeared (about August 10), and the yield was at the rate of 19 tons to the acre. The animals ate it well, and it should prove a satisfactory addition to the list of green feeds. A more detailed statement concerning the quality and value of this crop for soiling will be given in a future publication.

The station has found the following crops quite satisfactory for soiling purposes: peas and oats, the first seeding to be made April 25 and each ten days thereafter, ready to cut from June 25 to July 20; barnyard millet, first seeding to be made May 25 and another seeding two weeks later, ready for feeding from July 20 to August 10; sorghum to be seeded May 25, ready to cut August 10 to 30; Stowell's Evergreen sweet corn, or Longfellow field corn, seeded May 15 to 20, will serve admirably for September green fodder, and later if frosts are not severe.

Soy beans may be sown with the corn, but it is believed that, on the whole, more satisfactory results can be obtained by cultivating each crop separately. It is hoped to publish a bulletin on the subject of soiling in the near future. Copies of a former bulletin on this subject (No. 72) are not available.

Useful Legumes. — A study has been made of the composition, digestibility and yields of the more prominent leguminous crops, with a view to determine their practical adaptability to New England conditions, and it is desired

¹ Seed purchased of Wm. Henry Maule, Philadelphia, Pa., at \$2.25 a bushel.

to publish a concise description of this work in the near future.

Clover is unquestionably the most valuable legume, serving admirably as a soil renovator, cover crop, soiling crop, and as a component of the hay crop. Canada peas are valuable chiefly for soiling purposes, and in some cases as a cover crop. Sand vetch (*Vicia sativa*) makes a good legume to be sown in the autumn with wheat for early summer soiling. It also serves as a soil renovator and as a cover crop. Shammel, in Bulletin No. 149 of the Connecticut Experiment Station, has called attention to the value of this plant when sown after the removal of tobacco. It blossoms about June 1, and can then be plowed under, adding materially to the humus and nitrogen content of the soil. It seeds poorly, and the seed is very expensive, which will naturally much restrict its use. Alfalfa has been tried repeatedly on the station ground under favorable conditions, but it has not as yet proved a satisfactory crop for practical purposes. It is affected with "leaf-spot," winter-kills, and is crowded out by clover and grasses. Occasionally one hears of successes by Massachusetts farmers. It is suggested that our farmers try it in a small way ($\frac{1}{4}$ acre), and see if it will thrive in their locality. Soy beans (Brooks's medium green) and several varieties of cow peas have been carefully studied; the latter are best suited to a more southern climate. The soy beans thrive well in Massachusetts, and may be used with satisfaction as a soiling crop, and mixed with corn for silage purposes. It is believed, however, that it will prove more economical, as a rule, for farmers and dairymen possessing satisfactory markets and railroad facilities to purchase their protein in the form of high-grade concentrates, rather than attempt to grow it in the form of soy bean forage or seed. Soy beans may prove an economical crop for localities situated at some distance from markets and railroads.

Compilation of Analyses. — Attention is called to the tables of composition and digestion of American feed stuffs, recently compiled, and published in the Appendix to this report.

10. WORK IN PROGRESS.

Molasses and Molasses Feeds. — Work is in progress to determine the digestibility and comparative value and place in the farm economy of Porto Rico molasses and molasses feeds. Feeds of this character are being freely advertised and sold in our local markets. It is hoped to bring this work to a close early in the new year, and to report the results in bulletin form within a short time thereafter.

Nitro-cultures for Legumes. — The United States Department of Agriculture has called attention to the value of the cultures produced by its expert, Dr. Moore, for the different leguminous crops. Hellriegel of Germany was the first to scientifically demonstrate the symbiotic action of bacteria with the legumes, resulting in the fixation of atmospheric nitrogen. This subject has been given a great deal of study by many other scientists, particularly by Nobbe and his co-workers, who have isolated and prepared cultures suited to the different varieties of legumes. Moore claims that he has succeeded in isolating and developing varieties of bacteria that are especially active as nitrogen gatherers. This department has secured the Moore cultures for two years, and used them upon alfalfa, soy beans and cow peas. The directions were carefully followed in all cases, but no particular results were obtained that could be attributed directly to the action of the applied cultures. The yields for the soy bean and cow pea plots receiving the cultures were no greater than those not receiving them, neither did the plots thus treated show any noticeable increased nodular development. A newly seeded piece of alfalfa, inoculated with soil from an old alfalfa field, seemed to receive a decided help from the treatment, judging from the growth and apparent vigor of the plants. The writer would in no way condemn the Moore cultures, knowing the progress that has been achieved by numerous investigators along this line. Farmers may try the Moore cultures in a small way, but should not be disappointed if the results are not as expected. The daily press and popular journals have made altogether too extravagant

statements and claims regarding them. Work of this character still requires much study before the highest practical results are secured.

11. CHANGES IN STAFF.

Albert Parsons, B.S., for two years employed as inspector of concentrated feeds and of Babcock machines, resigned July 1, to accept a position as assistant superintendent at Hood Farm, Lowell, Mass. His place has been filled by the appointment of Frank G. Helyar, B.S., University of Vermont, 1905. Joseph G. Cook, B.S., assistant in animal nutrition, resigned August 1, to become superintendent of the farm at Norfolk, Mass., belonging to T. D. Cook & Co. Roy F. Gaskill, a recent graduate of the Massachusetts Agricultural College dairy course, succeeds him. E. S. Fulton, B.S., assistant chemist, severed his connection with this department September 15, having received an appointment with Dr. F. G. Benedict of Wesleyan University of Middletown, Conn., who has charge of the nutrition investigations for the United States Department of Agriculture. Mr. A. C. Whittier, B.S., University of Maine, 1905, has taken Mr. Fulton's place. The writer desires to express his highest appreciation of the faithfulness, interest and care exercised by all his co-workers in the prosecution of the various lines of work undertaken by this department during the past year.

PART II.—EXPERIMENTS IN ANIMAL NUTRITION.

1. BIBBY'S DAIRY CAKE.

J. B. LINDSEY.¹*Nature and Composition of the Cake.*

This material is made by J. Bibby & Sons, Liverpool, Eng., and is imported in the form of cake. It is composed chiefly of ground cotton-seed, together with locust or carob bean,² cereals (maize, wheat, etc.) or their by-products, fenugreek and salt; it possesses a pleasant taste and smell. A number of samples have been found that were quite mouldy, having probably been stored in a damp place. The sample used in the feeding experiment herein described had the following composition:—

	Bibby's Dairy Cake.	Standard Wheat Middlings for Comparison.	Gluten Feed for Comparison.
Water,	11.96	10.00	9.69
Ash,	7.89	4.30	1.40
Protein,	17.99	18.00	23.55
Fiber,	7.91	7.00	7.15
Extract matter,	45.05	55.70	55.08
Fat,	9.20	5.00	3.13

The cake has a high ash percentage, due partly to the presence of added salt, a moderate amount of protein and

¹ With E. B. Holland, P. H. Smith and J. G. Cook.

² The locust or carob tree is cultivated in Spain, the eastern Mediterranean regions and Egypt. The pods contain considerable quantities of sugar, and are eaten by both men and animals.

fiber, and quite a noticeable per cent. of fat. It is guaranteed to contain 18 to 20 per cent. of protein and 6 to 8 per cent. of fat, and usually meets these requirements. It has not been found to be very generally distributed.

Digestibility of Bibby's Dairy Cake.

The average results of six single trials with sheep are here given, together with the coefficients for standard wheat middlings and gluten feed for comparison. The full details of the digestion experiment have been reported in the seventeenth report of this station.

Coefficients of Digestibility.

	Bibby's Dairy Cake.	Standard Wheat Middlings for Comparison.	Gluten Feed for Comparison.
Dry matter,	70	73	85
Ash,	33	25	-
Protein,	66	77	85
Fiber,	31	30	76
Extract matter,	81	78	89
Fat,	92	88	83

In the several trials with Bibby's dairy cake the sheep experienced considerable difficulty in digesting the crude fiber, due probably to the fact that it was derived largely from cotton-seed hulls. It may be said that the total cake proved moderately digestible, the fiber having a low and the fat a high digestibility. Both in chemical composition and in digestibility Bibby's dairy cake closely resembled standard wheat middlings. Gluten feed contains 5 to 6 per cent. more protein, and is more digestible than the cake.

Cost of Digestible Matter.

	Bibby's Dairy Cake.	Standard Wheat Middlings.	Gluten Feed.
Pounds digestible matter in 2,000 pounds.	1,232	1,314	1,550
Cost of one pound (cents),	2.43	2.11	1.72

The above figures are based on the average wholesale prices of middlings and gluten feed for the year 1904, plus 10 per cent.; namely, \$26.70 for middlings and \$27.72 for gluten feed. Bibby's dairy cake cost \$30 a ton. The calculations show that a ton of wheat middlings furnished rather more digestible matter than a ton of Bibby's dairy cake, and at a somewhat less cost a pound. They further show that, if 1,550 pounds of digestible matter in a ton of gluten feed could be purchased for \$27.72, 1,232 pounds, being the quantity contained in a ton of Bibby's dairy cake, ought not to cost over \$22. In other words, Bibby's dairy cake at \$30 a ton furnishes digestible matter at some 37 per cent. advance over that contained in gluten feed at \$27.72 a ton.

Feeding Experiment with Bibby's Dairy Cake, Spring, 1904.

In order to test the efficacy of this cake as a food for milk production, four cows were divided as evenly as possible into two groups, and fed by the reversal method. All of the cows received first-cut hay, rowen and bran as a basal ration. In the first half, two of the cows received a definite quantity of the dairy cake and the other two a like quantity of gluten feed; in the second half, these two grain feeds were reversed.

Duration of Experiment.

Periods.	DATES.	Gluten Feed Ration.	Bibby's Dairy - Cake Ration.
I., : :	May 7 through May 27.	Red II. and Brighty.	Linnie and Blanche.
II., : :	June 4 through June 24.	Linnie and Blanche.	Red II. and Brighty.

Care of the Animals. — The cows were kept in roomy stalls, well carded, and turned into the yard some six or more hours each pleasant day.

Method of Feeding. — The animals were fed twice daily, the hay being given about an hour before milking, and the grain mixtures just before milking. The several grains were well mixed before being fed. Bibby's dairy cake was ground to the fineness of ordinary meal. Water was supplied the animals constantly by means of a self-watering device.

Character of Feeds. — The first-cut hay was a mixture of Kentucky blue-grass, timothy and red clover. The rowen was a mixture of second growth of grass and red clover, secured in good condition. The spring bran, gluten feed and Bibby's dairy cake were of good average quality.

Weighing the Animals. — The animals were weighed for three consecutive days at the beginning and end of each half of the trial.

Sampling Feeds. — The hay and rowen were sampled at the beginning, middle and end of each half of the trial, dry matter determinations made at once, and the several samples mixed for analysis. The grains were sampled daily, and preserved in glass-stoppered bottles. The cows received two ounces of salt daily.

Sampling the Milk. — The milk of each cow was sampled twice daily for five consecutive days of each week, and preserved with formaline in tightly corked bottles. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a small dipperful. Determinations of fat were made weekly, and solids every other week.

History of the Cows, Spring, 1904.

Name.	BREED.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yields, Beginning of Experiment (Pounds).
Red II., .	Jersey-Durham,	8	December, 1903.	59	30
Brighty, .	Grade Jersey, .	8	August, 1903.	124	17
Linnie, .	Grade Jersey, .	7	October, 1903.	65	21
Blanche, .	Grade Jersey, .	9	August, 1903.	121	22

Daily Rations consumed (Pounds).

RATION.	Cows.	Hay.	Rowen.	Bran.	Gluten Feed.	Bibby's Dairy Cake.
Gluten feed, . . .	Red II., .	18	6	4	4	—
	Brighty, .	14	6	3	3	—
	Linnie, .	14	6	3	3	—
	Blanche, .	17	6	3	4	—
Bibby's dairy cake, .	Red II., .	18	6	4	—	4
	Brighty, .	14	6	3	—	3
	Linnie, .	14	6	3	—	3
	Blanche, .	17	6	3	—	4
Average, gluten feed ration.	. . .	15.75	6	3.25	3.5	—
Average, Bibby's dairy cake ration.	. . .	15.75	6	3.25	—	3.5

It will be seen that the cows received the same basal ration daily, and in addition averaged 3.5 pounds of gluten feed or dairy cake.

Average Dry Matter and Digestible Organic Nutrients in Daily Ration (Pounds).

RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Gluten feed, average, .	24.99	2.36	4.15	7.73	.35	14.59	1: 5.4
Bibby's dairy cake, average.	24.91	2.07	3.96	7.27	.36	13.86	1: 6.0

The two rations furnished the same quantity of total dry matter daily. The Bibby's dairy cake ration contained rather less protein and about three-fourths of a pound less total digestible matter. This was due principally to the fact that Bibby's dairy cake was less digestible than the gluten feed. It would naturally be expected that Bibby's dairy cake ration would produce rather less milk, or cause the animals to shrink somewhat in live weight.

Total Yields of Milk Products (Pounds).

RATION.	Total Milk.	Average Daily Yield.	Total Solids.	Total Fat.	Butter Equivalent 85 Per Cent.
Gluten feed,	1,860.04	22.14	256.12	89.89	105.75
Bibby's dairy cake,	1,830.01	21.79	251.20	90.00	105.88

The yields obtained from the two rations, covering a period of twenty-one days in each case, were practically identical. If the periods had covered twice the length of time, the results would have been regarded as more satisfactory. Longer periods were not practicable, owing to the condition of the animals and the nearness of summer weather.

Average Composition of the Herd Milk.

RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).
Gluten feed,	13.77	4.83
Bibby's dairy cake,	13.73	4.92

The two rations produced milk having practically the same composition.

Food Cost of Milk Products.

RATION.	Total Milk.	One Hundred Pounds Milk.	One Pound Butter.
Gluten feed,	\$20 85	\$1 12	\$0 20
Bibby's dairy cake,	22 03	1 20	21
Percentage increased cost with Bibby's dairy cake.	5.66	7.14	5.00

In calculating the above results, gluten feed was charged at \$27.72 a ton, Bibby's dairy cake at \$30, bran at \$20, hay at \$15 and rowen at \$14. The increased cost of the milk and butter produced by the Bibby's dairy cake ration was due to the price asked for Bibby's dairy cake.

Herd Gain or Loss in Live Weight.

RATION.	Total Gain or Loss.
Gluten feed,	43 +
Bibby's dairy cake,	2 —

There appeared to have been a slight gain in live weight produced by the gluten ration. During the Bibby's dairy cake period the weight remained constant.

Conclusions.

1. Bibby's dairy cake, a manufactured product, resembles in chemical composition and digestibility standard wheat middlings. It has a sweet taste and an agreeable flavor and odor, due to the presence of the carob bean, fenugreek and salt.

2. It was found to contain slightly less digestible matter than middlings, and some 20 per cent. less than gluten feed. On the basis of digestible matter contained in the Bibby's dairy cake and in first-class gluten feed, the former should sell for 20 per cent. less a ton.

3. While the cake is readily eaten and highly relished by

all farm animals, it is believed that the agreeable flavor and odor do not make it worth the extra price asked.

4. In the feeding experiment, lasting twenty-one days, the four cows produced practically as much milk on the Bibby's dairy cake as on the gluten feed ration; the latter ration produced a slight gain in live weight. The cost of milk and butter was noticeably more on the Bibby's dairy cake ration. The experiment indicates that the Bibby's dairy cake ration furnished a sufficient quantity of digestible matter to meet the requirements of the several cows. Had the periods been longer, and the cows in a less advanced period of lactation, it is believed the differences would have been more striking.

5. Bibby's dairy cake, at prevailing market prices, is not regarded as an economical concentrate; it can be used, however, if desired, as the exclusive grain ration for sheep, young dairy stock and milch cows. From 5 to 8 pounds would be the usual daily allowance for the latter animals. Its chief use should be as an appetizer, to be mixed in small quantities with foods that, because of an inferior flavor, would not be otherwise readily consumed.

From the standpoint of economy, farmers will do well to produce their hay, silage and corn meal, and to purchase only those manufactured concentrates that are rich in protein, such as cotton-seed meal, gluten feed, distillers' and brewers' dried grains, wheat middlings and bran.

2. EUREKA SILAGE CORN, — ITS VALUE FOR MASSACHUSETTS FARMERS.

J. B. LINDSEY AND P. H. SMITH.

This corn is said to have originated in Virginia. It is a large southern dent, and is considerably used for silage purposes by New England farmers.

Brooks¹ of this station compared a number of dent varieties during the season of 1901. The Eureka grew to be 15 feet high, appeared to be quite heavily leaved, and when cut, September 14, the ears were just forming. This variety yielded rather heavier than the others, producing at the rate of 24 tons to the acre, containing 8,944 pounds of dry matter. Its digestibility was not determined. Brooks concluded that the heavy dents were not as satisfactory as the smaller varieties for New England conditions. At the solicitation of Ross Bros. of Worcester, who recommend and sell the Eureka seed for silage purposes, this department has made a more thorough study of the Eureka, and briefly presents the results and conclusions in the following pages.

Crop of 1903.

One-fourth acre of medium well-drained loam, in a good state of fertility, was treated with manure from well-fed dairy cows, at the rate of 6 cords to the acre. The manure was plowed in, and the land well fitted and seeded May 26, with Eureka corn, obtained of Ross Bros. The seed came up well, and the corn made as good growth as could be expected during the exceptionally cool season. Frosts held off until nearly the 1st of October, and the corn was allowed to grow until September 25, in order to insure a maximum

¹ Fourteenth annual report of the Hatch Experiment Station, pp. 32-34.

development. At that time it averaged 11½ feet in height, the ears had formed, and the kernels were just beginning to develop. When cut, it contained 82.6 per cent. of water, and yielded at the rate of 15 tons of green material to the acre.

Crop of 1904.

One-third of an acre of well-drained, light loam was plowed, manured at the rate of 6 cords to the acre and well fitted. The area was divided into two halves, and planted with Eureka and Sibley's Pride of the North corn, the latter a medium dent that will mature its seed in our latitude. Some of the seed failed to germinate, more particularly the Eureka, which necessitated some replanting. When the corn was 15 inches high it was thinned to about one stalk to the foot. The area was kept well cultivated and free from weeds. On July 12 the corn was growing fast and looked healthy, the Eureka being the taller. August 15 the Pride of the North was well tasseled and silked, while the Eureka tassels were just showing. The corn was cut September 15, at which time the Pride of the North averaged 9 to 10 feet in height and was fairly ripe, with kernels glazing. The Eureka was 12 to 13 feet high and quite immature, the ears being small and the kernels scarcely formed. Two plats, each 175 by 35 feet, were cut, stooked and eventually carried to the barn and carefully weighed. The Eureka yielded 936 pounds of dry matter, equal to 6,683 pounds per acre, equivalent to 20.4 tons of green corn (83.6 per cent. water); the Pride of the North yielded 877 pounds of dry matter, equal to 6,262 pounds per acre, equivalent to 13.9 tons of green corn (77.5 per cent. water).

Composition of Green Corn (Per Cent.).

	EUREKA.		Pride of the North, 1904.
	1903.	1904.	
Water,	82.60	83.60	77.50
Ash,	1.08	1.08	1.05
Protein,	1.63	1.48	1.85
Fiber,	4.77	5.48	4.97
Nitrogen-free extract,	9.65	8.11	14.06
Fat, . . . . .	.27	.25	.57
	100.00	100.00	100.00

The above analyses show that the Eureka, when cut in September, contained considerably more water and noticeably less nitrogen-free extract matter and fat than the Pride of the North.

Composition of Dry Matter (Per Cent.).

	WHOLE PLANT.				STOVER.		
	EUREKA.		Pride of the North, 1904.	Eureka, 1904.	Pride of the North, 1904.	Average, Forty-one Analyses, for Comparison.	
	1903.	1904.					
Ash,	6.19 ¹	7.85 ²	6.58	4.67	6.96	6.77	6.60
Protein,	9.34	9.82	9.01	8.22	8.00	7.23	7.60
Fiber,	27.41	32.70	33.43	22.11	36.49	34.45	34.20
Extract,	55.52	47.90	49.47	62.47	47.19	50.01	50.20
Fat,	1.54	1.73	1.51	2.53	1.36	1.54	1.40
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

¹ When cut in autumn.

² After being housed in barn until March.

The differences in the composition are much more noticeable with the water eliminated. The Eureka (whole plant) contained decidedly more ash and fiber, rather more protein and much less extract matter than the Pride of the North.

The analyses show that the Pride of the North had reached a more advanced stage of development than the Eureka, and consequently contained a much larger proportion of starchy matter. The stover from the two varieties was quite similar in composition.

Percentage of Water in Field-cured Material.

EUREKA.			PRIDE OF THE NORTH.	
Whole Plant.		Stover.	Whole Plant.	Stover.
59.92 ¹	68.92 ²	62.89 ³	37.84 ⁴	18.13 ⁵

¹ After being cured in barn for six months, 1903.

² As it came from field, 1904.

³ After being in barn about a month, 1904.

⁴ As it came from field, 1904.

⁵ After being in barn about three months.

The field-cured Eureka still continued to contain a high moisture content, due probably to its immaturity and to its unusually coarse, porous stems.

The Pride of the North had about the usual water content for matured corn that had been field cured. These figures show that in a ton of dried Eureka fodder, as drawn to the barn, there would be 1,380 pounds of water and 620 pounds of dry matter; and in a ton of Pride of the North there would be 757 pounds of water and 1,243 pounds of dry matter; in other words, each ton of Pride of the North would have twice the feeding value of Eureka, without taking into consideration the superior nutritive character of the dry matter, which will be alluded to under another heading.

The corn stover derived from the two varieties likewise showed marked differences in the water percentage present. The barn-cured Pride of the North stover was exceptionally dry.

Composition of Parts of Corn (Per Cent.).

[Dry Matter.]

	LEAVES.		STALKS.		EARS.		HUSKS.	
	Eureka.	Pride of the North.	Eureka.	Pride of the North.	Eureka.	Pride of the North.	Eureka.	Pride of the North.
Ash,	8.98	9.42	5.42	5.81	3.25	1.95	3.02	3.17
Protein,	14.53	14.53	4.80	4.55	12.00	9.82	8.66	5.40
Fiber,	28.43	25.00	35.77	31.94	19.47	11.37	24.64	27.32
Extract,	45.63	47.63	52.94	56.82	63.84	73.65	62.22	62.70
Fat,	2.43	3.42	1.07	.88	1.44	3.21	1.46	1.41
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The samples were taken immediately after the corn was cut (September 15), dried at a low heat, and preserved in glass-stoppered bottles. The leaves of the two varieties were similar in composition, and are the most valuable parts of the plant, aside from the ears. The stalks of the Eureka were characterized by containing more fiber than the other variety. The ears produced by the Eureka contained rather more protein and ash, decidedly more fiber and noticeably less fat and extract matter than those yielded by the Pride of the North. The analyses make clear that the ears obtained from the Eureka were quite imperfectly developed. The composition of the husks was more uniform.

Digestibility of the Corn.

The first digestion experiment was made in the autumn of 1903, with the Eureka green corn. Another experiment was made with the same corn, after it had been cured and housed for six months. Unfortunately, a digestion test was not made with the Pride of the North (whole plant). During the autumn of 1905, therefore, another sample of this variety was tested for digestibility. It was fully developed and well eared. Other experiments were made to test the digestibility of the stover of each of the two varieties produced in 1904. The several tests were made with the same sheep in each case, the results of which follow:—

	EUREKA.		Pride of the North, Green, 1905 (Two Sheep).	Eureka, Stover, 1904 (Two Sheep).	Pride of the North, Stover, 1904 (Two Sheep).
	Green, 1903 (Three Sheep).	Dry, 1903 (Two Sheep).			
Dry matter,	67	64	71	54	54
Ash,	42	40	34	45	31
Protein,	67	57	63	48	45
Fiber,	60	72	65	59	60
Nitrogen-free extract, .	72	64	77	53	54
Fat,	66	62	76	67	64

The green Eureka fodder (whole plant) and the same material dried showed only slight variation in the digestibility of total dry matter. The results correspond closely with those obtained by other experimenters with large southern varieties at a similar stage of growth. For some reason the fiber in the dry material was more fully digested than in the green substance, and the protein and extract matter less so. The Pride of the North (whole plant) proved to be rather more digestible than the Eureka, due to the fact that it was well eared. The digestible material in the Pride of the North, because of its content of matured grain, would naturally yield more net available energy than a like amount of digestible matter derived from the Eureka. The corn stover (all ears removed) from each of the two varieties appeared to be equally well digested.

Summary of Yields.

A definite quantity of each of the two varieties of green material was separated into husks, ears, leaves and stalks, in order to determine the relative proportions of each. The figures show percentages or pounds in 100.

(a) Yield of Parts.

PARTS.	EUREKA.			PRIDE OF THE NORTH.		
	First Trial.	Second Trial.	Average.	First Trial.	Second Trial.	Average.
Husks,	6.50	8.00	7.25	10.25	11.25	10.75
Ears,	6.25	8.25	7.25	21.25	23.00	22.11
Leaves,	22.75	21.75	22.25	20.00	20.00	20.00
Stalks,	65.00	62.25	63.62	47.50	46.00	46.75
	100.50	100.25	100.37	99.00	100.25	99.67

The results are in accordance with the teaching of the analytical data. The Eureka showed only 7.25 per cent. of ears, while the Pride of the North contained 22.11 per cent. The Pride of the North variety consisted of 46.75 per cent. of stalks, and the Eureka 63.62 per cent. The Eureka, even at its less advanced stage of growth, contained only slightly more leafy matter than the Pride of the North.

(b) Yield per Acre (Pounds).

	EUREKA.		Pride of the North, 1904.
	1903.	1904.	
Green material,	30,000	40,800	27,800
Dry matter,	5,220	6,691	6,255
Estimated digestible matter,	3,497 ¹	4,483 ¹	4,441 ¹

¹ Obtained by allowing 67 per cent. of the dry matter to be digestible in the Eureka, and 71 per cent. in the Pride of the North, as determined by actual experiment.

The above results indicate strongly that the Eureka, although a larger variety, yielding considerable more green material than the Pride of the North, is not likely to furnish any more actual food to the acre. In the present instances,

the party drawing the product of an acre of green Eureka corn to the barn would be transporting 34,109 pounds of water and 6,691 of dry matter, while in the case of the Pride of the North he would cart 21,545 pounds of water and 6,255 pounds of dry material ; in other words, to secure essentially the same quantity of actual food in the Eureka he would be required to handle 12,564 pounds extra water.

It is, of course, understood that the yield would vary from year to year, depending on soil and climatic conditions. It is believed, however, that the relative proportions would hold true, and that the farmer would secure as much actual food material from those varieties of corn that mature their seed, without being obliged to handle the extra bulk in the form of water.

Conclusions.

1. Eureka silage corn is a late dent variety ; it has large stalks, which appear to be thickly set with leaves. During the seasons of 1903 and 1904 it grew 11 to 13 feet high, and when cut, September 15, the ears were very immature (kernels just forming).

