PUBLIC DOCUMENT . . . . No. 31.

FORTY-FIRST ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1904.

BOSTON:
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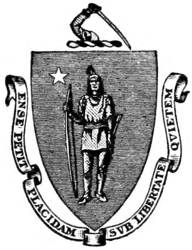

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Approved by
The State Board of Publication.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 8, 1904.

To His Excellency JOHN L. BATES.

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

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1904–1905.

Jan. 6, 1904, Wednesday, fall semester resumed, at 8 A.M.
February 3, Wednesday, fall semester ends.
February 4, Thursday, spring semester begins, at 8 A.M.
March 30, Wednesday, to April 5, Tuesday, } spring recess.
April 5, Tuesday, spring semester resumed, at 8 A.M.
June 11, Saturday, Grinnell prize examination of the senior class in agriculture.
June 12, Sunday, Baccalaureate sermon.
June 13, Monday, { Burnham prize speaking. Flint prize oratorical contest.
June 14, Tuesday, { Class-day exercises. Meeting of the alumni. Reception by the president and trustees.
June 15, Wednesday, commencement exercises.
June 16, 17, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Pittsfield; and at Horticultural Hall, Worcester.
September 20, 21, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.
September 22, Thursday, fall semester begins, at 8 A.M.
December 21, Wednesday, to Jan. 4, 1905, Wednesday, } winter recess.
January 4, Wednesday, fall semester resumed, at 8 A.M.
February 8, Wednesday, fall semester ends.
February 9, Thursday, spring semester begins, at 8 A.M.
March 29, Wednesday, to April 4, Tuesday, } spring recess.
April 4, Tuesday, spring semester resumed, at 8 A.M.
June 21, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

In the history of every institution of learning there comes a time when there must be either advance or retreat. There can be no halting place. Halting is decay, and decay is followed by slipping backward. If the growth has been healthy and normal, a movement forward must necessarily result; classes must increase in size and be divided into sections, in order to teach to the best advantage; new men must be added to the faculty, to provide for additional work; and an increased equipment, with larger and more numerous recitation rooms, must follow. Such a moment has apparently come to the college. For the last ten years the college has been slowly but steadily increasing in numbers, as the accompanying table of freshmen and whole number in college indicates: —

Year.	Number in Freshman Class.	Number in College.
1895,	16	190
1896,	20	133
1897,	27	122
1898,	35	151
1899,	34	161
1900,	42	176
1901,	31	185
1902,	62	224
1903,	54	212
1904,	62	249

From entering classes of 16 we have, then, in ten years nearly quadrupled our numbers, rising to 62, and the increase has been for the most part slow but steady. For the accommodation of our students we have only 12 recitation rooms and 7 laboratories. During this semester we are holding on an average 46 to 52 recitations daily. To add to our perplexities, in the chemical, botanical and entomological laboratories it is very difficult to hold exercises on consecutive hours, because necessarily uncompleted work must be left over. Chemical analyses or investigations by microscope may take three hours or as many days, and during that period to disturb the instrument would be the ruin of the problem. Every class containing over forty requires division, and four or five extra hours must be added to the work of men already overloaded. Even if it were not detrimental to the best interests of a class to have more than 40, we have only two recitation rooms which would accommodate more than that number, and both of these belong to the class above described. They are in effect laboratories.

The $10,000 granted under Resolves of 1883, chapter 46, and Resolves of 1886, chapter 34, is no longer adequate to provide for tuition. With the number of students now attending the college we ought to have $15,000 each year in order to fully compensate us for making tuition free. Technical institutions like our own, and requiring large expenditures in laboratories, charge an annual tuition fee of from $200 to $250; ours is only $120, — a mere pittance when compared with that charged by others. We ask, therefore, that for the purpose of providing the necessary scholarships to make tuition free in this State college, the sum of $15,000 be yearly appropriated, instead of $10,000. We ask this for the following specific reasons: —

1. The departments of physics, chemistry, botany, agriculture, horticulture, meteorology and entomology require a yearly outlay for material and apparatus that we are now unable to grant, from lack of funds; $200 apiece, or $1,600, is a small estimate per year.

2. The increasing number of students and the division of our classes require a number of assistants — three or four

— to enable us to furnish the best instruction and to relieve our present corps of teachers.

3. The growing demand for courses in the care of poultry, instruction in bee culture and the study of vegetable and animal tissue calls for opening short elective courses in those branches of farm life. The enormous extent of the poultry industry is scarcely appreciated, and yet from good authority we learn that during last year there was paid out by the people of Massachusetts more than twenty million dollars for eggs and poultry from outside the State. A petition has come to us, "urging that our plans include a practical, working poultry plant, somewhat after the manner of the one at the Maine station, — something that would be substantial and valuable." In the statistics of 1895 we find the following startling figures for our whole country: —

Total value of dairy products, ...	$454,900,000
Total value of poultry and products, . .	343,000,000

To provide for this inadequacy of revenue to furnish the theoretical and practical education required by its charter, the college asks that 40 additional scholarships, under Resolves of 1886, chapter 34, be established, at an increased annual expenditure of $5,000; and that $5,000 additional be appropriated annually to its income. To supply the lack of room the college asks that a horticultural building be erected and equipped, at a cost not to exceed $40,000, and $1,000 annual maintenance fund. This will provide for the classes in market gardening, horticulture, floriculture, greenhouse management and landscape gardening, and relieve the congested condition of the botanical department. A fine building, 50 by 70 feet, one story and a half on its front and three on its rear, containing laboratory, photographing rooms, landscape gardening and recitation rooms, can be put up for the sum indicated. The building is a necessity. The only room the department now can call its own is the botanical museum, where all specimens have been made useless by being pushed back to the wall to allow room for tables.

The year has in many respects been a hard one. The installation of our heating plant and the delay in completing it prevented our securing coal in the early part of the season, and we were at one time driven almost to the point of closing the college. Reduced to our last two or three tons, and not a ton to be purchased in town at any price, the faculty met to consider the question of closing the college until such time as a supply of coal could be procured. Through the courtesy of Amherst College we were enabled to borrow sufficient to keep our doors open until we could replenish our bins. But our loss was very heavy, the deficit in that one item footing up to $3,500.

The library has entirely outgrown its building. Twenty-eight hundred volumes have been withdrawn from circulation, and by the close of the present college year another thousand volumes of reference or books not frequently called for will have to be added. Another building, fireproof, with stackroom and all the adjuncts that add so much to the serviceableness of a modern library, is imperatively demanded. The present structure, erected in 1885, was built in connection with the chapel, and does not admit of enlargement. It can be utilized by turning it into one large recitation room in the centre, and using the one end for the president's office and records and the other as a practice room for the cadet band. The library should be kept up to the very highest state of efficiency. It is really the pivot on which the whole college turns, and should be the very centre of college life.

On this year expire two appropriations, one of $10,000 first granted by the Legislature of 1889 for four years and continued since by the Legislatures of 1892, 1896 and 1900 for the same period of time. Five thousand dollars of this appropriation was for the establishment of a labor fund, out of which needy students could be paid for labor performed. It would seem as if there could hardly be any question respecting the continuance of this fund. This college was founded, as the words of its charter proclaim, "in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." In this respect it stands unique. It is to promote an education both liberal and practical for the vast industrial class that fills our towns and cities. No command could have been stated more explicitly, nor could any command have been allowed a greater latitude in its interpretation, for it was left to the Legislature of each State to build up its own college in the way that best answered its own special needs. Bearing in mind this central idea of benefiting the industrial classes, we find, as we should naturally expect to find, nearly two-thirds of each class dependent either wholly or in part on the aid received from this fund. We find young men boarding themselves at a total expense of one dollar fifty cents per week, and others who during the same time have not enjoyed the comfort of a single warm meal. A large proportion of our students cannot complete their course without aid of this kind. They are willing to work, if work can only be given them. Our only regret is that the appropriation is not larger.

The other five thousand dollars was to provide the theoretical and practical education required by the charter of the college and the laws of the United States relating thereto. The chairs of English and veterinary science were at once created, and have continued ever since. It would be hard to find two chairs that would be more missed if the appropriation should be withheld.

Second, the appropriation of $8,000 was made in 1900, by chapter 50, and was to cover the general depreciation in stocks and consequent lowering of the college income, and for providing such instruction as was demanded by college charter. It was also made for four years, and the same urgent demand exists for its continuance as there did for its creation. The college cannot exist without it.

It is the policy of the State not to insure its property. For thirty-six years the college has borne that burden, insuring all its buildings, twenty-seven in number. With the establishment of a central heating and lighting plant, the danger from fire in buildings on the west side of the grounds is practically eliminated, and it would therefore seem wise to discontinue the insurance of buildings on the west side of the grounds, but to furnish a night watchman to care for property that has cost the State over a quarter million dollars. On the east and north of the heating and lighting plant are eight buildings that could be easily brought into the same system. In two of these buildings new furnaces are required now, and the third is a new building as yet without heat. Would it not be the part of economy and wisdom to complete the circuit, and heat and light all from the same plant?

Summing up briefly the necessities of the college, we ask for the following sums: —

Horticultural building and equipment,		$38,000
Maintenance fund of same (annual),		1,000
Scholarship fund (annual),		5,000
Insurance,		400
Special maintenance appropriation,		5,000
Deficit on coal,		3,500
Renewal of appropriations of 1900,	Labor,	5,000
	Endowment of two chairs,	5,000
	Maintenance,	8,000

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 8, 1904.

THE CORPORATION.

	TERM EXPIRES
WILLIAM R. SESSIONS of SPRINGFIELD,	1905
CHARLES L. FLINT of BROOKLINE,	1905
WILLIAM H. BOWKER of BOSTON,	1906
GEORGE H. ELLIS of BOSTON,	1906
J. HOWE DEMOND of NORTHAMPTON,	1907
ELMER D. HOWE of MARLBOROUGH,	1907
NATHANIEL I. BOWDITCH of FRAMINGHAM,	1908
WILLIAM WHEELER of CONCORD,	1908
ELIJAH W. WOOD of WEST NEWTON,	1909
CHARLES A. GLEASON of NEW BRAINTREE,	1909
JAMES DRAPER of WORCESTER,	1910
SAMUEL C. DAMON of LANCASTER,	1910
MERRITT I. WHEELER of GREAT BARRINGTON,	1911
CHARLES H. PRESTON of DANVERS,	1911

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,
WILLIAM H. BOWKER, CHARLES H. PRESTON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

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

Committee on Farm and Horticulture.*

Farm Division.

GEORGE H. ELLIS, N. I. BOWDITCH,
MERRITT I. WHEELER, WILLIAM R. SESSIONS, *Ch'man.*

Horticultural Division.

JAMES DRAPER, ELMER D. HOWE,
E. W. WOOD, *Chairman.*

Committee on Experiment Department.*

J. LEWIS ELLSWORTH, ELIJAH W. WOOD,
WILLIAM H. BOWKER, SAMUEL C. DAMON,
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

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

Board of Overseers.

STATE BOARD OF AGRICULTURE.

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

Examining Committee of Overseers.

JOHN BURSLEY (*Chairman*), . . of West Barnstable.
C. K. BREWSTER, ... of Worthington.
W. C. JEWETT, ... of Worcester.
ARTHUR A. SMITH, . . . of Colrain.
CHARLES H. SHAYLOR, . . of Lee.

The Faculty.

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

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

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

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

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

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

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

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

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

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

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

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

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

FRANK A. WAUGH, M.S.,
Professor of Horticulture and Landscape Gardening.

RICHARD S. LULL, PH.D.,
Associate Professor of Zoölogy.

PHILIP B. HASBROUCK, B.S.,
Associate Professor of Mathematics.
Adjunct Professor of Physics.

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

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

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

LOUIS R. HERRICK, B.Sc.,
Instructor in Modern Languages.

HOWARD L. KNIGHT, B.Sc.,
Instructor in English.

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* Absent on leave.

GEORGE F. FREEMAN, B.Sc.,
Instructor in Botany.

GEORGE O. GREENE, M.S.,
Instructor in Horticulture.

FRANCIS CANNING,
Instructor in Floriculture.

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

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, Ph.D.,
Registrar.

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

Graduates of 1903.*

Doctor of Philosophy.

Morrill, Austin Winfield, . . . Tewksbury.

Bachelor of Science.

Allen, William Etherington, . . .	Winthrop.
Bacon, Stephen Carroll, . . .	Leominster.
Barrus, George Levi, ...	Goshen.
Bowen, Howard Chandler (Boston Univ.),	Rutland.
Brooks, Philip Whitney (Boston Univ.),	Cambridge.
Cook, Joseph Gershom, . . .	Clayton.
Franklin, Henry James (Boston Univ.), .	Bernardston.
Halligan, Charles Parker, . . .	Roslindale.
Harvey, Lester Ford, ...	Woodbury, Conn.
Hood, William Lane (Boston Univ.), .	Vandiver, Ala.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1903.

Jones, Gerald Denison (Boston Univ.), .	South Framingham.
Lamson, George Herbert (Boston Univ.),	East Hampton, Conn.
Monahan, Neil Francis, ...	South Framingham.
Nersessian, Paul Nerses (Boston Univ.),	Marash, Turkey.
Osmun, Albert Vincent (Boston Univ.), .	Danbury, Conn.
Parsons, Albert, ...	North Amherst.
Peebles, William Warrington, . .	Washington, D. C.
Poole, Elmer Myron (Boston Univ.), .	North Dartmouth.
Proulx, Edward George, . . .	Hatfield.
Robertson, Richard Hendrie, . . .	Somerville.
Snell, Edward Benaiah, ...	Lawrence.
Tinkham, Charles Samuel, . . .	Roxbury.
Tottingham, William Edgar, . . .	Bernardston.
Tower, Winthrop Vose, ...	Melrose Highlands.
West, Myron Howard (Boston Univ.), .	Belchertown.
Total, ...	26

Senior Class.

Ahearn, Michael Francis, . . .	Framingham.
Back, Ernest Adna, ...	Florence.
Blake, Maurice Adin, ...	Millis.
Couden, Fayette Dickinson, . . .	Amherst.
Elwood, Clifford Franklin, . . .	Green's Farms, Conn.
Fahey, John Joseph, ...	Pittsfield.
Fulton, Erwin Stanley, ...	Lynn.
Gay, Ralph Preston, ...	Stoughton.
Gilbert, Arthur Witter, ...	Brookfield.
Gregg, John William, ...	South Natick.
Griffin, Clarence Herbert, . . .	Winthrop.
Haskell, Sidney Burritt, ...	Southbridge.
Henshaw, Fred Forbes, ...	Templeton.
Hubert, Zachary Taylor, . . .	Pride, Ga.
Newton, Howard Douglas, . . .	Curtisville.
O'Hearn, George Edmund, . . .	Pittsfield.
Parker, Sumner Rufus, ...	Brimfield.
Peck, Arthur Lee, ...	Hartford, Conn.
Quigley, Raymond Augustine, . .	Brockton.
Raymoth, Reuben Raymond, . . .	Goshen.
Staples, Parkman Fisher, . . .	Westborough.
White, Howard Morgan, . . .	Springfield.
Total, ...	22

Junior Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Barnes, Hugh Lester,	Stockbridge.
Bartlett, Francis Alonzo,	Belchertown.
Carter, Chester Merriam,	Leominster.
Craighead, William Hunlie,	Boston.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Amherst.
Gardner, John Joseph,	Milford.
Goodenough, Herbert Harold,	Worcester.
Hall, Jr., Arthur William,	North Amherst.
Hatch, Walter Bowerman,	Falmouth.
Hill, Louis William Barlow,	Greenfield Hill, Conn.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Amherst.
Hutchings, Frank Farley,	South Amherst.
Ingham, Norman Day,	Granby.
Kelton, James Richard,	Orange.
Ladd, Edward Thorndike,	Winchester.
Lewis, Clarence Waterman,	Melrose Highlands.
Lyman, John Franklin,	Amherst.
Merrill, Jr., Charles Edward,	Melrose.
Munson, Willard Anson,	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
Patch, George Willard,	Lexington.
Paul, Augustus Russell,	Framingham.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Swain, Allen Newman,	New Dorchester.
Taylor, Albert Davis,	Westford.
Tinkham, Henry Buffinton,	South Swansea.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth,	Natick.
Whitaker, Chester Leland,	Somerville.
Williams, Percy Frederic,	Natick.
Willis, Grenville Norcott,	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	39

Sophomore Class.

Abbott, Chester Denning,	Andover.
Bacon, Roland Aldrich,	Leominster.
Baird, Clarence Henry,	Holyoke.
Brett, Clarence Elmer,	Brockton.
Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.
Cutter, Frederick Augustus,	Pelham, N. H.
Farrar, Allan Dana,	Amherst.
Ferren, Frank Augustus,	Peabody.
Filer, Harry Burton,	Belchertown.
Foster, Samuel Cutler,	Boston.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Goodale, Ray Coit,	Suffield, Conn.
Hartford, Archie Augustus,	Westford.
Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hersem, Elbert Wood,	Westborough.
Hood, Clarence Ellsworth,	Millis.
Jones, Louis Franklin,	Somerville.
Kennedy, Frank Henry,	South Boston.
Mahoney, Francis Watson,	Boston.
Martin, James Edward,	Brockton.
Morse, Stanley Fletcher,	Watertown.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
O'Neil, William James,	Ayer.
Paige, George R.,	Amherst.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civille,	Natick.
Prenn, Joseph,	Amherst.
Racicot, Jr., Arthur Alphonse,	Lowell.
Rogers, Stanley Sawyer,	Boston.
Russell, Henry Merwin,	Bridgeport, Conn.
Scott, Edwin Hobart,	Cambridge.
Shannon, Alonzo Henry,	Amherst.
Sleeper, George Warren,	Swampscott.
Spurr, Fred Yerxa,	Melrose Highlands.

Stevens, Frederick Oramel, . . .	Amherst.
Strain, Benjamin, ...	Mt. Carmel, Conn.
Suhlke, Herman Augustus, . . .	Leominster.
Sullivan, Patrick Francis, . . .	Amherst.
Taft, William Otis, ...	East Pepperell.
Tannatt, Jr., Willard Colburn, . .	Dorchester.
Tinker, Clifford Albion, ...	West Tremont, Me.
Tirrell, Charles Almon, ...	Plainfield.
Walsh, Thomas Frederick, . . .	Ayer.
Watkins, Fred Alexander, . . .	Hinsdale.
Webb, Paul, ...	Hamden, Conn.
Wellington, Richard, ...	Waltham.
White, Vernon Ollise, ...	Attleborough.
Wholley, Michael Francis, . . .	Cohasset.
Wood, Alexander Henry Moore, . .	Easton.
Wood, Herbert Poland, ...	Hopedale.
Total, ...	56

Freshman Class.

Alley, Harold Edward, ...	Newburyport.
Amsden, Eugene Charles, . . .	West Gardner.
Armstrong, Arthur Huguenin, . .	Hyde Park.
Barlow, Waldo Darius, ...	Southbridge.
Bartlett, Earle Goodman, . . .	Chicago, Ill.
Brydon, Robert Parker, ...	Lancaster.
Caruthers, John Thomas, . . .	Columbia, Tenn.
Chace, Wayland Fairbanks, . . .	Middleborough.
Chadwick, Clifton Harland, . . .	Cochituate.
Chapman, Joseph Otis, ...	East Brewster.
Chapman, William Spaulding, . .	Attleborough.
Clark, Jr., Milford Henry, . . .	Sunderland.
Clementson, Lewis Towland, . . .	Millbury.
Cowles, Edward Russell, . . .	Deerfield.
Curtis, Jesse Gerry, ...	South Framingham.
Curtis, Walter Leon, ...	Scituate.
Dearth, George Augustus, . . .	Sherborn.
Denham, Edwin Tirrell, ...	Rockland.
Dickinson, Walter Ebenezer, . . .	North Amherst.
Dudley, Fred Samuel, ...	Montague.
Eastman, Jasper Fay, ...	Townsend.
Engstrom, Nils, ...	Lancaster.

Finkelstein, David Elias,	Philadelphia, Pa.
French, Vida Rachel,	Amherst.
Gould, Harry Wheeler,	Millbury.
Green, Herbert Henry,	Spencer.
Hall, Jr., Walton,	Marshfield.
Hanson, Stuart Waldo,	Boston.
Higgins, Arthur William,	Westfield.
Jones, Arthur Merrick,	Ludlow.
Kalina, Jacob,	New York, N. Y.
King, Clinton,	Easton.
Knox, Harry Cobb,	Roxbury.
Larned, Adelbert Joseph,	Amherst.
Leighton, Carl,	Lowell.
Leominster, William,	Long Plain.
Lincoln, Ernest Avery,	Fall River.
Livers, Susie Dearing,	Boston.
Marran, Bernerd James,	Great Barrington.
Parker, Charles Morton,	Newtonville.
Perkins, Edward Cook,	Springfield.
Peters, Frederick Charles,	Lenox.
Philbrick, Edwin Daniels,	Somerville.
Pierce, Henry Tyler,	West Millbury.
Pray, Rutledge Peyton,	Natick.
Raitt, John Archibald,	New York, N. Y.
Rice, Charles Arthur Allenham,	Springfield.
Russell, Herbert Osborne,	North Hadley.
Searle, George Whitney,	Westfield.
Shaw, Chester Linus,	Brockton.
Shaw, Edward Houghton,	Belmont.
Shaw, Frank Elmer,	Brockton.
Shuttleworth, Edwin Lewis,	Lawrence.
Smith, George Franklin,	Barre.
Stoddard, Calder Sankey,	Canton.
Summers, John Nicholas,	Campello.
Thompson, Clifford Briggs,	Halifax.
Walker, James Hervey,	Greenwich Village.
Watts, Ralph Jerome,	Littleton.
Whitney, John Frank,	Dana.
Total,	60

Two-Years Course.

Hunt, Justine,	Newton.	
Total,		1

Short Winter Courses

Bailey, Norman F.,	Pittsfield.	
Blessing, John M.,	Albany, N. Y.	
Carlson, Axel Robert,	Cambridge.	
Clark, Albert Phillips,	Pittsfield.	
Colburn, Ned Springer,	Haverhill.	
Cooke, Ernest Hubbard,	Austerlitz, N. Y.	
Dorling, Samuel William,	Spencer.	
Dwight, Daniel Hunt Miller,	Brewster.	
Eaton, Hovey Damon,	North Reading.	
Folsom, Sara Elizabeth,	Revere.	
Gage, William Allen,	Crown Point, N. Y.	
Gerber, Nelson,	Webster.	
Gilbert, Solon Mowry,	Auburn.	
Goold, James,	Albany, N. Y.	
Kilbon, Marshall Edwards,	Oberlin, Ohio.	
King, George William,	Dudley.	
Kohles, Herman,	Fitchburg.	
Lord, Jr., Edward Oliver,	Allston.	
MacDonald, Raymond Lewis,	Medway.	
Macomber, Walter White,	Sturbridge.	
Miller, Fred,	East Walpole.	
Mower, John Laidlaw,	Litchfield, Conn.	
Ramsdell, Elmer Pitts,	West Newton.	
Rogers, Harry Fred,	Westborough.	
Scott, Richard,	Shrewsbury.	
Sonoda, Takeshi,	Boston.	
Stygles, Clarence Heaman,	Hyde Park, Vt.	
Williamson, Oran Ethan,	Altamont, N. Y.	
Total,		28

Graduate Courses.

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

Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.	
Hodgkiss (B.Sc., M. A. C., '02), Harold Edward,	Wilkinsonville.	
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.	
Knight (B.Sc., M. A. C., '02), Howard Lawton,	Gardner.	
Osmun (B.Sc., M. A. C., '03), Albert Vincent,	Danbury, Conn.	
Tottingham (B.Sc., M. A. C., '03), William Edgar,	Bernardston.	
West (B.Sc., M. A. C., '02), David Nelson,	Northampton.	
Total,		7

Special Students.

Mills, Mabelle Ingalls Lovejoy,	Amherst.	
Russell, Ida Josephine,	Amherst.	
Spaulding, Olive Mary,	Mapleton, Conn.	
Total,		3

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	7	
Four-years course: —		
Graduates of 1903,	26	
Senior class,	22	
Junior class,	39	
Sophomore class,	56	
Freshman class,	60	
Two-years course,	1	
Winter courses,	28	
Special students,	3	
Total,		242
Entered twice,		3
Total,		239

OBJECT.

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

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

GRADUATE COURSES.

In response to the increasing demand for advanced work in various directions, the college has arranged for courses of study leading to the degrees of Master of Science and Doctor of Philosophy.

Honorary degrees are not conferred.

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

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

Courses for the Degree of Master of Science.

A course of study is offered in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary medicine. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

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

Courses for the Degree of Doctor of Philosophy.

The establishment of courses leading to this degree is the result of many calls for advanced study along certain economic lines neglected in most American universities, and is given only by those departments especially equipped for this grade of study, to graduates of this college or other colleges of good standing. The work required for the degree is intended to be so advanced in its character as to necessitate the greatest industry to complete it, with the belief that such severe requirements will result in the greatest credit to those who are successful. Four courses of study only are therefore open, viz., botany, chemistry, entomology and horticulture as major subjects, though a minor in zoölogy is also available.

At least three years are necessary to complete the work required; twenty hours per week to be devoted to the major subject, while from twelve to sixteen hours per week are required for each of the two minor subjects during one and a half years.

The work in the major and minors will necessarily differ with the previous training and needs of different students, but a general outline of the major in each subject is as follows: —

Botany. — Vegetable physiology, vegetable pathology, mycology, œcology, taxonomy, phylogeny, the history of botany, and the history and theory of evolution. The above subdivisions of botany will be, to a greater or less extent, pursued as necessitated by the previous training of the student and nature of the original problem undertaken. In this course it is also recommended that the student take, in addition to this prescribed minor work, a brief course in the history of philosophy and psychology, which at present will have to be provided elsewhere. Extensive reading of botanical literature, of both a general and specific nature, will be required in certain subjects, and occasional lectures will be given. A botanical conference is held monthly, wherein various new problems touching upon botanical science are considered by graduate students and those of the senior class electing botany. A thesis dealing with some economic problem in plant physiology or pathology, or both, and containing a distinct contribution to knowledge, will also be required.

Chemistry. — Advanced work in the following subjects: inorganic analysis, qualitative, of the rarer elements, and quantitative; crystallography; physical chemistry; descriptive and determinative mineralogy; chemical geology; soil formation; soil physics and chemistry; gas analysis; synthetic inorganic work; chemical theory and history; general organic chemistry; special topics in organic chemistry; elementary quantitative organic analysis; proximate qualitative and quantitative organic analysis, including determination of organic radicles; organic synthesis of aliphatic and aromatic compounds; problems in chemical manufacture; recent chemistry of plant nutrition; animal physiological and pathological chemistry, including foods, standards for feeding of all kinds, and, among secretions, milk and milk industries, and, among excretions, urine and urinalysis; toxicology; insecticides and fungicides; frequent examinations on current chemical literature.

Early in the course original work on some chemical subject pertaining to agriculture must be begun. The history and results of this work must be submitted before graduation, in the form of a thesis containing a distinct contribution to knowledge.

Entomology. — General morphology of insects: embryology; life history and transformations; histology; phylogeny and relation to other arthropods; hermaphroditism; hybrids; parthenogenesis; pædogenesis; heterogamy; chemistry of colors in insects; luminosity; deformities of insects; variation; duration of life.

Œcology: dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects, insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases; photography of insects and their work; methods of drawing for illustrations; field work on insects, and study of life histories; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

Journal club: assignments of the literature on the different groups of insects to different students, who report at monthly meetings summaries of all articles of value which have appeared during the month.

Required readings of the best articles on the various topics named above, and on the different orders of insects. This reading covers from 15,000 to 20,000 pages in English, French and German, and the candidate is examined on this, together with his other work, at the close of his course.

Thesis: a thesis with drawings, which shall consist of the results of original investigations along one or several lines, and which shall constitute a distinct contribution to knowledge, must be completed and accepted before the final examinations are taken.

Horticulture. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation, and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote himself continuously to it. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects. Advanced work will be required in the following subjects: systematic pomology, pomological practice, commercial pomology; systematic, practical and commercial olericulture; greenhouse plants and problems; floriculture; landscape gardening; plant breeding and general evolution; and questions of a physiological nature connected with propagation and pruning.

Other requirements and opportunities are: (1) periodical seminars with special lectures, by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits to orchards, gardens, greenhouses, estates and libraries outside the college grounds, always with some definite purpose in view; (4) and, finally, the preparation and publication of a thesis setting forth the results of the candidate's major study, which shall be an original and positive contribution to horticultural knowledge.

FOUR-YEARS COURSES.

Degree.

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

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni, provided that the candidate, in addition to the college course, shall have mastered in a preparatory school a three-years preparatory course in studies beyond those commonly presented in the grammar schools of Massachusetts.

Admission.

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

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

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

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

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

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen —

set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1904 and 1905 are: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Tennyson's "The Princess;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

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

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

The examinations for admission in 1904 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 16 and 17, and on Tuesday and Wednesday, September 20 and 21, as follows: —

First Day.	*Second Day.*
8.30 A.M. — Registration.	9 A.M. — Civil government.
9 A.M. — English.	10 A.M. — Algebra.
11 A.M. — General history.	2 P.M. — Physiology.
2 P.M. — Geometry.	3 P.M. — Physical geography.

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

ENTRANCE EXAMINATION PAPERS USED IN 1903.

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

ALGEBRA.

1. Factor $(7x+3)^2-(5x-4)^2$.
   Factor $152+11x-x^2$.

2. Simplify $\dfrac{\frac{1}{x}-\frac{2}{x^2}-\frac{3}{x^3}}{\frac{9}{x}-x}$.

3. Find cube root of expression

$$\frac{6b}{a}+\frac{6a}{b}-7+\frac{a^3}{b^3}-\frac{3a^2}{b^2}-\frac{3b^2}{a^2}+\frac{b^3}{a^3}.$$

4. Express with positive exponents and reduce to lowest terms

$$\left\{\frac{a^{-3}}{b^{-2/3}c}\right\}^{-\frac{3}{2}} \div \left\{\frac{(\sqrt{a^{-1/2}})\,(\sqrt[6]{b^3})}{a^2c^{-1}}\right\}^{-2}$$

5. Find the square root of the binomial surd $83+12\sqrt{35}$.

6. $x^{-1/2}+x^{-1/4}=6$. Solve for x.

7. $\left\{\begin{array}{l} x^3+y^3=407. \\ x+y=\ 11. \end{array}\right\}$ Solve for x and y.

8. $\left\{\begin{array}{c} \frac{1}{x^2}+\frac{1}{y^2}=\frac{61}{900} \\ xy=30 \end{array}\right\}$ Solve for x and y.

Geometry.

1. The area of an equilateral triangle is $9\sqrt{3}$. Find its side.

2. The perimeter of a regular hexagon circumscribed about a circle is $12\sqrt{3}$. What is the circumference of the circle?

3. Prove that two triangles having an angle of one equal to an angle of the other, are to each other as the products of the sides including the equal angles.

4. Prove that if two chords be drawn through a fixed point within a circle, the product of the segments of one chord is equal to the product of the segments of the other.

5. A parallel to one side of a triangle divides the other two sides proportionately. Prove only when the segments of each side are incommensurable.

Physical Geography.

1. Give the causes of the wind. What is a tornado? a cyclone? a typhoon?

2. Define a river terrace; a delta; a flood plain; a waterfall.

3. Explain the rain; dew; frost; hail.

4. Give two causes of mountain formation and examples of each. What causes an earthquake? a volcanic eruption?

5. Explain the cause of a spring; a geyser; an artesian well.

Civil Government.

1. Define the following: civil government, municipal government, a franchise, a charter, a veto, the writ of habeas corpus.

2. Name the three kinds of colonial government found in North America before the revolution. Show how they differed, and name the colonies that were under each.

3. Where and in what year was the Constitution of the United States framed? In what year did it go into effect? Name any

of the objects for which the people ordained and established the Constitution.

4. What qualifications must a man have that he may be —

(*a*) A voter in Massachusetts?

(*b*) A United States Senator?

(*c*) A President of the United States?

5. What is a direct tax, and how is the amount of each citizen's tax determined? What is an indirect tax? Give an example. Why should a citizen who has no children be taxed for the support of public schools?

6. Write on the following subjects, developing each in your own way, and aiming at clearness and accuracy of statement: —

(*a*) The Legislature of Massachusetts.

(*b*) The Supreme Court of the United States.

(*c*) Government ownership and control of the coal mines in Pennsylvania.

Physiology.

1. Describe the heart; explain the pulse; describe a red blood corpuscle.

2. Name the bones bounding in any way the mouth. Give the microscopic structure of bone.

3. Locate the kidney; what is its outlet? what its function?

4. Locate the pancreas, and give its function; also the liver and the epidermis.

5. Give the layers of the skin; describe a sweat gland; an oil gland; and the structure of a hair.

General History.

1. *Ancient History.*

(*a*) Distinguish broadly between the three families of the white race, the Hamitic, the Semitic and the Aryan.

(*b*) Write a few words upon the classes of society in ancient Egypt, and upon the Egyptians' worship of animals.