2. In comparison with Sibley's Pride of the North, a medium dent, which matures its ears in this latitude, the Eureka green corn, when cut, contained about 6 per cent. more water, noticeably more ash and fiber, and much less extract matter. The field-cured fodder of the Eureka still contained as high as 69 per cent. of water, while the Pride of the North contained only 38 per cent.

3. The leaves and husks of each variety did not vary greatly in composition. The ears and stalks of the Eureka contained more fiber and much less extract matter and fat than those of the Pride of the North.

4. The Eureka green fodder was found to be 67 per cent., and the same material dry 64 per cent., digestible ; a typical sample of Pride of the North, cut green, was 71 per cent. digestible. The stover of both varieties proved equally digestible.

5. The Eureka yielded about the same relative weight of green leaves as did the Pride of the North. It produced 64 per cent. of stalks and 7 per cent. of ears, while the Pride

of the North yielded 47 per cent. of stalks and 22 per cent. of ears.

6. The Eureka produced at the rate of 20 tons of green fodder, and the Pride of the North 13 tons of green fodder, to the acre. The latter, however, contained nearly as much dry and digestible matter (actual food material) as did the former. The excess yield of Eureka green corn, therefore, consisted of water.

7. Had the seasons of 1903 and 1904 been more favorable to the growth of corn, it is probable that both varieties would have produced larger yields. It is very doubtful, however, if the Eureka would have matured its grain.

The writer, therefore, thinks it unwise to grow such late dents as the Eureka, and believes the northern farmer will secure better feed for less money by holding fast to those varieties that will mature not later than September 10 or 15.

It is well known that immature corn, such as the Eureka, undergoes more serious decomposition when ensiled than do well-matured varieties, which would still further detract from its nutritive value.

3. CONCERNING WHEAT BRAN.

J. B. LINDSEY.¹

(1) *Introduction.*

Until within comparatively recent times, wheat bran and corn meal have formed the two staple concentrated feeds for dairy stock, and in spite of the large variety of concentrates now in the market, the former still continues to be used largely by the great majority of dairymen in our eastern States. The reasons for this are not difficult to find. A good quality of bran is uniformly palatable; it can be fed in considerable quantities without producing any ill effects; it acts as a slight laxative; it furnishes more digestible protein than corn; and it serves as a very satisfactory diluter or distributor of the heavy concentrates, such as the glens, cotton-seed meal and flour middlings. It is believed, however, that the nutritive material contained in bran can be purchased more cheaply in other concentrates, and that New England farmers often use more of it than economy warrants.

Attention is called in the present paper to the composition, digestibility, cost of digestible matter and the fertilizer ingredients in bran, as compared with other concentrated feeds, and likewise to experiments I. and II., in which corn silage is compared with wheat bran as a distributor of the heavy concentrates. Note particularly the brief discussion of the results, at the end of the article.

¹ With E. B. Holland, P. H. Smith and J. G. Cook.

(2) *Average Composition of Concentrates.*

INGREDIENTS.	Wheat Bran.	FOR COMPARISON.				
		Cotton-seed Meal.	Gluten Feed.	Distillers' Dried Grains.	Brewers' Dried Grains.	Malt Sprouts.
Water,	10.00	7.00	8.50	8.00	8.00	11.00
Ash,	6.40	6.50	1.70	1.70	3.80	5.80
Protein,	16.00	45.10	26.50	33.00	23.10	27.10
Fiber,	10.00	6.10	7.20	13.10	10.80	11.80
Extract matter (starchy),	53.00	24.20	53.10	32.40	49.40	42.90
Fat,	4.60	11.10	3.00	11.80	4.90	1.60

Wheat bran contains noticeably less protein than any of the other important by-products. Nitrogen-free extract matter usually is the fodder group next in value to the protein. The quantity contained in bran is approximately equal to that found in gluten feed, and not greatly in excess of the percentage in brewers' grains and malt sprouts.¹ Most of the several feeds enumerated contain about similar fiber percentages.

(3) *Digestibility of the Concentrates.*

The figures in the following table show the pounds of digestible fodder groups contained in one ton of the several feeds.

Wheat bran is shown to contain rather less total digestible matter and noticeably less digestible protein than any of the several feeds tabulated. The two carbohydrate feeds, corn and hominy meals, are naturally deficient in protein, but very rich in digestible starchy matter and fat.

¹ The quantity of extract matter in cotton-seed meal is quite small, due to the exceptionally high protein percentage.

Organic Matter digestible in 2,000 Pounds.

INGREDIENTS.	Wheat Bran.	Cotton-seed Meal.	Gluten Feed.	Brewers' Dried Grains.	Malt Sprouts.	Distillers' Dried Grains.	Corn Meal.	Hominy Feed.
Protein,	254	800	440	364	434	448	130	142
Fiber,	58	68	110	114	78	160	-	44
Extract matter,	732	298	964	574	580	520	1,328	1,110
Fat,	60	196	50	90	32	206	60	152
Totals,	1,404	1,362	1,564	1,142	1,124	1,334	1,518	1,448

Retail Cost of One Pound of Digestible Matter.

	Spring and Winter Bran. 1901 to 1904.	Cotton-seed Meal. 1901 to 1904.	Gluten Feed. 1901 to 1904.	Distillers' Dried Grains. 1904 to July, 1905.	Brewers' Dried Grains. 1904.	Malt Sprouts. 1901 to July, 1905.	Corn Meal. 1901 to 1904.	Hominy Meal. 1901 to 1904.
Market price per ton,	\$22 48	\$29 17	\$26 05	\$27 00	\$22 50	\$21 00	\$26 12	\$25 03
Cost of one pound of digestible matter (cents),	2.04	2.15	1.67	2.03	1.97	1.87	1.70	1.72

The above figures are quite instructive. They show that digestible matter in bran, cotton-seed meal and distillers' and brewers' dried grains has cost about the same for a number of years, while in the form of malt sprouts the price has been somewhat less.¹ Corn and corn by-products (gluten and hominy feed) have furnished digestible matter for uniformly less money than it could be purchased for in the form of either bran, cotton-seed meal, distillers' or brewers' residues.

Retail Cost of Digestible Protein.

[Allowing 1 cent for digestible carbohydrates, .5 cent for digestible fiber and 2.25 cents for digestible fat.]

	Spring and Winter Bran. 1901 to 1904.	Cotton-seed Meal. 1901 to 1904.	Gluten Feed. 1901 to 1904.	Distillers' Grains. 1904 to July, 1905.	Brewers' Grains. 1904.	Malt Sprouts. 1904.
Market price per ton, .	\$22 48	\$29 17	\$26 05	\$27 00	\$22 50	\$21 00
Cost of one pound of digestible protein (cents).	5.40	2.72	3.00	3.65	3.91	3.25

Cotton-seed meal furnishes digestible protein for the least money, gluten feed standing next in order, while protein in the form of wheat bran is decidedly expensive. Naturally, carbohydrate feeds, corn and the like, are not economical sources of protein.

(4) *Fertilizing Ingredients in a Ton of Concentrates.*

	Wheat Bran.	Cotton-seed Meal.	Gluten Feed.	Distillers' Grain.	Brewers' Grains.	Malt Sprouts.
Nitrogen,	51	144	85	106	74	86
Potash,	28	37	-	-	17	33
Phosphoric acid, . . .	42	50	7	60	21	29
Valuation per ton, . . .	\$12 34	\$30 18	\$16 00	\$19 78	\$15 25	\$18 47
Percentage valuation of retail cost.	54	103	62	73	68	88

Bran is quite rich in the mineral ingredients phosphoric acid and potash, being exceeded only by cotton-seed meal.

¹ The retail price of malt sprouts and brewers' dried grains has been rather difficult to ascertain, for the reason that comparatively small quantities are sold in Massachusetts markets.

The corn by-products (gluten feed and distillers grains) contain only a trace of potash. The money valuations are based on current market prices, namely: nitrogen, 18.5 cents; potash, 4.25 cents; and phosphoric acid, 4 cents a pound. The fertilizing elements in the several feeds are in as desirable a form as those in the best grades of unmixed fertilizing stock. Bran is shown to contain fertilizer ingredients equal to 54 per cent. of its cost, and cotton-seed meal is fully equal to its cost; the others are considerably in excess of the bran.

It is not to be inferred that after the several feeds have passed through the animal their fertilizing ingredients have as high a money value as before they were consumed. In fact, some 20 per cent. has been retained by the animal, more or less loss has unavoidably occurred in the manurial residue, and they are in a much more bulky condition, which requires considerable additional labor to apply them. Nevertheless, the figures show clearly that the combined fertilizer ingredients in bran have noticeably less value than in any of the other by-products.

Conclusions.

1. Wheat bran contains noticeably less total as well as less digestible protein than any of the other nitrogenous by-products.

2. The total digestible matter in bran is likewise less than in the other prominent concentrates; thus, cotton-seed meal contains 24 per cent. more, gluten feed 44 per cent., distillers' grains 21 per cent. and corn meal 38 per cent.

3. For several years past the cost of a pound of digestible matter in bran, cotton-seed meal, distillers' and brewers' dried grains has been about the same; it could be purchased in the form of gluten feed, corn and hominy meals for some 20 per cent. less.

4. A pound of digestible protein in wheat bran cost 100 per cent. more than in cotton-seed meal, 80 per cent. more than in gluten feed and 50 per cent. more than in distillers' dried grains.

5. Because of its relatively low protein percentage, the

fertilizer ingredients in bran have from 10 to 50 per cent. less money value than those contained in the other by-products.

6. The nutritive material and especially the protein contained in wheat bran must be regarded, therefore, as relatively expensive. Because of its palatability, its laxative effect and its desirability as a diluter or distributor of the heavy concentrates, it will continue to be used by many farmers as a portion of the grain ration for dairy stock. See practical deductions as to the use of bran, on page 223.

(5) *Wheat Bran v. Corn Silage as a Distributer of the Heavy Concentrates.*

EXPERIMENT I. SPRING, 1903.

Object of the Experiment. — Wheat bran has been shown to be an expensive feed, judged solely from the amount of nutritive material it contains. The present experiment was undertaken to see if silage would not serve as a distributor equally as well as bran. Such being the case, the farmer could use *home-grown* corn, or corn and cob meal, in place of an equal amount of bran, and, by feeding in addition a few pounds daily of cotton-seed meal and malt sprouts or flour middlings, get along with a minimum quantity of *purchased* grain.

Plan of the Experiment. — The cows, ten in number, were high-grade Jerseys. Eight had calved early the previous autumn, and two, Pearl and Red 2d, the preceding December.

The animals were divided as equally as possible into two lots of five each, and both herds fed for two weeks upon the so-called bran ration, consisting of silage, hay, cotton-seed meal, flour middlings and wheat bran. In the second period, lasting five weeks, one lot of cows, known as Herd I., continued to receive the same ration; and the other lot, Herd II., was fed the so-called silage ration, consisting of silage and hay, cotton-seed meal, flour middlings and corn and cob meal. In each of the two periods one week was considered preliminary.

In interpreting the results, it is proposed to note the weekly yields produced in the second period by both herds on different grain rations, as compared with the weekly yields of the first periods, when the two herds received the same grain ration, thus ascertaining the comparative efficacy of the two different grain rations fed in the second period. The yields obtained in the first period are to be used simply as a basis for comparison.

Duration of the Experiment.

Period I.

Herd.	CHARACTER OF RATION.	Cows.	Date.	Number of Weeks.
I., .	Bran as distributor,	Brighty, Pearl, Linnie, Roda, Doliska.	March 30 ¹ -April 5.	1
II., .	Bran as distributor,	Red II., Dora, Blanche, May, Daisy.	March 30-April 5.	1

Period II.

I., .	Bran as distributor,	Brighty, Pearl, Linnie, Roda, Doliska	April 12 ¹ -May 10.	4
II., .	Silage as distributor,	Red II., Dora, Blanche, May, Daisy.	April 12-May 10.	4

¹ Preceded by preliminary period of seven days.

General Care of the Animals. — The experiment was carried out in the station barn, especially set apart for such work. Each animal was kept in a roomy stall, well carded, and turned daily into a yard for exercise. The cows were in good condition, and quite contented.

Method of Feeding. — The cows were fed twice daily, and water was before them constantly. In case of the bran ration, the several grains composing it were carefully mixed, and fed just before milking. The grains used in the silage ration — cotton-seed and corn meals and flour middlings — were likewise mixed, and the resulting combination quite thoroughly mingled with the silage by means of a four-tined fork, and fed previous to milking. One quart of the bran ration weighed .80 of a pound, and 1 quart of the grain ration fed with the silage weighed 1.4 pounds, the former being naturally much more bulky.

Character of the Feed Stuff's. — The bran was from spring wheat, the other grains were of the usual good quality. The silage, made from rather poorly eared corn, was of average quality. The hay was largely Kentucky blue-grass, with some clover.

Weighing the Animals. — The animals were weighed on three consecutive days at the beginning and end of the second period.

Sampling Feeds. — The coarse foddere were sampled three times during the second period, dry matter determinations made immediately, and composite samples analyzed. Small samples of the grains were taken daily and placed in glass-stoppered bottles.

Sampling Milk. — The milk of each cow was sampled twice daily for five consecutive days of each week of the two periods, and preserved with formaline in tightly corked bottles. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a small dipper full.

Average Ration consumed by Each Cow Daily (Pounds).

First period: both herds, bran ration.

HERD.	First Cut Hay.	Silage.	Bran.	Cotton-seed Meal.	Flour Middlings.	Corn and Cob Meal.
I., . . .	12.52	26.10	3.60	2.00	2.00	—
II., . . .	13.60	29.00	3.80	2.10	2.10	—

Second period: Herd I., bran ration; Herd II., silage ration.

I., . . .	12.80	25.70	3.60	2.00	2.00	—
II., . . .	13.60	29.00	—	2.10	2.10	3.80

Herd I. received practically the same quantity of grain and roughage daily in each period; the same can be said of Herd II. Herd II. needed and received slightly more than Herd I. during both periods.

Average Dry and Digestible Daily Nutrients consumed by Each Cow (Pounds).

Herd I.: both periods, bran ration.

PERIOD.	Dry Matter.	Protein.	Carbo-hydrates.	Fat.	Total.	Nutritive Ratio.
I., . . .	22.98	2.42	11.38	.69	14.49	1:5.4
II., . . .	23.16	2.43	11.46	.69	14.58	1:5.4

Herd II.: first period, bran ration; second period, silage ration.

I., . . .	24.85	2.58	12.36	.74	15.68	1:5.4
II., . . .	24.78	2.26	13.29	.73	16.28	1:6.5

Herd I. received the same quantity of digestible nutrients during both periods. Herd II. received more total digestible matter in the first period than did Herd I., but the nutritive ratio of the fodder groups was the same. In the second or silage period Herd II. consumed rather more total digestible nutrients than in the first period, but less digestible protein, the nutritive ratio being somewhat wider (1:6.5, instead of 1:5.4). This increase of digestible matter consumed was due to the higher digestibility of the corn and cob meal.

Weight of Animals at Beginning and End of Second Period (Pounds).

HERD.		Brighty.	Pearl.	Linnie.	Roda.	Doliska.	Red II.	Dora.	Blanche.	May.	Daisy.	Gain or Loss.
I., . . .	Beginning, .	850	958	815	860	761	-	-	-	-	-	+ 67
	End, . . .	874	967	828	864	778	-	-	-	-	-	
II., . . .	Beginning, .	-	-	-	-	-	1,003	875	1,168	1,048	850	+ 94
	End, . . .	-	-	-	-	-	1,003	905	1,177	1,076	877	

Each herd made a slight gain during the period. The difference is unimportant.

Yield of Milk and Milk Ingredients (Pounds).

First period: both herds, bran ration.

HERD.	Cows.	Total Milk.	Daily for Cow.	Total Solids.	Total Fat.	Butter Equivalent (85 Per Cent.).
I.,	Brighty, . . .	127.25	18.18	20.06	8.21	9.66
	Pearl, . . .	218.00	31.14	29.89	10.90	12.82
	Linnie, . . .	157.00	22.43	22.62	8.48	9.98
	Roda, . . .	110.74	15.82	15.32	5.65	6.65
	Doliska, . . .	184.99	26.43	23.29	7.03	8.27
Total,		797.98	114.00	111.18	40.27	47.38
II.,	Red II., . . .	262.49	37.50	32.31	11.02	12.96
	Dora, . . .	142.60	20.37	20.29	7.27	8.55
	Blanche, . . .	150.62	21.52	22.61	7.91	9.31
	May, . . .	139.50	19.93	21.41	7.88	9.27
	Daisy, . . .	123.00	17.57	19.45	7.38	8.68
Total,		818.21	116.89	116.07	41.46	48.77

Second period: Herd I., bran ration; Herd II., silage ration.

I.,	Brighty, . . .	509.74	18.21	80.84	32.41	38.13
	Pearl, . . .	879.70	31.42	125.70	46.44	54.65
	Linnie, . . .	679.00	24.25	97.84	36.60	43.06
	Roda, . . .	439.82	15.71	62.37	22.17	26.08
	Doliska, . . .	773.21	27.61	97.73	29.15	34.30
Total,		3,281.47	117.20	464.48	166.77	196.22
II.,	Red II., . . .	1,048.58	37.45	131.91	43.62	51.32
	Dora, . . .	581.83	20.78	85.65	31.48	37.04
	Blanche, . . .	609.73	21.78	92.25	32.01	37.66
	May, . . .	497.49	17.77	78.11	27.96	32.89
	Daisy, . . .	480.68	17.17	77.53	29.99	35.28
Total,		3,218.31	114.95	465.45	165.06	194.19

Average Weekly Yields of Each Herd (Pounds), and Percentage Gain or Loss.

Herd I.

PERIODS.	Milk.	Solids.	Fat.	Butter Equivalent (85 Per Cent.).
I.,	798.0	111.2	40.3	47.4
II.,	820.4	116.1	41.7	49.1
Percentage gain or loss, II. over I.,	+ 2.8	+ 4.4	+ 3.5	+ 3.6

Herd II.

PERIODS.	Milk.	Solids.	Fat.	Butter Equivalent (85 Per Cent.).
I.,	818.2	116.1	41.5	48.8
II.,	804.6	116.4	41.3	48.5
Percentage gain or loss, II. over I.,	- 1.7	+ .3	- .4	- .6

It will be seen that Herd I., which received the bran ration during both periods, made a slight gain during the second period in the quantity of milk and milk ingredients; while Herd II., which received the silage ration in the second period, underwent a slight loss. The differences are so slight as to prevent any positive conclusions. They indicate, however, that the bran ration produced slightly better results than the silage ration, due possibly to the excess of protein in the former ration.

Dry and Digestible Matter required to produce Milk, Milk Solids and Milk Fat.

Herd I.: both periods, bran ration.

PERIOD.	DRY MATTER REQUIRED TO PRODUCE —			DIGESTIBLE MATTER REQUIRED TO PRODUCE —		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
I.,	100.80	7.23	19.97	63.56	4.56	12.60
II.,	98.81	6.98	19.44	62.21	4.40	12.24

Herd II : first period, bran ration; second period, silage ration.

I.,	106.32	7.49	20.98	67.04	4.73	13.23
II.,	107.78	7.45	21.01	70.83	4.90	13.81

Herd I. required slightly less dry and digestible matter to make milk and milk ingredients in the second period. Herd II. took a little more dry and digestible matter in the second period to make a definite quantity of milk, milk solids and milk fat. On the basis of the above figures, it may be concluded that the bran ration produced a trifle better results than the silage ration.

Food Cost of Milk and Butter.

Herd I.: both periods, bran ration.

PERIOD.	One Hundred Pounds Milk.	One Hundred Pounds Butter.
I,	\$1 03	\$17 33
II.,	1 01	16 81

Herd II.: first period, bran ration; second period, silage ration.

I.,	\$1 08	\$18 11
II.,	1 13	18 74
Percentage increased cost, Period II. over Period I.	+4.6	+3.5

The cost of milk and butter is based upon hay at \$15 a ton, silage at \$3.50, bran at \$22, corn and cob meal at \$26, cotton-seed meal at \$30 and middlings at \$25. The cost of milk and butter produced by Herd I. in both periods was nearly identical, and the slight variations may be attributed to experimental error. The increased cost of the milk and butter produced by Herd II. in the second period was due largely to the then existing excess cost of the corn and cob meal over that of the bran, and not to the feeding effect of the two rations.

Fertilizer Ingredients in Rations (Cost).

First period: Herd I., bran ration.

19.46 pounds nitrogen, valued at	\$3 31
13.81 pounds potash, valued at	69
7.75 pounds phosphoric acid, valued at	31
Total,	<u>\$4 31</u>

Fertilizer Ingredients, etc. — Concluded.

First period: Herd II., bran ration.

20.90 pounds nitrogen, valued at	\$3 55
14.98 pounds potash, valued at	75
8.26 pounds phosphoric acid, valued at	33
Total,	<hr/> \$4 63

Second period: Herd I., bran ration.

78.16 pounds nitrogen, valued at	\$13 29
55.65 pounds potash, valued at	2 78
31.02 pounds phosphoric acid, valued at	1 24
Total,	<hr/> \$17 31

Second period: Herd II., silage ration.

78.38 pounds nitrogen, valued at	\$13 32
54.89 pounds potash, valued at	2 74
24.86 pounds phosphoric acid, valued at	99
Total,	<hr/> \$17 05

The total quantity and valuation of fertilizer ingredients were nearly identical in each ration.

Conclusions.

1. The animals were in good condition during the entire experiment, hence the silage proved equally as satisfactory as bran for distributing the heavy concentrates (cotton-seed meal and flour middlings).

2. The so-called bran ration produced a trifle more milk and milk ingredients than did the silage ration. Furthermore, it required a little less dry and digestible matter to make a definite quantity of milk ingredients with the former ration.

3. It cost several per cent. more to produce milk with the silage ration; but this difference was due primarily to the temporarily increased market price of the corn and cob meal, and not to the feeding effect of the ration.

EXPERIMENT II. — WINTER, 1904.

Object of the Experiment. — The object of this experiment was quite similar to the one already described; namely, to see if corn silage could not be employed in place of wheat bran as a distributor of the heavy concentrates.

Plan of the Experiment. — This experiment was conducted on the reversal plan. The cows were divided into two lots of four each. In the first half of the experiment one lot received the so-called bran ration at the same time the other lot received the silage ration. In the second half these conditions were reversed.

*Duration of Experiment.**First Half.*

CHARACTER OF RATION.	Date.	Number of Weeks.	Cows.
Bran as distributor, . . .	January 16 through February 26.	6	Blanche, Brighty, Doliska, Dora.
Silage as distributor, . . .	January 16 through February 26.	6	Daisy, Linnie, May, Roda.

Second Half.

Bran as distributor, . . .	March 5 through April 15.	6	Daisy, Linnie, May, Roda.
Silage as distributor, . . .	March 5 through April 15.	6	Blanche, Brighty, Doliska, Dora.

Care of Animals and of the Product. — The general care of the animals and the method of feeding and of sampling the milk have been described in the preceding experiment. Each cow was weighed for three consecutive days at the beginning and end of each half of the experiment, the weighing being done in the afternoon before feeding and watering.

Character of the Feeds. — The weights of a quart of the two grain mixtures were about the same as those fed in the former experiment, the bran ration being much the more bulky. The bran was derived from winter wheat, and was light and flaky. Corn meal was used in place of corn and cob meal, the latter not being available. The cotton-seed meal and flour middlings were of the usual good quality.

The silage was largely corn, with a slight admixture of soy beans. The corn and soy beans were grown together, but, owing to the cool summer of 1903, the beans made a very light growth and produced scarcely any seeds. The corn, likewise, was poorly cared, and the total yield of the mixture was only about 8 tons to the acre. The silage was not at all decomposed or unduly acid, and was considered of fair quality. The hay was largely Kentucky blue-grass, of good quality, cut when in full to late blossom.

Rations consumed Daily (Pounds).

Wheat Bran Ration.

Cows.	First Cut Hay.	Silage.	Bran.	Corn Meal.	Flour Middlings.	Cotton-seed Meal.
Blanche, . . .	16.0	34.6	3.5	-	2.0	1.5
Brighty, . . .	13.0	30.0	3.0	-	2.0	1.0
Doliska, . . .	12.0	30.0	3.0	-	2.0	1.0
Dora,	13.0	30.0	3.0	-	2.0	1.0
Daisy,	13.0	30.0	3.0	-	2.0	1.0
Linnie,	15.0	30.0	3.0	-	2.0	1.0
May,	16.0	30.0	3.0	-	2.0	1.0
Roda,	12.0	30.0	3.0	-	2.0	1.0
Average, . . .	13.8	30.6	3.1	-	2.0	1.1

Silage Ration.

Blanche,	15.0	35.0	-	3.0	2.0	2.0
Brighty,	12.0	30.0	-	2.5	2.0	1.5
Doliska,	11.0	28.1	-	2.2	2.0	1.4
Dora,	12.0	30.0	-	2.5	2.0	1.5
Daisy,	12.0	30.0	-	2.5	2.0	1.5
Linnie,	14.0	30.0	-	2.5	2.0	1.5
May,	14.0	26.9	-	2.3	1.8	1.4
Roda,	11.0	30.0	-	2.5	2.0	1.5
Average, . . .	12.6	30.6	-	2.5	2.0	1.5

*Dry and Digestible Matter in Daily Rations (Pounds).**Wheat Bran Ration.*

Cows.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Blanche, . . .	27.12	2.54	4.36	8.45	.63	15.98	1:5.6
Brighty, . . .	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Doliska, . . .	21.78	2.04	3.43	6.98	.52	12.97	1:5.7
Dora, . . .	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Daisy, . . .	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Linnie, . . .	24.44	2.18	3.97	7.67	.54	14.36	1:5.9
May, . . .	25.33	2.23	4.15	7.89	.55	14.82	1:6.0
Roda, . . .	21.78	2.04	3.43	6.98	.52	12.97	1:5.7
Average, . . .	23.55	2.16	3.77	7.45	.54	13.92	1:5.7

Silage Ration.

Blanche, . . .	26.28	2.46	4.15	9.03	.68	16.32	1:5.9
Brighty, . . .	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Doliska, . . .	20.15	1.90	3.14	7.03	.53	12.60	1:6.0
Dora, . . .	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Daisy, . . .	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Linnie, . . .	23.53	2.13	3.76	8.06	.58	14.53	1:6.2
May, . . .	22.49	2.00	3.63	7.61	.54	13.78	1:6.2
Roda, . . .	20.87	1.99	3.22	7.38	.56	13.15	1:6.0
Average, . . .	22.33	2.07	3.51	7.74	.58	13.90	1:6.0

Average Daily Rations (Pounds).

CHARACTER OF RATIONS.	Hay.	Silage.	Bran.	Corn Meal.	Flour Middlings.	Cotton-seed Meal.
Bran,	13.8	30.6	3.1	-	2.0	1.1
Silage,	12.6	30.0	-	2.5	2.0	1.5

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

CHARACTER OF RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.				Nutritive Ratio.
		Protein.	Carbo-hydrates.	Fat.	Total.	
Bran,	23.55	2.16	11.22	.54	13.92	1:5.7
Silage,	22.33	2.07	11.25	.58	13.90	1:6.0

The average daily bran ration, consisting approximately of 14 pounds of hay, 31 pounds of silage (about a bushel), 3 pounds of bran, 2 pounds of flour middlings and 1 pound of cotton-seed meal, may be considered a good type of a dairy ration, and quite similar to combinations in use by many milk producers who buy all of their grain. It was the aim in preparing the silage ration to do away with the bran by substituting home-grown corn, and at the same time to produce a combination that would contain essentially the same quantity and proportion of digestible nutrients. This was accomplished by feeding 2.5 pounds of corn meal instead of 3 pounds of bran, and 1.5 pounds of cotton-seed meal in place of the 1 pound fed in the bran ration.

Assuming that the farmer produced the hay, silage and corn meal in the ration, he would only use 3.5 pounds daily of purchased grain, costing 4.7 cents, while the bran ration would require a daily cash outlay for grain of 7.25 cents.

The two rations contained almost identical quantities of digestible protein and of total digestible nutrients. Both rations appeared to be equally well relished by the animals. The entire herd consumed the bran ration without the least irregularity, while on the silage ration the cow May suffered an attack of indigestion which caused her to shrink noticeably in her milk, and rendered it necessary to reduce her feed for some ten days. Whether this disturbance may be attributed to the character of the ration, or to other causes, it is difficult to state with certainty. Cow Doliska, while receiving the silage ration, underwent an attack of mammitis in one quarter of the udder, which decreased her milk yield, and made it necessary to take away temporarily a considerable portion of her grain ration. This cow was producing a large yield of milk during the experiment, but was not in first-class physical condition. It seems probable that her condition rendered her sensitive to the combination of heavy grain, even though it was distributed through the silage.

*Weight of Animals at Beginning and End of Experiment (Pounds).**Wheat Bran Ration.*

	Blanche.	Brighty.	Doliska.	Dora.	Daisy.	Linnie.	May.	Roda.	Total Gain or Loss.
Beginning,	1,176	832	753	887	842	841	1,020	852	} + 29
End,	1,146	841	741	876	863	854	1,024	887	

Silage Ration.

	Blanche.	Brighty.	Doliska.	Dora.	Daisy.	Linnie.	May.	Roda.	Total Gain or Loss.
Beginning,	1,121	838	714	868	823	828	1,013	831	} + 18
End,	1,133	836	720	884	830	823	990	838	

The animals practically maintained their weight on each of the rations.

*Yield of Milk and Milk Ingredients, with Percentage Gain or Loss (Pounds).**Wheat Bran Ration.*

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent. ¼ added.
Blanche,	1,004.08	23.91	145.19	51.51	60.10
Brighty,	790.62	18.82	122.39	49.73	58.02
Doliska,	1,105.37	26.32	134.97	40.24	46.95
Dora,	909.16	21.65	126.10	44.28	51.66
Daisy,	715.10	17.03	110.05	41.48	48.39
Linnie,	914.35	21.77	130.57	48.92	57.07
May,	834.73	19.87	123.54	43.99	51.32
Roda,	834.03	19.86	115.93	39.95	46.61
Totals,	7,107.44	21.15	1,008.74	360.10	420.12

Silage Ration.

Blanche,	1,009.62	24.04	145.79	50.99	59.49
Brighty,	790.06	18.81	123.88	50.25	58.63
Doliska,	909.17	21.65	114.28	34.55	40.31
Dora,	874.78	20.83	125.01	44.44	51.85
Daisy,	798.06	19.00	123.14	46.13	53.82
Linnie,	997.35	23.75	141.82	52.86	61.67
May,	836.97	19.93	126.55	46.28	53.99
Roda,	930.92	22.16	126.42	43.19	50.39
Totals,	7,146.93	21.27	1,026.89	368.69	430.15
Percentage gain of silage over bran ration.	0.5	-	1.7	2.2	-

The yields are slightly in favor of the silage ration, but the differences are so small as to have no particular significance. Had cows May and Doliska remained undisturbed during the experiment, this increased yield would have been more pronounced.

Average Composition of Herd Milk (Per Cent.).

CHARACTER OF RATION.	Total Solids.	Fat.	Solids not Fat.
Wheat bran,	14.19	5.07	9.12
Silage,	14.37	5.16	9.21

While the results show that the silage ration produced milk a trifle richer in both fat and solids not fat, the slight difference is without any important signification.

Dry and Digestible Matter required to produce Milk and Milk Ingredients (Pounds).

CHARACTER OF RATION.	DRY MATTER.			DIGESTIBLE MATTER.		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
Wheat bran,	111.35	7.85	21.98	65.84	4.64	13.00
Silage,	104.96	7.31	20.35	65.33	4.55	12.67

While the results show that in case of the silage ration it required a little less *dry matter* to produce a definite quantity of milk and butter fat, they also show that in case of both rations practically the *same quantity of digestible matter* was necessary to produce an equal quantity of milk products.

Food Cost of Milk Products.

CHARACTER OF RATION.	Total Milk.	One Hundred Pounds Milk.	One Quart Milk (Cents), ¹	One Pound Butter (Cents)
Wheat bran,	\$77 76	\$1 09	2.45	18.5
Silage,	75 42	1 06	2.38	17.5
Percentage increased cost of bran over silage ration.	3.1	2.8	2.9	5.8

¹ 2.25 pounds is the commercial figure allowed for one quart of milk; the theoretical quantity is 2.15 pounds, the excess of .10 of a pound being allowed for loss in handling.

With hay at \$15 a ton, silage at \$3.50, bran at \$22, corn meal at \$24, cotton-seed meal at \$28 and middlings at \$26, the silage ration produced milk and butter slightly cheaper than did the bran ration. This difference in cost is due partly to the temporary variation in the cost of the several grains, and partly to the slightly more favorable effect of the silage ration.

Approximate Fertilizer Ingredients in Rations (Cost).

Wheat Bran Ration.

172.29 pounds nitrogen, valued at	\$30 15
134.92 pounds potash, valued at	5 40
68.04 pounds phosphoric acid, valued at	2 72
Total,	<u>\$38 27</u>

Silage Ration.

169.99 pounds nitrogen, valued at	\$29 69
119.77 pounds potash, valued at	4 79
54.88 pounds phosphoric acid, valued at	2 20
Total,	<u>\$36 68</u>

The total rations consumed by the herd contained nearly the same quantity of plant food. There was a slight excess of potash and phosphoric acid in the bran ration, due to the richness of the bran in these two mineral constituents.

Conclusions.

1. The silage ration produced slightly more milk and milk ingredients at a trifle less cost than did the bran ration.
2. A little less dry and digestible matter was required to produce a given quantity of milk products with the former ration.
3. Two animals were temporarily out of condition while receiving the silage ration. This may have been partly due to the effects of the heavy concentrates and partly to other causes.

Discussion of Results.

1. In both experiments hay and corn silage served as the roughage, while a mixture of cotton-seed meal, flour middlings and bran, or cotton-seed meal, flour middlings and

corn meal or corn and cob meal, served as the two grain rations; bran acted as a diluter of the heavy concentrates in one case, and corn silage in the other.

2. In the first experiment the results were slightly favorable to the bran ration, while in the second experiment the conditions were reversed. The differences were so trifling that it may be said that for practical purposes both rations produced equally satisfactory results.

3. As a practical deduction, the writer would suggest that farmers who keep comparatively small herds, and who personally look after the feeding, may reduce the quantity of *purchased grain* to 3 or 4 pounds daily per head, and substitute home-grown corn in place of wheat bran. Five to 7 pounds of grain daily is the usual allowance for cows producing about 10 quarts of milk of average quality. This grain mixture may consist of $1\frac{1}{2}$ pounds of cotton-seed meal, 2 pounds of flour middlings and $2\frac{1}{2}$ to 3 pounds of corn or corn and cob meal daily; or $1\frac{1}{2}$ pounds of cotton-seed meal, 2 pounds of oat middlings or rye feed and $2\frac{1}{2}$ to 3 pounds of corn meal. Malt sprouts may be substituted for the wheat, oat or rye middlings. The several grains after being mixed should be distributed through the silage or cut hay with the aid of a fork. This method of feeding will enable the farmer to get along with a minimum *cash outlay* for grain ($4\frac{1}{2}$ cents daily), and at the same time he will be supplying a well-balanced ration, rich in elements of fertility. The method will be more particularly suited to farmers not having easy transportation facilities, and who sell their dairy products to the creamery.

4. Farmers and dairymen who cannot closely supervise the feeding, and who desire to feed more than 5 to 7 pounds of grain daily, will probably find it advisable to use one-third to one-half wheat bran in compounding the grain mixture. Distillers' grains and malt sprouts have also been shown to be quite satisfactory distributors of the heavy concentrates.¹

¹ Bulletin No. 94 of this station.

REPORT OF THE BOTANIST.

G. E. STONE; ASSISTANT, N. F. MONAHAN.

The long period of dry weather during the past summer has rendered many plants free from certain types of fungous diseases. On the other hand, the dry conditions were favorable for the outbreak of other troubles. A considerable amount of rain fell, and a more or less prolonged period of cloudy and damp weather prevailed during the latter part of August and first of September, which brought on some severe cases of blight. This rainy and damp period, coming as it did after the severe drought, exerted a peculiar influence on the quality of fruit, and in some instances it was responsible for inducing a renewed activity of the reproductive organs of plants. It is well known that favorable conditions following a check often stimulate vital activity along the lines of reproduction, and it was not surprising to find some wild plants responding in this manner.

DOWNY MILDEW OF TOMATO.

(*Phytophthora infestans*, DBy.)

The damp and rainy period following the prolonged dry season caused an unusual outbreak on tomato plants, namely, the downy mildew, which is the same as that giving rise to the late blight of potatoes. It is seldom that this mildew attacks tomatoes, in this State at least, to any extent; but this season the damage was quite severe and widely disseminated, especially injuring the younger vegetative portions of the plants.

POTATO ROT.

(*Phytophthora infestans*, DBy.)

The fungus mentioned above was also responsible to a large extent for damage to potatoes, causing them to rot, especially those grown on moist land. During the early part of the season potatoes as a whole were remarkably free from blight, and not until the rainy and damp period came in September did they display any alarming troubles. In some instances quite a large percentage was destroyed by rot. The spraying of potatoes in this State has not met with that degree of success that it has in other New England States, one reason being that the early blight often occurs here quite disastrously, and obtains a foothold early in the season.

Spraying for this trouble should commence early in June, when the plants are about one-fourth grown, and continue until late in the season. Another factor underlying successful spraying is pressure; at least 50 pounds' pressure should be maintained by the pump, to secure the best results. Experiments at the college this year showed material gain in the quantity of potatoes secured from sprayed crops, as compared with those not sprayed.

CUCUMBER AND MELON BLIGHT.

The dry summer with its freedom from moisture proved favorable for cucumbers and melons, and these crops were not severely affected, at least previous to September, with either the downy mildew or anthracnose. During the past fall there has occurred considerable infection to greenhouse crops, especially those started early. For the last six or seven years the downy mildew (*Plasmopara Cubensis* (B. & C.) Humphrey) has occurred generally upon greenhouse cucumbers started early in the house, and occasionally the anthracnose (*Colletotrichum Lagenaarium* (Pass.) Ell. & Hals.) appears in the fall, but we know of no instances where either of these blights has wintered in greenhouses. Both of these blights must therefore at present be considered as left over from summer. The anthracnose, however,

usually makes its appearance in the spring on greenhouse plants, and the mildew about the 15th of August on either outdoor or greenhouse crops. Both of these blights can be readily controlled in the greenhouse by judicious attention to cultural methods. Neither of them will survive if attention is given to light, ventilation and especially moisture. When the foliage is kept dry these fungi are unable to get a start. In case syringing is necessary to keep the red spider down, it should be done in the morning in bright sunlight, at which time the plants will dry out readily. In case these blights have attained some headway, the pipes should be painted with sulphur and oil. Beneficial results have been reported by different growers who have tried this method.

SUN SCALD.

The general interest manifested in shade trees in this State is quite apparent from the large number of specimens sent us each year, and the amount of correspondence touching upon various matters concerning them. The number of cases of sun scald to shade trees the past summer was unprecedented. This was particularly noticeable in rock maples and white pines, although this same trouble occurred with many trees and shrubs to some extent. The sun scald on rock maples was unusually abundant, and more severe than usual. Some trees which were under our observation had as much as ninety per cent. of their foliage as dry and crisp as casted leaves. Some maple trees possess the peculiarity of having their leaves badly scorched each year, where other trees of the same species located near them are entirely free from this trouble.

As a result of the prolonged drought and the excessive heat during mid-summer, many rock maples developed foliage of a peculiar bronze color. There was also much premature fall coloring and defoliation on many trees. The cause of so much sun scald during the past summer was drought and dry winds.

Where fine specimens of lawn or roadside trees exist, every effort should be made to maintain them in the best

condition possible. A deep, rich, loamy soil, well supplied with organic matter, constitutes a good guarantee against sun scald.

BURNING OF CONIFERS AND EVERGREENS.

The burning or drying up of leaves commonly seen on conifers and other evergreens in spring is the result of winter or spring injury. Trees affected in this manner show the burning generally on one side, which coincides with the direction of some prevailing wind or storm. This is a genuine scald, similar to that prevailing on other trees, and occurs at a time when the ground is frozen and drying winds prevail. This is usually brought about by a sudden rise of temperature in the early spring when the plants are in frozen ground, at which time transpiration is active. Under these conditions root absorption is limited, whether the soil is moist or dry, and burning results.

An arbor vitæ hedge, which has been under our observation for some years, located on high ground with a severe exposure, becomes burned more or less every year. Frequently the burning is on the southeast side and occasionally on the southwest, but more often on the northwest, which is the direction of the prevailing winds.

There is a considerable amount of burning to conifers and rhododendrons in this State, and not infrequently this is so bad that the specimens are ruined. Much of this injury occurred during the winter of 1904-05, on evergreens located on private estates and in nurseries. One nurseryman states, for example, that all his evergreens, which included various species of abies, buxus, chamaecyparis, juniperus, picea, pseudotsuga, taxus, thuya and tsuga, burned last winter, and other nurserymen have experienced trouble with retinosporas and varieties of thuya or arbor vitæ.

Our native conifers are seldom injured in this manner except when transplanted in some uncongenial place, or where the environment is more or less modified. Swamp cedar burns frequently when taken from the swamp and

grown in ordinary soil, and the arbor vitæ, sparingly found as a native in this State, frequently burns when planted on high or more or less dry land with severe exposure. This holds good also for hemlocks, and to a certain extent for pines and junipers.

WINTER-KILLING.

The disastrous effects of winter-killing are probably more discernible in the State at the present time than for many years; at least, we have no recollection of seeing so much damage done to so large a variety of trees and shrubs as has occurred in the last two or three years. The winter of 1903-04 was extremely severe on most of the native and exotic plants, including trees, shrubs and vines; and, while the winter of 1904-05 was not so severe in many ways, the past summer has done much to emphasize any trouble that was present to a slight degree before. The winter of 1902-03 was also a severe one, although the effects of killing during that period were largely above ground.

The symptoms of winter-killing are tolerably well marked in most instances, especially to the trained observer, and it is seldom that it need be confounded with anything else, neither is it always necessary to make extensive examinations of root systems to ascertain root killing. Furthermore, because a plant is native constitutes no evidence of its ability to withstand unusually severe conditions, since unusual seasonal peculiarities often render them less hardy. For example, the Labrador tea, which is a native of Labrador, has been known to winter-kill in this State, although the climatic conditions of this State are decidedly milder than those of Labrador. There are several classes of winter injury which may readily be distinguished, some of which are not unusual, and can be found every year. There is killing of that portion of the plant above ground as well as killing of the root systems, the latter being extremely common during the winter of 1903-04. Besides these types of injury mentioned above, there frequently occur frost cracks, twig killing, bud injuries, blisters to leaves, etc. The latter has occurred occasionally in leaves of apple trees in the spring

when they were tender, and frequently results in almost complete defoliation of apple trees during August. This trouble has been studied by Sorauer in Germany, by Stewart in New York, and by Stone and Smith in this State.

Some of the conditions which underlie winter-killing are as follows:—

Severe cold, causing frost to penetrate to a great depth.

Sudden and severe cold following a prolonged warm spell in the fall, in which case the wood tissue is tender and immature.

Conditions which favor a soft growth and immaturity of wood. Various causes may be responsible for this, such as growth in a low, moist soil, too heavy manuring or fertilization, or absence of sufficient sunlight.

General low vitality, caused by insect pests and fungous diseases and lack of moisture in the soil.

Insufficient soil covering, such as lack of organic matter, light mulching and snow covering in winter.

Location in unusually windy and exposed places, etc.

Species with a limited maximum range for cold are especially susceptible. There are innumerable examples at hand which will furnish illustrations of the various causes of winter-killing. For example, low vitality is well illustrated by the large number of old apple trees which have died in the last two years. The old, neglected orchards were the worst sufferers from the effects of winter-killing, and many isolated trees, such as cherry trees that had received no care for some years, were badly affected.

In one instance a number of peach trees and various kinds of shrubbery, both native and exotic, were severely injured where located near an overflow from a cesspool, while similar shrubbery near by was not injured in the least. This injury was due to the more rapid and tender growth of those plants which received benefit from the cesspool overflow. Perfectly hardy native plants, being deprived of a normal amount of light or grown in too dry places, are winter-killed readily; and Japanese maples on high, dry ground with severe exposure are extremely subject to winter-killing.

By far the most noticeable effects of winter-killing have

occurred above ground. This in some cases has resulted in local injuries to the trunk or in the loss of a few limbs, which has been responsible for completely ruining the symmetry of many valuable specimens, while in other instances many plants have died back to the ground. Some of the plants which have been affected in this way are as follows: Japanese maples, sycamore and Norway maples, apple, peach, plum, cherry, quince, grape vines, Japanese clematis, matrimony vine, roses, Forsythias, California privet, *Amorpha fruticosa*, *Callicarpa purpurea* and *Americana*, *Ampelopsis tricuspidata*, *Deutzia scabra* and *gracilis*, *Diervilla florida-candida*, *Catalpa bungei*, *Exochorda grandiflora*, *Hibiscus syriacus*, *Magnolia tripetala*, *Lonicera japonica-halliana*, *Stephanandra flexuosa*, *Viburnum tomentosum*, *Tamarix tetrandra*, *Rhus semialata* and *Æsculus pavia*.

Among the native plants may be mentioned the pine, ash, oak, white birch, alder, spice bush and holly. We observed large clumps of white birch and alders winter-killed above ground. The winter-killing of branches and twigs often occurs on young Japanese maples, especially where exposure is severe or when not given the best cultural conditions; and the young twigs of Norway and sycamore maples and horse-chestnuts have been quite susceptible to winter-killing of late. The killing of the buds and wood occurred in forsythias, peach and roses. Much of this winter-killing of branches, etc., is generally followed by an outbreak of *Nectria cinnabarina* and *Schizophyllum*.

As previously stated, the winter of 1903-04 was extremely severe in the amount of root killing which took place. The trees showing injury were the apple, pear, peach, quince, cherry, plum, white pine, red and rock maples, butternut, ash, oak and elm. Among shrubs, vines, etc., were the grape, raspberry and blackberry.

Many of the exotic ornamental plants suffered in the same way, such as, for example, the deutzias, California privet, etc.; in fact, many of the native and exotic species showed killing both above and below ground. The trees which have shown root killing the worst are apples, red maples, butternuts and pines. The effects of the winter-killing of

roots manifest themselves in many ways. Sometimes the plant is killed outright, while in other instances only a slight injury is caused. Many maples, for example, were killed outright, while others lost only a certain per cent. of their roots, thus causing thin tops, and where this injury was not very extensive many of the thin-top trees recovered in one year.

In some instances the leaves at the top of the red maple remained in a half-developed condition throughout the summer. In such cases the leaves were rather pale in color, and they assumed a peculiar pendulent position on the branches. These trees have also for the past two years manifested a premature autumnal coloration, especially on those portions with poorly developed foliage, the result of a limited water supply caused by winter-killing of the roots.

Apple trees were affected to a large extent by root killing, and many hundreds of them have succumbed. In many cases these trees would have been saved if severe pruning had been practised at the time of the first appearance of this trouble, since severe pruning of the tops of the trees would have balanced the root and branch systems. Peach, plum and quince trees were affected in the same way, but the trouble was not nearly so general with these. The same holds true for blackberries, raspberries and grapes. One of the peculiarities displayed by many of these plants consisted in their leaving out and bearing fruit, then suddenly collapsing.

The white pine was the most extensively affected tree. These trees in some localities were so severely affected that many of them died during the spring following the winter of 1903-04. In some severe cases the trunks were frozen and badly injured, but in the greater majority of cases the tips of the new leaves became brown and died. The dry summer of 1905 was severely trying for these partially affected pines. Had a normal water supply been available, this injury would not have resulted. The specimens which we examined had a large percentage of the small, fibrous roots killed, but in no case observed had the large roots been injured. This pine injury extends throughout the

whole State, but appears to be less common in the Connecticut valley than elsewhere.

One of the most distinctive features connected with the pine during the past summer was the burning of the tips of the leaves. In most cases the young, new leaves commenced to turn yellow at their ends, as if sun scorched, but usually grew worse; and in many instances all the needles turned yellow, subsequently died and dropped off. This might not occur on the whole tree, but on only one or more branches. Occasionally this trouble would occur before the young needles reached their normal length; and in such cases the needles would be short and the tree would present a stunted foliage, as we sometimes see on pines grown in very dry soil. Many were inclined to believe that some fungous disease was affecting the pines. Our examinations of the young needles in early summer showed no indications of fungi being present, and others have reported the same results. Subsequently, however, there appeared various species of fungi on the leaves, and in some cases on the branches, etc. This was merely a natural result following the weakened condition of the tree, caused by the affected root system.

Mrs. Flora W. Patterson of the Department of Agriculture in Washington, who had exceptional opportunities to examine the pine trouble as it occurred in New England and elsewhere during the summer, reports at least six different species of fungi upon the needles and branches. From examination of considerable material gathered in this State she has reported having found *Phoma Harknessii*, Sacc., *Septoria parasitica*, Hartig, *Hendersonia foliicola*, Berk. The *Septoria* was found in connection with the leaves that had their tips burned, and the *Hendersonia* was associated with a general yellowing or irregular spotting of the needles, while the *Phoma* was found with a quite different and by no means common trouble, causing no serious injury to the trees.

In conclusion, we would state that the trouble affecting the pine in this State was due primarily to the extreme winter-killing of the roots during the winter of 1903-04,

together with the unusually severe drought occurring in the summer of 1905. The occurrence of so many different fungi on the pine, which especially predominated during the late summer and fall, was very largely a secondary result of the weakened condition of the tree caused by winter-killing.

RELATION BETWEEN SOIL AERATION AND GERMINATION AND GROWTH.

For some time our attention has been given to the relation existing between seed germination and plant development, and soil texture and aeration. This problem possesses a practical bearing, inasmuch as it underlies the question of soil selection for specific crops. It is not our purpose at present to go extensively into this subject, but only to touch upon one phase of it. It is well known to gardeners and others that aeration, or the presence of air in soils, plays quite an important role in the development of seedlings. This experiment was made to determine what effects forcing air through soil would have upon germination and growth. For this purpose we made use of loam placed in two boxes, 18 by 18 by 18 inches. In each box there was a round funnel, $4\frac{1}{2}$ inches in diameter, buried under the soil $1\frac{1}{2}$ inches from the surface. Both funnels were connected with block tin tubes leading outside of the box, one of which was attached for a period of six hours each day to a water blower, and the other remained unconnected. Lettuce seed, which is quite susceptible to aeration, was employed, and 1,500 seeds were placed in each box, and the necessary data pertaining to germination, etc., were noted.

Table showing Results of Aeration on Growth of Lettuce Seedlings, 1,500 Seeds in Each Box.

	Number of Plants obtained.	WEIGHT OF SEEDLINGS (GRAMS).		Average Gain in Weight (Per Cent.).
		Total.	Average.	
Un aerated,	977	83	.0847	-
Aerated,	1,210	152	.1239	46.27

From the preceding table it will be noted that there was considerable more seed germinated in the aerated box than in the unaerated one, as noted by the number of plants obtained; and that the average weight of the seedlings in the aerated exceeded those in the unaerated by 46 per cent. The seeds in the aerated box showed decided acceleration in germination, there being a difference of at least thirty-six hours in favor of the aerated seed. This experiment lasted from October 5 to November 8, and the difference in the size of the plants became more marked each day. In the aerated box the plants were noticeably larger over the funnel, while in the unaerated box the plants were largest near the edges of the box, where the soil had shrunk away from the sides, which enabled the roots of the seedlings to have free access to air.

That oxygen plays an important part in the germination of lettuce seed is quite evident from many experiments we have made with this species. The mere fact of covering lettuce seed loosely or sifting fine loam on them results frequently in enormous differences in the germination. Such seeds as lettuce and white clover are particularly susceptible to aeration; and, according to our numerous experiments, these seeds germinate best in soils of loose texture.

COMPARISON OF STERILIZED LOAM AND SUBSOIL.

Some experiments were conducted two years ago by Mr. S. R. Parker, then a senior specialist in the agricultural department of the college, which necessitated using a sterilized soil. In all of Mr. Parker's cultures, which were made in a soil very poor in organic matter, there was an extremely poor and sickly growth of soy bean in those pots which had been sterilized, whereas the growth was good in pots which had not been steamed. The experiments were carried on in our greenhouse, and the results were so different from those occurring in sterilized loam that it was considered wise to repeat them.

A soil similar to this had previously been sterilized for the growth of tobacco seedlings, without producing similar disastrous effects upon the plants. In the single experiment

given here we made use of a similar soil, namely, a yellow subsoil loam, containing little organic matter. Eight pots were selected, four of which contained loam and four subsoil. Of these, two each of the loam and subsoil pots were sterilized, and two each of the remaining pots were left unsterilized. The results follow.

Table showing Growth of Soy Bean in Sterilized and Unsterilized Loam and Subsoil.

	Total Number of Pots used.	AVERAGE LENGTH (CM.) OF STEMS IN—		Gain (+) or Loss (–) in Sterilized Soil (Per Cent.).
		Unsterilized Soil.	Sterilized Soil.	
Loam,	4	9.53	10.87	+ 14.05
Subsoil,	4	9.79	4.14	– 57.70

The number of seeds germinated in unsterilized loam and soil was 30, that for the sterilized 34, showing a slight gain in favor of sterilization, which is unimportant, considering the small number of seeds used. There is also a gain in height of loam plants of 14 per cent. in favor of sterilization, while in the subsoil series there is a loss of 57 per cent. due to treatment. The subsoil pots also showed a poor, sickly development. This corresponded in every way with the results obtained by Mr. Parker in his experiments. This experiment shows, among other things, that extreme precaution is necessary in drawing deductions from experiments in which the soil is sterilized, especially where inoculation work is undertaken in connection with soil organisms.

INFLUENCE OF SOIL STERILIZATION ON SEED GERMINATION.