(*c*) Tell the story of the Trojan war.

(*d*) State briefly for what the following Romans are to be remembered: Coriolanus, Regulus, Cataline, Cæsar, Mark Antony, Cicero, Nero.

2. *Mediœval History.*

(*a*) What was the Teutonic influence, as compared with the classical and the Hebrew, which helped to form mediæval and later on modern European civilization?

(*b*) Who were the Anglo Saxons? the Normans? In what way were they connected with the early history of England?

(*c*) One of the mediæval institutions of the church was monasticism. Explain briefly what this was, and what great good it performed.

3. *Modern History.*

(*a*) Give a brief account of some of the early explorers of the new world, and also state what European nations took the lead in early voyages of discovery and colonization.

(*b*) What was Puritanism, in what European country did it find its firmest supporters, and in what way was the movement related to the early history of our country?

(*c*) Name the wars in which the United States has engaged, state the approximate dates and the underlying causes.

ENGLISH.

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

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

(*a*) Shakespeare's early days.
(*b*) Shakespeare in London.
(*c*) Goldsmith: the man and the writer.
(*d*) Scott's place in English Literature.
(*e*) An outline of Tennyson's life.
(*f*) Lowell and the Mexican war.
(*g*) Lowell's life in Cambridge.
(*h*) George Eliot's early life.
(*i*) An outline of George Eliot's life.

2. Choose any five from the following list of subjects, and write a paragraph or two on each subject chosen. Give title in each case.

(*a*) Shakespeare's attitude toward the Jew, as shown in "The Merchant of Venice."

(*b*) Some interesting characters in Goldsmith's "The Vicar of Wakefield."

(*c*) Relations of the Norman and the Saxon, as depicted in Scott's "Ivanhoe."

(*d*) The enduring lesson of Tennyson's "The Princess."

(*e*) The relation between the nature pictures and the story in Lowell's "The Vision of Sir Launfal."

(*f*) A comparison of the two brothers, Godfrey Cass and Dunstan Cass, in George Eliot's "Silas Marner."

COURSES OF INSTRUCTION FOR THE DEGREE OF BACHELOR OF SCIENCE.

Agriculture.

Introductory: relations of federal and state governments to agriculture, four lectures, history of agriculture, tenure of land, rents, holdings, etc., six lectures.

Freshman year, first semester, three hours a week required. Animal breeding: Shaw's "Breeding Animals," lectures and discussion of principles of breeding. — Assistant Professor Cooley.

Sophomore year, seven weeks, first semester, four exercises a week in class room required. Breeds of farm live stock, sheep, cattle: lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, nine weeks, first semester, four exercises a week in class room required. Horses and swine: lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, eight weeks, second semester, three hours a week required. Dairying: lectures on dairy farming, milk production, handling and marketing of milk, milk preservation and modification, and products of milk. Text-book, Wing's "Milk and its Products." — Assistant Professor Cooley.

Sophomore year, ten weeks, second semester, required. Soils: formation, classification, composition; physical and chemical characteristics, and their relations to maintenance and increase in productiveness. Brooks's "Agriculture," Vol. I., supplemented by lectures and laboratory work. — Professor Brooks.

Junior year, ten weeks, first semester, elective. Methods of soil improvement, including tillage, drainage and irrigation. Brooks's "Agriculture," Vol. I., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Manures: production, composition, properties, adaptation and use. Brooks's "Agriculture," Vol. II., supplemented by lectures and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Stock judging. — Assistant Professor Cooley.

Junior year, second semester, elective. Fertilizers, including a critical study of their production, composition, properties, adaptation and use; and green manuring. Brooks's "Agriculture," Vol. II., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Senior year, four weeks, first semester, four hours a week, elective. Silos and ensilage: historical development; the merits and methods of construction of the different kinds of silos; the crops suited for ensilage; ensilage machinery; the methods of filling the silo; and the nature and extent of the changes taking place in ensilage as affecting food value. Lectures, books of reference and practical exercises. — Professor BROOKS.

Senior year, seven weeks, first semester, four hours a week, elective. Feeding animals: principles of digestion and animal nutrition, a study of feeding stuffs (coarse and concentrated). The relation of food to product; compounding rations. Armsby's "Cattle Feeding," lectures and discussion. — Assistant Professor COOLEY.

Senior year, seven weeks, first semester, four hours a week, elective. Dairying: selection and management of the dairy farm, dairy cattle, chemical and physical properties of milk, etc., cream, butter, cheese and by-products. — Assistant Professor COOLEY.

Senior year, first and second semester, two exercises a week, for ten weeks. Dairy practice: use of separators, Babcock tester, butter making, etc. — SPECIALISTS.

Senior year, second semester, elective. The crops of the farm and crop rotation; including a study of the origin and agricultural botany of all the leading crops of the farm; annual forage crops, grasses and legumes, cereals, root crops, vegetables, tobacco and other special commercial crops; the production and use of each, the varieties and methods of improvement, the adaptation to soil, the special manurial requirements and the methods of raising and harvesting are considered. Lectures, reference books and field work. — Professor BROOKS.

Senior year, second semester, elective. Agricultural experimentation: objects, methods, sources of error; interpretation of results. Lectures and study of reports, bulletins, etc. — Professor BROOKS.

Senior year, second semester, elective. Farm management: selection of the farm, its subdivisions and equipment, buildings, fences, roads, water supply; farm capital, permanent, perishable and floating; the labor of the farm and its management, farm power and farm machinery. Lectures and practical exercises. — Professor BROOKS.

Seminar courses, by arrangement, for advanced students.

Special problems requiring experiment or other research investigation will be assigned to students fitted for and desiring such work.

Training and practice in the use of farm implements and machines by arrangement when desired.

HORTICULTURE.

This department endeavors to give the student a working knowledge of horticulture on its practical and on its scientific side. The attempt is made to inculcate a taste and an enthusiasm for horticultural pursuits, in place of distaste and dislike for the drudgery of farm life. On these things success and further progress chiefly depend.

The courses now offered are as follows, though others will be added as occasion requires: —

1. Sophomore class, second semester. The fundamental operations of horticulture, — propagation, pruning and cultivation, — as related to the physiology of the plant. During the first half of this course Bailey's "Nursery Book" is used as a text. — Mr. GREENE.

2. Junior year, first semester. Pomology: this course covers the three natural divisions of the subject, viz.: (*a*) systematic pomology, or the study of the fruits themselves; (*b*) practical pomology, or the practice of fruit growing; (*c*) commercial pomology, or the principles underlying the marketing of fruits. The course is pursued by means of text-books, lectures, laboratory and field exercises. — Mr. GREENE.

3. Junior year, first semester, four periods weekly. Plant breeding: based on a thorough examination of the laws of heredity and of variation, and of the principal theories of evolution. Lectures, accompanied by practice and direct experiments in crossing and hybridizing plants. — Professor WAUGH.

4. Junior year, second semester, four periods weekly. Market gardening, including vegetables and small fruits; locations, soils, methods of cultivation and marketing. Text-book, Bailey's "Principles of Vegetable Gardening;" lectures and field exercises. — Mr. GREENE.

5. Individual problems will be assigned to seniors who elect horticulture. This gives the student an opportunity for specialization in various lines of fruit growing, vegetable culture, greenhouse management, landscape gardening, etc. — Professor WAUGH, Mr. GREENE and Mr. CANNING.

A seminar made up of all students electing advanced work in horticultural or landscape gardening meets at regular intervals for the discussion of any matters pertaining to the subject. Successful and noted horticulturists from outside the college are frequently present at these meetings, to speak on the topics with which they are especially identified.

Landscape Gardening.

The college wishes to promote the work in landscape gardening in every way possible. The aim of the courses is to give the general student an understanding of the fundamental principles of design and of good taste, as applied to gardening; and to prepare advanced students for the practice of landscape gardening in its various branches.

Although a variety of other work along related lines is available, the courses now definitely offered are as follows: —

1. Junior year, four periods weekly. Materials: this course is designed to give the student an intimate acquaintance with the trees, shrubs and other plants used in landscape gardening. — Professor WAUGH and Mr. CANNING.

2. Junior year, second semester, four hours a week. Elements of landscape design: the fundamental principles underlying the artistic development of parks, estates, gardens and other areas, together with some of the simpler applications to practical conditions. During the first half of the term Waugh's "Landscape Gardening" will be used as a text. — Professor WAUGH.

3. Senior year, first and second semesters, four laboratory periods weekly. Advanced landscape gardening: lectures, conferences, field exercises and extensive practice work, with criticism. The student is given definite problems to solve, these problems being arranged in such an order as to develop the subject logically in the student's mind. — Professor WAUGH and Mr. CANNING.

CHEMISTRY.

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

The courses are as follows: —

Freshman year, second half of second semester, four hours a week. General chemistry, part 1: principles of chemistry; non-metals. Newth's "Inorganic Chemistry." — Assistant Professor HOWARD.

Sophomore year, first semester, six hours a week. General chemistry, part 2: metals. — Assistant Professor HOWARD.

Second semester, five hours a week. Subject continued: dry analysis. — Assistant Professor HOWARD.

Junior year, first semester, eight hours a week. Qualitative and quantitative analysis; organic chemistry. Four hours a week, special subject. — Professor WELLINGTON.

Second semester, ten hours a week. Organic chemistry. Remsen's "Organic Chemistry." Five hours a week, special subject. — Professor WELLINGTON.

Senior year, elective, first semester, three hours a week. Chemical industries. — Professor GOESSMANN.

Eight hours a week, quantitative analysis and physical chemistry. Reychler-McCrae's "Physical Chemistry." — Professor WELLINGTON and Assistant Professor HOWARD.

Second semester, eight hours a week. Advanced work, with lectures. — Professor WELLINGTON.

GEOLOGY.

1. Mineralogy, junior year, first semester, seven weeks, three hours a week. A course of systematic determinative mineralogy, based on Brush's "Manual." This work is carried on in the laboratory, and consists in determining the minerals by a study of lustre, fusibility, hardness, color, streak, specific gravity, etc., and by some of the simpler chemical tests. — Assistant Professor HOWARD.

2. Geology, junior year, second semester, eleven weeks, three hours a week. Dynamical, structural and historical geology, based upon recitations assigned from Scott's "Introduction to Geology." Topics in economic geology are also assigned, mainly from Tarr's "Economic Geology," to each member of the class in turn, upon which the student is expected to report. Ample opportunity for illustration is afforded by the museum collection and excursions in the Connecticut valley. — Professor LULL.

Zoölogy.

1. Anatomy and physiology, freshman year, one-half of the second semester, four hours a week. Martin's "The Human Body" (advanced course) is used as a text-book, from which recitations are assigned, supplemented by lectures and demonstrations, illustrated by means of anatomical models and charts. — Professor Lull.

2. Zoölogy, sophomore year, first semester, one lecture and recitation and one laboratory period each week. This course aims to give a brief general survey of the animal kingdom, and consists of a series of laboratory studies of a number of different types illustrative of the principal groups, supplemented by a lecture course amply illustrated by the very complete museum collection. Recitations, both oral and written, are assigned upon the knowledge gained in the laboratory, from the lectures, and from Parker and Haswell's "Manual of Zoölogy." — Professor Lull.

3. Zoölogy, junior year (elective for students in the biological course), first semester, four exercises of two hours each; second semester, three exercises of two hours each. A course in systematic zoölogy, based upon Parker and Haswell's "Text-book of Zoölogy." The laboratory course embraces the morphology of an ample series of forms representative of the different types of animals, considerable attention being paid to anatomical and histological methods, as well as to the knowledge gained thereby. Lectures and recitations are of the nature of informal discussions. — Professor Lull.

Political Science.

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

Economics, junior year, second semester, four hours a week. (1) The elements of political economy are taught by means of text-book (this year F. A. Walker's "Political Economy, Briefer Course") and lectures, the aim being to make the student familiar with the generally accepted facts, definitions, principles and laws of the science, and to train him to criticise theories, scrutinize facts and weigh arguments. (2) The industrial history of England and of the United States is studied. Gibbins' "Industrial History of England" is used. (3) The following elective courses are offered: economics of agriculture; banks and banking; problems of the currency; trusts, or monopolistic corporations; transportation;

socialism. (4) Practical economics. Each member of the class selects for investigation a question in which he is interested, and devotes two or three months to its solution.

Papers giving the results of research, prepared by members of the class, are read and discussed by the students. Each student is asked to explain and defend from criticism the statements and the conclusions made in the paper he presents. The department has at its disposal a working library and a collection of material for the use of students. — Professor WALKER.

Constitution of the United States, senior year, four hours a week during half of the first semester and the whole of the second semester. (1) Political institutions. By use of text-book (Woodrow Wilson's "The State") and lectures the student is led to understand what is the government, municipal, state and federal, now existing in the United States. This government is compared and contrasted with the governments of England, France and Germany. Care is taken to familiarize the student with the practical methods of legislation, of nominating conventions, of elections and of administrations. (2) Constitutional history of England and of the United States, with discussions relating to the origin, nature, scope, and purpose of government. — Professor WALKER.

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

ENGLISH.

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

The following courses are offered: under (*a*) rhetoric and oratory; under (*b*) American literature and English literature; under (*c*) argumentation. The elective course in the senior year is in language and literature.

1. *Rhetoric.* — This course extends through the two semesters of freshman year and through the second semester of sophomore year. In the first semester of freshman year work is confined to essay writing, and to personal criticism, by the instructor, of the

students' compositions. This criticism is offered at stated intervals to each student individually, according to a posted schedule of appointments. At the beginning of the semester necessary information with regard to the preparation of essays is furnished each student. In the second semester of freshman year the study of literary types is undertaken in the form of class room work in prose composition, including exposition, persuasion, narration, description, and, in prose diction, including usage and style. Special attention is given to the training of the inventive ability of the student. The text-book used is Baldwin's "College Manual of Rhetoric." In the second semester of sophomore year individual work in essay writing is again taken up, largely based upon the previous work of the class in American literature (see 3, below). Here also personal criticism is offered. — Mr. KNIGHT.

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

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

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

4. *Argumentation.* — Four hours a week during the first semester of junior year are given to written and oral argumentation. The course is outlined as follows: (*a*) principles of argumentation as laid down in a text-book or by lecture; (*b*) briefs and brief-making; (*c*) briefs developed into forensics and submitted for personal criticism; (*d*) debates. —Professor MILLS.

Senior elective course, two semesters, four hours a week. The work in this course is upon the following subjects: (*a*) English language, its origin, history and development, with particular attention to the study of words as outlined in Anderson's "A Study of English Words;" (*b*) English literature, principally of the eighteenth and nineteenth centuries. — Professor MILLS.

VETERINARY SCIENCE.

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

Senior year (elective), first semester, four hours a week. Veterinary hygiene; comparative (veterinary) anatomy; general pathology. — Professor PAIGE.

Second semester, four hours a week. Veterinary materia medica and therapeutics; theory and practice of veterinary medicine; general, special and operative surgery; veterinary bacteriology and parasitology; medical and surgical clinics. — Professor PAIGE.

The instruction in bacteriology is given by means of lectures, recitations and laboratory exercises. The object of this course of study is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and their relation to such processes as decomposition, fermentation, digestion and production of disease. The toxic substances resulting from the growth of organisms are considered, as well as the antitoxines used to counteract their action.

Senior year, half of the first semester, four laboratory exercises of two hours each a week required. — Professor PAIGE.

Botany.

The object of the course in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. The undergraduate work extends through six semesters. The first two semesters are required. An outline of the course follows: —

Freshman year, first semester, five hours a week. Laboratory work and lectures; histology and physiology of the higher plants. This includes a study of the minute structure of the plant organism, such as stems, roots, leaves, seeds, etc., together with their function and chemical and physical properties. This course extends into the next semester. — Mr. Freeman.

Freshman year, second semester, three hours a week. Laboratory work, lectures and text-book; outlines of classification and morphology of the higher plants. This course follows the preceding one, and commences about the first of March. It is devoted to a study of the relationship of plants, their gross structure, together with extensive individual practice in flower analysis. An herbarium of two hundred species of plants is required. — Mr. Freeman.

Junior year, first semester, five hours a week, two laboratory exercises and one lecture period a week. Cryptogamic botany. This includes a study of the lower forms of plant life necessary for a comprehension of the following courses. — Mr. Freeman.

Junior year, second semester, five hours a week, two laboratory exercises and one lecture period a week. Elements of vegetable pathology and physiology. This course includes a study of the common fungous diseases of crops, and consideration of the methods of prevention and control of the same. The plant's function as related to susceptibility to disease is also taken up. All of the junior botany is included in four of the junior elective courses. — Professor Stone.

Senior year (elective), both semesters, three laboratory exercises and one lecture period a week. (*a*) Plant physiology; (*b*) plant pathology. Either course is optional. This course is adapted to students who desire a more detailed knowledge of plant diseases and plant physiology. Extensive use is made of the valuable and constantly increasing experiment station literature. — Professor Stone.

Mathematics, Physics and Engineering.

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

Mathematics.

Freshman year, first semester, five hours a week. Higher algebra, including ratio and proportion, progressive binomial theorem, series undetermined coefficients, logarithms, continued fractions, permutations. Wells' "College Algebra." — Professor Hasbrouck.

Second semester, two hours a week. Solid geometry. Wells' "Solid Geometry." — Professor Hasbrouck.

Plane trigonometry, two hours a week. Phillips and Strong's "Elements of Trigonometry." — Professor Hasbrouck.

Junior year, for mathematical and chemical students, first semester, four hours a week. Analytic geometry of the line, circle, conic sections and higher plane curves. Wentworth or Bowser's "Analytic Geometry." — Professor Ostrander.

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

Physics.

Sophomore year, first semester, four hours a week. Elementary mechanics of solids, liquids and gases, heat and sound. Dana's "Elementary Mechanics," Carhart's "University Physics." — Professor Hasbrouck.

Second semester, four hours a week; electricity, magnetism and light. Carhart's "University Physics." — Professor Hasbrouck.

Senior year, elective for those students who have taken junior mathematics; first semester, four hours a week. Analytic mechanics. Peck's "Analytic Mechanics." — Professor Hasbrouck.

Second semester, four hours a week. Laboratory work. — Professor Hasbrouck.

Civil Engineering and Surveying.

Sophomore year, second semester, two exercises of two hours a week. Plain surveying, with field work, including the use of the usual surveying instruments. "Surveying Manual," Pence & Ketchum. — Professor OSTRANDER.

Instruction in civil engineering will be given in two distinct courses of one year each, the courses alternating. They will be open to students of the junior and senior classes as indicated below. The course of 1904–1905 will be for students in mathematics only. First semester, three hours' recitation and two hours' draughting a week; stresses in roofs, bridges and graphic statics. Merriman and Jacoby's "Roofs and Bridges," Parts I. and II.

Second semester, four hours a week. Hydraulics and sanitary engineering. Merriman's "Hydraulics and Lectures." — Professor OSTRANDER.

The course of 1905–1906 will be required of juniors and seniors taking the courses in mathematics and landscape gardening.

First semester, four hours a week. Strength of materials, foundations and masonry construction. Text-book and lectures. — Professor OSTRANDER.

Second semester, three hours' recitation or lectures, and two hours' field work or draughting, a week. Topographic and higher surveying, highway construction and the measurement of earthwork pavements and railroad construction. Text-book and lectures. — Professor OSTRANDER.

Drawing.

Junior year, first semester, two two-hour sessions a week for students in mathematics and landscape gardening; freehand drawing.

Second semester, two two-hour sessions a week, mechanical and topographic drawing.

ENTOMOLOGY.

The importance of a knowledge of insects in every department of life is recognized by placing an introductory course in this subject as a required study in the junior elective courses: (1) agriculture, (2) horticulture, (3) biology, (4) landscape gardening. For those who desire a further knowledge of it, because of its importance to their future occupations, a senior elective is offered, so shaped as to be of especial value for those who expect to take up agriculture, horticulture, landscape gardening, forestry or science teaching as life occupations.

Junior year, second semester, four exercises a week, of two hours each. Lectures, laboratory and field work: general consideration of insect structure and life histories; systematic study of the groups of insects, with particular reference to those of economic importance; methods for preventing or checking their ravages; insecticides and apparatus for their use; the collecting, mounting and naming of insects, and examination of the work of insects in the field and laboratory. — Prof. H. T. FERNALD.

Senior year (elective), first and second semesters, four laboratory exercises of two hours each a week; lectures, laboratory and field work; advanced morphology of insects; economic entomology; training in the determination of insects; use of literature on entomology; study of life histories; value and application of insecticides; thesis on insects most closely related to future occupation of the student. — Professors C. H. FERNALD and H. T. FERNALD.

MODERN LANGUAGES.

French. — Course I.: requires, for the two semesters of the freshman year, four hours a week first semester, four hours a week second semester. The aim of this course is to enable the student to read modern French fluently, especially that found in scientific journals and treatises. The first ten weeks are devoted to gaining a thorough mastery of the accent, and such principles of grammar and syntax as are covered by the first half of Whitney's "French Grammar." Great stress is laid upon the acquisition of a correct accent, a good vocabulary, and a thorough comprehension of the main idiomatic difficulties of the language. This course is further strengthened by constant drill in pronunciation, exercises and composition. — Mr. HERRICK.

Course II.: elective for both semesters of the senior year, four hours a week. The aim of this course is to equip the student with a general knowledge of classical literature, and a working knowledge of the language as it is spoken and written in the French capital to-day. Drill is furnished in composition, principles of syntax and sight translation. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Mr. HERRICK.

Spanish. — Given this year as a special elective for both semesters, four hours a week. The special aim is to enable students planning future fields of work in Spanish-speaking countries to acquire sufficient speaking and writing knowledge of the Castilian dialect to enable them to start to best advantage. Especial attention is given to conversation, the method employed being that found in Marion and Garennes' "Introdución á la Lengua Castellana." Grammar rudiments, accent and idiomatic difficulties are thoroughly studied; the acquisition of a good working vocabulary is insisted upon, and the course is further strengthened by practice in writing from dictation, constant drill in pronunciation, exercises and composition, and the reading of books characteristic of modern Spanish life and customs. — Mr. Herrick.

German. — Course I.: required for both semesters of sophomore year, four hours a week first semester, three hours a week second semester. Facility in translation is the main object in view, with particular reference to scientific writings. The work consists of a study of the rudiments of grammar and of translation. — Mr. Herrick.

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

Different books are used from year to year, but the following list will give an idea of the nature of the work: —

Course I.: Joynes Meissner's "German Grammar," Guerber's "Märchen und Erzählungen," Hauff's "Das Kalte Herz," Moser's "Der Bibliothekar." — Mr. Herrick.

Course II.: Lessing's "Emilia Galotti," and "Minna von Barnhelm," Hodge's Courses in "Scientific Reading."

Students electing Course II. must have a good record in Course I. or must pass a satisfactory examination therein. — President Goodell.

Military Science.

In compliance with the provisions of an act of Congress of July 2, 1862, military instruction under a regular army officer, detailed for this purpose, is required of all able-bodied male students. Men are excused from attendance upon the exercises of this department only on a surgeon's certificate, given by Dr. Charles F. Branch, the college physician.

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

In order to further stimulate the study of military science in colleges, the War Department issued General Orders, No. 6, dated Washington, D. C., Aug. 24, 1903, as follows: —

The reports of the regular inspections of the colleges and schools to which officers of the army are detailed, in pursuance of law, as principals or instructors, will annually hereafter be submitted to the general staff for its critical examination, and the chief of staff will report to the Secretary of War, from the institutions which have maintained a high standard, the six institutions whose students have exhibited the greatest interest, application and proficiency in military training and knowledge. The President authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions, provided sufficient vacancies exist after caring for the graduates of the military academy at West Point and the successful competitors in the annual examination of enlisted men. . . .

By order of the Acting Secretary of War,

S. B. M. Young,

Lieutenant-General, Chief of Staff.

Course I.: out of doors, an exercise of one hour, three times a week, Mondays, Tuesdays and Thursdays; infantry drill by squad, company, and battalion; guard mounting, dress parade, inspection and review; artillery drill by detachment; target practice. A guard is mounted five times in each week, and the guard maintained under practical instruction for one hour in each exercise.

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

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

Course II.: theoretical instruction for freshmen, one hour a week for both semesters, comprises recitations in infantry drill regulations; "United States Service Manual."

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

SYNOPSIS OF THE COURSES OF INSTRUCTION.

[The figures indicate the number of exercises a week; light-faced type, recitation periods of one hour each; heavy-faced type, laboratory periods of two hours each.]

FRESHMAN YEAR.

First Semester.

Language,	English,	3	
	French,	4	
Mathematics,	Algebra,	5	
Science,	Agriculture,	4	
	Botany, 2+**1**,	3	
Military,	Tactics,	1	
History,		2	
		—	22

Second Semester.

Language,	English,	4	
	French,	4	
Mathematics,	Geometry and trigonometry,	4	
Science,	Anatomy and physiology, half semester, Chemistry, half semester,	4	
	Botany, **1**+1,	2	
History,		2	
		—	20

SOPHOMORE YEAR.

First Semester.

Language,	English,	4	
	German,	4	
Physics,		4	
Science,	Agriculture,	4	
	Chemistry,	**3**	
	Zoölogy, **1**+1,	2	
		—	21

Second Semester.

Language,	English,	4	
	German,	3	
Physics,		4	
Surveying,		**2**	
Science,	Agriculture, 2+**1**,	3	
	Chemistry,	**2½**	
	Horticulture,	3	
		—	21½

Junior Year.

First Semester.

Course	Subject	Hours	Total
Course in agriculture,	Agriculture, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in horticulture,	Horticulture,	4	
	Horticulture, 1+3,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	English,	4	
		—	21
Course in biology,	Zoölogy, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in chemistry,	Chemistry,	4	
	Agriculture, 3+1,	4	
	Mathematics,	4	
	Geology,	3	
	English,	4	
	Special subject,	2	
		—	21
Course in mathematics,	Analytical geometry,	4	
	Engineering, 1+3,	4	
	Free hand drawing,	2	
	Landscape gardening,	4	
	Geology,	3	
	English,	4	
		—	21
Course in landscape gardening,	Landscape gardening,	4	
	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Free hand drawing,	2	
	Horticulture,	3	
	Geology,	3	
	English.	4	
			22

Second Semester.

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

Senior Year.

First Semester.

The following subjects are required in all courses: —

Bacteriology, half semester, 4, Constitution of the United States, half semester, 4,	4	
Military science,	1	
	—	5

Second Semester.

Constitution of the United States,	4	
Military science,	1	
	—	5

From the following the student must elect three courses, closely correlated with his junior year course; only one course in language can be elected: —

Agriculture,	4	Physics,	4
Horticulture, 3+1,	4	Engineering,	4
Veterinary,	4	English,	4
Botany, 3+1,	4	French,	4
Landscape gardening,	4	German,	4
Entomology, 3+1,	4	Spanish,	4
Chemistry, 3+1,	4	Latin,	4

COURSES OF INSTRUCTION FOR SPECIAL STUDENTS.

A Two-Years Course for Women.

Women are received who wish to pursue the studies named below. There is no charge for tuition. Board may be obtained in the dining hall, and also rooms, so far as the accommodations will permit.

First year, first semester: soils, fertilizers and cultivation, four hours a week; elementary botany, five hours; French, four hours; free-hand drawing, four hours.

Second semester: propagation and pruning (horticulture, one hour), three hours; botany, — morphology, plant analysis, five hours; chemistry, descriptive, five hours; vegetable gardening, four hours; French, four hours.

Second year, first semester: pomology, three hours a week; greenhouse construction and management, three hours; botany, — structure and physiology of plants, five hours; zoölogy, two hours; chemistry, five hours; German, four hours.

Second semester: landscape gardening, three hours a week; floriculture, four hours; vegetable pathology, five hours; entomology, three hours; chemistry, five hours; German, three hours.

Short Courses.

These courses are open to persons of both sexes. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. No entrance examination is required. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

I. Dairy Farming.

	Hours per Week.
Soils, tillage and methods of soil improvement; manures and fertilizers and their use; crops and rotations,	4
Breeds and breeding of dairy stock; judging to scale of points,	2
Fodders and feeding farm live stock,	1
Stable construction and sanitation,	1
Common diseases of stock; prevention and treatment,	1
Dairy products: their general characteristics; testing,	2
Chemical composition of milk and of special milk products,	1
Botany,	2
Horticulture,	3
Entomology,	3
Dairy practice, including testing, use of separators, butter making, preparation of certified and modified milk, and pasteurization,	4
Practice in horticulture,	1

Begins first Wednesday in January, and continues ten weeks.

II. Horticulture.

	Hours per Week.
Soils, tillage, manures, etc.,	4
Plant propagation and pruning,	3
General fruit growing,	3
Market gardening,	3
Botany,	4
Entomology,	3
Practice work in seed testing, seeding, grafting, budding, transplanting, judging fruit, etc.	

Begins first Wednesday in January, and continues ten weeks. This course will not be given unless at least eight men register for it.

III. Short Course in Bee Culture.

	Total Hours.
The structure of bees, with special reference to their work (Prof. H. T. Fernald),	5
Flowers and fruits in their relations to bees (Professor Stone),	10
Honey crops, and how to grow them (Professor Brooks),	5
Bees and bee keepers' supplies (Professor Paige),	10
Work in the apiary, under direction of an expert,	20
Instruction by specialists,	4

This course begins the fourth Wednesday in May, and continues two weeks, but will not be given unless applied for by at least six students.

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables are stocked with the best breeds of horses, cattle, sheep and swine. Attached to the barn is a dairy building equipped with the latest machinery, driven by an electric motor. The laboratory is provided with the latest forms of apparatus for mechanical analysis of soils and determination of their physical characteristics. Provision has been made in the laboratory for the study of seeds and crops and for germination trials. Power has been introduced into the laboratory, so that farm machinery may be operated for purposes of demonstration. The department has also a line of instruments for use in drainage and irrigation practicums. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution and the theory and practice of agriculture. Three large lecture rooms, one in south college and two in the dairy building, and five rooms for laboratory and dairy purposes, have been assigned to this department.

Horticulture.

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

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

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

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

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

Chemistry.

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

Geology.

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

Zoölogy.

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

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

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

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

Veterinary Science.

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

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

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

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

Botany.

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

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

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

Mathematics, Physics and Engineering.

Surveying. — The department possesses a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by performing a required amount of field work. Among the larger instruments are two plain compasses, railroad compass with telescope, surveyor's transit, two engineer's transits with vertical arc and level, solar compass, omnimeter with verniers reading to ten seconds, adapted to geodetic work, Queen plane table, two wye levels, dumpy level, builder's level, sextant, hand level, and a large assortment of levelling rods, flag poles, chains, tapes, etc. For draughting, a vernier protractor, pantograph, parallel rule, etc., are available.

Physics. — Among the apparatus in use for general instruction in general physical processes may be found a set of United States standard weights and measures, precision balances, spherometer, vernier calipers, etc.; in mechanics, apparatus to illustrate the laws of falling bodies, systems of pulleys and levers, motion on an incline plane, and the phenomena connected with the mechanics of liquids and gases. The usual apparatus for lecture illustration in heat, light and sound are also in the possession of the department. In electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, among which may be enumerated a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, Mascart quadrant electrometer, Siemens electro-dynamometer, as well as reflecting galvanometers and Wheatsone bridges for ordinary determinations of currents and resistance.

Military Science.

In addition to a large campus, suitable for battalion drill, the military department possesses a special building in which there is a drill room 60 by 135 feet, an armory, a recitation room, an office for the commandant, and a field gun and gallery practice room. The building also has a large bathroom immediately adjoining the armory.

In a plot of ground north of the college buildings there is a rifle range, marked for practice at distances of 100 and 200 yards. The range is furnished with a revolving target suitably protected by earthworks. The national government supplies, for the use of the department, arms and equipments; the Springfield cadet rifle and two breech-loading rifled steel guns, calibre 3.2, with complete equipments and ammunition.

The State supplies instruments for the college band.

Students are held responsible for all articles of public property while in their possession.

The Chapel-Library Building.

One of the most attractive and commodious buildings belonging to the college is the chapel-library. It has a commanding position, approximately in the centre of the group of buildings adjoining the campus. The chapel occupies the entire second story. A large room, capable of seating about four hundred, is used for daily prayers, Sunday services, the various commencement exercises, and not infrequently for lectures or social gatherings. The room has an excellent pipe organ. Two adjoining rooms are used for small religious gatherings, and meetings of the class teachers and of the faculty. The rooms can be thrown open so as to become a part of the main audience hall.

The entire lower story is given over to the library. This library is available for reference or investigation, and is open daily, except on Sundays, from 8 A.M. to 5 P.M. and from 6.30 to 8.30 P.M. It is open on Sundays from 10 A.M. to 1 P.M. The volumes at present number 24,563. The library contains carefully selected books in the departments of agriculture, horticulture, botany, entomology and other natural sciences. Sociology, economics, history, literature, the fine arts and the useful arts are well represented. Constant additions will be made to secure the latest and best works in the several departments of learning.

Dining Hall.