In a previous report¹ the results of a similar series of experiments were described, and this paper is a continuation of the earlier one. As in the preceding series, the seeds selected were in most cases from an old lot, which possessed a rather low germinating capacity. The object of these experiments was to ascertain the degree of acceleration in germination which would result from plant seed in steril-

¹ Fifteenth annual report of the Hatch Experiment Station, p. 41, 1903.

ized soil. Results of a similar nature have been observed by us a number of times in an incidental way when utilizing sterilized soils in our general experimental work in the greenhouse. The seeds were planted in boxes 18 by 12 by 3 inches, and previous to planting the soil in the sterilized boxes was heated by steam to a temperature of about 212° F. for one hour. The soil used constituted a good typical loam, characteristic of this region, and the sterilized and unsterilized soils were identical in every way except as to steaming. Other conditions, such as heat, light, degree of moisture, etc., were made the same as far as practicable. In Nos. 15 to 23, inclusive, 600 seeds were used in three separate experiments, where 100 seeds were sown in sterilized soil and 100 in unsterilized soil. In Nos. 25 to 34, inclusive, 800 seeds each were employed, there being two experiments. No. 39 is the result of only one experi-

Table showing the Germination of Seeds in Sterilized and Unsterilized Soil.

LABORATORY NUMBER.	Kind of Seed.	Total Number of Seeds tested.	NUMBER GERMINATED IN —		Per Cent. gained.
			Sterilized Soil.	Unsterilized Soil.	
15,	Turnip, . . .	600	159	54	35.00
16,	Radish, . . .	660	148	101	15.66
17,	Onion,	600	148	94	18.00
18,	Red clover, . .	600	236	203	11.00
19,	Lettuce, . . .	600	289	267	7.33
20,	Musk melon, . .	600	—	—	—
21,	Lettuce, . . .	600	208	51	52.33
22,	Tomato,	600	79	63	5.33
23,	Crimson clover,	600	15	4	3.66
25,	Melilotus, . . .	800	133	109	5.75
26,	Spinach, . . .	800	378	246	33.00
27,	Peppergrass, . .	800	233	106	31.75
29,	Japanese millet,	800	—	—	—
32,	White mustard,	800	242	65	44.25
33,	White carrot, . .	800	—	—	—
34,	Winter vetch, . .	800	30	8	5.50
39,	Soy bean, . . .	1,000	365	175	38.00
Average, . . . .	. . . . .	—	—	—	21.89

ment, this being made in the greenhouse bench soil; 500 seeds were sown in unsterilized soil and 500 in sterilized soil.

The data given in the table show that there occurred a positive gain in germination of the seed sown in sterilized soil. Nos. 20, 29 and 33, however, were old seed, which had apparently lost their power of germinating, and the stimulating effect induced by soil sterilization evidently had no effect on them. There is no reason for believing that when seeds have once lost their germinating power, or, in other words, are dead, this process will revive them. The percentage gained in some instances is quite marked, while in others it is insignificant. The average obtained from this series is 21 per cent. On account of the low germinating capacity prevailing here in many instances, the percentage gained is only indicative, since it would be necessary to employ a larger number of seeds to obtain more accurate averages. It should be pointed out, however, that better results than those given in these experiments have been observed many times in connection with lettuce, cucumber, melon seed, etc., in the greenhouse, where seed was used on a much larger scale. The degree of acceleration in germination is also marked, a feature which has been frequently noticed by us before. The number of seeds germinated during the first few days of these experiments, including Nos. 15 to 34, inclusive, was 169 for the sterilized soil and 146 for the normal loam, or a gain of 14 per cent. in favor of the sterilized soil. In the former series of experiments, previously noted, we obtained 25 per cent. of acceleration at the end of four days. There undoubtedly exists a difference in seeds in their response to stimulation in sterilized soils. Tomatoes, for example, respond but little if any to this method of treatment. The cause of this variation in different species of seeds is not known. Experiments are now being made along different lines which may throw some light on this question. The benefit to be derived from sowing seed in sterilized soil, both from a physiological and pathological point of view, is important enough to warrant in many instances its practice.

INFLUENCE OF SOIL DECOCTIONS ON SEED GERMINATION.

Some attempt has been made in the following experiments to ascertain the cause underlying the effects which sterilized soil has on seed germination. The question has often arisen, In what manner does soil sterilizing affect seed germination? Is the cause underlying this form of stimulation a mechanical one, or a chemical one? In all probability both mechanical and chemical factors play a role here. If, however, the stimulus is of a chemical nature (and such types of stimulation are common enough to seeds), we would expect some response to occur on the part of the seeds when treated with decoctions of sterilized soils. For special reasons we therefore selected two types of soils, one of which was a typical Amherst loam, fairly rich in organic matter and suitable for greenhouse culture; the other soil a yellow loam of the nature of an Amherst subsoil, deficient in nitrogen and containing only a slight amount of organic matter. Three sets of experiments were carried out with each soil. In each set there was a boiled loam and subsoil, a sterilized loam and subsoil, and a normal loam and subsoil. The boiling and sterilizing lasted fifteen minutes, the latter being mostly done in an autoclave, under fifteen pounds pressure and at a temperature of 250° F. In all cases 400 grams of soil were employed. The soils were placed in percolators, with 500 c.c. of distilled water, and allowed to stand for twelve hours and to percolate very slowly. Four hundred grams of normal loam and subsoil, that is, soil that is not treated, were percolated in the same manner as the others. In addition to the above tests, tap water cultures were employed as checks, and run parallel in every way to the others.

In some instances, however, distilled water was used, besides the tap water, but since no difference existed between them, the distilled water tests were discontinued. After a percolate had been obtained for the various soils, the seeds were soaked in them for six hours, and then placed in germinators of the Zurich type, or into germinators composed of flower pot saucers provided with filter paper. In one or two instances the soy bean was germinated in sawdust.

TABLE I. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil; 800 Seeds used in Each Treatment, except with the Soy Bean, where only 700 were used, making a Total of 21,700 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . . .	28.3	25.5	33.0	33.9	34.9	18.6	32.6
Buckwheat, . . .	59.8	72.0	70.7	69.5	70.8	53.5	73.1
Radish, . . .	52.7	51.7	53.1	51.8	56.7	48.5	52.3
Lettuce, . . .	70.2	82.3	71.8	80.7	77.6	71.6	61.8
Average, . . .	52.7	57.8	57.1	58.9	60.0	48.0	54.9
Total average,	52.7	57.4		59.4		51.5	

The preceding table shows the results obtained from experiments in which 21,700 seeds were employed. Since a large number of seeds were used in these experiments, quite accurate averages were obtained, and the factors due to variation are eliminated to a large extent. There is apparently a slight gain due to treatment shown in these experiments. The best average results were given by the boiled subsoil and loam, followed by the normal, while the sterilized loam is below the tap water seeds. By noting carefully the results obtained in these experiments, together with the nature and color of the decoctions, we surmised that the decoctions were too strong for the best results, consequently they were diluted with water to one-half strength in the next experiment.

TABLE II. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to Half Strength; 600 Seeds used in Each Treatment, making a Total of 16,800 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . . .	50.0	50.2	51.0	55.5	53.5	55.2	51.7
Buckwheat, . . .	77.2	70.5	81.2	82.5	83.5	72.5	73.0
Radish,	48.0	53.2	48.0	59.7	53.0	60.5	58.5
Lettuce,	82.2	83.7	87.2	78.0	73.7	74.0	80.8
Average, . . .	64.3	64.4	66.8	68.9	65.9	65.5	66.0
Total average,	64.3	65.6		67.4		65.7	

These experiments are similar to the previous ones, except that half-strength decoctions were used in all cases. The results obtained from these three experiments are remarkably uniform in character, the tap water giving practically the same results as the decoctions.

TABLE III. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to One-fourth Strength; 600 Seeds used with Radish and Buckwheat, 400 Seeds with Lettuce and Soy Bean, making a Total of 14,000 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . . .	84.0	74.5	89.5	73.0	83.5	77.5	84.0
Buckwheat, . . .	66.5	91.7	85.0	93.7	91.7	82.7	83.7
Radish,	65.5	64.5	62.5	46.5	50.0	55.5	56.5
Lettuce,	74.5	72.7	72.7	63.7	70.7	65.2	69.5
Average, . . .	72.6	75.8	77.4	69.2	73.9	70.2	73.4
Total average,	72.6	76.6		71.5		71.8	

In the experiment with the one-fourth strength decoctions, 14,000 seeds were employed, representing three experi-

ments. There is a slight increase shown in this series, due to treatment, which is the most marked in the normal loam and subsoil.

TABLE IV. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to One-eighth Strength; 200 Seeds used in Each Treatment, making a Total of 5,600 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN—						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . . .	75.5	75.0	75.5	85.5	85.0	87.0	80.5
Buckwheat, . . .	66.5	82.0	83.0	84.5	81.5	78.5	83.5
Radish,	55.0	70.0	69.0	77.5	81.5	78.5	72.0
Lettuce,	70.0	68.5	74.5	98.9	73.0	77.0	79.5
Average, . . .	66.7	73.8	75.5	86.6	80.2	80.2	78.8
Total average,	66.7	74.6		83.4		79.4	

The experiment with one-eighth strength decoction shows a decided gain throughout in the treated seeds, the most marked being given by the boiled and sterilized loams and subsoil decoctions. No further dilutions were tried, but from a careful study of the results of these experiments we are inclined to the belief that if more dilute solutions were used an increased gain would occur, especially in the sterilized series, since the most highly colored decoctions were obtained from the sterilized soils and the next highest color from the boiled soils. It appears to us that the sterilized decoctions were too strong, even when diluted to one-eighth strength. Some variation in the strength of the decoctions is likely to occur as a result of different percolators, and the failure of the one-fourth and one-half strength to show more of an acceleration may be attributed to this cause.

The following table gives the number of seeds that germinated in the first twenty-four hours in the preceding experiments, including tables I., II., III. and IV., from which the degrees of acceleration and retardation due to treatment can be obtained.

TABLE V. — Showing the Degree of Retardation and Acceleration in Germination of Seeds soaked for Six Hours in Decoctions of Different Strengths made by diluting 500 c.c. of Water which had percolated through 400 Grams of Soil treated as below.

	Number of Seeds per Treatment.	PER CENT. GERMINATED IN TWENTY-FOURS HOURS IN—						
		Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
<i>Soy Bean.</i>								
Full strength, . . .	600	27.7	27.5	30.5	33.1	29.5	8.3	27.5
Half strength, . . .	200	22.0	20.0	17.0	21.0	23.0	23.0	23.5
<i>Buckwheat.</i>								
Full strength, . . .	600	56.0	70.1	73.6	63.1	66.6	33.8	70.8
Half strength, . . .	400	55.0	44.2	57.5	57.2	31.7	36.7	46.2
Quarter strength, . . .	400	43.7	59.5	50.2	57.2	59.0	52.7	64.5
Eighth strength, . . .	200	58.5	70.0	66.0	78.0	74.5	62.0	62.5
<i>Radish.</i>								
Full strength, . . .	800	36.7	27.0	29.8	30.5	37.5	16.6	32.0
Half strength, . . .	400	28.0	37.5	30.2	41.7	37.5	43.0	32.2
Quarter strength, . . .	400	45.0	43.5	39.0	17.5	24.0	37.0	37.0
Eighth strength, . . .	200	32.5	64.5	61.5	68.0	73.0	69.5	61.0
<i>Lettuce.</i>								
Full strength, . . .	800	37.5	35.8	39.3	34.5	41.5	37.3	35.1
Half strength, . . .	400	59.0	72.5	63.2	74.0	46.0	50.2	70.7
Quarter strength, . . .	400	67.0	52.0	55.7	44.5	51.5	53.5	56.5
Eighth strength, . . .	200	51.0	55.0	55.0	83.0	52.0	72.0	64.5
Average, . . .	-	41.8	45.3	44.7	47.3	43.7	39.1	45.9
Average normal and total treated.	-	41.8	45.0		45.5		42.5	
		41.8	44.3					

This table gives the results of germination during the first twenty-four hours of 42,000 seeds, and the degree of acceleration obtained corresponds in a general way with the total number germinated as given in the preceding tables; or, in other words, the relationship between acceleration and the total number of seeds germinated is similar. Comparing the average number of seeds germinated during the first twenty-four hours by the various treatments with tap water, there are no important differences shown. On the whole,

however, there is a gain or acceleration due to treatment, the maximum acceleration being shown by the boiled loam.

A comparison of the different strengths of solutions shows that the one-eighth dilution produced the best results of any of the treatments, that for boiled loam being the highest. This series of experiments shows that decoctions of soils variously treated induce acceleration in seed germination, and that a larger number of seeds germinated in decoctions than in tap water. This increase is quite marked in dilute decoctions (one-eighth strength), and would probably be increased to some extent if the dilution should be carried still further. In these experiments we have a chemical explanation for the cause underlying acceleration and increased germinating capacity in sterilized soils. Undoubtedly driving out the gases and the subsequent absorption and renewal of fresh oxygen in sterilizing practices acts beneficially to soil and induces the seeds to germinate more quickly, as is shown by the aerating experiments previously reported. By the process of aeration, or by soaking seeds in dilute decoctions, many seeds germinate that otherwise would not; but there is no ground for belief that any of these stimulating processes actually revive or rejuvenate worthless seeds to a greater extent than would result from the most favorable conditions for germination.

Sterilized subsoil, or that lacking in humus, has the same effect on germination as sterilized loam rich in organic matter; but it inhibits growth to a very large extent, thereby differing in this respect. It would appear, therefore, that a considerable amount of humus is necessary in soils, in order that they may be materially benefited by sterilization.

The reason that bacteria multiply more and plants grow much more luxuriantly in sterilized soils is undoubtedly due to the fact that a larger amount of available material for plant development is present. Why subsoils and those poor in organic matter give rise to a greatly inhibited growth is not so clear at present, and we are not prepared to offer any explanation of this phenomenon.

SEED SELECTION.

It is a well-known fact that heavy, well-developed seeds produce more vigorous and more productive plants than lighter seeds of the same variety. This is altogether a reasonable statement, because the heavy, well-filled seed has the more perfect embryo, and also has the larger supply of plant food on which to support the seedling until the plant is capable of getting its nourishment from the air and soil.

With such crops as wheat, rye and the grasses, the selection of seed is not of so very great importance, because usually an overabundance of seeds is planted, and sufficient seeds develop so that in the natural struggle for existence in their overcrowded state the weaker and less vigorous plants are crowded out and only the more vigorous and healthy plants reach maturity; and this number which reaches maturity represents the maximum number of plants that can be developed under existing conditions, so that nothing in the crop is lost by this crowding out of the weaker plants. On the other hand, with greenhouse, market gardening and general field or what is known as hoed crops, the conditions are entirely different. In this case each plant has its full share of light, heat and space, and a poor, weakly plant is just so much loss, not only because it occupies a space that ought to produce a well-developed plant, but also because a number of undersized, weakly plants in a crop detracts from the market value of the crop as a whole, and also because weak plants are more subject to disease, and act as a breeding-place for diseases that may infect the whole crop; therefore, the careful selection of seed becomes an important factor in growing plants. In the case of large seeds, such as corn, this selection is comparatively an easy matter. An ear of corn of the desired type, having kernels of a desirable size and shape and of full development, may be picked out, and by discarding the poor, undeveloped seeds at either end the rest of the seeds may be utilized for planting. Here knowledge of the type of seed and judgment only may be relied upon. Beans, peas, etc., may be selected in much the same way, with reasonable assurance that the best results will be

obtained. In the case of such seeds as lettuce, turnip, cabbage, tobacco and other small seeds this method of separation is not practicable, and other methods have to be resorted to.

From early times the separation of seeds by means of water has been practised to a considerable extent. In this case the seed is placed in a quantity of water, well shaken and let stand a few minutes, then the seeds which do not sink are removed, and only those that have sunk used for planting.

The results of some of our experiments with this method of separation are given in the tables following.

TABLE I. — *Showing the Results of Germination with Onion and Lettuce Seed separated by the Water Method; 400 Seeds used in Each, or a Total of 1,600.*

SEED.	PER CENT. GERMINATED OF —		Per Cent. Increase of Germination of Heavy over Light.
	Light.	Heavy.	
Onion,	38.0	85.0	142.5
Onion,	50.0	58.5	17.0
Onion,	44.0	88.0	100.0
Lettuce,	68.0	90.0	32.3

TABLE II. — *Showing the Results of Seed Germination and Growth of Onion Seedlings separated by Water; 200 Seeds in Each Lot, or a Total of 400 used.*

ONION.	Per Cent. of Germination.	Number of Plants.	WEIGHT OF PLANTS (GRAMS).		Average Per Cent. gained of Heavy over Light.
			Total.	Average.	
Heavy (sank),	42.5	85	18.1	.213	37.42
Light (floated),	19.5	38	5.9	.155	-

This method, however, is not entirely satisfactory, because many of the heavier seeds are buoyed up by air bubbles and therefore thrown away, and in our work we have noticed that a few of the undersized seeds also go to the bottom.

Many investigators¹ have carried this process still farther, and separated their seeds by what is known as the specific gravity method. In this case solutions of salt (sodium chloride), ammonium nitrate, sodium nitrate, potassium nitrate and calcium chloride have been used. For this purpose solutions of different specific gravities have been made, in which the seeds were placed, first in that solution with the highest specific gravity. The seeds which floated in this solution were skimmed off and placed in that of the next highest specific gravity, and so on. It has been found that by this method seeds of the same variety, of a uniform, sound condition, differ in specific gravities only within a very narrow range. This, however, does not seem to be a very practical plan, as it involves the making of solutions of tested specific gravity and quite a little mechanical manipulation. Another method, known as the specific gravity sampling method, is perhaps of less value, as in this case one lot of seed is compared with others in bulk, without separating the poor and undeveloped seeds. It amounts simply to the choosing of the best lot from several samples of seeds.

The separation of seeds by sieves would seem to be the easiest and most practical way, and this method with us has given very good results. We used a series of four sieves, having round perforations of 2 mm., 1.5 mm., 1 mm., and .05 mm. respectively. Ten grams of seed were weighed out and run through this series of sieves, with the following results:—

TABLE III. — *Showing the Results of sifting Seeds, in which 10 Grams were employed.*

NUMBER OF SIEVE.	Size of Seed.	Weight in 10 Grams of Seed (Grams).	Per Cent.
No. 1,	2.0-1.5 mm.	1.015	10.15
No. 2,	1.5-1.0 mm.	6.689	66.88
No. 3,	1.0- .5 mm.	1.800	18.00
No. 4, . . . . .	.5- .0 mm.	0.491	4.91

¹ Among whom may be noted V. A. Clarke, New York (Geneva) Experiment Station, Bulletin No. 256.

Five hundred seeds were then counted out from each of these four grades or sizes of seeds, with the exception of No. 4 (.5-.0 mm.), which was composed entirely of chaff, dirt, etc. These were sown in flats and allowed to grow for four weeks, when the seedlings were taken up, counted and weighed, with the following results:—

TABLE IV. — *Showing the Results of Germination and Growth of Seedlings from Three Experiments with Sifted Lettuce Seed; 1,500 Seeds used in Each Experiment, making a Total of 4,500 Seeds employed.*

SIZE OF SEED.	Per Cent. germinated.	Number of Seedlings.	WEIGHT OF SEEDLINGS (GRAMS).		Average Per Cent. gained in Weight of Large over Small Seedlings.
			Total.	Average.	
2.0-1.5 mm., . . .	56.7	672	347.5	.518	98.42
1.5-1.0 mm., . . .	53.5	642	293.7	.457	75.09
1.0-.5 mm., . . .	40.4	485	126.3	.261	-

From this table it will be seen that of the large 16.3 per cent. and of the medium 13.1 per cent. more seeds germinated than of the small seeds, and that the four-weeks-old seedlings from the large seed averaged 98.42 per cent. and those from the medium seed 75.09 per cent. heavier than those from the small seed. It will also be noticed that the differences in the per cent. of germination and the weight of seedlings from the large and medium seeds were not very great; but the difference between the germination, and especially in the weight of seedlings of the larger and small seeds, is very marked.

We are of the opinion that it would pay a grower to separate his lettuce seed with a sieve having a mesh of one millimeter in diameter ($\frac{1}{25}$ inches), and to use only such seed as did not pass through a sieve of this size. From these plants he could make a further selection, as is customary at the time of transplanting. This would result in saving considerable ground space which is valuable, and not only would a more vigorous and uniform setting of lettuce be obtained, but the treatment would also eliminate many weak and undesirable plants, which are more likely to be sus-

ceptible to disease. In other words, much of the selection would be done more cheaply and easily by sifting the seed than as it is done at the present time, by selection in the seed bed. A sieve of the size mentioned can easily be made by purchasing from almost any tin shop a piece of colander tin of 1 millimeter mesh, which can very readily be soldered to a suitable rim, or even fastened to a tomato can which has had the bottom removed.

Our experiments in sifting seed have been confined, however, for the most part to lettuce seed; and, while these seeds can be separated in this way very easily, much more difficulty would be experienced in separating some other types of seed, such as turnip or tobacco; and another objection to this method is that the size and weight of seeds do not necessarily correspond, that is to say, a large seed may not necessarily be a heavy one. When seeds are separated by sifting, while the largest size contains practically all of the heaviest seeds and the lighter seed is practically all in the small sizes, there will be a few light seeds in the larger size and a few heavy seeds in the smaller sizes, so that this method by no means gives an absolute division of the seeds by weight, which is the ideal method of seed selection.

Mr. A. D. Shamel of the Connecticut (New Haven) Experiment Station uses a very satisfactory method for the separation of tobacco seed, which we can do no better than describe in his own words:—

This seed separator consists of a glass tube 1 inch in diameter and 5 feet long, and a glass receptacle for holding the seeds, having the diameter of the long glass tube, and so arranged with a finely woven wire screen in the bottom as to hold the seeds in the receptacle, and at the same time freely admit a current of air directly into the seed. The top of this receptacle is fitted with a coupling into which the long glass tube can be set and held in place. The current of air is developed by a common foot bellows and regulated with a valve. The seed to be separated is poured into the receptacle, usually about 1 to 2 ounces at a time, the glass tube set in place and a current of air pumped into the seed. The lightest seed and chaff are first blown out of the tube, and next the small seed. Small

seed of the same character as the larger seed have proportionally more surface than the larger, consequently the small as well as the light seed is removed by this machine.

This seems to be the most satisfactory way of separating seed that has yet been devised, and no doubt some simple, inexpensive instrument modelled from this device will soon be available for every farmer and seed grower. The particular advantages of this method seem to be that this device is adaptable to all kinds of small seeds, the only adjustment needed being in the regulation of the amount or force of air sent through, and that by this method the seed is separated according to weight.

In conclusion, we believe it desirable with many kinds of garden seeds to separate the seed and discard all except the large, well-developed, mature and heavy seed, because:—

First.—About 33 per cent. of seeds as placed on the market consist of dirt, chaff, and small, undesirable seeds.

Second.—Small or light seeds do not germinate well, and their seeds produce only poor, small, undesirable plants, which prove inferior in every way.

Third.—Heavy seeds produce healthy, large, well-developed plants, that will give maximum crops.

Fourth.—Seed selection or separation is an inexpensive process that gives good results.

ASPARAGUS RUST.

The past summer in most parts of Massachusetts has been an extremely dry one, and especially favorable, as was early anticipated, to an early and severe attack of asparagus rust. The confinement of the rust, or at least its injurious stage, to special localities has been the same this season as in other years; in other words, it has been confined to soils especially coarse, and easily affected by drought.

Since 1896 there have been about three severe outbreaks of the rust in this State, such outbreaks being identified with a dry summer, or at least with seasons where there have existed long periods between rainfalls. The fall or teleuto stage, however, has been present every year since

1896, and it has always been widely distributed. Any bed which has become once infected with this stage remains so, but fortunately the damage occurring from teleutospore infection is insignificant, and in the majority of cases not discernible. Asparagus rust has now become quite well distributed over the United States, but its virulence does not show itself in the same degree for every locality, and the problem of control is by no means everywhere the same, since factors enter into the problem which do not possess the same significance for all locations. In this State rust is most intimately associated with lack of vigor, and more particularly with those factors which underlie vigor, such as supply of water and judicious fertilizing. For this reason the most efficient remedies are based upon those practices the application of which induce vigor. There are a number of remedies which can be applied, some of which have given excellent results. Thorough cultivation and fertilization in more than one instance have given results which have proved superior to any other method of treatment. We have observed that the results from weekly cultivation combined with judicious fertilization have proved very satisfactory. Irrigation has also proved very effectual during dry seasons; but there is possibly a tendency for asparagus to become too succulent with repeated irrigation, which might possibly render the plant more susceptible to infection.

We also believe that an efficient practice pertaining to rust infection consists of burning the old brush in the fall, since a large number of teleutospores are destroyed, which, if left remaining in the ground over winter, would germinate freely in the spring and constitute a dangerous source of infection. We have repeatedly attempted to germinate teleutospores in the early winter, but failed. They will germinate freely in March, however. Moreover, the roots from infested plants, when transplanted in the greenhouse in the fall and left there for a year and allowed to develop tops, have never shown any tendency to rust. This would seem to indicate that not only is a resting period essential, as is usually the case for spores, but freezing also is essential. We are of the opinion that most beds are infected in

this State by teleutospores during the spring and summer, and that the mycelium works up through the stem; and if the conditions for the plant are unfavorable, pustules bearing uredospores will break out in July or August, whereas, if the conditions for the plant are favorable, pustules bearing teleutospores will make their appearance during September or later.

In case uredospores break out in the plant during July and August, other beds in the vicinity, if in suitable condition, will invariably become infected. If, however, the crop is in a vigorous condition, even if located close by, it will resist the outbreak of the rust. This, indeed, has occurred many times in beds side by side, although of different age and vigor, and in the case of those beds more or less remote it may be stated that there are hundreds which have never had any uredo outbreak.

We observed a young bed of asparagus the past summer, about two years old, which had never been cut, and which had a teleutospore outbreak early in July. This bed suffered much from drought, and was not in an especially vigorous condition. It was, however, located on soil of fine texture, intermingled with coarse pebbles. There was little inclination for the plants of this bed to grow worse, notwithstanding the fact that drought prevailed, and it remained in practically the same condition all summer. On dry soil this never occurs, since it is the uredo stage that makes its appearance in these soils in July and August; and plants infected with this stage turn brown in a short time after they become infected. Moreover, the teleutospore outbreak occurring in summer is a perfectly harmless factor, as far as immediate infecting of the bed is concerned. Our studies of the rust problem have shown that there is an intimate connection existing between the texture and water contents of soils and uredospore outbreaks, and a series of water determinations of different soils during the season would probably bring out some interesting facts.

Spraying with Bordeaux mixture has not proved satisfactory in this State as a means of controlling the rust, and little or no use is now made of it for this purpose.

Some reports have been made concerning the use of the

sulphur wash spray recommended by Prof. R. E. Smith, formerly of this station. This mixture, which consists of sulphur, soap, potash and water, possesses remarkable sticking qualities, and it is undoubtedly the most efficient mixture recommended for spraying for asparagus rust.

AN APPLICATION OF THE COPPER SULFATE TREATMENT.

Early in the summer the college pond became so overrun with Algæ as to be unsightly, and the smell of this decaying vegetable matter was so unpleasant that it became necessary to treat it.

Microscopic examinations of the water showed that it contained a considerable amount of short suspended filaments, of a slightly whitish or greenish color, which proved to be *Anabaena flos-aquæ*, a form of Algæ found frequently in public water supplies, and which gives rise to considerable trouble. The water content of the pond was roughly determined, and then treated with 1 part of copper sulfate to 4,000,000 parts of water. The required amount of copper sulfate was placed in a loosely woven sack and hung over the stern of a canoe, which was paddled around the pond in concentric circles for about one-half an hour, when all the copper sulfate was dissolved. This is the method recommended by Drs. Moore and Kellerman in their work on treating reservoirs with copper sulfate. A careful examination of samples taken twenty-four hours after treatment showed a slight decrease in *Anabaena*, and in two or three days it had practically disappeared.

Spirogyra, which was present along the shores near the inlet at the time of treatment, was not affected, and subsequently a number of large clumps were found in a flourishing condition in different parts of the pond, and many forms of Algæ, such as *Desmidiæ* and *Diatoms*, appeared not to be in the least affected by the treatment. Neither did the animal life seem to be affected in any way by the treatment, as no ill effects could be noted on the fish, frogs, tadpoles or other fauna inhabiting the water.

Of the *Protozoa*, the *Ceratium* was very numerous both before and after treatment, and was in no wise affected by

the copper. *Daphna*, a form of Crustacea, was also plentiful, and experienced no ill effects from the copper treatment.

From day to day the bacterial contents of the water were determined, with the results shown in the following table :—

Copper Sulfate Test on Massachusetts Agricultural College Pond Water.

DATE OF TAKING SAMPLE.	Number of Bacteria per Cubic Centimeter of Water.
1905.	
June 17 (one hour after treatment),	6,224
June 19,	3,463
June 20,	219
June 21,	336
June 22,	1,583
June 23,	1,187
June 24,	538
June 25,	1,144
June 26,	1,399
June 27,	1,144
June 28,	616
June 29,	763
June 30,	1,145
July 1,	1,078
July 3,	1,078
Sept. 16,	990
Sept. 17,	1,017
Sept. 18,	990
Sept. 19,	636

From this table it will be seen that the bacteria decreased very rapidly for the first few days after treatment, and, while they slowly increased again, they never reached their former numbers. The results obtained on June 24, 28 and 29 may be attributed to an unusually clear or settled state of the water on those days, while when the other samples were taken the water was considerably agitated, either from the effects of rain or wind.

A second treatment was contemplated in September for the

purpose of studying the effects of copper sulfate on bacteria ; but as the bacteria showed no appreciable increase at this time, we thought it not worth while to inaugurate another experiment. Samples of water taken one hour and twenty-four hours after treatment were tested for copper by the foods and feeding department of the station ; and, while possible traces of the copper were found, they were so small and uncertain that no copper could be reported. In these tests the ferrocyanide method was employed, which in numerous other cases has failed to give reliable results where such small quantities of copper are present.

At the time these chemical tests were being made for copper there came to our notice a test described and recommended by Dr. Ewerts,¹ which claimed to detect one part of copper in 30,000,000 parts of water. This test is based on the inhibiting action of copper to diastatic action. This method was given a trial in the foods and feeding chemical laboratory, and found to be unsatisfactory. Quite likely, however, a detailed study of this latter method, together with some practice, will prove it to be of some value.

The result of this single experiment with copper sulfate in treating the college reservoir is not sufficient in itself to allow deductions of great value. They corroborate, however, the experiments made by Messrs. Moore and Kellerman on the Belchertown reservoir, and those made elsewhere, in showing that *Anabaena* is extremely susceptible to copper, and can readily be killed by this method of treatment. Moreover, the general clearing up and rapid disappearance of odor from the water two or three days after treatment, together with the falling off of bacteria, was quite noticeable. It should be stated, however, that there was a fall of about 20° in the temperature on the third day after treatment, which would have a tendency to affect *Anabaena* ; and about one and one-half inches of rain fell between the 19th and 24th of June.

¹ Ztschr. Pflanzenkrank, Bd. XIV., 3 Heft., p. 133.

A COMPARISON OF THE NUMBERS OF BACTERIA IN STERILIZED AND UNSTERILIZED SOILS.

BY A. VINCENT OSMUN.

There has been repeated inquiry as to the effect sterilization of soil has upon its bacterial flora. In the absence of any reliable experiments touching upon this question, it has frequently been assumed that by soil sterilization the bacteria, and especially the beneficial ones, are destroyed, hence injuring the soil. In regard to this question, it may be stated that little is known about either the so-called beneficial or injurious bacteria of greenhouse soils; and, in consequence of a paucity of knowledge upon this phase of the subject, positive statements are out of place. From what is already known about the effects of soil sterilization upon plant growth and the changes which such soil undergoes, it might be assumed upon *a priori* grounds that soil bacteria would be found to exist more abundantly in sterilized soil than in unsterilized soil. Moreover, it must be borne in mind that absolute sterilization is never accomplished, but something more closely approaching pasteurization takes place. All bacteria are by no means killed, as has been shown by various tests made at this station.¹ Subjecting soils to steam heat has a marked stimulating effect on the growth of plants. Observations at this station and experience of growers have shown this to be true. Just why this treatment of soil should stimulate the growth of plants is not known. Sorauer² suggests that steam heat makes the humus compounds more available to plants. It is not unlikely that steam flowing through a soil also improves its mechanical condition.

The stimulating effect of soil sterilization on plant growth suggested a similar effect on the bacterial content of soil so treated; and in order to obtain more evidence regarding this point this experiment was planned:—

Two boxes about 20 inches square and 9 inches deep and of equal weights were filled to the depth of about 5 inches

¹ Hatch Experiment Station, Massachusetts Report, 1902, pp. 77, 78.

² Sorauer, *The Physiology of Plants*, pp. 45, 46.

with equal amounts by weight of soil from the supply bin of the station greenhouse. Before filling the boxes a quantity of soil from the bin was thoroughly mixed, and the boxes filled from that, so that the soils in the two boxes were as nearly alike as possible. The soil in one box was treated for half an hour with flowing steam applied through perforated tubes buried beneath the surface; the soil in the other box was untreated. One week after sterilization a sample was taken from each box for the determination of the numbers of bacteria in the soil, after which the boxes were placed on a platform scale and brought to equal weights with water. Water was similarly applied every day during the experiment, and the soil always contained from 17 to 20 per cent. moisture. Samples for the determination of the quantitative bacterial content of these soils were taken at intervals of about two weeks. The soil was frequently stirred, and at the times of sampling the entire contents of each box were thoroughly mixed and pulverized.

The results of this experiment are tabulated in the accompanying table: —

Showing the Relative Number of Bacteria in Sterilized and Unsterilized Loam.

DATE OF TAKING SAMPLE.	NUMBER OF BACTERIA PER GRAM OF DRY SOIL.	
	Sterilized.	Unsterilized.
1905.		
April 3,	6,742,000	56,273,000
April 18,	64,596,000	39,080,000
May 1,	66,089,000	31,372,000
May 16,	29,963,000	8,029,000
June 1,	26,666,000	14,634,000

The figures in this table show that steam flowing through soil for half an hour not only does not kill all the bacteria in that soil, but that it seems to act as a stimulus, causing rapid multiplication of numbers. Practically all vegetative forms would be killed, but most spores would be uninjured, and, given favorable conditions after treating, would germinate. One week after sterilization the treated soil contained

nearly 7,000,000 bacteria per gram. This number is probably considerably in excess of the number in the same soil immediately after sterilization, but it indicates that treating soil with live steam at about 210° F. for half an hour does not kill all the bacteria in that soil. The untreated soil contained a good number of bacteria at the beginning, — about 56,000,000.

During the four weeks immediately after the first samples were taken there was a phenomenal increase in the number of bacteria in the sterilized soil. From 7,000,000 per gram at the beginning the number had advanced to nearly 65,000,000 at the end of two weeks, and after four weeks to over 66,000,000. On the other hand, the number in the untreated soil showed a steady decrease, for which no cause is at present apparent.

After six weeks the numbers of bacteria in both sterilized and unsterilized soils had dropped way below the numbers found at the end of four weeks. During the next two weeks the sterilized soil continued to drop off, though not to any great extent, while the unsterilized soil advanced.

At this point it became necessary to discontinue the taking of samples because of the press of other work.

We are unable to account for the decrease in numbers of bacteria in either sterilized or unsterilized soil. A similar decrease in numbers of bacteria has been noted in other experiments in the greenhouse in which unsterilized soil was used. The temporary increase in numbers in the sterilized soil may be attributed to the stimulus given by the steam heat; and it appears also that sterilization had a tendency to overcome, for a time at least, the antagonistic agency or agencies which caused the decrease in the unsterilized soil.

More extended experiments and observations are necessary before definite conclusions can be reached regarding the effect of so-called sterilization on the bacterial contents of soils; but from the results obtained in this experiment and from tests of other soils, both sterilized and unsterilized, we may conclude that steam treatment of soils greatly stimulates bacterial development in them, and that if certain as yet unknown adverse conditions can be removed, the high numbers may be retained indefinitely.

REPORT OF THE ENTOMOLOGISTS.

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

The year 1905 has been marked by a great abundance of insects of many kinds, while the two years preceding were equally marked by their scarcity. To this fact is probably due the large increase in the amount of correspondence the present year, nearly two thousand letters having been sent out, besides an unrecorded amount of printed matter, in answer to questions received.

Investigations as to the number of broods and times of appearance of the codling moth and oyster-shell scale have been continued during the season, and should be repeated for several years to come, that reliable date averages may be obtained, and thus the best times for the treatment of these insects be ascertained.

Several private insecticides have been more or less tested and the results noted, statements of these having been supplied in each case to the persons sending the materials. While some of these substances were shown to have a certain value for the destruction of insects, it was noticeable that they were no more effective than well-known insecticides costing less, or that they were injurious to the foliage of the plants they were tested on. In fact, none of the materials tested at this station during the year can be considered as adding anything of value to our present list of standard insecticides, though it has taken considerable time from other work to establish these negative results.

The collections of the division have, as usual, been given the needed care and have been added quite considerably to during the year, while additional facts as to the distribution of insect pests in Massachusetts and their habits have been

gathered and recorded. The card catalogue has been kept abreast of the new publications and improved in many ways, and requests for the information it contains are frequently received from other stations and from individuals.

Some study has been given to the carnation twitter, and the identity of the insect causing this trouble has been ascertained with considerable though not absolute certainty. Further investigations on this subject will be made during the coming year if material to study can be obtained.

Special researches have also been continued on the Asilidæ or robber flies; the Pyralidæ, a group including many very injurious insects; the Bombinæ or bumble bees and their habits; and on the Sphecidæ or digger wasps, these studies being of the entire groups; while a Cecidomyiid on oak, the stalk borer and several other species have received special attention individually.

The erection of a new greenhouse during the summer has greatly improved the facilities of the division for entomological research, besides being an excellent example of modern greenhouse construction. With a house which is reasonably tight and which can be kept warm during the winter it has been possible to begin a series of experiments to determine the resistant power of various forcing crops to fumigation. The business of raising crops under glass in Massachusetts is a very large one, and in too many places is greatly interfered with by the presence of insects which can only be controlled by fumigation with hydrocyanic acid gas. The strength of fumigation necessary to destroy these insects is now well known in most cases, but the charge which the plants can resist under all conditions of growth is not; and many an owner has refused to fumigate a badly infested house for fear of killing his plants along with the insects. From the experiments now under way, and which it will require several years to complete, it is believed that data can be obtained of such a nature that any person who desires to treat a greenhouse will be able to do so with entire safety to the plants, and yet kill the insects which may be present.

INSECTS OF THE YEAR.

The present year has been favorable for the rapid increase of insects in Massachusetts, and, though no one species has been present in overwhelming abundance, each has done its part in attacking crops of all kinds.

The San José scale is as abundant as it has ever been in the State, and is spreading farther each year. Where its presence is neglected it makes itself speedily felt; but with the methods we now have for its control there is no reason why it should be more than a nuisance in the future, requiring treatment every two or three years, like any of our other pests.

Cutworms and wire worms have given much trouble, particularly in the eastern and central portions of the State, while but little has been heard of root maggots this season.

The army worm has caused considerable injury locally on some of the cranberry bogs and elsewhere in southeastern Massachusetts, and in the central and western parts of the State the moths of this pest have been more abundant than for some time. It has now been nearly ten years since the last outbreak of this insect, and it is not unlikely that another may be due before long, if unknown factors do not develop to prevent it.

Inquiries about insects have covered a wider range than usual, but the most numerous questions have been about several species of scale insects, plant lice of different kinds, red spiders, borers, datanas, the bean weevil and the red-humped apple-tree caterpillar.

Since the Legislature placed the work on the gypsy and brown-tail moths in the hands of a special commission, no particular attention has been given them here; but some facts observed in connection with their distribution are here noted, as they have been gathered by members of the station. A few tents of the brown-tail moth were observed in Amherst last spring and others were received from Martha's Vineyard, while several were found on Nantucket last fall, showing that this insect is widely distributed over the State. Several cases have also been reported to the station of the presence

of the gypsy moth outside of the territory originally occupied by it, and these observations have been confirmed by inspectors of the Gypsy Moth Commission. That this insect is now rapidly spreading there can be no doubt, and it is too probable that the entire State will before long be infested by these two insects, which are among the worst enemies to man which occur in the United States.

APPENDIX.



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 excrement, 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 1905.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the different bulletins and annual reports of the State inspector of fertilizers from 1873 to 1895, which are contained in the reports of the secretary of the Massachusetts State Board of Agriculture for these years, and in the bulletins of the division 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 analyses 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.

Sea-weed ashes,	1	1.47	-	-	-	-	-	-	-	-	-	-	-	-	8.76	6.06	4.37	-	2.98	-	6.00	68.05
* Tan-bark ashes,	1	1.50	-	-	-	.52	-	.77	-	-	-	-	-	-	24.29	-	-	-	-	-	-	13.54
* Wood ashes,	5.55	12.08	-	-	-	5.42	6.07	.06	1.42	-	-	-	-	-	32.98	3.31	7.43	-	-	-	-	16.51
* Wool-waste ashes,	1	8.40	-	-	-	27.24	-	.26	-	-	-	-	-	-	2.88	-	-	-	-	-	-	27.82
* Wood charcoal,	2	3.65	-	-	-	.40	-	.16	-	-	-	-	-	-	-	-	-	-	-	-	-	1.58
* Walnut-wood ashes,	1	3.73	-	-	-	5.06	-	2.07	-	-	-	-	-	-	40.73	-	-	-	-	-	-	2.29
* Waste lime from tannery,	2	.88	-	-	-	-	-	-	-	-	-	-	-	-	54.78	-	-	-	-	-	-	2.83
* Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	-	.38
Virginia marls,	2	15.98	-	-	-	.61	.37	.44	.09	.08	.69	-	-	-	7.25	.21	-	-	.66	7.25	-	64.23

3. Refuse Substances.

Ammoniate,	1	5.88	-	-	11.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	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 dust,	1	5.06	-	-	3.06	-	-	-	-	17.80	-	-	-	-	7.24	10.56	-	-	-	-	-	-	-	-
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	13.49	-	-	.24	-	-	5.46	-	1.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue-green algae (<i>Lepidibia lepidocaulis</i>),	1	16.26	-	-	4.25	-	-	.73	-	.19	-	-	-	-	3.53	2.06	1.18	-	-	-	-	-	5.53	
* Burned bone,	5	2.06	-	-	-	-	-	-	-	37.33	-	-	-	-	2.71	35.66	-	-	-	-	-	-	.96	
* Coconut-fibre pith,	1	6.20	3.78	-	.34	-	-	.84	-	.03	-	-	-	-	-	.57	-	-	-	-	-	-	1.01	

1 Trace.

2 None.

Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.97	4.13	-	-	34.88		
* Soot,	2	8.69	-	-	.77	1.57	.17	.87	.72	.23	.47	-	-	-	-	-	2.42	1.19	6.38	-	-	-	71.07	
* Tankage,	76	8.02	-	11.27	4.11	5.88	-	-	21.02	.76	14.00	-	-	-	6.37	7.50	-	-	-	-	-	-	-	31.18
* Tobacco dust,	5	5.04	58.08	2.25	1.54	1.80	6.81	1.53	2.43	1.38	.61	-	-	-	-	-	3.49	-	-	-	-	-	-	4.17
Tobacco leaves,	1	13.05	21.01	-	-	2.75	-	7.24	-	.43	-	-	-	-	-	-	4.17	2.17	.32	-	-	-	2.70	
* Tobacco stems,	2	10.15	23.76	2.20	1.39	2.09	8.68	5.72	7.20	1.02	.32	.67	-	-	-	-	5.46	-	-	-	-	-	1.86	
* Tobacco stalks exposed to the ac- tion of weather.	2	7.62	-	1.40	1.18	1.29	4.01	.52	2.26	.92	.38	.65	-	-	-	-	-	-	-	-	-	-	.75	
* Teopik fibre,	1	56.54	-	-	-	.53	-	-	1.26	-	.55	-	-	-	-	-	5.15	-	-	-	-	-	-	
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	3.51	-	-	2.34	.51	-	-	-	-	-	-	-	-	
* Undried tankage,	1	29.00	-	-	-	1.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
* Vegetable mould,	1	26.07	-	-	-	.62	-	.66	-	-	.45	-	-	-	-	-	-	-	-	-	-	-	-	
* Wool dustings,	1	14.10	16.04	-	-	3.65	-	.23	-	.32	-	-	-	-	-	-	1.02	-	-	-	-	-	9.25	
* Wool waste,	13	40.71	30.12	8.36	.39	3.65	5.92	.29	1.68	1.02	.65	.56	-	-	-	-	2.39	-	-	-	-	-	31.58	
Wool washings, water,	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	-	.49	.28	-	-	-	-	-	
* Wool waste and sheep manure,	1	7.13	-	-	-	2.63	-	2.20	-	-	.64	-	-	-	-	-	-	-	-	-	-	-	-	
Wool washings, acid,	1	-	-	-	-	-	-	4.20	-	-	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	
Wool washings, alkaline,	1	92.03	3.28	-	.49	-	-	1.09	-	-	-	-	-	-	-	-	.92	.04	-	-	-	-	.22	
Whale meat, raw,	1	44.50	1.04	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.92	
Waste from lactate factory,	1	34.11	-	-	.68	-	-	-	-	-	.67	-	-	-	-	-	22.59	-	-	-	-	-	-	
* Whalebone scrapings,	1	6.90	-	-	13.01	-	-	-	-	-	.26	-	-	-	-	-	-	-	-	-	-	-	-	
* Water abstract of dry forest leaves,	1	99.46	.16	-	.00	-	-	.63	-	-	.022	-	-	-	-	-	.025	-	-	-	-	-	-	

1 None.

* Novassa phosphate,	1	5.77	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-
Odorless phosphate,	6	2.99	-	-	.52	.64	.38	21.74	18.40	19.54	-	.52	19.82	-	-	-	51.42	-	-
* Phosphatic slag,	9	.57	-	-	-	-	-	21.78	14.71	17.73	-	5.27	12.46	-	-	-	39.60	-	-
* Peruvian guano,	39	13.58	37.61	13.50	4.44	6.36	4.08	1.14	2.62	20.60	5.90	14.85	3.72	5.49	5.64	-	12.85	-	6.60
Rat guano from Florida,	1	10.32	-	-	3.32	-	-	6.85	-	2.30	-	-	-	-	-	-	-	-	1.15
* South Carolina rock phosphate,	5	.80	-	-	-	-	-	-	-	31.87	25.58	28.06	3.40	24.60	-	-	-	-	-
South Carolina floats,	1	.83	-	-	-	-	-	-	-	23.39	-	-	-	-	-	-	-	-	-
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	35.89	-	-	-	-	-	44.89	-	-
* Tennessee phosphate,	1	.37	-	-	-	-	-	.44	-	33.00	-	-	-	-	-	-	-	-	-
Upton phosphate,	1	9.67	-	-	-	-	-	-	-	46.15	-	37.84	2.31	-	-	-	-	-	-

5. *Animal Excrement, etc.*

* Barnyard manure,	38	73.38	8.29	.69	.18	.42	.92	.25	.53	.59	.10	.31	-	-	-	-	-	-	-	5.57
* Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	33.26	3.65	-	-	.48	-	-	.88	-	.24	-	-	-	-	-	-	-	-	-
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	.45	-	-	-	-	-	.39	-	-	3.78
* Guinea-pig manure,	1	8.35	-	-	-	1.74	-	-	1.66	-	.55	-	-	-	-	-	-	-	-	-
* Hen manure,	4	43.21	-	1.83	.42	.87	2.96	.43	1.11	3.43	.63	1.62	-	-	1.24	-	1.19	.89	-	23.69
Hen-house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	1.62	-	-	-	-	-	-	-	-	71.07
Horse manure,	1	11.21	-	-	-	.74	-	-	2.82	-	1.46	-	-	-	-	-	-	-	-	12.60
* Liquid manure,	1	96.56	-	-	-	.56	-	-	.62	-	.61	-	-	-	-	-	-	-	-	-
Pondrotte, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	5.74	-	-	-	-	-	-	-	-	4.65
* Sheep manure,	70	8.33	17.60	2.97	.85	2.13	3.42	.68	2.13	2.24	.22	1.46	-	-	-	-	3.36	-	-	28.49

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.	Ferrie and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
<i>I. Chemicals, Refuse Salts, etc.</i>													
* Carbonate of potash, high grade,	67.6	-	-	1,218.4	-	-	-	-	-	-	-	-	-
* Carbonate of potash,	364.4	-	-	384.8	-	-	-	390.4	-	-	-	-	7.8
Carnallite,	-	-	-	274	-	153	-	264	-	11	-	881	-
* Kainit,	63.6	-	-	249.4	-	379.4	47.4	127.4	-	405	-	412.8	42.6
Krugite,	96	-	-	168	-	105	249	176	-	639	-	133	269
* Muriate of potash,	31.2	-	-	997.8	-	133.8	-	11	-	-	-	976	14
* Nitrate of potash,	19.6	-	266	891.4	-	-	-	-	-	-	-	7	-
* Nitrate of soda,	30.4	-	309.4	-	-	710	-	-	-	-	-	10	10
* Nitro lime,	18.4	-	168.4	-	-	-	586	-	-	-	-	-	45.6
Nitre salt cake,	121	-	46	17	-	591	-	-	-	955	-	-	78
Phosphate of potash,	75	-	-	651	750	-	-	-	-	269	-	-	18
Phosphate of ammonia,	121	-	297	-	877	-	-	-	-	249	-	-	16
* Potash refuse from manufacture of cyanide of potash,	785	-	19	147	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	19.8	-	414.8	-	-	-	-	-	-	1,200	-	-	-

*Sulfate of potash,	16.4	-	985	-	89.2	-	30	-	914.4	-	-	.15
*Sulfate of potash-magnesium,	76.6	-	506.8	-	125	51.4	277.2	-	894.4	-	39	45.2
*Sillicate of potash,	157.2	-	411.8	-	-	-	-	-	722	-	-	-
*Sulfate of magnesia,	475	-	-	-	-	56	348	-	1,189	-	-	115
*Sulfate of soda,	28	-	-	-	-	-	-	-	37	-	925	-
Saltpetre waste,	51	44	273	-	741	15	4	-	-	-	-	-
*Vegetable potash,	72.6	-	519	51	-	413	-	-	-	-	-	194
2. <i>Ashes, Marls, Lime Compounds, etc.</i>												
Acetylene gas-tank refuse,	84	-	-	-	-	1,183	-	-	-	-	-	-
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,	233	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	132	-	-	11	1,620
*Ashes from peach-tree trimmings,	11	-	98	49	151	375	-	210	44	-	-	271
*Ashes from soft coal and sawdust,	67.2	-	14.6	14.8	-	56	-	-	-	-	-	1,390.6
Ammoniated marl,	65	-	-	208	-	-	-	-	-	-	-	-
*Bleachery refuse,	84	-	16	-	234	716	-	-	-	-	-	462
Bituminous coal ashes,	73	-	8	9	-	38	-	-	-	-	-	1,483
*Brick-yard ashes,	11.6	-	69	29.4	-	486.6	-	-	-	-	-	932.6
*Coal and wood ashes,	25.4	-	8.80	23	-	47.8	-	-	-	-	-	1,618.8

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.	Ferrie and Aluminic Oxides.	Sniphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. Ashes, Marls, Lime Compounds, etc.—Con.														
* Cotton-seed hull ashes,		146.2	—	—	450.6	169.8	—	160.6	252.8	—	—	—	—	342.4
* Corn-cob ashes,		109.4	—	23.6	494.6	94.4	—	140	—	25.6	—	—	—	762.4
* Carbonate of lime,		9	—	—	—	—	—	1,046.2	—	—	—	—	—	—
Gypsum,		33	—	—	—	—	—	1,017	—	—	—	—	—	57
Gas-house lime,		223.2	—	—	—	—	—	963.8	166	—	383.2	—	—	179.8
Green sand marl (Virginia),		25	—	—	23	187	—	516	—	103	—	—	—	826
* Hemp ashes,		—	—	—	49.6	34.8	—	1,299.4	—	—	—	—	—	63.8
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,		227	—	—	40.8	15.6	—	829.8	26	—	—	—	—	135.6
* Leather-scrap ashes,		118.8	—	3	44.6	57.8	—	156	—	—	—	—	—	921.6
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,	310.8	-	.02	5.80	.40	-	- ²	-	-	-	-	-	-
Marl (North Carolina),	14	-	-	1	11	-	439	12	-	-	-	-	1,004
* Nova Scotia plaster (gypsum),	129	-	-	-	-	-	675	15	-	807	-	-	116
Olive earth (Virginia),	39	-	-	5	275	-	383	-	120	-	-	-	1,011
Onondaga plaster (New York gypsum),	265	-	-	-	-	-	600	93	-	650	164	-	197
* Oyster-shell lime,	-1	-	-	-	7.60	-	1,110.8	-	-	-	189	-	176.4
* Picker-waste ashes,	6	-	-	131	24	-	-	-	-	-	-	-	1,269
* Patent-process lime,	-1	-	-	-	-	-	1,157.4	-	-	-	-	-	180.6
Peat ashes,	93	-	-	9	2	-	46	53	123	-	-	-	903
* Prepared lime,	-1	-	-	-	-	-	79.8	1,389.6	.0	31	-	-	-
* Pine-wood ashes,	55.2	-	-	87.4	61.4	-	472.2	-	-	-	-	-	749.2
* Peat,	306	409.4	18.4	.8	1.6	-	17.6	-	-	-	-	-	324.6
* Plastering,	144	-	-	-	4.40	-	2.30	-	-	-	-	-	13.30
* Pulp ashes,	-1	-	-	9.2	2.4	-	1,354.4	-	-	-	-	-	140
Railroad-tie ashes,	94	-	-	18	11	-	50	-	-	-	-	-	1,604
* Refuse ashes from sawdust,	278.4	-	-	71.6	151.4	-	635.2	-	-	-	-	-	505.4
Sea-weed ashes,	29	-	-	18	6	175	121	87	-	60	-	132	1,273
* Tan-bark ashes,	30	-	-	10.4	15.4	-	485.8	-	-	-	-	-	270.8

1 None.

2 Trace.

Raw wool,	139	151	258	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	73
* Rawhide dust,	290	-	278.2	-	21.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Refuse from glass factory,	330	-	-	390	-	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, green,	1,370	474	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	274.6	715	25.2	64.4	28.8	119.4	97.6	19.2	24.4	-	-	-	-	-	-	-	-	-	-	-	-	-	3.2
Residue from water filter,	1,884	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Silt deposit,	143	-	22.8	7.8	5	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	145	-	49	-	64	-	79	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	781
* Sizing paste,	1,245.6	-	32.6	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sizing waste,	1,480	-	.2	8	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29
* Sludge from sewage beds,	739	619.4	21.4	4	5.6	-	86.8	-	52.4	-	-	-	-	-	-	-	-	-	-	-	-	-	75.6
Soap-grease refuse,	585	1,028	22	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26
Soup from horse rendering,	1,462	-	24.6	1.4	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1,842.8	-	22.4	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Spent bone-black,	23	-	-	-	620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sugar-beet refuse,	154	-	127.8	194.4	-1	140	-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
Sunac waste,	1,261	136	24	65	-	-	23	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	200	5	.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 None.