A colonial dining hall, built of brick and equipped with all modern conveniences, was completed and opened February, 1903, for the accommodation of students. A committee composed of two members of the faculty, two members of the student body, and the steward, manages the affairs of the dining hall.

The hall contains a number of suites of rooms which may be secured for occupancy by young women attending any of the departments of the college.

The Heating, Lighting and Power Plant.

This plant is located in the ravine, near the chemical laboratory. It is equipped with two large boilers, an engine and an electric generator. Here steam is generated which heats the college buildings on the west side of the public highway, extending from the dining hall to the veterinary laboratory. Here also is produced the electricity which lights all the buildings and the grounds of the college. Electric power is also generated which is used to drive the machinery in the dairy and in the barn. Connected with the plant is a machine shop in which much work is done for the college. The plant affords opportunity for students in mechanical and electrical engineering to observe the modern utilization of steam and electricity.

EXPENSES.

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

Rooms. — It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere. For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. All rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

Board. — Board at the new dining hall has been $3.25 per week; in private families, $4 to $5.

Incidental Expenses. — The military suit must be obtained immediately upon entering college, and used in the drill exercises prescribed. The following fees are applied towards the maintenance of the several laboratories: chemical, $15 per semester used;

zoölogical, $2 per semester used sophomore year, other classes $4 per semester; entomological, $3 per semester used. The fee for use of the botanical laboratory for two periods of one hour during each week is $1 per semester; other periods will be charged for proportionally. Some expense is also incurred for text-books. In exceptional cases incidental expenses necessitate additional charges.

Room rent, in advance,	$15 00	$45 00
Board, $3.25 to $4 per week,	117 00	144 00
Fuel,	13 00	13 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
	$180 50	$256 00

In addition to the above expenses, $120 tuition is charged to foreigners.

SCHOLARSHIPS.

Established by Private Individuals.

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

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

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

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

Congressional Scholarships.

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

State Scholarships.

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

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

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

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

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

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

THE LABOR FUND.

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

PRIZES.

Burnham Rhetorical Prizes.

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

Flint Prizes.

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

Grinnell Agricultural Prizes.

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

Hills Botanical Prizes.

The Hills prizes of thirty-five dollars, given by the late Henry F. Hills of Amherst, will this year be awarded to members of the senior class as follows: fifteen dollars for the best general herbarium; fifteen dollars for the best collection of Massachusetts trees and shrubs; and five dollars for the best collection of Massachusetts grasses.

Winter Course Prizes.

The dairy prizes, given by the Massachusetts Society for Promoting Agriculture, to members of the short winter course. Two sets of prizes are offered: the first set consists of three prizes of fifty, thirty and twenty dollars, respectively, given for general excellence in all branches of the course as offered; the second set consists of three prizes of twenty-five, fifteen and ten dollars, respectively, for excellence in the making of butter.

Award of Prizes, 1903.

Grinnell Agricultural Prizes (Senior). — First prize, Paul Nerses Nersessian; second prize, Elmer Myron Poole.

Hills Botanical Prizes (Senior). — First prize, Albert Vincent Osmun; second prize, Gerald Denison Jones.

Flint Oratorical Prizes (Junior). — First prize, Fayette Dickinson Couden; second prize, George Edmund O'Hearn.

Burnham Declamation Prizes (Sophomore and Freshman). — First sophomore prize, William Hunlie Craighead; second sophomore prize, George Howard Allen; first freshman prize, Vernon Ollise White; second freshman prize, Alonzo Henry Shannon.

Military Honors (Senior). — The following cadets were reported to the Adjutant-General, U. S. A., and to the Adjutant-General of Massachusetts, as having shown special aptitude for military service: William E. Allen, George L. Barrus, Neil F. Monahan.

Winter Course in Dairy Farming. — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, $50, Mrs. Sara E. Folsom; second prize, $30, Samuel W. Dorling; third prize, $20, Nelson Gerber.

Massachusetts Society for Promoting Agriculture: for highest scoring butter, first prize, $25, Clarence H. Stygles; second prize, $15, William A. Gage; third prize, $10, Samuel W. Dorling.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, $10, Samuel W. Dorling; second prize, $7.50, Elmer P. Ramsdell; third prize, $5, Herman Kohles; fourth prize, $2.50, James Gould.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one ton Stockbridge fertilizer, Mrs. Sara E. Folsom.

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

RELIGIOUS SERVICES.

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

LOCATION.

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

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

REPORTS.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, Jan. 1, 1903, to Jan. 1, 1904.*

	Received.	Paid.
Cash on hand Jan. 1, 1903,	$6,632 71	–
State Treasurer, Morrill fund,	16,666 66	–
State Treasurer, endowment fund,	11,439 41	–
State Treasurer, endowment fund, special appropriation,	1,115 00	–
State Treasurer, maintenance appropriation,	5,000 00	–
State Treasurer, maintenance appropriation, special,	8,000 00	–
State Treasurer, scholarship appropriation,	10,000 00	–
State Treasurer, labor appropriation,	5,000 00	$4,713 34
Labor fund,	21 03	–
Gassett scholarship fund, income,	40 00	28 75
Mary Robinson scholarship fund, income,	33 31	12 94
Whiting Street scholarship fund, income,	50 40	61 06
Grinnell prize fund, income,	50 00	55 00
Hills fund, income,	344 19	209 49
Library fund, income,	421 84	210 92
Burnham emergency fund, income,	95 00	90 00
Salary,	269 59	30,545 72
Extra instruction,	–	390 00
Botanical laboratory,	160 50	141 03
Chemical laboratory,	640 66	176 08
Entomological laboratory,	88 30	31 83
Veterinary laboratory,	1,009 25	743 79
Zoölogical laboratory,	134 25	114 82
Landscape gardening,	5 00	24 89
Term bill,	3,596 19	1,247 31
Advertising,	–	484 20
Heating and lighting,	2,713 80	10,719 29
Agricultural department,	808 83	1,856 41
Farm,	10,115 66	12,678 81
Horticultural department,	5,111 30	7,736 36
Expense,	1,778 14	11,811 34
Insurance,	–	689 00
Investment,	5 00	–
Individual labor fund,	200 00	18 94
Cash on hand Jan. 1, 1904,	–	6,754 70
	$91,546 02	$91,546 02

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1903, to Jan. 1, 1904, and find the same correct and properly kept. All disbursements are vouched for, the balance being six thousand seven hundred fifty-four dollars and seventy cents ($6,754.70), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Jan. 1, 1904.

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

Labor fund,	$307 69
Gassett scholarship fund,	48 16
Mary Robinson scholarship fund,	20 37
Whiting Street scholarship fund,	21 20
Grinnell prize fund,	71 24
Hills fund,	205 13
Library fund,	210 92
Burnham emergency fund,	110 56
Individual labor fund,	262 17
Veterinary laboratory,	796 00
College,	4,701 26
	$6,754 70

BILLS RECEIVABLE JAN. 1, 1904.

Farm,	$505 71
Term bill,	879 49
Heating and lighting,	685 60
	$2,070 80

BILLS PAYABLE JAN. 1, 1904.

Farm,	$951 93
Horticultural department,	152 84
Expense,	901 92
Heating and lighting,	925 15
	$2,931 84

INVENTORY — REAL ESTATE.

Land (Estimated Value).

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

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 00	
Amounts carried forward,	$130,075 00	$44,350 00

Amounts brought forward,	$130,075 00	$44,350 00
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding house,	2,000 00	
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		248,775 00
		$293,125 00

EQUIPMENT.

Botanical department,	$4,210 00
Horticultural department,	13,506 89
Farm,	18,790 85
Chemical laboratory,	1,981 00
Botanical laboratory,	2,831 53
Entomological laboratory,	15,425 00
Zoölogical laboratory,	2,200 00
Zoölogical museum,	6,000 00
Veterinary laboratory,	5,909 08
Physics and mathematics,	5,500 00
Agricultural department,	3,500 00
Library,	24,973 00
Fire apparatus,	500 00
Band instruments,	350 00
Furniture,	1,250 00
Text-books,	350 00
Tools, lumber and supplies,	240 00
Heating and lighting plant,	50,753 00
	$158,270 35

SUMMARY.

Assets.

Total value of real estate, per inventory,	$293,125 00
Total value of equipment, per inventory,	158,270 35
Bills receivable,	2,070 80
Investment, New York Central & Hudson River Railroad stock,	100 00
Cash on hand,	4,701 26
	$458,267 41

Liabilities.

First National Bank of Amherst, note,	$6,000 00	
Burnham emergency fund, note,	3,000 00	
Bills payable,	2,931 84	
		$11,931 84
		$446,335 57

	Fund.	Income in 1903.
MAINTENANCE FUNDS.		
Technical educational fund, United States grant,*	$219,000 00	$7,300 00
Technical educational fund, State grant,*	141,575 35	4,139 41
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890,	–	16,666 66
Hills fund,	8,542 00	344 19
MAINTENANCE APPROPRIATIONS.		
State appropriation made by Legislature of 1900 for four years,	–	5,000 00
Labor appropriation made by Legislature of 1900 for four years,	–	5,000 00
State appropriation made by Legislature of 1900 for four years ($8,000),	–	8,000 00
SCHOLARSHIP FUNDS.		
Whiting Street fund,	$1,260 00	50 40
Gassett fund,	1,000 00	40 00
Mary Robinson fund,	858 00	33 31
SCHOLARSHIP APPROPRIATIONS.		
State appropriations by the Legislature of 1886,	–	10,000 00
PRIZE FUND.		
Grinnell prize fund,	$1,000 00	50 00
MISCELLANEOUS FUNDS.		
Library fund,	$10,546 12	421 84
Burnham emergency fund,	5,000 00	95 00
		$57,140 81

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

GIFTS.

From German Kali Works, New York, one ton high-grade sulfate of potash; one and nine-tenths tons muriate of potash; one-tenth ton sulfate of potash-magnesia; one-half ton kainite; one hundred pounds nitrate of potash.

Chilian Nitrate Works, New York, five and one-half tons nitrate of soda.

Massachusetts Society for Promoting Agriculture, Boston, two hundred dollars in prizes for dairy school.

B. von Herff, New York, one ton kainite (value $15) for prize in dairy school.

Standard Package Company, Boston, twenty-four butter pails.

D. H. Burrell & Co., Little Falls, N. Y., one eight-bottle Facile tester complete; one four-bottle Facile tester complete.

W. H. Bowker (M. A. C., '71), Boston, one ton Stockbridge fertilizer (value $35) for prize in dairy school.

Hermann Thiemann, Manchester, one Branxholn brooder.

A. A. Southwick (M. A. C., '75), Taunton, one boar.

W. B. Lew, Amherst, specimen of bone tumor.

C. S. Dickinson, North Amherst, calculus from horse.

William Sim, Cliftondale, sixty violet plants.

American Percheron Horse Breeders and Importers Association, Chicago, Ill., one share capital stock of the association.

Loans.

From De Laval Separator Company, New York, seven separators; one milk heater.

The Vermont Farm Machine Company, Bellows Falls, Vt., five separators; two hand testers; one steam turbine tester.

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

P. M. Sharples, West Chester, Pa., two separators.

From The Empire Cream Separator Company, Bloomfield, N. J., two separators.

Cornell Incubator Company, Ithaca, N. Y., one incubator; one brooder.

The Star Incubator and Brooder Company, Lincoln, N. Y., one incubator.

The Cyphers Incubator Company, Buffalo, N. Y., two incubators, one brooder.

FARM REPORT.

The same general policy has been followed on the college farm this year as in previous years, but farm operations have not been attended with the usual success. The comparative failure of a number of our crops is, however, fully accounted for by the abnormalities of the season. First came a period from about the middle of April to about the 10th of June during which we had but little more than one-half an inch of rain. This protracted spring drought, unparalleled, I think, in the recollection of men now living, made the conditions for germination and starting of crops exceedingly unfavorable. Corn required replanting once, and in a portion of our fields twice, and even then the stand was imperfect. The necessity for replanting made the crop exceptionally late at the start; still, with a normal season, fair results might have been obtained. Following the drought, however, came a period of very excessive rainfall and abnormally low temperatures. The summer continued so cold that corn, in common with all other crops requiring relatively high temperatures, made very slow progress; as a consequence, the growth was weak, the crop small, and no part of it ripened. The entire area was put into the silo, but some of it had not reached even such degree of maturity as is regarded desirable for ensilage. The very frequent and abundant rains beginning about the 10th of June rendered the care of all crops, whose growth was relatively feeble, exceptionally difficult. The crops did not furnish the shade, ordinarily of great assistance in keeping down weeds, while the wet condition of the soil and the constant rains rendered frequent cultivation a necessity to keep the fields clean. The cost of caring for our crops, therefore, was exceptionally high. To the credit of the farm superintendent it should be stated that he continued "faithful to the end," and that the fields, in spite of the difficulties, were kept clean.

The only good crops of the year were hay, roots and celery, although potatoes did relatively much better than corn. The nature of the farm operations and the financial results with the several crops are shown in the following table: —

College Farm Crops, 1903.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.*	Labor and Seed.			
Carrots,	½	–	11	$13 50	$23 28	$88 00	$51 22	–
Celery,	1	200 doz. bunches.	–	23 80	64 56	200 00	111 64	–
Corn,	35	–	270	491 05	533 90	945 00	–	$79 95
Hay,	66	–	114.5	–	–	2,061 00	–	–
Rowen,†	41	–	39.25	–	–	228 00	–	–
Potatoes,	11	1,169 large. 150 small.	–	189 45	396 70	701 40 22 50	137 75	–
Turnips,	2	–	6.875	–	19 07	68 70	49 63	–
Mangles,	½	–	25	13 50	35 90	100 00	50 60	–
Japanese millet,	4	100	6 straw.	24 69	48 95	220 00	146 36	–

* One-half value of manure and three-fourths the value of the fertilizers. † Rowen on 25 acres pastured.

System of Manuring.

The manures and fertilizers used for the several crops of the year are shown by the following table. Our practice is to take the manure out from the pits in which it is accumulated, for the most part during the winter, and to spread at that season. Much of it, accordingly, lies upon the surface several months. This manure, spread upon the surface during the winter, is plowed in on the old fields in the spring. If applied to sod land which was fall-plowed, then the manure is worked into the ground with a disc harrow in the spring. The fertilizers used for the several hoed crops, with the exception of the nitrate of soda and about half each of the acid phosphate and the potash, are spread broadcast with a machine on the plowed land, and harrowed in. The nitrate of soda and a part of the phosphate and potash are mixed and put into the drill. For the potato crop, about two-thirds of the fertilizers used are commonly put in the drill; for the small crops, such as carrots, turnips and mangles, all the fertilizers are put on broadcast. For our grass lands, fertilizers where used are applied with Steven's fertilizer distributer in early spring.

Manures and Fertilizers for the Several Crops per Acre.

	Celery, One Acre.	Corn, Thirty-five Acres.	Millet, Four Acres.	Old Mowings, Twenty-five Acres.	Potatoes, Eleven Acres.	Carrots, One-half Acre.	Mangles, One-half Acre.
Manure (cords),	8	4	-	-	-	8	8
Nitrate of soda (pounds),	150	100	100	120	125	200	200
Acid phosphate (pounds),	-	-	-	-	400	-	-
Sulfate of potash, high grade (pounds),	200	125	150	-	250	-	-
Muriate of potash (pounds),	-	-	-	120	-	350	350
Dried blood (pounds),	-	-	-	-	150	-	-
Tankage (pounds),	-	-	-	-	250	-	-
Phosphatic slag (pounds),	500	300	500	300	-	600	600

Experiments in the Use of Manures and Fertilizers.

A. Method of Application of Barnyard Manure.

There is possibly a question whether the practice of spreading the manure upon our fields which are to be tilled, and leaving it upon the surface until spring, is wise. We are testing this question in a field which has a considerable slope, on the grounds of the experiment station, and a statement of the results will be found in the report of the agriculturist. We are testing the same question on level land on the grounds of the college farm. Two plots of one acre each are used in this experiment. This experiment began in 1902. The crop for that year was corn. Manure was applied to these plots at the rate of 6 cords per acre. On the one plot this manure was spread as hauled; on the other it was all placed in one large heap, and from this heap it was spread in the spring just before plowing. In manuring the land alternate loads are taken to the two plots, so that we are reasonably sure that manure of the same quality is used on each.