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 Phosphate	Sodium Oxide.	Calcium Oxide (lime).	Magnesium Oxide.	Ferrie and Alu- minic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.	
3. Refuse Substances—Con.															
* Sludge from sewage-precipitating tanks,		755	-	18	5	12	-	62	44	171	8	47	-	574	
* Sewage,		1,082.2	1,432.8	11	5.4	12.6	-	-	-	55.8	-	-	6.6	617.4	
Salt mud,		1,067	824	8	7	-	19	18	7	83	-	-	-	638	
* Salt marsh mud,		1,201	616.4	4.8	2.8	1.6	-	2.2	-	-	-	-	41.2	757.6	
* Soot,		172	-	15	17	9	-	58	24	128	-	-	-	1,421	
* Tankage,		160.4	-	117.6	-	28.0	-	-	-	-	-	-	-	-	
* Tobacco dust,		100.8	1,173.6	36	58.6	12.2	-	61.8	-	-	-	-	-	623.6	
* Tobacco stems,		203	475.2	41.8	144	13.4	-	109.2	-	-	-	-	-	54	
Tobacco leaves,		261	420	55	145	9	-	83	43	6	-	-	-	83	
* Tobacco stalks exposed to the action of weather,		152.4	-	25.8	45.2	13	-	-	-	-	-	-	-	37.2	
* Teopik fibre,		1,131	-	11	25	11	-	103	-	-	-	-	-	15	
Turf,		386	127	39	-	-	-	-	-	-	-	-	-	-	
* Dried tankage,		580	-	21	-	70	-	-	-	-	-	-	-	-	
* Wool waste,		214.2	692.4	61	33.6	11.2	-	47.8	-	-	-	-	-	601.6	

* Wool dustings,	282	320.8	73	5.8	6.4	-	20.4	-	-	185
Wool washings, water,	-	-	-	7.8	-	10	6	-	-	-
Wool washings, acid,	-	-	-	8.4	-	8	12	.4	-	-
Wool washings, alkaline,	1,841	66	2	22	-	18	1	-	-	4
Whale meat, raw,	800	21	9.7	-	-	-	-	-	-	-
* Wool waste and sheep manure,	142.6	-	52.6	44	12.8	-	-	-	-	-
Waste from lactate factory,	682	-	14	-	13	-	452	-	-	138
* Whalebone scrapings,	14	-	200	-	5	-	-	-	-	-
* Water abstract of dry forest leaves,	1,989	3	.08	.6	.44	-	.5	-	-	-
Vegetable mould,	521.4	-	12.4	13.2	9	-	-	-	-	-
<i>4. Guanos, Phosphates, etc.</i>										
* Acid phosphate,	212.2	-	-	-	315	-	-	-	-	-
* Apatite,	1	-	-	-	704	-	-	-	-	-
* Bone ash,	7	-	-	-	783	-	-	-	-	-
* Belgian phosphate,	4.2	-	-	-	190.8	-	825.4	-	-	-
Bone-black,	92	-	-	-	566	-	-	-	-	73
Brockville phosphate,	5.0	-	-	-	70.4	-	-	-	-	129
Bat guano from Texas,	80.2	365	129	26	75	-	-	-	-	40
Bat guano from Florida,	313	-	195	35	67	-	-	-	-	387
* Bat guano from Havana, Cuba,	116.6	-	86.6	17.2	90.4	123.4	220.8	115.2	-	189.4
Cuban guano,	485	-	33	-	267	-	-	-	-	63
Caribbean guano (orehilla),	146	-	-	-	535	-	739	66	54	25

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.

The results of chemical analyses of twenty prominent garden crops (green) show the following average composition, expressed in parts per thousand :—

Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

A computation of the results of the above analyses of green garden vegetables shows the following relative proportion of the three essential ingredients of plant food :—

Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

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 limits pays, as a rule, better than a scanty one. (C. A. GOESSMANN.)

I. 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.
Ericaceae:—										
* Cranberries,	996	—	1.8	.9	.1	.3	.1	.3	—	—
* Cranberries,	894	.8	—	1.0	—	.2	.1	.3	—	—
Rosaceae:—										
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 — <i>Con.</i>										
* 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.
Chenopodiaceae:—										
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	10.1	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
* Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	—	—

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — <i>Con.</i>										
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
Crucifere:—										
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 (<i>Dolichos</i>), green,	788	2.9	-	3.1	.6	3.0	1.0	1.0	-	-
* Small pea (<i>Lathyrus Sylvestris</i>), 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

Fertilizing Constituents of Garden Crops — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
<i>Liliaceae — Con.</i>										
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	—	—
<i>Solanaceae : —</i>										
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	—	—
Umbellifere: —										
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. Wolf. 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.
<i>Fruits.</i>			
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.
Viticeæ :—			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
<i>Garden Crops.</i>			
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.
Convolvulacæ: —			
Sweet potato,	1	4.6	3.0
Crucifera: —			
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
Cucurbitacæ: —			
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.
Gramineæ — <i>Con.</i>			
* 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 (<i>Dolichos</i>), green, .	1	3.1	2.9
* Small pea (<i>Lathyrus sylves-</i> <i>tris</i>), 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.
Solanaceæ — <i>Con.</i>			
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 Alu- minic Oxides.	Insoluble Mat- ter in Hydro- chloric Acid.
Average of twenty analyses, Paris green, . . . . .	.88	59.00	30.89	-	-	-	4.74	-	-	-	-	-	-	-	-	.20
Average of four analyses, "Lion brand, new-process Paris green,"	4.64	54.91	7.93	-	-	-	-	-	-	-	6.65	-	15.76	.55	-	1.00
Average of fourteen analyses of Paris green collected in the general markets in 1900-01.	.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, . . . . .	.63	-	-	1.58	78.86	-	-	-	-	-	-	-	-	-	3.80	-
Sulphathic,	1.40	-	2.61	-	-	-	-	-	48.28	-	4.73	-	18.60	-	-	1.63
Death to rose bugs,	2.95	-	1.65	-	-	-	-	-	34.53	-	4.35	-	17.76	-	-	.49
Professor De Graff's carpet bug destroyer, Oriental fertilizer and bug destroyer,	95.81	-	-	-	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
Non-poisonous potato bug destroyer, Tobacco liquor,	87.14	2.38	-	-	-	-	-	-	-	-	.64	3.00	-	3.50	1.38	1.50
Tobacco liquor,	37.71	-	-	-	-	-	-	2.12	-	-	-	-	68.29	-	.23	-
Tobacco liquor,	40.89	-	-	-	-	-	-	.63	-	-	-	-	3.07	6.55	-	-
Tobacco liquor,	-	-	-	-	-	-	-	4.68	-	-	-	-	1.47	16.34	.01	-
Nicotina,	10.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Peroxide of silicic,	1.65	.57	.35	-	-	-	-	-	-	-	-	-	-	-	-	38.12
											49.66		41.18			2.31

COMPILATION OF ANALYSES OF FODDER ARTICLES
AND DAIRY PRODUCTS, MADE AT AMHERST,
MASS., 1868-1905.¹

E. B. HOLLAND AND P. H. SMITH.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

I. — Green fodders.

- (a) Meadow grasses and millets.
- (b) Cereal fodders.
- (c) Legumes.
- (d) Mixed and miscellaneous.

II. — Silage.

III. — Hay and dry, coarse fodders.

- (a) Meadow grasses and millets.
- (b) Cereal fodders.
- (c) Legumes.
- (d) Straw.
- (e) Mixed and miscellaneous.

IV. — Vegetables, fruits, etc.

V. — Concentrated feeds.

- (a) Protein.
- (b) Starchy.
- (c) Poultry.

VI. — Dairy products.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES. (For
classification, see A and C.)

C. ANALYSES OF DAIRY PRODUCTS.

¹ Part III. of the report of Department of Foods and Feeding.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.
I. — GREEN FODDERS.											
(a) Meadow Grasses and Millets.											
Johnson grass (<i>Andropogon barkeri</i>),	1	75	1.4	1.2	8.9	13.2	0.3	—	—	—	—
Orelard grass (<i>Dactylis glomerata</i>),	7	70	2.1	2.9	10.4	13.7	0.9	—	—	—	—
Tall oat grass (<i>Arrhenatherum elatius</i>),	4	70	1.6	2.3	10.8	14.7	0.6	—	—	—	—
Common millet (<i>Chenopodium italicum</i>),	16	80	1.0	1.5	6.5	10.5	0.5	0.9	4.6	7.0	0.31
Canary bird seed millet (<i>C. Italica</i>),	1	80	1.6	1.0	7.1	10.0	0.3	—	—	—	—
Early harvest millet (<i>C. Italica</i>),	1	80	1.4	1.1	7.4	9.7	0.4	—	—	—	—
Golden millet (<i>C. Italica</i>),	1	80	1.2	0.8	7.0	10.7	0.3	—	—	—	—
Hungarian grass (<i>C. Italica</i>),	3	80	1.4	1.9	5.8	10.5	0.4	1.2	4.1	7.0	0.2
Japanese millet (<i>C. Italica</i>),	12	80	1.2	1.7	6.2	10.5	0.4	0.9	3.8	7.0	0.3
Millet (<i>Panicum miliaceum</i>),	1	80	1.1	1.1	5.3	11.7	0.8	—	—	—	—
Broom-corn millet (<i>P. miliaceum</i>),	1	80	1.2	1.3	6.4	10.7	0.4	—	—	—	—
Hog millet (<i>P. miliaceum</i>),	1	80	1.4	1.5	6.5	10.2	0.4	—	—	—	—
Japanese broom-corn millet (<i>P. miliaceum</i>),	2	80	1.2	0.9	6.2	11.4	0.3	—	—	—	—

1 Same coefficients used as for Hungarian grass.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — Continued.

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — Con.											
<i>(a) Meadow Grasses and Millets — Con.</i>											
Barnyard millet (<i>Panicum crus-galli</i>),	3	28	1.7	1.9	6.6	9.4	0.4	1.2	4.8	6.7	0.2
Pearl millet (<i>Pennisetum spicatum</i>),	1	28	1.4	1.4	6.9	10.1	0.2	—	—	—	—
Japanese millet (variety uncertain),	3	28	1.1	1.2	7.1	10.2	0.4	0.6	4.4	6.8	0.3
<i>(b) Cereal Fodders.</i>											
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	2.3	5.7	6.8	0.4
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	1.8	4.1	9.8	0.3
Corn fodder,	48	28	1.0	1.6	4.7	12.3	0.4	1.0	3.0	9.3	0.3
Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	0.7	2.8	8.8	0.4
Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	2.6	4.1	6.9	0.6
Oats in bloom,	1	75	1.7	1.6	1.9	12.0	0.7	1.1	5.0	7.4	0.5
Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	2.0	4.7	7.1	0.5
Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	—	—	—	—
Rye,	2	75	1.4	1.9	8.0	13.2	0.5	1.5	6.4	9.4	0.4
Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	2.1	6.6	8.4	0.4

(c) Legumes.

Alfalfa (<i>Medicago sativa</i>),	6	80	1.6	2.7	6.2	9.1	0.4	2.0	2.7	6.6	0.2
Horse bean (<i>Faba vulgaris</i>),	1	85	0.9	2.5	4.3	6.9	0.4	-	-	-	-
Soy bean (<i>Glycine hispida</i>),	14	80	2.1	3.5	5.4	8.1	0.9	2.7	2.4	6.2	0.5 ³
Soy bean (early white),	4	80	2.6	3.4	4.5	9.0	0.5	2.7	2.0	6.9	0.3
Soy bean (medium green),	16	80	2.2	4.1	5.3	7.8	0.6	3.2	2.4	6.0	0.3
Soy bean (medium green), in bud,	1	80	2.5	4.2	5.5	7.3	0.5	3.3	2.8	5.3	0.3
Soy bean (medium green), in blossom,	5	80	2.3	4.0	5.5	7.7	0.5	3.1	2.6	5.5	0.3
Soy bean (medium green), in pod,	9	78	2.3	4.5	5.9	8.6	0.7	3.5	2.7	6.6	0.4
Soy bean (medium black),	2	80	2.5	3.8	4.7	8.0	1.0	3.0	2.1	6.2	0.6
Soy bean (late),	4	80	2.6	4.6	4.2	8.0	0.6	3.6	1.9	6.2	0.3
Clover, alsike (<i>Trifolium hybridum</i>),	8	80	2.3	3.3	5.1	8.5	0.5	-	-	-	-
Clover, crimson (<i>T. incarnatum</i>),	2	80	2.8	3.1	6.0	7.6	0.5	2.4	3.4	5.6	0.3
Clover, mammoth red (<i>T. medium</i>),	4	80	1.9	3.0	5.8	8.9	0.4	-	-	-	-
Clover, medium red (<i>T. pratense</i>),	13	80	1.8	3.1	5.7	8.8	0.6	2.0	3.0	6.3	0.4
Clover, medium red, in bud,	2	80	2.1	3.6	4.7	9.0	0.6	2.4	2.5	6.6	0.4 ⁴
Clover, medium red, in blossom,	3	79	1.9	3.5	6.0	9.0	0.6	-	-	-	-
Clover, medium red, seeding,	2	75	2.3	3.8	7.2	11.0	0.7	2.4	3.7	7.2	0.4
Sweet clover (<i>Medicago alba</i>),	4	80	1.9	3.8	6.3	7.4	0.6	-	-	-	-
Cow pea (<i>Vigna catalpa</i>),	12	85	2.0	2.8	3.5	6.3	0.4	2.1	2.1	5.1	0.2 ⁵

¹ Same coefficients used as for corn fodder.

² Same coefficients applied to oats in several stages of growth.

³ Same coefficients applied to all soy beans except to medium green varieties in different stages of growth.

⁴ Coefficients taken from the German.

⁵ Same coefficients applied to all cow peas.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.
1.—GREEN FODDERS — <i>Con.</i>											
(c) Legumes — <i>Con.</i>											
Cow pea, black,	4	85	2.3	3.1	3.4	5.9	0.3	2.4	2.0	4.8	0.2
Cow pea, Whip-poor-will,	5	85	1.9	2.5	3.7	6.6	0.3	1.9	2.2	5.3	0.2
Canada beauty pea (<i>Pisum arvense</i>),	1	85	1.2	2.4	4.4	6.6	0.4	-	-	-	-
Canada field pea (<i>P. arvense</i>),	6	85	1.3	3.2	4.3	5.8	0.4	-	-	-	-
Canada field pea (<i>P. arvense</i>), in bud,	2	85	1.1	3.2	4.1	6.1	0.5	2.6	2.5	4.3	0.31
Canada field pea (<i>P. arvense</i>), in blossom,	3	87	1.2	2.8	3.8	4.8	0.4	2.3	1.7	3.6	0.2
Canada field pea (<i>P. arvense</i>), in pod,	2	84	1.2	2.3	4.8	6.3	0.4	1.9	2.2	4.8	0.2
English gray pea (<i>P. arvense</i>),	1	85	1.4	3.1	4.5	5.5	0.5	-	-	-	-
Prussian blue pea (<i>P. arvense</i>),	1	85	1.3	2.8	4.5	5.9	0.5	-	-	-	-
Flat pea (<i>Lathyrus silvestris vagneri</i>),	2	85	1.3	4.4	3.7	5.0	0.6	-	-	-	-
Sainfoin (<i>Onobrychis sativa</i>),	1	75	2.1	4.4	6.0	11.6	0.9	-	-	-	-
Serradella (<i>Ornithopus sativus</i>),	3	85	1.6	2.2	4.1	6.5	0.3	-	-	-	-
Sulla (<i>Hedysarum coronarium</i>),	2	75	2.3	4.3	5.2	12.5	0.7	-	-	-	-
Spring vetch (<i>Vicia sativa</i>),	4	85	1.4	2.7	4.5	6.1	0.4	1.9	2.0	4.6	0.2

Winter or sand vetch (<i>Vicia villosa</i>),	7	85	2.1	3.4	4.4	4.7	0.4	2.8	2.8	3.6	0.3
Winter or sand vetch (<i>V. villosa</i>), in bud,	2	86	2.4	3.3	3.5	4.4	0.4	-	-	-	-
Winter or sand vetch (<i>V. villosa</i>), in blossom,	4	82	2.5	4.2	5.5	5.4	0.4	3.5	3.5	4.2	0.3
Kidney vetch (<i>Anthyllis vulneraria</i>),	1	85	2.0	2.8	2.3	7.4	0.5	-	-	-	-
<i>(d) Mixed and Miscellaneous.</i>											
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	2.1	3.5	5.6	0.4
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	2.1	3.4	6.1	0.3 ²
Corn and soy bean,	3	80	1.5	2.6	5.0	10.4	0.5	-	-	-	-
Corn and cow peas,	1	80	1.8	2.1	5.3	10.4	0.4	-	-	-	-
Sweet corn and cow peas,	1	80	1.5	1.8	4.8	11.4	0.5	-	-	-	-
Millet and peas,	1	80	1.8	2.4	7.5	8.0	0.3	-	-	-	-
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	-	-	-	-
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	-	-	-	-
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	2.1	3.8	6.3	0.4
Sorghum and cow peas,	1	80	1.6	1.6	6.5	9.9	0.4	-	-	-	-
Vetch and oats (1-1),	3	80	1.8	3.0	6.3	8.4	0.5	2.3	4.3	5.7	0.2
Vetch and oats (1-1),	1	80	1.8	2.7	6.0	8.8	0.7	-	-	-	-
Wheat and vetch,	4	80	1.6	3.4	6.4	8.1	0.5	2.6	4.4	5.9	0.3
Apple pomace,	6	83	0.6	1.0	2.9	11.6	0.9	-	1.9	9.9	0.4
Sugar-beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	0.9	2.1	5.0	-
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	-	-	-	-

¹ Same coefficients applied to Canada field peas in blossom and in pod.

² Same coefficients used as for barley and peas.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — <i>Con.</i>											
(d) <i>Mixed and Miscellaneous</i> — <i>Con.</i>											
Carrot tops,	1	48	2.8	1.2	2.7	9.9	0.4	-	-	-	-
Prickly comfrey (<i>Synphyltum asperinum</i>),	1	57	2.8	2.3	1.5	6.1	0.3	-	-	-	-
Purslane (<i>Portulaca oleracea</i>),	1	91	1.5	2.3	1.6	3.4	0.2	-	-	-	-
Dwarf Essex rape (<i>Brassica napus</i>),	1	58	2.4	1.9	2.9	7.2	0.6	1.7	2.5	6.6	0.31
Summer rape (<i>B. napus</i>),	1	58	2.8	2.1	2.7	6.9	0.5	1.9	2.3	6.3	0.2
Winter rape (<i>B. napus</i>),	1	55	3.3	2.3	1.8	7.1	0.5	2.0	1.6	6.5	0.2
Sorghum (<i>Andropogon sorghum</i>),	7	78	1.3	1.7	5.5	11.1	0.4	-	-	-	-
Spurry (<i>Spergula arvensis</i>),	1	72	2.6	2.9	7.0	15.4	0.1	-	-	-	-
Teosinte (<i>Euchlaena Mexicana</i>),	2	70	2.3	2.3	9.4	15.6	0.4	-	-	-	-
II. — SLAGS.											
Apple pomace,	1	55	0.6	1.2	3.3	8.8	1.1	-	2.2	7.5	0.52
Corn,	47	80	1.1	1.7	5.4	11.1	0.7	0.8	3.5	7.7	0.5
Corn and soy bean,	6	76	2.3	2.7	7.3	10.9	0.8	1.7	4.5	8.5	0.7
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	-	-	-	-
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	1.6	5.0	4.2	0.7

III. — HAY AND DRY COARSE FODDERS.

(a) *Meadow Grasses and Millets.*

Canada blue-grass (<i>Poa compressa</i>),	1	14	4.8	5.9	31.3	42.1	0.9	2.5	22.2	26.5	0.3
Kentucky blue-grass (<i>Poa pratensis</i>),	3	14	6.4	7.7	30.5	39.7	1.7	4.4	19.2	21.0	0.7
Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	-	-	-	-
English hay (mixed grasses),	102	14	5.3	7.9	27.7	42.8	2.3	3.7	18.0	25.3	1.0
Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	-	-	-	-
Meadow fescue (<i>Festuca elatior pratensis</i>),	7	14	7.1	5.8	32.2	39.3	1.6	3.0	21.6	23.2	0.9
{ Barnyard grass (<i>Panicum crus-galli</i>),	1	14	8.6	13.1	29.0	33.6	1.7	-	-	-	-
{ Barnyard millet (<i>P. crus-galli</i>),	8	14	7.3	8.2	28.4	40.4	1.7	5.2	17.6	21.0	0.8
{ Hungarian grass (<i>Chaetochloa Italica</i>),	3	14	6.3	8.4	24.6	45.0	1.7	5.0	16.7	30.2	1.1
Orchard grass (<i>Dactylis glomerata</i>),	7	14	5.9	8.3	29.9	53.3	2.6	5.0	18.2	21.6	1.4
Tall oat grass (<i>Arrhenatherum elatius</i>),	4	14	4.6	6.4	30.9	42.1	1.9	3.3	17.0	24.4	1.1
Red-top (<i>Agrostis alba vulgaris</i>),	6	14	4.6	6.5	28.5	44.9	1.5	4.0	17.4	27.8	0.8
Red-top (<i>A. alba vulgaris</i>), early cut,	1	14	4.3	5.8	30.9	43.3	1.7	-	-	-	-
Red-top (<i>A. alba vulgaris</i>), late cut,	1	14	4.1	6.0	31.0	43.2	1.7	-	-	-	-
Rowen,	29	14	6.4	11.4	23.9	41.3	3.0	7.9	15.8	26.4	1.4
Italian rye grass (<i>Lolium italicum</i>),	4	14	6.4	7.1	28.6	42.2	1.6	-	-	-	-
Perennial rye grass (<i>Lolium perenne</i>),	4	14	7.9	10.1	25.4	40.5	2.1	-	-	-	-

1 Same coefficients applied to all varieties of rape.

2 Same coefficients used as for fresh apple pomace.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — Continued.

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	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.											
Black grass (<i>Juncus Gerardi</i>),	3	16	7.4	7.0	24.3	43.1	2.2	4.1	14.3	22.4	1.0
Branch grass (<i>Distichlis spicata</i>),	2	16	7.6	6.8	22.4	45.1	2.1	3.8	12.1	22.1	0.7
Flat sage (<i>Spartina stricta maritima</i> var.),	1	16	8.2	6.6	25.0	41.8	2.4	3.4	15.0	23.0	0.9
Fox grass (<i>Spartina patens</i>),	2	16	5.8	6.7	22.5	46.9	2.1	4.0	11.9	24.9	0.8
High-grown salt hay (largely <i>Spartina patens</i>),	1	16	7.0	6.3	22.2	46.4	2.1	3.8	11.8	24.6	0.8
Cove mixture (black grass and red-top),	1	16	6.0	7.4	23.2	45.6	1.8	3.6	13.9	24.2	0.7
Mixed salt hay (largely fox grass and branch grass),	1	16	8.4	5.5	22.5	45.5	2.1	2.3	13.1	23.7	0.6
Salt hay (variety uncertain),	2	16	4.3	3.4	21.0	49.8	2.5	-	-	-	-
Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	2.4	8.8	20.5	0.8
Timothy (<i>Phleum pratense</i>),	8	14	4.2	8.4	28.1	43.4	1.9	4.0	14.1	26.9	1.0
Timothy (<i>P. pratense</i>), early cut,	1	14	4.0	5.7	31.0	43.5	1.8	3.2	17.7	27.4	0.9
Timothy (<i>P. pratense</i>), late cut,	1	14	3.9	5.2	29.7	45.2	2.0	2.2	13.7	26.7	1.0
White-top (<i>Agrostis vulgaris</i> var.),	1	14	6.0	11.2	24.4	41.5	2.9	-	-	-	-

Salt hays.