In 1902 the yields on the two plots were as follows: first acre, winter-spread manure, 3,850 pounds corn on the ear; second acre, manure piled in winter and hauled in spring, 3,510 pounds of corn on the ear. For the past season the crop was Longfellow corn. It did not reach sufficient maturity for husking, and so was put into the silo. The yields were as follows: for the winter-spread manure, 5.95 tons; for the manure piled in winter and spread in the spring, 5.59 tons. It will be seen that for both years the crop on the winter-spread manure has slightly exceeded that on manure piled in winter and spread in spring. The differences in both years, however, are comparatively small, and it is not believed they should be regarded as indicating an advantage in favor of winter-spreading. We are justified simply in saying that, so far, the experiment furnishes no evidence that there has been a loss in the fertilizer value of the manure spread in the winter and left on the surface until spring.

B. Experiments with Nitrate of Soda, Muriate of Potash and Phosphatic Slag on Grass Lands.

Plots of about one-half acre each were laid out on some of the farm mowings in 1899, for experiments in the use of nitrate of soda and muriate of potash, each alone and in combination. The fertilizers applied to these plots from 1899 until the present year were as follows: to one plot in each mowing nitrate of soda was applied annually at the rate of 150 pounds per acre; to another plot, nitrate of soda 150 pounds, and muriate of potash 100 pounds, per acre annually; to the third plot, muriate of potash alone at the rate of 100 pounds per acre annually. The results in one of these mowings which has not been plowed for something like twenty years are of much interest, and they will be briefly reported here. The following table shows the fertilizers applied and the rates of yield in the several years: —

Experiments with Nitrate of Soda and Muriate of Potash on Grass Lands.

FERTILIZERS.	Pounds per Acre.	Yield per Acre (Pounds).				
		1899. First Crop.	1900. First Crop.	1901. First Crop.	1902. First Crop.	1902. Second Crop.
Nitrate of soda, . . .	150	1,960	1,480	2,430	2,230	1,404
Nitrate of soda, . . .	150	–	–	–	–	–
Muriate of potash, . .	100	1,990	1,760	1,730	2,740	2,080
Muriate of potash, . .	100	2,020	1,340	1,930	1,700	1,630

As the result of experiments on the station grounds and of general observation, it was concluded at the end of last year that the product on these plots might be still further improved by the addition of basic or phosphatic slag on some of them. At the same time some changes in the amount of the other fertilizers used were made. The materials applied to the several plots and the rates of yield per acre for the past year are shown in the following table: —

Experiments with Nitrate of Soda, Muriate of Potash and Phosphatic Slag on Grass Lands.

FERTILIZERS.	Pounds per Acre.	Yield per Acre (Pounds).			
		North Plots.		South Plots.	
		First Crop.	Second Crop.	First Crop.	Second Crop.
Nitrate of soda, . .	200	1,450	423	985	640
Nitrate of soda, . .	150	–	–	–	–
Phosphatic slag, . .	500	1,150	721	903	935
Muriate of potash, .	150	–	–	–	–
Phosphatic slag, . .	500	–	–	–	–
Muriate of potash, .	150	1,460*	643	1,275	880

* This plot was cut about a week later than the other two.

Owing to the peculiar character of the season, it is not believed that any of the fertilizers greatly influenced the first crop, and it may be doubted whether the phosphatic slag has yet exercised much influence, as it is well understood that it is a relatively slow-acting fertilizer, especially when left upon the surface. The results for this year, then, as for preceding years, are to be mainly attributed to the influence of the relatively small amounts of fertilizer used previous to the present season.

One of the most interesting points in connection with these experiments is the influence of the fertilizers upon the character of the hay produced and on the proportion of grasses and clovers in the different plots. As was stated last year, the turf on one of these fields (north plots) at the beginning of the experiment was composed chiefly of Kentucky blue-grass, with here and there a few roots of orchard grass and occasionally a clover plant. On the south plots the mowing was reseeded about ten years ago, and there was some timothy and orchard grass, a little clover and considerable Kentucky blue-grass. Where the nitrate of soda is used alone, the product is now made up wholly of grasses, and in the half acre hardly a single clover plant can be found. The product of the plots to which the nitrate of soda and muriate of potash were annually applied, and to which phosphatic slag has now been added, is a good mixture of grass and clover. The product of the third plot, to which potash alone was applied previous to this year, and which now receives potash and phosphatic slag, is very rich in clover, and the character of the turf appears to be improving from year to year. As was stated in my last annual report: "The grasses, which at first did not appear to be much benefited by the application of potash, at the present time appear to be more vigorous than on either of the other plots. It would seem that these are now making use of some of the nitrogen taken from the air by the clovers which are so abundant in this plot. Red clover, which is the prevailing species, is not a long-lived plant. It maintains itself in mowings by seeding, and as the older clover plants die, the grasses growing in the same plot feed upon the products of the decay of the clover roots and stubble; so that in the end we appear to benefit grasses as well as clovers to a marked degree by the continuous use of a fertilizer whose benefits in the first instance are confined almost exclusively to clovers." It is hoped that the application of phosphatic slag, which has now been begun and which will be continued annually, will still further improve the yield on those plots receiving it.

The total cost of the fertilizers applied to the several plots may be readily computed from the following statements: nitrate of soda in the open market costs in considerable quantities about $43 per ton; the phosphatic slag used was imported from England, and laid down in Amherst at a cost of about $12 per ton; the muriate of potash costs in large quantities about $41 per ton.

Live Stock.

During the past year we have had practically no disease among our live stock, with the exception of numerous severe cases of strangles. All our colts and some of the mature horses had this disease; and it most unfortunately terminated fatally in the case of the French Coach stallion "Lance," our most valuable animal. His was a most aggravated attack of this disease, which involved practically all the glands of the throat and head, and ultimately led to pleuro-pneumonia and blood poisoning. Everything possible that veterinary medicine could suggest was done for the animal, but, as post-mortem examination showed, the lesions were so extensive that his case must have been considered as really hopeless almost from the start.

It is a matter for sincere congratulation that the tuberculin test, repeated last winter, showed our herd to be free from tuberculosis.

The kinds and numbers of the several classes of live stock are shown below: —

Horses. — French Coach, 1 stallion, 1 mare, 2 fillies; Percheron, 1 stallion; German Coach, 1 mare; French Coach half-blood, 2 colts; Percheron three-fourths blood, 2 mares; sucking colt, 1; work horses, 5.

Neat Cattle. — Jersey, 1 bull, 3 cows, 2 heifers, 1 calf; Holstein-Friesian, 3 cows, 1 heifer; Ayrshire, 1 bull, 3 cows, 1 heifer; Shorthorn, 1 bull, 1 cow; grade, 36 cows, 10 heifers, 4 calves; total, 68 head.

Sheep. — Southdown, 7 breeding bucks, 50 ewes, 4 lambs; total, 61 head.

Swine. — Berkshire, 1 boar, 5 sows, 5 pigs; small Yorkshire, 2 boars, 1 sow, 5 pigs; Chester White, 8 shoats; total, 27 head.

The Milk Record.

During the past year we have continued the policy of gradually disposing of the least satisfactory milkers in our herd. The average product is not yet entirely satisfactory, but we are undoubtedly making considerable improvement. During the year ten grade heifers have produced their first calves, and many of these have made very satisfactory records. The total number of individuals milked for the year is 42; among these were the ten heifers with first calf above mentioned. The total yield of milk has been 215,-367 pounds, — an average per cow of 5,128 pounds. The average butter fat test for the herd is about 4.2 per cent., which makes the average yield of butter fat per individual cow 218.38 pounds.

Improvements.

The chief improvements of the year are the following: —

About four acres in Durfee pasture, from which the stumps were removed last year, have been plowed and produced a good crop of potatoes. It will be seeded next season. The area devoted to the production of pasture crops for our hogs has been doubled, involving the erection of considerable new hog-proof fence. The New England Anchor fence has been used for this purpose, and promises to give excellent satisfaction.

A number of minor improvements have been made in and about the farm buildings. These include the removal of partitions and laying of cement floors in that part of the barn which was formerly occupied by the boiler and dynamos; the piping of the sheep barn for steam, to be used during the lambing season or after shearing of the sheep in February; the placing of a partition with rolling doors between the sheep and the cattle in the west wing of the barn; the construction of grain bins in the loft of this wing of the barn, with shutes respectively to the sheep floor and the basement where the hogs are kept; and the repainting of the steel roofs of the stable and barns. One of the silos, which has been in use about ten years, was found to need relining; this work has been done in a substantial manner, and the lining has been painted with hot tar.

A large amount of work has been done in grading about the new dining hall and heating plant, and in building new roads and walks connected with these buildings; for this work, however, the farm department has been paid out of the appropriation made for the purpose.

The Farm Finances.

The cash receipts for the year are $9,624.79, and there is due on accounts for sales made during the year the sum of $384.70; this, added to the cash receipts, makes a total of $10,009.49. Last year the similar total was $9,013.59; there is an increase, therefore, for this year of $995.90. The total expenses of this year amounted to $13,593.05. The inventory at the present time amounts to $18,790.85, which is $866.15 greater than the inventory of last year. The cash received during the year has come from the following items: milk and cream, $2,843.33; cattle, including calves for veal, $319.35; horses, including fees for the use of stallions, $859; swine, $682.54; sheep, $133.40; hay, $161.14; potatoes, $550.10; celery, $116.80; team labor, $1,744.53; manual labor, $794.63; onions, $49.98; soy beans, $285; Japanese barnyard millet seed, $317.80; wool, $47.50; pasturage, $21; sawdust, $22.30; lumber, $19.83; ice, $261.46; fertilizers, $57.84; and sundries, $337.06. The increased expenses of the year are accounted for chiefly by the increased cost of caring for crops and fields, due to the abnormal season. Two items, the practical failure of the corn crop and the loss of the stallion "Lance," very nearly account for the financial loss which is the outcome of the operations of the year.

WM. P. BROOKS,
Professor of Agriculture.

AMHERST, Jan. 2, 1904.

MILITARY DEPARTMENT.

Pres. H. H. Goodell, *Massachusetts Agricultural College.*

Sir: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1903.

I have been in charge of the department of military science and tactics during the entire year. The instruction has been both theoretical and practical, and conducted in compliance with college regulations and War Department orders.

Under the provisions of General Orders No. 94, War Department, 1902, this instruction is graded, in respect to the military course, as of the second class, requiring the following minimum of exercises, viz.: —

Practical. — (1) Infantry drill regulations through the school of the soldier, squad, company and battalion both in close and extended order; (2) advance and rear guards, out-posts and marches; (3) the ceremonies pertaining to reviews, inspections and parades, guard mounting and escort of the colors; (4) infantry target practice; (5) instruction in first aid to the injured; (6) a guard to be mounted five times, weather permitting, each week of the college year, and the guard practically instructed for one hour in the posting and relief of sentinels and their duties.

Theoretical. — (1) Infantry drill regulations; (2) the manual of guard duty; (3) small arms firing regulations; (4) army regulations and articles of war; (5) the following records: enlistment and discharge papers, descriptive lists, morning reports, field and monthly returns, requisitions and property returns; (6) lectures, one on the organization of the United States Army, one on patrols and out-posts, one on camps and camp hygiene, three on lines and bases of operations, two on attack and defence of advance and rear guards, outposts and convoys.

This order has been strictly complied with, and additional lectures given on the several subjects. Only seniors and freshmen have been required to take theoretical instruction, each class once per week.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.: —

Mondays, recitation of freshmen, first division, 2.30 P.M.; drill and instruction in the ceremony of guard mounting and duties of sentinels, 3.45 P.M.

Tuesdays, the same practical instruction as for Mondays, with an additional guard at 4.45 P.M.

Thursdays, the same as Mondays, second division of freshmen.

Fridays, recitation of seniors at 4.30 P.M.

Saturdays, inspection of dormitories, including students' rooms, 8.30 A.M.; instruction in guard duty and duties of sentinels, 8.15 to 10.15 A.M. The latter exercise is required only of those students who have incurred demerits in the military department, such as unauthorized absence from drill or inspection, or room not in proper order.

Drills are both in close and extended order; target practice by squad during the drill order hour; battalion drills are usually preceded by parade and review.

The order of drill commences with small squads in the school of the soldier, and proceeds, step by step, with and without arms, until the freshmen become proficient, when they are assigned to companies, after which the exercises include all movements in company and battalion drill.

To avoid tiresome monotony, the drills are varied as much as consistent with official regulations, to embrace field artillery; gallery practice; firing (indoors) at an iron target with a reduced charge of powder, two grains; and Butt's Manual of Physical Drill, the latter in the drill hall during the winter months, when the weather is too inclement to drill out of doors. The progress made from day to day seems tedious, but at the close of the college year the result has been satisfactory.

One hundred and five students have had target practice during the past year, at short ranges, with the Springfield cadet rifle; fair progress has been made, but much more might have been accomplished with more time. This is a subject of the greatest importance, which calls for more time than the schedule permits, but which cannot be remedied without encroaching upon the other departments considered equally important. Only one hour of target practice each regular drill day, during favorable weather, fails to arouse very much enthusiasm. To become a good marksman requires a careful study of the mechanism of the rifle, and frequent practice upon the rifle range under various conditions of weather. If some provision could be made by the State, providing tentage and camp equipage to enable the whole student body to go into camp for one week in each college year, and the time be given to instruction in guard and out-post duty, target practice, construction of shelter trenches and the subject of castrametation, it would, in my opinion, prove of great value; I therefore recommend it.

I also respectfully submit the recommendation that a physician be employed and paid by the State to devote one or two hours each day attending any of the students who may require medical attendance. I am led to make this recommendation by the apparent necessity of it. It is the natural disposition of most men to neglect employing a physician until the illness becomes serious; especially is this the case with young men of limited means, who have to pay for such service, and who have to husband every resource in order to get through college. This reason alone will, I trust, appeal to those who have the interest of the college under consideration in making appropriations. Such a measure will also prevent the spread of contagious disease. The student should be required to pay for the necessary medicine.

The band, under the leadership of Arthur L. Peck, member of the senior class, is doing good work, and merits all the encouragement that has been given it in the way of appropriations. These appropriations have not been large, but sufficient to place the band upon a permanent footing. No provision was made for it last year, but I submit the recommendation that $150 be appropriated for the coming year, made necessary by the following reasons, viz.: two or three new instruments will be required, to replace those that are still the private property of students; also, new music is required from time to time, as occasion arises.

All the buildings under my supervision are in good condition, except that the drill hall is greatly in need of shingling, or what, in my opinion, would eventually prove cheaper, — a slate roof. This recommendation has been embraced in previous reports. The plumbing in all the buildings, as far as I can ascertain, is in good sanitary condition.

Under the provisions of General Orders No. 94, War Department, 1902, the following-named students of the class of 1903 were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown special aptitude in military exercises, viz.: William E. Allen, George L. Barrus and Neil F. Monahan.

Under the provisions of General Orders No. 6, War Department, dated Aug. 24, 1903, the President of the United States authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions of this character that have maintained a high standard, and whose students have exhibited the greatest interest, application and proficiency in military training and knowledge; such appointment to be made after caring for the graduates of the Military Academy at West Point and the successful competitors in the annual examination of enlisted men. This, in my opinion, is a prize of great value, well worth striving for, and should inspire the ambition of every student. There will always be vacancies of this grade in the army to be filled in this way. Although the order provides for the appointment of only one each year from each of the institutions mentioned, yet the others can take a just pride and satisfaction in the honor of helping to raise this college to that high standard, and there is no good reason why we should not accomplish it. An army officered by such young men as this institution graduates will never fail to reflect credit upon the country.

Those who are familiar with the object of military instruction in educational institutions will undoubtedly commend the wise provisions of law and regulations which require it; but, beyond the purpose specifically expressed, it becomes the duty of every instructor of military science to teach those principles of devoted loyalty to our common country, not a mere passive compliance with law, but an aim to higher citizenship, a reverence for the traditions of the country; the benefits that they, as students, derive from it; and an ever-ready willingness to give their best service in upholding the honor of it when such service becomes necessary; a love and respect for the flag as a symbol of those principles upon which our nationality rests. To teach such principles has been and will continue to be my purpose.

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

2 3.2-inch breech-loading steel guns, with implements complete.
2 8-inch mortars, with implements.
2 mortar beds.
2 carriages and limbers for 3.2 B.L. steel rifles.
147 Springfield cadet rifles, model 1884.
147 sets infantry accoutrements.
51 headless shell extractors.
1 set reloading tools.

6 non-commissioned officers' swords, steel scabbards.
14 non-commissioned officers' waist belts and plates.
14 sliding frogs for waist belts.
100 blank cartridges for field guns.
5,000 metallic rifle ball cartridges, calibre 45.
4,000 metallic blank cartridges, calibre 45.
300 friction primers, radial, for field guns.
18,000 cartridge primers, small arms.
9,000 round balls for gallery practice.
35 pounds of powder for small arms reloading.
7,000 pasters, white and black.
185 paper targets, "A" and "B."
1 set of marking rods, disks and brushes for gallery practice.