(b) *Cereal Feeders.*

Corn stover, from field,	44	40	3.9	4.6	20.6	30.1	0.8	1.7	13.2	17.8	0.5	
Corn stover, very dry,	44	20	5.2	6.1	27.4	40.2	1.1	2.2	17.5	23.7	0.7	
Oats,	6	15	6.9	11.7	25.5	38.3	2.6	6.2	13.0	21.1	1.6	
(c) <i>Legumes.</i>												
Alsike clover,	8	15	9.7	14.0	23.1	36.1	2.1	9.2	11.6	23.8	8.0	
Manmoth red clover,	4	15	8.2	13.1	24.4	37.6	1.7	-	-	-	-	
Medium red clover,	13	15	7.6	13.2	24.2	37.4	2.6	7.7	13.1	23.9	1.4	
(d) <i>Straw.</i>												
Barley,	2	15	4.8	6.5	32.2	30.0	2.5	1.3	18.0	21.1	1.1	
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	-	-	-	-	
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	2.4	13.7	24.0	1.1	
Millet (<i>Chenopodium Italica</i>),	1	15	5.3	3.6	35.2	30.5	1.4	-	-	-	-	
Millet (<i>Panicum crus-galli</i>),	1	15	4.6	5.2	30.4	42.7	2.1	-	-	-	-	
Millet (<i>P. miliaceum</i>),	1	15	5.2	3.3	35.9	38.1	2.5	-	-	-	-	
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	-	-	-	-	
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	0.7	15.9	16.3	0.4	
(e) <i>Mixed and Miscellaneous.</i>												
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	-	-	-	-	
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	-	-	-	-	
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	-	-	-	-	

1 Coefficients taken from the German.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—HAY AND DRY COARSE FODDERS— <i>Con.</i>											
<i>(c) Mixed and Miscellaneous—Con.</i>											
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	8.9	14.8	23.9	1.5
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	8.3	13.1	21.1	1.4
Wheat and vetch,	4	15	6.8	14.5	27.2	34.4	2.1	10.7	17.7	23.4	1.3
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	-	-	-	-
IV.—VEGETABLES, FRUITS, ETC.											
Apples,	2	77	0.7	1.0	1.5	18.3	0.5	-	-	-	-
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	-	-	-	-
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	-	-	-	-
Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	1.5	0.9	10.5	0.1
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	1.0	-	4.2	-
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	-	-	-	-
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	-	-	-	-
Granberries,	1	89	0.2	0.5	1.2	8.5	0.6	-	-	-	-
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	1.0	0.3	7.7	-

Paranips,	1	80	1.5	1.3	1.5	15.0	0.7	-	-	-	-
Potatoes,	22	80	0.9	2.1	0.5	16.4	0.1	1.0	-	14.8	-
Potatoes,	93	80	-	-	-	14.3 ¹	-	-	-	-	-
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	1.0	1.0	6.8	0.2
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	-	-	-	-
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	1.4	1.2	6.3	0.2
V.—CONCENTRATED FEEDS.											
(a) Protein.											
Horse beans,	1	14	3.8	25.8	7.0	48.6	0.8	-	-	-	-
Red adzuki beans,	2	14	3.6	21.0	4.0	56.7	0.7	-	-	-	-
Saddle beans,	1	14	5.3	13.0	4.1	49.4	14.2	-	-	-	-
Soy bean,	5	14	5.0	31.2	4.7	28.4	16.7	-	-	-	-
Soy bean (medium green),	2	14	4.6	35.6	3.9	24.6	17.3	32.4	-	19.9	16.1
Blood meal, Armour's edible,	3	11	3.1	84.3	-	1.2	0.4	70.8	-	-	-
Brewers' dried grains,	9	10	3.4	23.5	12.0	45.6	5.5	19.0	5.9	26.0	4.9
Brewers' wet grains,	1	77	0.7	6.7	3.8	9.8	2.0	5.3	2.0	5.7	1.8
Buckwheat feed,	2	10	3.2	15.9	22.0	44.8	4.1	-	-	-	-
Buckwheat middlings,	3	10	4.7	26.7	6.8	44.6	7.2	22.7	1.1	37.0	6.4
Coconut meal,	3	9	4.7	20.4	11.0	40.6	4.3	-	-	-	-
Cotton-seed meal,	319	7	6.6	45.3	6.3	24.6	10.2	38.1	2.2	19.2	9.6
Cotton-seed meal (low grade),	32	8	4.6	24.9	18.0	37.0	7.5	18.2	6.8	25.2	6.8

1 Starch.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—CONCENTRATED FEEDS— <i>Con.</i>											
<i>(a) Protein—Con.</i>											
Dairy feed, H ₂ O,	11	8.0	3.3	18.1	12.9	53.5	4.2	13.8	4.5	38.5	3.5
Distillers' dried grains, largely from corn,	56	8.0	1.7	31.7	12.3	34.2	12.1	23.1	11.7	27.7	11.5
Gluten feed,	192	8.5	1.7	26.2	7.2	53.3	3.1	22.3	5.5	47.4	2.6
Gluten flour, wheat,	1	5.5	0.4	84.8	0.2	8.1	1.0	—	—	—	—
Gluten meal, wheat,	2	8.0	0.9	39.8	0.8	48.9	1.6	—	—	—	—
Gluten meal,	138	9.5	1.0	36.0	2.1	49.1	2.3	31.7	—	43.2	2.1
King gluten meal (old process),	6	7.0	1.2	33.3	1.8	43.6	13.1	—	—	—	—
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	15.7	—	37.2	10.1
Flaxseed meal,	2	7.0	3.5	23.5	5.5	23.3	37.2	—	—	—	—
Linseed meal (new process),	52	9.0	5.5	37.5	8.9	36.4	2.7	31.5	6.6	29.1	2.4
Linseed meal (old process),	113	8.5	5.2	34.3	8.6	36.5	6.9	30.5	4.9	28.5	6.1
Malt sprouts,	17	11.0	5.6	26.4	12.6	43.0	1.4	20.1	12.5	36.6	1.2
Bibby's dairy cake,	4	10.0	7.7	19.7	8.6	44.9	9.1	13.0	4.0	36.4	8.4
Blomo feed,	4	20.0	7.6	13.0	11.6	44.2	0.6	8.2	8.9	33.6	0.1

Holstein sugar feed,	1	8.0	6.7	12.6	10.0	60.0	2.7	8.3	4.4	48.6	2.4
Macon sugar feed,	2	6.0	6.6	14.0	10.2	61.6	1.6	8.3	4.5	50.5	1.3
Sucrene dairy feed,	8	10.0	6.3	16.6	11.7	52.1	3.3	10.1	8.4	38.0	3.1
Sucrene oil meal,	3	9.0	5.7	23.2	10.7	48.6	2.8	-	-	-	-
Oat middlings, fine,	4	9.0	2.3	15.8	2.4	64.3	6.2	12.8	1.2	61.7	5.8
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	15.7	4.6	46.4	0.9
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	44.6	0.8	22.7	9.6
Proteins,	4	8.0	2.5	21.8	10.0	51.1	6.6	-	-	-	-
Rye feed,	15	11.0	3.2	14.7	3.8	64.6	2.7	11.8	-	56.8	2.4
Wheat middlings (hour),	106	10.0	3.2	19.2	3.2	59.6	4.8	16.9	1.2	52.4	4.1
Wheat middlings (standard),	308	10.0	4.3	17.9	7.0	55.8	5.0	13.8	2.1	43.5	4.4
Wheat mixed feed, bran and middlings,	732	10.0	5.3	17.0	8.2	55.0	4.5	13.2	5.1	42.4	3.9
Wheat mixed feed, adulterated,	7	10.0	4.3	12.3	15.5	54.6	3.3	7.7	4.3	38.8	3.0
Wheat bran,	379	10.0	6.2	16.3	10.0	53.1	4.4	12.6	3.9	37.7	2.8
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	12.2	4.6	38.9	3.2
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	11.8	2.3	37.1	1.9
(b) Starchy.											
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	-	-	-	-
Barley,	6	12.0	2.4	11.2	5.7	66.8	1.9	7.8	2.9	61.5	1.7
Broom-corn seed,	2	14.0	2.1	9.6	7.0	63.8	3.5	-	-	-	-
Buckwheat,	1	12.0	1.9	9.9	10.3	63.5	2.4	-	-	-	-

1 Digestion coefficients taken from the German.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.	Protein.	Fibre.	Nitrogen-free Extract.	Pat.
V.—CONCENTRATED FEEDS— <i>Con.</i>											
<i>(b) Starchy—Con.</i>											
Cassava starch refuse,	1	12	1.6	0.8	6.1	78.8	0.7	—	—	—	—
Cerealine,	4	11	2.6	11.1	4.9	62.7	7.7	8.9	4.0	50.6	6.2
Cocoa dust,	1	7	6.3	14.4	5.5	42.7	24.1	—	—	—	—
Cocoa shells,	1	5	8.4	18.0	15.9	50.9	1.8	—	—	—	—
Cocconut meat,	1	1	0.8	9.9	7.5	15.3	65.5	—	—	—	—
Corn bran,	2	11	2.0	10.8	12.4	53.8	4.0	5.8	7.3	46.0	3.1
Corn cobs,	6	8	1.3	2.7	31.3	56.2	0.5	0.5	17.8	27.0	—
Corn and cob meal,	38	11	1.4	8.9	6.7	68.4	3.6	5.0	3.1	60.2	3.0
Corn kernels,	93	11	1.3	10.2	2.0	71.6	3.9	—	—	—	—
Corn meal,	46	14	1.3	9.8	1.9	63.2	3.8	6.3	—	63.7	3.5
Sweet corn kernels,	3	11	1.9	12.5	2.4	64.9	7.3	—	—	—	—
Corn and oat feed,	48	10	3.0	9.1	9.9	64.8	3.2	—	—	—	—
Corn and oat feed (Victor),	39	10	3.5	8.6	11.3	62.9	3.7	6.1	5.4	52.2	3.2
Corn, oat and barley feed,	8	10	3.1	11.4	8.3	62.4	4.8	—	—	—	—

Corn, oat and barley feed (Schumacher's),	14	8	4.0	11.3	11.8	60.3	4.6	-	-	-	-	-
Corn screenings,	1	11	2.1	7.4	2.9	72.6	4.0	-	-	-	-	-
Cotton hulls,	5	11	2.6	5.3	39.7	39.0	2.4	-	15.9	16.0	2.1	-
Cotton-hull bran,	1	11	1.9	2.3	35.0	48.7	1.1	-	-	-	-	-
Cotton-seed feed,	4	11	3.1	10.5	36.0	35.9	3.5	5.4	16.6	19.8	3.0	-
Dairy feed (Quaker),	33	8	4.6	13.2	16.8	54.3	3.1	9.2	9.2	32.0	2.3	-
Flaxseed screenings,	1	7	5.4	15.7	16.5	44.5	10.9	-	-	-	-	-
Hominy meal,	120	11	2.5	10.4	4.2	64.1	7.8	6.8	2.8	57.0	7.2	-
Horse feed (H-O),	13	9	3.1	12.6	9.8	62.0	3.5	8.8	5.5	51.5	2.8	-
Maizeine,	1	5	2.7	10.0	7.9	66.0	8.4	-	-	-	-	-
Mellen's food refuse,	1	7	3.9	11.4	7.1	67.2	3.4	-	-	-	-	-
Millet seed,	4	12	2.6	11.1	7.7	62.9	3.7	-	-	-	-	-
Barnyard millet seed,	1	11	3.3	12.2	7.6	60.3	5.6	-	-	-	-	-
Molasses, Porto Rico,	2	24	6.8	3.1	-	66.1	-	-	-	-	-	-
Dried molasses beet pulp,	3	8	5.4	9.5	15.4	61.3	0.4	6.1	12.9	55.8	-	-
Oat kernels,	9	11	3.0	12.4	8.5	60.4	4.7	10.7	2.6	47.7	3.81	-
Oats, ground,	9	12	3.0	12.3	8.4	59.7	4.6	10.1	1.2	51.3	3.71	-
Oat feed,	110	7	5.3	8.0	21.5	55.3	2.9	5.5	7.1	28.2	1.5	-
Oat feed (low grade),	17	7	5.5	5.1	26.4	54.4	1.6	3.2	8.4	18.0	1.5	-
Oat feed, Canada,	2	7	5.4	13.2	24.8	44.7	4.9	9.1	8.2	22.8	4.3	-
Parson's "six-dollar" feed,	1	11	7.9	10.0	17.9	51.1	2.1	5.9	8.4	32.7	1.7	-

1 Coefficients obtained from digestion experiments with horses.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Concluded.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—CONCENTRATED FEEDS— <i>Con.</i>											
(b) <i>Starchy—Con.</i>											
Pea bran,	2	11	2.7	10.0	39.7	35.6	1.0	-	-	-	-
Peanut feed, largely husks,	2	10	2.6	8.9	56.4	16.6	5.5	6.3	6.2	8.1	5.0
Peanut husks,	1	13	1.2	5.0	63.0	13.1	1.7	-	-	-	-
Peanut shells,	2	7	2.8	7.1	62.2	19.0	1.9	-	-	-	-
Rice, cleaned,	1	11	0.3	8.5	0.1	79.8	0.3	-	-	-	-
Rice bran,	2	11	12.7	6.8	20.6	42.8	6.1	4.3	6.0	33.4	5.4
Rice meal,	2	11	8.2	11.8	5.3	50.8	12.9	7.3	-	46.7	11.7
Rye middlings,	1	11	3.6	11.7	3.3	65.4	5.0	-	-	-	-
Speltz,	1	8	3.9	11.5	11.1	62.9	2.2	-	-	-	-
Starch refuse,	2	12	1.8	4.8	3.8	76.3	1.3	-	-	-	-
Wheat kernels,	11	11	1.8	12.4	2.7	70.2	1.9	-	-	-	-
Wheat flour,	2	12	0.4	9.9	0.1	76.8	0.8	-	-	-	-

(c) *Poultry.*

American poultry food,	.	.	.	.	.	.	.	.	.	13.1	6.5	63.6	5.9	-	-	-
Cut bone,	.	.	.	.	.	.	.	.	.	20.7	-	0.2	31.6	-	-	-
Raw ground bone,	.	.	.	.	.	.	.	.	.	23.9	-	3.4	0.3	-	-	-
Cut clover,	.	.	.	.	.	.	.	.	.	17.9	20.5	41.8	3.0	-	-	-
H-O poultry food,	.	.	.	.	.	.	.	.	.	17.4	4.4	60.2	5.3	-	-	-
Meat and bone meal,	.	.	.	.	.	.	.	.	.	39.5	-	6.3	10.8	-	-	-
Meat scrap,	.	.	.	.	.	.	.	.	.	50.8	-	4.5	18.1	-	-	-
Mutton scrap,	.	.	.	.	.	.	.	.	.	39.9	-	5.3	14.7	-	-	-
Granulated milk,	.	.	.	.	.	.	.	.	.	35.9	-	18.1	9.6	-	-	-

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES.¹

[Figures equal percentages or pounds in 100.]

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I.—GREEN FODDERS.					
<i>(a) Meadow Grasses and Millets.</i>					
Orchard grass,	4	70	0.43	0.56	0.13
Millet,	1	80	0.29	0.43	0.11
Barnyard millet,	3	80	0.30	0.67	0.10
Hungarian grass,	1	80	0.30	0.42	0.12
Japanese millet,	3	80	0.33	0.22	0.10
<i>(b) Cereal Fodders.</i>					
Corn fodder,	22	80	0.39	0.30	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
<i>(c) Legumes.</i>					
Alfalfa,	4	80	0.44	0.31	0.11
Horse bean,	1	85	0.41	0.21	0.05
Soy bean (early white),	1	80	0.57	0.55	0.13
Soy bean (medium green), average,	14	80	0.64	0.53	0.14
Soy bean (medium green), in bud,	1	80	0.66	0.58	0.15
Soy bean (medium green), in blossom,	5	80	0.64	0.60	0.13
Soy bean (medium green), in pod,	7	78	0.72	0.52	0.17
Soy bean (medium black),	1	80	0.70	0.50	0.16
Soy bean (late),	1	80	0.60	0.68	0.14
Alsike clover,	6	80	0.53	0.50	0.15
Mammoth red clover,	3	80	0.50	0.27 ²	0.12
Medium red clover, average,	10	80	0.52	0.57	0.11
Medium red clover, in bud,	2	80	0.58	0.71	0.13
Medium red clover, in blossom,	3	79	0.51	0.58	0.12
Medium red clover, seeding,	2	75	0.61	0.65	0.13
Sweet clover,	1	80	0.43	0.40	0.12
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09

¹ Many 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.)

² Evidently below normal.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES—*Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I.—GREEN FODDERS— <i>Con.</i>					
(c) <i>Legumes—Con.</i>					
Canada field peas, average,	6	85	0.50	0.38	0.12
Canada field peas, in bud,	2	85	0.50	0.44	0.11
Canada field peas, in blossom,	2	87	0.45	0.32	0.11
Canada field peas, in pod,	2	84	0.52	0.37	0.13
Cow pea, average,	9	85	0.45	0.47	0.12
Black cow peas,	4	85	0.40	0.47	0.12
Whip-poor-will cow peas,	5	85	0.49	0.47	0.12
Flat pea,	1	85	0.75	0.32	0.10
Small pea,	1	85	0.40	0.31	0.09
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	85	0.36	0.37	0.12
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	85	0.36	0.45	0.10
Hairy or sand vetch, average,	5	85	0.55	0.51	0.13
Hairy or sand vetch, in bud,	2	86	0.52	0.54	0.12
Hairy or sand vetch, in blossom,	3	82	0.65	0.57	0.16
Kidney vetch,	1	85	0.44	0.28	0.08
Average for legumes,	-	-	0.53	0.44	0.12
(d) <i>Mixed and Miscellaneous.</i>					
Vetch and oats,	4	80	0.30 ¹	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Carrot tops,	1	80	0.69	1.08	0.13
Prickly comfrey,	1	87	0.37	0.76	0.12
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
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	8	80	0.26	0.29	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 ²
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11

¹ Too low; 0.43 nearer correct.² Evidently too high.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES—*Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III.—HAY AND DRY COARSE FODDERS.					
<i>(a) Meadow Grasses and Millets.</i>					
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),	13	14	1.34	1.61	0.32
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
<i>(b) Cereal Fodders.</i>					
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	1.90	0.65
<i>(c) Legumes.</i>					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16 ²	0.52
Medium red clover,	10	15	2.21	2.42	0.47
<i>(d) Straw.</i>					
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
<i>(e) Mixed and Miscellaneous.</i>					
Vetch and oats,	4	15	1.29 ³	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

¹ Too high; 1.90 nearer correct.³ Too low; 1.80 nearer correct.² Evidently below normal.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES—*Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
IV.—VEGETABLES, FRUITS, ETC.— <i>Con.</i>					
Beets, red,	8	88.0	0.24	0.44	0.09
Sugar beets,	4	86.0	0.24	0.52	0.11
Yellow fodder beets,	1	89.0	0.23	0.56	0.11
Mangolds,	3	88.0	0.15	0.34	0.14
Carrots,	3	89.0	0.16	0.46	0.09
Cranberries,	1	89.0	0.08	0.10	0.03
Parsnips,	1	80.0	0.22	0.62	0.19
Potatoes,	5	80.0	0.29	0.51	0.08
Japanese radish,	1	93.0	0.08	0.40	0.05
Turnips,	4	90.0	0.17	0.38	0.12
Ruta-bagas,	3	89.0	0.19	0.49	0.12
V.—CONCENTRATED FEEDS.					
(a) <i>Protein.</i>					
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,	3	14.0	5.61	2.12	1.82
Blood meal (Armour's),	1	11.0	13.55	0.18	0.26
Brewer's dried grains,	2	8.0	3.68	0.86	1.06
Cotton-seed meal,	130	7.0	7.16	2.01	2.86
Distillers' dried grains,	20	8.0	4.50	0.31	0.61
Gluten feed,	72	8.5	4.17	0.37	0.72
Gluten meal,	46	9.5	5.87	0.21	0.55
Linseed meal (new process),	21	9.0	5.97	1.42	1.79
Linseed meal (old process),	43	8.5	5.32	1.29	1.64
Malt sprouts,	12	11.0	4.32	2.00	1.56
Bibby's dairy cake,	1	10.0	2.94	1.67	2.07
Sucrene feed,	1	10.0	2.62	2.08	0.55
Pea meal,	1	10.0	3.04	0.98	1.81
Peanut meal,	1	8.0	7.84	1.54	1.27
Proteina,	1	8.0	3.04	0.58	1.02
Rye feed,	11	11.0	2.36	1.08	1.60
Wheat middlings (flour),	32	10.0	3.16	1.05	1.66
Wheat middlings (standard),	77	10.0	2.92	1.28	2.04
Wheat mixed feed,	223	10.0	2.76	1.43	2.57
Wheat bran,	98	10.0	2.63	1.40	2.82

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES—*Concluded.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V.—CONCENTRATED FEEDS— <i>Con.</i>					
<i>(b) Starchy.</i>					
Ground barley,	1	13.0	1.56	0.34	0.66
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
Corn and cob meal,	29	11.0	1.38	0.46	0.56
Corn kernels,	13	11.0	1.82	0.40	0.70
Corn meal,	3	14.0	1.92	0.34	0.71
Corn and oat feed (Victor),	2	10.0	1.38	0.61	0.59
Corn, oat and barley feed (Schumachers),	1	8.0	1.80	0.63	0.83
Cotton hulls,	3	11.0	0.75	1.08	0.18
Hominy meal,	49	11.0	1.66	0.78	1.25
Common millet seed,	2	12.0	2.00	0.45	0.95
Japanese millet seed,	1	12.0	1.58	0.35	0.63
Molasses (Porto Rico),	1	24.0	0.51	3.68	0.12
Dried molasses beet pulp,	1	8.0	1.60	1.47	0.16
Oat kernels,	1	11.0	2.05	-	-
Oat feed,	14	7.0	1.26	0.75	0.48
Oat feed (low grade),	15	7.0	0.88	0.70	0.35
Peanut feed,	2	10.0	1.46	0.79	0.23
Peanut husks,	1	13.0	0.80	0.48	0.13
Louisiana rice bran,	1	11.0	1.42	0.83	1.70
Rye middlings,	1	11.0	1.87	0.82	1.28
Damaged wheat,	1	13.0	2.26	0.51	0.83
Wheat flour,	2	12.0	2.02	0.36	0.35
<i>(c) Poultry.</i>					
American poultry food,	1	8.0	2.22	0.52	0.98
Meat and bone meal,	10	6.0	5.92	-	14.68
Meat scraps,	4	9.0	7.63	-	8.11
VI.—DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19 ¹	0.16 ¹
Human milk,	3	88.1	0.24	-	-
Skim milk,	22	90.3	0.59	0.18 ²	0.20 ²
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	-	-

¹ From Farrington and Woll.² From Woll's Handbook.

C. ANALYSES OF DAIRY PRODUCTS.

[Per Cent.]

NAME.	Number of Analyses.	Sours.			Fat.			Proteids (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	4,103 ¹	19.55	10.02	13.03	10.70	1.50	4.43	3.56 ²	-	0.73 ³
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 ⁴	-	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),	149	94.84	82.55	87.28	89.33	75.94	83.04	1.10 ⁵	3.14	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	-	-
Milk powder (Creamora), one-third skimmed,	1	-	-	93.49	-	-	24.96	23.78	-	6.93
Milk powder (Mileora), skim milk,	1	-	-	90.17	-	-	0.38	30.89	-	8.88

¹ Largely station herd, Jersey blood predominating.² Average of 331 samples.³ Average of 250 samples.⁴ Nitrogen.⁵ Curd and natural ash.

COEFFICIENTS OF DIGESTIBILITY OF AMERICAN
FEED STUFFS.—EXPERIMENTS MADE IN THE
UNITED STATES.¹

J. B. LINDSEY AND P. H. SMITH.

Experiments with Ruminants.
Experiments with Swine.
Experiments with Horses.
Experiments with Poultry.
Experiments with Calves.

Complete through Dec. 31, 1905.

¹ Being a portion of the report of the Division of Foods and Feeding.

EXPERIMENTS WITH RUMINANTS.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. — GREEN FODDERS.									
(a) <i>Meadow Grasses and Millets.</i>									
Grass, meadow, young,	1	1	69	-	-	45	74	72	55
Grass, meadow, young, 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
Barley and millet in blossom (Massachusetts),	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	61-68 67	60-72 68
Hungarian grass, early to late bloom,	3	8	61-71 66	61-74 68	-	53-72 63	65-76 70	64-71 67	48-85 62
(b) <i>Cereal Fodders.</i>									
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
Corn fodder, dent, immature,	5	14	61-74 68	-	42-43 42	56-80 66	56-76 65	64-79 71	37-83 68

EXPERIMENTS WITH RUMINANTS—Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).	
I.—GREEN FODDERS—Cont.										
(b) <i>Cereal Fodders</i> —Con.										
Corn fodder, dent, milk,	3	9	70	-	-	61	64	76	78	
Corn fodder, dent, mature,	9	17	68	72	31	53	57	73	74	
Corn fodder, dent, mature, R. & W., coarse,	1	2	51-54 52	-	-	20-28 24	46-47 46	57-61 59	74-82 78	
Corn fodder, Eureka silage, ears just forming,	1	3	64-69 67	-	42-43 42	67-68 67	56-61 60	70-74 72	65-67 66	
Corn fodder, Sanford, mature,	2	4	63-73 63	67-75 71	14-50 31	46-57 52	67-80 75	67-75 71	53-74 66	
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	
Oat fodder, bloom to early seeding,	3	5	-	56-65 62	49-68 60	68-76 73	43-63 55	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	
Sorghum fodder, blossom,	1	2	73-73 73	-	-	51-56 53	74-75 75	78-78 78	81-82 81	

Sorghum fodder, Early Amber, past blossom,	1	{	61-62 61	-	-	38-42 40	42-45 42	70-71 71	7	
Sorghum fodder, average both samples,	2	{	67	-	-	46	50	74	74	
<i>(c) Legumes.</i>										
Alfalfa fodder,	1	{	61-61 61	-	40-40 40	73-75 74	42-43 43	71-72 72	38-39 39	
Soy beans, variety uncertain, before bloom,	1	{	-	61-67 66	-	77-80 79	45-55 50	71-73 72	50-58 54	
Soy beans, variety uncertain, seedling,	1	{	-	61-63 62	-	68-71 69	38-43 41	72-75 73	49-59 54	
Soy beans, medium green, full blossom,	1	{	-	62-63 63	22-28 25	76-78 77	45-49 47	69-73 71	46-54 50	
Soy beans, medium green, seedling,	4	{	62-69 65	65-69 67	16-45 28	74-84 78	31-53 45	71-81 77	31-69 55	
Clover, crimson, late blossom,	1	{	-	68-70 69	-	77-77 77	54-58 56	74-75 74	63-69 65	
Clover, red, late blossom,	1	{	65-67 66	-	-	66-68 67	52-53 53	76-79 78	63-66 65	
Clover, rozen, late blossom,	1	{	-	60-62 61	-	61-62 62	51-54 52	64-68 65	60-61 61	
Clover, average two samples,	2	{	65-67 66	60-62 61	-	61-68 65	51-54 53	64-79 72	60-66 63	
Cowpeas, ready for sowing,	2	{	66-77 68	72-76 74	19-28 23	73-77 76	57-62 60	76-84 81	56-62 59	
Canada field peas, before bloom,	1	{	68	71-72 71	-	81-83 82	62-62 62	71-71 71	50-55 52	
Canada field peas, bloom to seedling,	2	{	60-67 64	-	26-45 37	79-83 81	40-52 45	72-80 76	45-64 55	

EXPERIMENTS WITH RUMINANTS — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. — GREEN FODDERS — Con.									
(c) <i>Legumes</i> — Con.									
Spring vetch (<i>Vicia sativa</i>),	1	{ 2 }	62-62 62	-	17	71-72 71	42-46 44	75-77 76	57-60 59
Winter or hairy vetch (<i>Vicia villosa</i>), bloom,	4	{ 14 }	66-78 71	-	29-45 42	79-88 83	52-73 63	68-84 77	63-82 71
(d) <i>Mixed and Miscellaneous</i> .									
Apple pomace,	2	{ 6 }	66-80 72	-	24-63 49	-	36-85 65	80-90 85	39-52 46
Barley and peas, bloom,	3	{ 4 }	-	55-71 65	52-55 54	73-81 75	38-61 52	56-76 68	54-65 59
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	51-70 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
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
Winter wheat and hairy vetch,	2	{ 5 }	68-71 69	-	40-46 44	63-78 75	66-71 68	71-76 73	54-61 57

II. — SILAGE.

Soy bean silage, goats,	1	{	52—56 59	-	-	71—80 76	47—52 55	46—58 52	66—77 72
Soy bean silage, steers,	1	{	50—50 50	-	-	54—56 55	42—44 43	61—61 61	47—62 49
Soy bean silage, mammoth yellow, bloom,	1	{	52—65 58	63—73 67	-	57—69 61	51—67 59	74—80 76	48—60 52
Soy bean silage, average,	3	{	56	67	-	66	53	65	57
Soy bean and barnyard millet silage,	1	{	54—65 59	-	-	55—62 57	61—73 69	54—63 59	69—75 72
Soy bean and corn silage (9 beans, 14 corn),	4	{	62—73 69	71—75 72	39—48 42	54—68 63	51—73 62	73—81 78	67—91 83
Clover silage,	2	{	32—32 44	36—54 45	26—51 36	22—40 35	41—55 48	31—56 45	36—60 45
Corn silage, dent, immature, average all trials,	7	{	59—68 64	60—68 64	31—35 33	42—65 53	54—78 68	60—70 66	61—85 71
Corn silage, dent, mature, average all trials,	9	{	57—76 66	60—77 70	24—48 37	21—63 50	45—80 64	63—83 71	65—90 82
Corn silage, dent, Leaming, immature,	2	{	59—66 62	60—68 64	31—35 33	46—51 49	54—71 63	62—66 65	61—77 72
Corn silage, dent, Pride of the North, mature,	1	{	72—76 74	-	24—28 26	-	72—73 73	81—83 82	72—82 77
Corn silage, dent, Virginia, mature,	1	{	57—74 64	60—75 66	-	21—55 39	51—69 58	66—79 72	65—84 77
Corn silage, Sanford, ears glazing,	1	{	74—76 75	76—77 77	47—48 48	54—54 54	77—78 78	78—80 79	76—78 77
Corn silage, dent, average all trials,	16	{	64	70	37	49	65	69	77
Corn silage, flint, mature, small varieties,	4	{	68—78 75	66—80 77	-	48—73 65	75—79 77	71—83 79	-

EXPERIMENTS WITH RUMINANTS — *Continued.*

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
II. — SILAGE — <i>Cont.</i>									
Corn silage, dnd, large white, partly cured,	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 }	69—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, steamed,	1	{ 2 }	73—74 73	75—76 76	46—50 48	53—57 55	75—76 76	75—77 76	90—90 90
Corn silage, sweet, mature,	1	{ 2 }	67—70 68	68—72 70	—	53—55 54	68—74 71	71—73 72	82—85 83
Kafir corn silage, well matured,	1	{ 3 }	54—56 55	56—59 57	—	22—33 28	57—59 57	59—62 62	47—54 50
Oat and pea silage,	1	{ 2 }	63—68 65	63—70 67	52—53 52	74—75 73	58—65 61	64—70 67	73—77 75
Cow pea silage,	1	{ 4 }	59—60 60	—	—	57—58 57	59—54 52	72—73 72	62—64 63
Sorghum silage, well matured,	1	{ 3 }	51—60 57	53—62 59	—	6—13 9	51—63 58	59—67 64	53—60 56
Silage, mixture of corn, sunflower heads and horse beans, ¹	1	{ 2 }	64—68 66	66—70 68	40—41 41	69—65 63	56—64 60	71—74 72	75—78 77

Silage, mixture of corn, sunflowers (whole plant) and horse beans. ¹	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) <i>Meadow Grasses and Millets.</i>									
Kentucky blue-grass (<i>Poa pratensis</i>), bloom, .	1	1	56	-	42	57	63	53	43
Canada blue-grass (<i>Poa compressa</i>), bloom, .	1	2	62-63 62	-	42-42 42	43-44 43	70-71 71	63-63 63	36-39 37
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 (<i>Bahia Dactyloides</i>),	1	1	55	-	6	54	65	62	62
Chest or cheat (<i>Bromus secdinus</i>),	1	1	45	-	23	42	46	49	32
Colorado upland hay (urgely <i>Agropyrum tenax</i>),	2	6	47-53 56	45-59 52	40-48 43	58-67 62	54-63 59	49-66 57	16-53 34
Crab grass (<i>Eragrostis Neo Mexicana</i>), ripe, .	3	8	47-57 53	-	29-52 43	30-56 58	50-66 60	50-59 53	30-52 43
Meadow fescue (<i>Festuca elatior pratensis</i>), bloom.	1	2	60-61 61	-	46	51-53 52	-	58-60 59	53-54 54
Johnson grass (<i>Andropogon halepensis</i>),	2	3	57	-	-	40	68	57	38
Barnyard millet, well headed,	1	3	57-58 57	-	63-64 63	63-64 64	60-64 62	50-52 52	44-50 46
Barnyard millet, just heading out,	1	2	59-62 61	-	51-52 52	56-59 58	66-71 69	55-59 57	47-49 48
Cat-tail millet (<i>Pennisetum spicatum</i>),	1	2	61-64 62	-	-	61-65 63	65-68 67	58-60 59	45-48 46

Millets.

¹ Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — <i>Con.</i>									
(a) <i>Meadow Grasses and Millets — Con.</i>									
Millet.	1	1	54	-	31	23	56	58	49
			{ 61-66 65	{ 66-67 66	-	-	{ 67-68 68	{ 67-67 67	-	64
Millet (<i>Chaetochloa Italica</i>).	1	2	{ 52-58 56	-	{ 16-32 24	{ 30-32 31	{ 60-66 63	{ 52-59 56	{ 48-52 50
			{ 54-55 60	{ 60-66 62	{ 37-53 47	{ 34-65 57	{ 49-70 60	{ 56-67 61	{ 41-58 50
Mixed grasses, rich in protein (8-10 per cent.).	15	{	{ 49-59 55	{ 51-61 58	{ 16-36 30	{ 37-54 47	{ 46-50 45	{ 56-66 59	{ 34-57 45
Mixed grasses, timothy predominating.	5	{	{ 38-40 39	-	-	{ 31-37 34	{ 30-36 33	-	{ 46 44
Meadow, swale or swamp hay.	1	2	{ 51-57 55	-	{ 39-43 41	-	{ 53-57 55	{ 56-59 58	{ 54-58 56
Tall oat grass (<i>Arrhenatherum elatius</i>), late bloom.	1	2	{ 60-68 64	{ 61-69 65	-	{ 49-68 58	{ 65-71 68	{ 62-69 65	{ 36-63 50
Wild oat grass (<i>Danthonia spicata</i>).	2	3	{	{ 56 54	-	{ 59 59	{ 60-67 64	{ 54 54	{ 55-57 56
Orchard grass, ten days after bloom.	1	1	56	56	-	60	61	55	55
Orchard grass, stage not given.	1	2	{ 73 73	{ 73 73	{ 52 52	{ 73 73	{ 76 76	{ 74 74	{ 67 67
Orchard grass, average both samples.	2	3	56	56	-	60	61	55	55
Pasture grass.	1	3	73	73	52	73	76	74	67

Prairie grass (<i>Sporobolus Asper</i>),	1	56	-	25	18	61	61	57
Red-top,	2	58-62 60	59-64 61	-	60-62 61	61-62 61	59-65 62	44-59 51
Rowen, mixed grasses,	3	-	63-68 65	-	-	62-72 66	60-69 65	44-51 47
Rowen, chiefly timothy,	1	-	62-67 64	-	60-69 68	62-73 66	60-65 63	48-51 49
Rowen, average all trials,	4	-	65	-	69	66	64	47
{ Black grass (<i>Juncus Gerardi</i>),	2	50-62 56	-	67-71 69	53-63 58	50-66 59	46-59 52	37-51 44
{ Branch grass (<i>Distichlis spicata</i>),	2	49-57 52	-	58	-	48-57 54	45-55 49	27-42 35
{ Flat sage (<i>Spartina stricta maritima var.</i>),	1	55-58 57	-	61-62 62	50-55 52	60-61 60	54-57 55	33-40 36
{ Fox grass (<i>Spartina patens</i>),	3	51-56 51	-	57-59 58	56-63 60	46-60 53	51-55 53	17-51 36
{ Salt hay mixture, fox and branch grasses, etc.,	1	52-56 54	-	68-70 69	41-43 42	54-61 58	51-54 52	26-30 28
{ Timothy, in bloom,	4	54-66 59	51-67 58	33-34 34	50-60 57	50-62 57	57-72 63	26-62 48
{ Timothy, past bloom,	8	47-61 52	43-62 52	30-68 59	32-50 43	32-57 46	53-70 59	22-70 51
{ Timothy, stage unknown,	1	57-62 59	57-62 59	47-54 50	38-41 40	-	-	-
{ Timothy, average all trials,	24	55	56	39	48	50	62	50
{ Timothy fed with cotton-seed meal (16 hay, 1 meal),	1	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	49-55 52	-	9-30 20	27-38 32	43-51 47	58-62 60	52-54 53

Slate hays.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — <i>Con.</i>									
<i>(a) Meadow Grasses and Millets — <i>Con.</i></i>									
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—1 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	—	—	—	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	—	— 58
Timothy and red-top, late bloom,	1	7	48—60 54	—	11—24 19	37—43 39	49—63 55	55—66 60	28—51 42
White grass (<i>Triticum repens</i>),	2	4	60—63 61	61—64 62	—	40—64 58	56—68 62	62—70 66	54—60 57
<i>(b) Cereal Fodders.</i>									
Barley hay,	1	4	59	62	—	65	62	63	41
Corn fodder, dent, immature, average all trials, . .	6	15	51—70 62	51—71 63	39—47 43	20—67 50	45—77 67	55—70 62	44—84 65
Corn fodder, dent, immature, B. & W.,	1	4	51—64 57	—	—	20—36 27	45—74 59	57—66 61	66—84 76

Corn fodder, dent, in milk,	5	{	{	50-66 63	-	-	44-51 50	50-71 64	61-69 66	67-79 75
Corn fodder, dent, mature,	10	{	{	57-70 66	-	16-30 23	30-61 45	43-73 63	61-81 73	56-82 70
Corn fodder, flint, ears forming,	1	{	{	69-72 70	71-73 71	-	69-73 70	72-73 72	71-73 71	63-71 67
Corn fodder, flint, mature,	5	{	{	63-73 70	-	-	56-79 64	63-80 76	63-78 71	50-79 71
Corn fodder, sweet, mature,	3	{	{	60-71 67	62-74 70	-	54-73 64	70-77 74	57-73 68	63-71 74
Corn stover, dent, Pride of the North,	1	{	{	53-55 54	-	29-33 31	45-45 45	58-63 61	53-55 54	63-66 65
Corn stover, Eureka silage, ears just forming,	2	{	{	54-64 50	-	40-46 43	57-58 53	56-72 65	53-64 59	63-67 65
Corn stover, average all trials,	11	{	{	53-64 57	49-58 55	29-46 41	11-58 36	52-74 64	53-64 59	49-77 67
Corn stover, below ear,	1	{	{	64-69 67	-	-	15-27 21	71-75 74	65-73 69	79-80 80
Corn stover, above ear,	1	{	{	52-58 55	-	-	17-27 22	63-72 71	50-57 54	62-65 64
Corn stover, minus pith (by hand),	1	{	{	54-57 55	55-59 57	-	16-23 20	60-65 63	55-58 57	70-75 72
Corn stover, minus pith, ground (Marsden's process),	1	{	{	63-64 63	-	46-55 49	57-62 60	60-61 61	65-66 66	82-83 83
Corn stover, minus pith, ground (Marsden's process), steamed,	1	{	{	51-59 56	-	47-55 50	59-60 60	37-54 48	57-62 59	70-85 80
Corn stover, minus pith, average,	3	{	{	51-64 58	55-59 57	46-55 50	16-62 47	37-65 57	55-66 61	70-85 78
Corn stover, blades and husks,	1	{	{	60-68 65	-	15-35 23	41-55 48	67-76 73	64-71 66	53-64 58

EXPERIMENTS WITH RUMINANTS—Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III.—HAY AND DRY COARSE FODDERS— <i>Con.</i>									
(b) <i>Cereal Fodders—Con.</i>									
Corn stover, tops and blades,	1	2	59-60 60	-	-	54-57 55	71-72 71	62-63 62	71-72 71
Corn stover, leaves,	1	2	55-56 56	-	-	43-49 56	54-67 61	57-61 59	61-65 63
Corn stover, leaves,	1	2	62-67 65	-	-	28-41 35	75-80 78	66-70 68	52-59 56
Corn stover, leaves, average both trials,	2	4	55-67 61	-	-	28-39 46	54-80 70	57-70 64	52-65 60
Corn stover, husks,	1	2	71-73 72	-	-	24-35 30	78-81 80	- 75	23-42 33
Kafir corn fodder,	1	4	59-62 61	-	5-11 8	34-42 38	56-63 60	64-68 66	57-67 61
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 both trials,	2	5	57	-	24	34	67	60	75
Oat hay, bloom to milk,	2	6	51-59 55	50-61 55	35-54 45	47-63 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

Oat straw,	1	2	49-52 50	51-53 52	-	-	57-58 58	52-55 53	35-41 38
Sorghum fodder, Minnesota Early Amber,	1	3	58-60 58	54-55 54	41-49 44	40-47 43	42-56 49	57-67 61	62-67 65
Sorghum fodder, leaves,	1	2	60-66 63	-	-	59-62 61	65-76 70	62-67 65	46-47 47
Sorghum fodder, bagasse,	1	1	61	-	-	14	64	65	46
<i>(c) Legumes.</i>									
Alfalfa, first crop, budded to full bloom,	8	17	56-72 63	-	34-67 58	61-84 71	31-65 49	68-76 72	23-61 41
Alfalfa, second crop, budded to full bloom,	6	12	58-67 62	-	38-59 51	64-81 75	41-49 45	70-79 73	34-48 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,	15	31	62	-	54	72	47	72	41
Alfalfa, average all trials,	21	39	62	-	53	72	47	72	43
Soy bean,	1	2	62-63 62	-	-	70-72 71	59-62 61	66-71 69	19-40 29
Clover, alsike, full to late bloom,	4	9	55-64 59	56-65 60	-	64-71 66	40-59 50	59-74 66	21-69 38
Clover, crimson,	3	9	57-65 62	52-58 56	-	64-73 69	32-58 45	52-74 62	29-54 44
Clover, red,	7	18	49-67 57	51-66 54	0-41 30	47-69 58	42-70 54	56-72 64	40-70 55
Clover, white,	1	1	66	67	-	73	61	70	51
Clover, rowen,	2	4	-	58-60 59	42-50 46	60-69 65	45-51 47	62-64 63	58-60 60

EXPERIMENTS WITH RUMINANTS — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).	
III.—HAY AND DRY COARSE FODDERS — Con.										
(c) <i>Legumes</i> — Con.										
Cow pea,	1	2	59	—	—	61—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	
Spring vetch (<i>Vicia sativa</i>),	1	2	65—67 66	66—68 67	52—53 53	69—71 70	54—61 58	71—72 72	70—72 71	
Winter or hairy vetch (<i>Vicia villosa</i>),	1	6	68—71 69	—	34—46 42	81—83 82	60—63 61	71—75 73	69—74 70	
(d) <i>Mixed and Miscellaneous</i> .										
Buttercups (<i>Ranunculus acris</i>),	1	2	56	57	—	56	41	67	70	
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	51	—	32	64	47	54	85	
Cotton-seed feed, average both (4 to 1) trials,	3	8	56	—	33	44	53	59	90	

Cotton-seed feed, average all trials,	7	23	52	-	30	51	46	55	86
Cotton-seed hulls,	4	13	{ 35-47 41	-	-	0-25 6	0.5-58 47	13-46 34	58-89 79
Oats and peas,	2	7	{ 56-67 61	56-67 60	54-65 58	69-78 73	50-64 58	54-66 61	51-69 59
Oats and sand vetch,	1	2	{ 55-55 55	56-56 56	43-46 44	64-66 65	48-56 49	58-59 59	58-67 63
Oats and spring vetch,	2	5	{ 57-63 59	-	-	60-71 65	47-67 57	34-65 59	17-76 52
Oats and vetch, average,	3	7	58	58	56	65	55	59	55
Salt bush (<i>Atriplex Argentea</i>),	1	3	{ 46-47 46	31-32 31	71-72 72	65-68 66	3-15 8	46-51 49	50-55 52
Wheat and sand vetch,	2	6	{ 64-69 66	-	33-60 47	70-77 74	63-66 65	67-71 68	62-67 64
White weed (<i>Leucanthemum vulgare</i>),	1	2	58	58	-	58	46	67	62
IV.—ROOTS AND TUBERS.									
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	-
Potatoes,	1	3	{ 73-80 77	75-81 78	-	43-45 44	-	87-93 91	-
Ruta-bagas,	1	2	{ 84-90 87	89-93 91	-	75-86 80	61-87 74	94-95 95	77-92 84
English flat turnips,	1	2	{ 91-95 93	93-99 96	-	84-95 90	89-117 100	96-97 97	92-92 86

1 Four hulls to one meal.

EXPERIMENTS WITH RUMINANTS—Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-Free Extract (Per Cent.).	Crude Fat (Per Cent.).
V.—CONCENTRATED FEED STUFFS.									
<i>(a) Protein.</i>									
Soy bean meal, variety unknown,	2	3	75-79 78	-	-	89-91 90	0-73 33	68-73 71	81-88 89
Soy bean meal, medium green, coarse ground,	2	4	81-98 90	-	42-77 57	88-95 91	-	61-100 81	89-97 93
Bibby's dairy cake,	2	6	61-81 70	-	18-44 33	58-76 66	1-68 46	71-88 81	81-99 92
Blood meal, Armour's,	1	2	-	-	-	80-88 84	-	-	-
Brewers' dried grains,	2	5	56-62 62	-	-	78-84 81	28-62 49	51-60 57	87-93 89
Buckwheat middlings,	1	3	71-79 75	-	26-41 36	83-86 85	8-26 17	79-87 83	87-92 89
Cotton-seed, raw,	1	2	63-69 66	-	-	66-70 68	65-86 76	49-50 50	-
Cotton-seed, roasted,	1	2	53-58 56	-	-	44-50 47	62-69 66	50-53 51	68-75 72
Cotton-seed meal,	4	12	67-90 79	81-95 88	84	76-96 84	26-55 35	66-96 78	87-100 94
Cotton-seed meal, high grade (Maine),	1	2	90	95	-	83	-	96	100
Cotton-seed meal, medium grade (Maine),	1	2	67-79 75	73-83 78	-	81-86 81	40-47 44	73-91 82	95-95 95

Cotton-seed meal, low grade (Maine),	1	2	60-63 62	62-67 65	-	72-73 73	30-45 38	66-70 68	87-93 90
Cotton-seed meal, high grade, dark colored, slightly fermented (Maine).	1	2	81-91 86	85-95 90	-	82-83 83	-	90-100 95	95-100 98
Dairy feed, H-O,	2	4	65-65 65	-	-	68-80 76	14-13 35	67-75 72	83-86 84
Distillers' dried grains, brand R, largely from rye, .	1	2	56-59 58	-	-	56-63 59	-	61-73 67	80-86 84
Distillers' dried grains, largely from corn,	8	17	70-89 79	-	-	66-80 73	50-100+ 95	69-87 81	86-98 95
Germ oil meal,	2	5	72-83 76	-	-	65-77 73	-	68-82 76	95-98 96
Gluten feed,	7	13	85-91 86	92-93 93	-	85-86 86	-	80-90 89	-
Gluten meal,	4	8	75-95 87	-	-	86-93 88	-	78-94 88	91-99 93
Linseed meal, old process,	1	3	75-82 79	-	-	86-93 89	38-71 57	76-79 78	86-92 89
Linseed meal, new process,	1	3	75-83 78	-	-	82-86 85	49-100 74	82-87 84	90-96 93
Linseed meal, new process, Cleveland flax,	3	9	76-88 83	-	-	-	-	-	-
Linseed meal, new process, average,	4	12	82	79	-	84	74	80	89
Malt sprouts,	1	1	67	68	-	80	34	69	100
Malt sprouts (Mass.),	1	3	75-89 82	-	3-33 19	74-77 76	98-100 99	76-91 85	74-100 87
Malze feed (Chicago),	1	2	82-85 84	-	-	83-84 84	68-76 72	84-87 85	90-90 90

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS — <i>Con.</i>									
(a) <i>Protein</i> — <i>Con.</i>									
Oat middlings, fine,	1	{ 2 }	88—91 90	—	31—40 36	80—81 81	21—77 49	94—97 96	93—94 94
Pea meal,	1	{ 2 }	85—88 87	86—89 88	—	80—86 83	25—26 26	93—94 94	52—57 55
Cow pea meal,	1	{ 2 }	85—88 87	—	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Rye feed, bran and middlings,	1	{ 3 }	77—83 82	—	25—48 35	78—82 80	—	86—89 88	79—99 90
Wheat bran, springs,	3	{ 7 }	62—70 67	69—74 71	20—32 25	74—82 76	22—76 44	70—80 74	38—83 63
Wheat bran, winter,	1	{ 3 }	57—66 62	—	—	75—79 77	—	62—76 65	51—80 64
Wheat bran, average all trials,	4	{ 10 }	66	—	—	77	39	71	63
Wheat feed flour,	1	{ 2 }	67—67 67	70—70 70	—	78—80 79	—	73—78 76	—
Wheat middlings, flour,	2	{ 4 }	75—86 82	81—84 83	—	82—91 88	33—40 36	84—91 88	82—86 86
Wheat middlings, standard,	2	{ 6 }	—	73	25	77	30	78	88
Wheat mixed feed, bran and middlings,	2	{ 4 }	71—78 73	73—81 76	34—43 37	77—79 78	47—79 62	74—79 77	81—92 87
Wheat 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

(b) *Starchy.*

Cerealine feed,	1	3	{	89—92 90	-	79—81 80	72—92 82	93—97 95	78—83 81
Chop feed, corn bran and germ,	2	6	{	71—92 80	-	56—77 67	54—70 62	64—92 84	61—86 82
Corn bran,	2	4	{	70—71 70	-	53—55 54	50—65 59	74—80 77	69—85 77
Corn cobs,	1	2	{	59—60 59	-	13—22 17	65—66 65	90—90 90	44—56 50
Corn meal, coarse,	2	4	{	74—83 84	75—94 86	45—54 48	-	79—91 86	-
Corn meal, fine,	2	3	{	87—89 88	89—90 90	48—63 54	-	87—95 91	-
Corn meal, average all trials,	9	21	{	74—98 88	75—94 90	40—87 66	-	79—100 92	71—99 91
Corn and cob meal,	1	3	{	74—85 79	-	43—65 52	2—86 45	86—91 88	82—85 84
Corn and out feed, Victor,	1	3	{	74—76 75	-	66—75 71	36—58 48	81—85 83	84—86 87
Kafir corn kernels,	2	6	{	29—58 43	-	28—54 41	-	34—62 45	-
Kafir corn meal,	2	5	{	54—76 66	-	36—62 53	-	67—84 77	25—62 46
White Kafir heads,	1	4	{	14—35 24	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Dairy feed, Quaker,	3	8	{	58—64 62	52	62—72 70	54—56 55	55—71 59	72—80 74
Hominy meal,	3	8	{	71—91 82	11—60 37	54—74 65	2—100+ 67	82—94 89	88—95 92

EXPERIMENTS WITH RUMINANTS — Concluded.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS — Con.									
(b) <i>Starchy</i> — Con.									
Horse feed, H.O,	3	{ 5 }	70—77 74	—	—	62—81 70	52—59 56	79—85 83	74—87 80
Alma dried molasses beet pulp,	1	{ 2 }	82—87 85	—	55—69 62	59—69 64	83—84 81	89—93 91	—
Blomo feed,	1	{ 2 }	64—69 67	—	31—32 32	61—64 63	51—72 61	73—79 76	14—17 16
Holstein sugar feed,	1	{ 3 }	70—74 71	—	21—43 33	61—71 66	26—62 44	79—82 81	86—89 88
Macon sugar feed,	1	{ 2 }	69—72 71	—	20—21 20	57—61 59	36—51 44	81—83 82	74—81 82
Sucrene dairy feed,	1	{ 2 }	67—72 69	—	28—47 38	57—64 61	70—73 72	71—75 73	93—96 95
Molasses feeds, average last three,	3	7	70	—	36	63	52	80	88
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
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
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

Molasses Feeds.

Peanut feed, largely husks,	1	2	32-32 32	-	70-71 71	10-13 12	41-58 49	90-90 90
Rice meal,	1	2	71-76 74	-	-	-	89-95 92	91-92 91
Rice bran,	2	4	56-66 62	-	1-31 18	13-42 21	76-81 78	52-92 72
Rye meal,	1	2	85-90 87	-	82-85 84	-	89-94 92	63-65 64
Rice polish,	1	2	82-83 83	-	65-66 66	22-23 22	92-93 93	66-81 74

EXPERIMENTS WITH SWINE.

Barley meal,	1	1	80	80	81	49	87	57
Linseed meal, old process,	1	4	76-79 77	-	83-90 86	10-14 12	82-87 85	78-82 80
Matze kernels,	1	1	82	82	69	38	89	46
Matze meal,	2	2	89-90 90	91-92 92	86-90 88	29-49 39	94-94 91	76-82 80
Maize meal with cobs,	1	1	76	77	76	29	84	82
Hog millet seed (<i>Panicum miliaceum</i>),	1	1	73	-	68	33	92	59
Pea meal,	1	1	90	92	89	78	95	50
Potatoes,	1	4	97	-	84	-	98	-
Wheat, whole,	1	?	72	-	70	30	74	60
Wheat, cracked,	1	?	82	-	80	69	83	70
Wheat shorts (middlings),	1	2	71-79 77	-	71-75 73	25-48 37	85-86 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 Forage.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Corn kernels,	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
Corn stover minus pith, ground (Marsden's process),	1	{ 2 }	40-59 50	-	6-37 22	65-70 68	38-71 55	39-54 47	48-72 60
Oat kernels,	1	{ 2 }	67-77 72	-	31-36 33	84-87 86	13-19 31	75-83 79	80-85 82
Oats, ground, same as above,	1	{ 2 }	73-78 76	-	9-19 29	81-83 82	0.6-2.8 14	85-87 86	79-81 80
Oats, average of both,	2	{ 4 }	74	-	31	84	22	82	81
Timothy hay,	1	{ 2 }	39-48 44	-	29-39 34	18-24 21	37-48 43	44-50 47	44-51 47

EXPERIMENTS WITH POULTRY.

Corn kernels,	1	{ 3 }	-	86	-	44-58 50	-	90-96 92	88-95 92
Corn kernels,	1	{ 5 }	-	86-87 87	-	80-87 84	1-25 15	88-91 89	81-87 85
Corn meal,	1	{ 3 }	-	85	-	41-55 48	-	91-92 91	92-94 93
Kaffir-corn kernels,	1	{ 3 }	-	86	-	50-55 58	17-22 20	90-98 96	71-76 74

Kafir corn meal,	1	3	{	-	-	42-44 43	30-42 35	95-97 96	82-84 83
Meal,	1	2	{	-	-	90-91 91	-	-	86-87 87
Oats,	1	2	{	-	-	68-81 74	4-11 8	65-75 71	77-85 81
Cow peas,	1	3	{	-	-	32-48 40	2-43 18	86-88 87	87-90 89
Cow pea meal,	1	3	{	-	-	40-49 44	8-11 10	84-91 88	75-88 87
Wheat,	1	1	{	-	-	77	-	89	89

EXPERIMENTS WITH CALVES.

Whole milk,	2	2	{	-	-	90-98 95	-	-	93-99 97
Pasteurized whole milk,	2	9	{	-	-	88-95 93	-	-	91-99 95
Cooked whole milk,	1	3	{	-	-	80-94 87	-	-	92-99 95
Raw skim milk,	1	3	{	-	-	94-95 95	-	-	-
Skim milk, with sheep,	1	3	{	96-102 97	46-74 62	93-96 94	-	100	- 100

Literature. — The following publications have been consulted in compiling the foregoing tables of digestibility: —

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