All of this property is in good condition and well cared for. There is no signal property on hand.

One hundred and ninety-eight students have received practical instruction in the military department during the year, some for only a short period, on account of not remaining in college. These figures include the class of 1903.

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

Commandant.

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

Staff.

Cadet Adjutant, ... HOWARD M. WHITE.
Cadet Quartermaster, ... CLIFFORD F. ELWOOD.
Cadet Sergeant Major, ... MAURICE A. BLAKE.

Company A.

Cadet Captain, ... FAYETTE D. COUDEN.
Cadet First Lieutenant, ... REUBEN R. RAYMOTH.
Cadet Second Lieutenant, ... MICHAEL F. AHEARN.
Cadet First Sergeant, ... SIDNEY B. HASKELL.
Cadet Sergeant, ... FREDERICK L. YEAW.
Cadet Sergeant, ... WILLARD A. MUNSON.
Cadet Sergeant, ... GRENVILLE N. WILLIS.
Cadet Sergeant, ... RAYMOND A. QUIGLEY.
Cadet Corporal, ... GEORGE W. PATCH.
Cadet Corporal, ... THOMAS F. HUNT.
Cadet Corporal, ... BERTRAM TUPPER.
Cadet Corporal, ... ZACHARY T. HUBERT.
Privates, 48; aggregate, 60.

Company B.

Cadet Captain,	CLARENCE H. GRIFFIN.
Cadet First Lieutenant,	HOWARD D. NEWTON.
Cadet Second Lieutenant,	Vacancy.
Cadet First Sergeant,	FRED F. HENSHAW.
Cadet Sergeant,	GEORGE H. ALLEN.
Cadet Sergeant,	JOHN J. GARDNER.
Cadet Sergeant,	EDWIN W. NEWHALL.
Cadet Sergeant,	ALBERT D. TAYLOR.
Cadet Corporal,	WALTER B. HATCH.
Cadet Corporal,	FRANK F. HUTCHINGS.
Cadet Corporal,	LOUIS W. HILL.
Cadet Corporal,	JAMES R. KELTON.

Privates, 46; aggregate, 57.

Band.

Cadet First Lieutenant,	ARTHUR L. PECK.
Cadet First Sergeant,	ERNEST A. BACK.
Cadet Sergeant,	PARKMAN F. STAPLES.
Cadet Corporal,	ARTHUR W. GILBERT.
Cadet Corporal,	JOHN W. GREGG.
Cadet Corporal,	SUMNER R. PARKER.

Privates, 14; aggregate, 20.

Total in military department: 2 captains, 4 first lieutenants, 2 second lieutenants, 1 sergeant major, 2 first sergeants, 9 sergeants, 11 corporals, 108 privates; aggregate, 149.

Respectfully submitted,

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

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

I. Condition and Progress of the Institution, Year ended June 30, 1903.

The time for the commencement of elective courses has been shifted from senior year to the beginning of junior. This change has been made in the direct interest of the students, to allow them greater choice of subjects and a longer time for pursuing them. A course in agricultural physics is now offered, and connected courses in landscape gardening, horticulture, floriculture and the care and management of greenhouses have been opened. The State has erected and equipped, at a cost of $40,000, a dining hall capable of accommodating 400 students, and furnishing lodging for 15 or 20 female students. In like manner the State has installed, at a cost of $46,505, a heating and lighting plant, which is now in satisfactory use in ten of the college buildings.

II. Receipts for and during the Year ended June 30, 1903.

1. State aid: —	
(*a*) Income from endowment,	$4,263 22
(*b*) Appropriation for current expenses,	33,000 00
(*c*) Appropriations for building or for other special purposes,	86,505 00
2. Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) Additional endowment, act of Aug. 30, 1890,	16,666 66
(*c*) For experiment stations, act of March 2, 1887,	15,000 00
3. Fees and all other sources,	2,824 39
Total,	$165,559 27

III. Property, Year ended June 30, 1903.

Value of buildings,	$248,775 00
Value of other equipment,	124,358 62
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60
Value of farm and grounds,	$42,000 00
Number of acres of land allotted to State under act of July 2, 1862,	360,000
Amount of land grant fund of July 2, 1862,	$219,000 00
Amount of other permanent funds,	141,575 35
Number of bound volumes in library, June 30, 1903,	25,258

IV. Faculty during the Year ended June 30, 1903.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	23
2. Number of staff of experiment station,	20

V. Students during the Year ended June 30, 1903.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	177
2. Graduate courses,	7
Total, counting none twice,	184

APPENDIX.

EXPLANATION OF PLATES.

[All the figures greatly enlarged.]

PLATE I.

FIG. 1.—Larva of second instar (crawling young).

FIG. 2.—Antenna of same.

FIG. 3.—Leg of same.

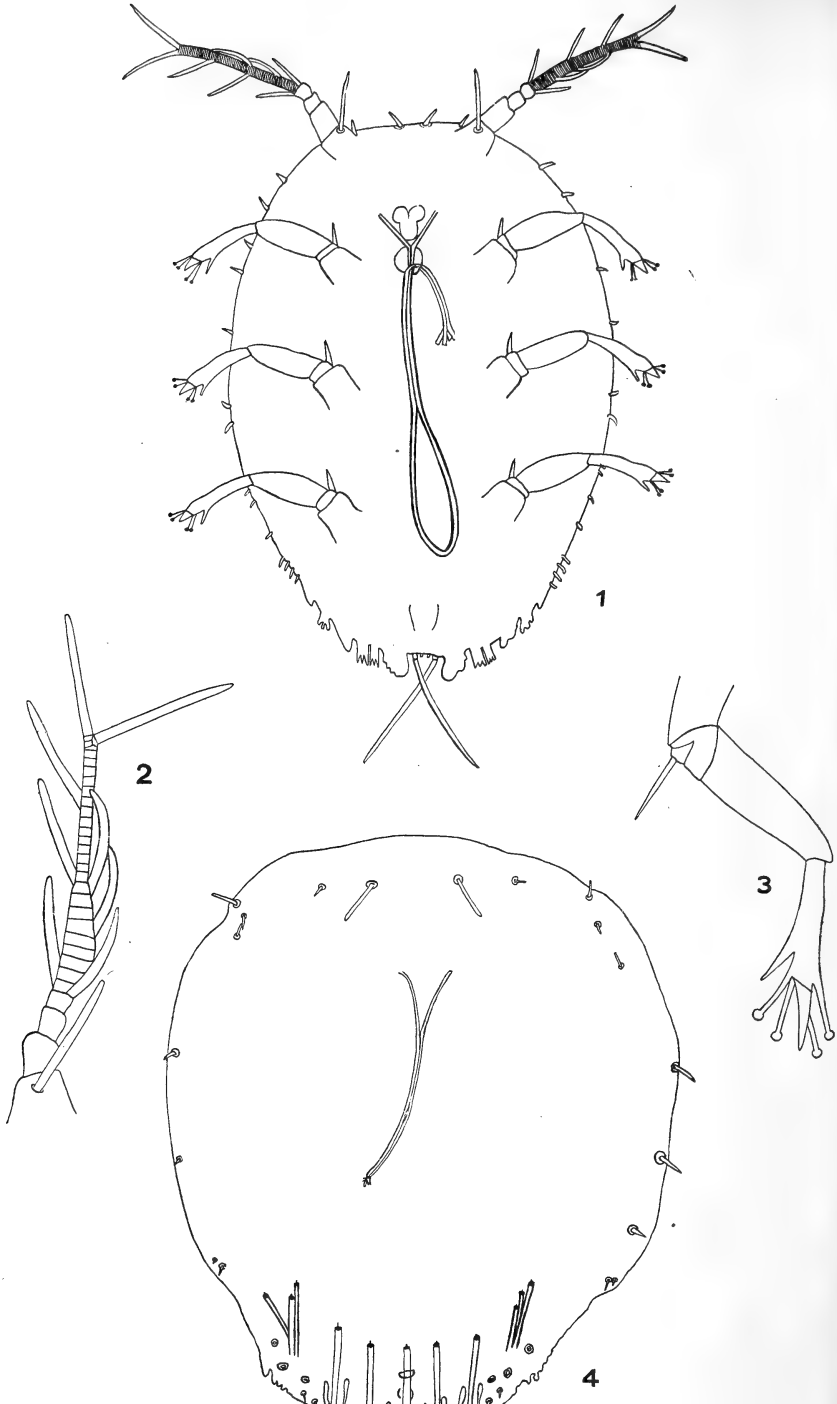
FIG. 4.—Third stage, female.

PLATE II.

FIG. 1.—Adult female.

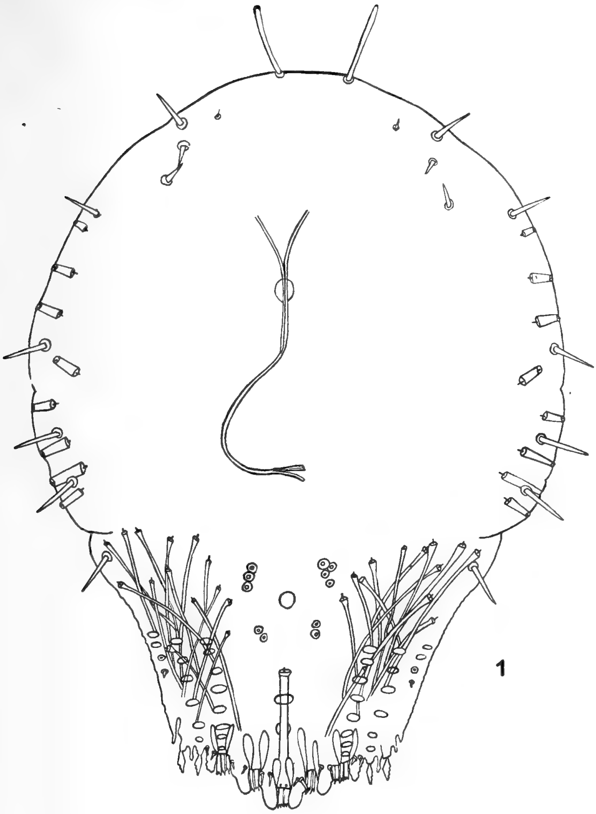
FIG. 2.—Pygidium of female, third stage.

FIG. 3.—Pygidium of female, adult.



H. E. Hodgkiss del.

Plate 1.



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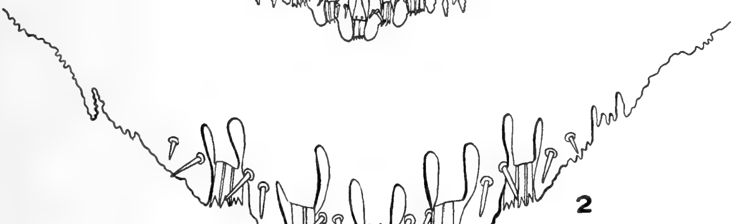

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H. E. Hodgkiss del.

Plate 2.

THE LIFE HISTORY AND TREATMENT OF A COMMON PALM SCALE.

(*Chrysomphalus dictyospermi* Morgan.)

BY HAROLD E. HODGKISS, B.SC.

Entomological Laboratory, Massachusetts Agricultural College.

This paper is the result of a request from Mr. W. R. Pierson of Cromwell, Conn., for advice on the control of a troublesome coccid in his large palm houses. The writer is greatly indebted to Mr. Pierson for the material with which to make his investigations.

While at work on the treatment it seemed advisable to trace the life history, and to determine, if possible, the true systematic position of the insect, which was found to be a common palm scale, — *Chrysomphalus dictyospermi* Morg. Keeping in mind the fact that the typical *Chrysomphalus dictyospermi* Morg. is not known, the strikingly close resemblance of the named varieties, and the difference between the puparium of the type and of each variety, the writer holds that the species herein described is too close to the type to be distinguished under a varietal name.

It has also seemed wise to present the early stages according to a plan which is not accepted by all, but which seems desirable to most entomological workers. I here regard the ovum as the first instar, the escape from the ovarian membranes as the first ecdysis, etc.

Life History.

First Instar. — Ovum, elongate oval; .15 to .16 mm., longest diameter; .10 to .11 mm., greatest width; amnion transparent, thrown off when the young are thrust out from the body of the parent.

This instar is found entirely within the body of the female. During this period the segmented appendages — legs, antennæ and mouth parts — are formed; spines and a rudimentary pygidial fringe also appear; a pair of medium lobes is quite prominent at this period.

Second Instar (Plate I., Fig. 1). — Elongate oval; length, .60

mm.; width, .40 mm.; color, light yellow. Antennæ with five segments, the distal one twice as long as segments two, three and four together; ringed, and terminating in two long, chitinous hairs; six slightly shorter hairs are situated on this segment, also one hair on the anterior face of the proximal segment.

Legs: coxa large, trochanter smaller, femur much swollen; tarsi represented by a slightly hooked projection. On the upper face of the trochanter is a long, chitinous hair, and near the distal end of the tibia is a projection or spur. The tarsal hook is surrounded by four knobbed hairs. The mouth parts are specialized to form a long, sucking tube or rostral filament. The pygidium is not distinctly constricted. The pygidial fringe shows the following characters: median lobes prominent, large, serrated on the lower lateral margin; second pair of lobes very slightly produced and sometimes faintly serrated; third pair of lobes rudimentary. Between the median lobes are two long, chitinous hairs; the median and second pairs of lobes are separated by two simple plates, and between the second pair of lobes and the rudimentary lobes is one simple plate.

Four small spines mark the adult abdominal constrictions. Between the antennæ are two chitinous hairs, and another is situated just above the basal segments of each antenna. Other hairs are shown in Plate I., Fig. 1.

During the first few hours of this instar the insects are crawling larvæ. Soon after birth, waxy filaments are seen exuding from pores of the body. Within twelve hours after birth the larva becomes quiescent, and the filaments, at first transparent, begin to form an opaque covering; this gradually darkens, the upper surface having the appearance of a hoary incrustation. As the scale grows, it becomes nipple shaped, with a depressed area around the centre.

Second Ecdysis. — About ten days after the larva emerges the second molt occurs; at this period the legs and antennæ are thrown off with the larval skin. From around the margin of the first larval covering a new secretion forms, flattening toward its circumference, or, in a few specimens, rising to form a more or less well-defined circular ridge. The hoary incrustation is present only on the more elevated part of the nipple, where it persists even in the fourth instar.

Third Instar (Plate I., Fig. 4). — Pale yellow; .54 mm. long by .46 mm. cephalic width; not as distinctly pyriform as in adult; body slightly constricted cephalad; spines similar to adult; pygidial fringe showing lobes, plates and spines as in the adult, but slightly smaller. Rudimentary projections of the body chitin occur beyond the third pair of lobes. Tubular spinnerets are present, but at this time are incompletely developed. Anus just above the median lobes. Antennæ replaced by a pair of antennal hairs. Rostral filaments present.

The pygidial lobes become more prominent and more distinctly constricted on their outer lateral margin. The median and second pairs of lobes lose their serrated lateral margin, while the third pair becomes distinctly serrated on the outer margin. The chitinous projections beyond these lobes are in different degrees of development, and do not assume the hastate form peculiar to the adult until the next instar. The hairs between the median lobes (second instar) are replaced by a pair of simple, fringed plates. The plates between the second and third pairs of lobes have increased to the normal number, — three. There is a slight cephalic constriction of the body.

In all coccids at this period there is, generally, a distinction between the sexes. Much time was spent in trying to rear males of this species from the material at hand, but without success; all the young coccids eventually became adult females, and in their turn produced other females only.

Third Ecdysis. — About eighteen or twenty days after casting the first larval skin the insect molts again, this time to assume the adult form. The larval skin becomes surrounded by a flattened, thin secretion, covering the adult insect; and very often this becomes interwoven with the epidermis of the plant, so that the color and texture of the scale is difficult to determine.

Puparium, or Scale of Adult Female. — This is circular or elongate oval; ochreus brown to castaneus, and in older specimens often whitish. Exuviæ central, or nearly so, ochreus, shining; first larval secretion with a central boss and ring; second secretion with or without a well-defined ring; margin flattened to epidermis of leaf, by which, in many cases, it seems to be covered; ventral scale a thin secretion on the leaf. Diameter 1 to 1.75 mm.

Adult Female (Plate II., Fig. 1). — Pyriform; light yellow; pygidium large, broad at apex, slightly angular; cephalic area slightly constricted; abdominal segments distinct; antennæ present as antennal hairs; rostral filaments longer than body. The pygidium shows the following characters: edge with three pairs of large subequal lobes, their inner lateral margins concave for about one-half their length, abruptly rounding; the outer lateral margin distinctly notched, giving a bilobed appearance; the second pair of lobes similar in shape, but smaller; the third pair smaller, the outer lateral margin of each distinctly serrated. Five pairs of vasiform thickenings of the chitinous integument are situated above and continuous with the margin above the lobes; one pair at the base of each median lobe, one thickening at the inner base of the second pair of lobes and one between the second and third lobes on each side, also one over the inner base of the third pair of lobes. Between the median lobes are two simple, fringed plates, and between the median and second lobes are two plates fringed in a somewhat similar manner; there are three plates between the second and third lobes, the inner plates narrow, elongate, and with lateral serrations, the outer plate wide and with a long fringe. Beyond the lobes are two well-developed hastate projections from the border, serrate on the outer lateral margin. Other projections from the border of the pygidium occur, but these seem to be without special or typical form; they are generally narrow outgrowths of the chitin, about one-half the length of the hastate projections. At the base of each lobe two spines are found, and another occurs beyond the serrations on each side of the pygidium; other spines on the body are shown in Plate II., Fig. 1. Tubular spinnerets are present, the longest extending to the articulation of the pygidium with the preceding segment; a single median spinneret arises from a pore between the median lobes. Circumgenital glands are present in four groups, and generally 4/2, 4/2, but vary considerably, so that the range is $\frac{3,\ 4,\ 5}{2}$, the lower laterals invariably being 2. The adult female is viviparous.

About a week or ten days after the last molt ova may be seen within the female, and the life history is complete, the time required for this ranging from thirty to forty days. The female gives birth to larvæ for a period of about two weeks, during the first part of which the young are the most abundant. The number of young produced by one female is not greater than twenty-five, the average about twenty. The generations run into each other, and no definite time can be stated at which to expect the young, the conditions of each habitat being found to govern the rapidity of reproduction.

Adult Male. — True male not known. As stated above, all the attempts to secure the male of this species have been unsuccessful. As a result of this, and also from statements of other writers that "the perfect male is unknown," it is safe to conclude that in this region, at least, no male form is present, and, this being true, the female must be considered as parthenogenetic.

Food Plants. — The following food plants are given in "Coccidæ of the World:" *Dictyospermum album*, *Erythrina indica*, *Cycas*, *Latania*, palms, rose, mango, etc.

Parasite. — A hymenopterous parasite has been reared from material of *Chrysomphalus dictyospermi* at hand, and proves to belong to the family *Chalcididæ*, sub-family *Aphelininæ*. A specimen sent to Washington, D. C., was determined by Dr. W. H. Ashmead as *Aspidiotiphagus citrinus* Craw.

Systematic Position.

The original description of the type does not give an exact picture of the insect described; on the other hand, it provides considerable latitude within which to place other representatives of the same species. The varietal forms also show a similar latitude, and a critical study indicates considerable variation from what is generally considered as being the typical form.

One of the differences is in the third pair of lobes. The type is described as having the outer lateral margin serrated; * in the variety *arecæ* Newst. no mention is made of serration on these lobes; † in the description of the variety *pinnulifera* Mask., as described under the name *jamaicensis* Ckll., ‡ no reference is made to serrations on these lobes; the variety *mangiferæ* Ckll., once described as a separate species, but now known to be a variety of this insect, has serrated third lobes, but also rudimentary fourth lobes.§ My description follows the type in detail, but differs from the variety *mangiferæ* in showing no trace of rudimentary fourth lobes.

Another difference is in the fringing of the interlobal plates. Here, again, the descriptions of type and varieties allow a wide range; probably the most noticeable difference may be seen between the variety *arecæ* Newst. and the one herein described. The former is described as having short, fringed plates; ‖ the figure gives them an even, regular fringe; my description and figure show an irregular fringe, similar to the type figure.

A third difference is noticed in the hastate projections beyond the third lobes. The type is described and figured as having two, serrated on the outer lateral margin; ¶ the varieties have from two

* Ent. Mon. Mag., Vol. XXV., p. 352 (1888-89).

† Mon. Brit. Coccidæ, Newst., Vol. I., p. 107, Plate XII., Fig. 6 (1900).

‡ Can. Ent., Vol. XXVI., p. 129 (1894).

§ Bull. 6, T. S. Div. of Ent., United States Department of Agriculture, p. 24 (1897).

‖ Mon. Brit. Coccidæ, Newst., Vol. I., p. 107, Plate XII., Fig. 6 (1900).

¶ Ent. Mon. Mag., Vol. XXV., Plate 5, Fig. 2.

to five, and not all are serrated laterally; my description shows two hastate projections, serrated on their outer lateral margins; it also shows other chitinous projections, the shape and size of which are not definite, and, not being constant, may be ruled out of this discussion.

The well-known differences in the color of the puparium may also be considered. This may vary, however, under different climatic conditions to which it may be subjected. As has been noted, the puparia under observation have a tendency toward a lighter coloration than those hitherto described.

If we can accept the above statement as an explanation of the discrepancy between the type and its known representatives, and then weigh the very slight differences between the type and the insect herein described, as shown by the above comparison, there seems to be good ground to consider this insect as being too near the type to be given a varietal name; therefore, I conclude that this species is the *Chrysomphalus dictyospermi* described in Ent. Mon. Mag., Vol. XXV., p. 352 (1888–89). The bibliography on this species may be found in the "Coccidæ of the World."

Economic Importance.

This scale insect infests greenhouses in greater or less abundance, the physiological condition of the food plant being the factor which determines its increase or decrease. The importance of this palm scale is generally realized only in large palm houses, one palm grower expending about $2,000 per year to check its ravages, and it may be safely stated that many other florists have as large an expense account against this small insect.

The cause of this damage is the method by which the insect procures its nourishment. This is obtained by thrusting its rostral filament through the epidermis of the leaf, and drawing out its fluid nourishment from the tissue. As this process is continued, the epidermis becomes covered with minute punctures, each surrounded by a yellowish ring. This is a serious detriment to the plant, impairing its value, as well as making it unsightly for decorative purposes. The unsightly appearance of the infested plant thus lowering its market value seems to be the only reason for the importance the scale has obtained. In all the plants under observation only one died, and that was not due to the effect of this insect.

Remedies.

Treatment of scale insects can be effected, generally, in one of two ways, or by both together. Sometimes one will fail entirely, and the other will prove partly efficient.

In experimenting for the remedies, the method of soap washes was abandoned because in practical use against this palm scale it had failed to fulfill the requirements. The writer, having used these washes and seen their inefficiency, and having known the experience of one of the largest palm growers in the country, soon abandoned experiments along that line. The alternative method was by fumigation. The most effective fumigant known for coccids is hydrocyanic acid gas, and this seemed also the most feasible, since cheapness as well as efficiency was desired. The data on the experiments with this substance are given below.

The experiments were made at the insectary of the Massachusetts Agricultural College, under the supervision of Prof. C. H. Fernald and Dr. H. T. Fernald, to whom I am much indebted for valuable hints and suggestions on the preparation of this paper.

In order to isolate the palm from other plants in the greenhouse, a fumigating box was used, containing about 15 cubic feet of space, and perfectly tight. The palms were kept under the same conditions as in any greenhouse, and the results of the experiment can thus be directly applied.

Cost of potassium cyanide (KCN), about 50 cents per pound; of sulphuric acid (H_2SO_4), from 2½ to 10 cents per pound, according to the quantity purchased.

Data of Experiments.

1. Rate, .075 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day clear, cool; temperature, 62° F. Foliage covered with moisture in spots; fumigated from 4.30 to 5 P.M., after sun was low, but while quite light. Results: scales partly killed, new growth on plant slightly injured.

2. Rate, .075 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day dull, rainy. Foliage covered with moisture; fumigated from 4.30 to 5.10 P.M., after sun was low, but yet quite light. Results: scales dead, new growth badly injured.

3. Rate, .10 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day cloudy, wet; temperature, 58° F. Plant free from moisture; fumigated from 5.30 to 6.10 P.M.,

after sun was low, but not dark. Results: scales dead, old and new growth badly injured.

4. Rate, .15 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day cool, clear; temperature, 59° F. Plant free from moisture; fumigated at 5.30 P.M., after sun was low, but while quite light. Results: scales dead, new growth badly injured.

5. Rate, .2 gram KCN per cubic foot of space; length of fumigation, thirty minutes. Day clear, cool; temperature, 58° F. Plant free from moisture; fumigated at 6 P.M., at dusk. Results: scales dead, tips of new growth badly injured.

6. Rate, .2 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day cool, cloudy; temperature, 58° F. Plant free from moisture; fumigated at 5 P.M., during fading light. Results: scales dead, palm very badly injured.

7. Rate, .25 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day clear, cool; temperature, 65° F. Plant free from moisture; fumigated at 5.30 P.M., daylight. Results: scales dead, only old growth present, very slightly injured.

8. Rate, .05 gram KCN per cubic foot of space; length of fumigation, forty minutes. Day rainy; temperature, 45° F. Fumigated at 11 A.M., daylight. Results: scales not killed, young growth showed serious injury some weeks afterward.

9. Rate, .075 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day dull, sky overcast, but sun came out after experiment began; temperature, 50° F. Fumigated at 11 A.M., daylight. Results: palm quite sensibly injured, scales dead; young growth only.

10. Rate, .075 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day cool, clear; temperature, 50° F. Plant free from moisture; fumigated at 5 P.M., after sundown, dark. Results: no injury to young growth.

11. Rate, .10 gram KCN per cubic foot of space; length of fumigation, ten minutes. Day cool, clear; temperature, 50° F. Plant free from moisture; fumigated after sundown in total darkness. Results: no damage to young growth.

12. Rate, .075 gram KCN per cubic foot of space; length of fumigation, thirty minutes. Day cool, clear; temperature, 55° F. Plant free from moisture; fumigated after dark. Results: no injury to plant.

13. Rate, .075 gram KCN per cubic foot of space; length of

fumigation, forty minutes. Day cool, clear; temperature, 40° F. Plant free from moisture; fumigated after sundown in total darkness. Results: no damage to young growth.

14. Rate, .10 gram KCN per cubic foot of space; length of fumigation, twenty minutes. Day clear, cool; temperature, 40° F. Plant free from moisture; fumigated after sundown, in total darkness. Results: no injury to plants.

Results and Recommendations.

The above experiments were made with reference to the many conditions to which the plants are subjected in the greenhouse. Varying conditions of heat, moisture, daylight and darkness have been studied, until it has been clearly shown that the plants must be treated after dark, and the foliage must be free from moisture, to obtain the best results. If fumigated before dark, the plants are more likely to show the effects of treatment, although none will be killed; even the largest amount of potassium cyanide used has failed to kill the entire palm, but the injury was too serious to warrant further experiments with large amounts. Palms treated in daylight with a small amount of cyanide, and injured, have been uninjured when that same amount was used after dark.

Palms on which water remained during fumigation were injured by an amount of the gas which could be used without danger to plants free from moisture, and the part affected was only that portion of the leaf on which the water remained. In order to kill the insect, the experiments show that a relatively large amount of potassium cyanide must be used; while a larger amount can be used for a shorter period of time without injury to the tender young growth, and with complete destruction of the insects, providing the fumigating is done after dark.

The exact amount of potassium cyanide to recommend for use in any greenhouse is difficult. The difference in the tightness of different houses naturally calls for a greater or less amount of gas to be generated. The danger attending its use can never be too greatly emphasized; and, for the assistance of those not acquainted with its preparation and use, I recommend the book, "Fumigation Methods," by Johnson.* This work is indispensable to any one who has occasion to use hydrocyanic acid gas as an insecticide.

Potassium cyanide to the amount of .075 gram per cubic foot of space for a period of forty minutes destroys all the scales, without

* Orange, Judd Company, Nos. 52 and 54 Lafayette Place, New York City. Price, $1.

injury to the tenderest growth. A maximum amount that can be safely used is .10 gram per cubic foot of space for a period of twenty minutes; but for ordinary palm fumigation the smaller amount will prove to be the better.

Attention to a proper airing of the house is of great importance, and must be accomplished by means of ventilators opened from the *outside*. The house should be aired for a period of thirty to forty minutes after fumigation before any one enters.

The recommendations may be summed up in the following: —

1. Use .075 gram KCN per cubic foot of space for forty minutes, or a maximum of .10 gram per cubic foot of space for twenty minutes. The minimum amount is preferable.
2. Have palms free from moisture.
3. Fumigate only after dark.
4. Prepare suitable ventilation to be used after fumigation.
5. Open house for forty minutes after fumigation, and then close for the night.
6. *Keep out of the house until it is thoroughly ventilated.*

SIXTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1904.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

HENRY H. GOODELL, LL.D.,	*Director.*
WILLIAM P. BROOKS, Ph.D.,	*Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Chemist* (fertilizers).
JOSEPH B. LINDSEY, Ph.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
FREDERICK R. CHURCH, B.Sc.,	*Assistant Agriculturist.*
NEIL F. MONAHAN, B.Sc.,	*Assistant Botanist.*
HENRI D. HASKINS, B.Sc.,	*First Assistant Chemist* (fertilizers).
——— ———	*Second Assistant Chemist* (fertilizers).
RICHARD H. ROBERTSON, B.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).
WILLIAM E. TOTTINGHAM, B.Sc.,	*Assistant Chemist* (foods and feeding).
ALBERT PARSONS, B.Sc.,	*Inspector* (foods and feeding).
JOSEPH G. COOK, B.Sc.,	*Assistant* (foods and feeding).
——— ———	*Assistant Horticulturist.*
——— ———	*Assistant Horticulturist.*
FRED. F. HENSHAW,	*Observer.*

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

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

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.

No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 85. Concentrated feeds.
No. 86. Orchard treatment for the San José scale.
No. 87. Cucumbers under glass.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 91. Injuries to shade trees from electricity.
No. 92. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903.

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

ANNUAL REPORT

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

For the Year ending June 30, 1903.

Cash received from United States Treasurer, . .		$15,000 00
Cash paid for salaries, ...	$6,829 37	
for labor, ...	3,216 52	
for publications, ...	860 08	
for postage and stationery, . .	360 32	
for freight and express, . .	130 65	
for heat, light, water and power, .	355 77	
for seeds, plants and sundry supplies,	810 76	
for fertilizers, ...	716 85	
for feeding stuffs, . . .	587 17	
for library, ...	56 18	
for tools, implements and machinery,	196 13	
for furniture and fixtures, . .	35 03	
for scientific apparatus, . .	87 90	
for travelling expenses, . .	105 50	
for contingent expenses, . .	121 00	
for building and repairs, . .	530 77	
		$15,000 00

Cash received from State Treasurer, . .	$11,200 00	
from fertilizer fees, . .	4,215 25	
from farm products, . .	2,298 12	
from miscellaneous sources, .	3,291 04	
		$21,004 41
Cash paid for salaries, ...	$10,303 59	
for labor, ...	2,446 47	
for publications, ...	353 03	
for postage and stationery, . .	254 39	
for freight and express, . .	45 41	
Amount carried forward, . . .	$13,402 89	

Amount brought forward,	$13,402 89	
Cash paid for heat, light, water and power,	605 03	
for chemical supplies,	1,025 44	
for seeds, plants and sundry supplies,	378 43	
for fertilizers,	14 38	
for feeding stuffs,	700 36	
for library,	27 91	
for tools, implements and machinery,	39 54	
for furniture and fixtures,	1 50	
for scientific apparatus,	195 41	
for live stock,	61 45	
for travelling expenses,	694 94	
for contingent expenses,	245 86	
for building and repairs,	412 71	
Cash on hand,	3,198 56	
		$21,004 41

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1903; that I have found the same well kept and classified as above; and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance in the treasury.

CHARLES A. GLEASON,
Auditor.

AMHERST, Sept. 2, 1903.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The close of the present year completes a period of fifteen years of meteorological observations at this station. From the records obtained during this time the mean values of the several weather elements for each month have been computed, and the results will be used as the normals of this station for the purpose of comparison. Charts showing the more important meteorological data are being prepared for the exhibit of this division at the St. Louis Exposition.

Last year, when this station arranged to furnish the United States Weather Bureau with the usual voluntary observer's records, the advisability of changing our times of observation from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., to conform to the times of observation at other stations, was considered, and it was thought best not to make the change at that time. Our printed forms for permanent record being all used, it was thought best to provide for the above change in preparing new record books. This has accordingly been done, and the change from tri-daily to semi-daily observations will be made at the close of a five-year period, on Jan. 1, 1904. The records being largely controlled by our self-registering instruments, the change should not appreciably affect our results for comparison with the normals already deduced.

The usual 4-page bulletins, giving the more important daily records, with the monthly means and summary of the weather, have been issued the first of each month. An annual summary will be prepared and published as a part of the December bulletin.

The local forecasts sent out by the New England section of the United States Weather Bureau have been received during the year, and the signals displayed from the flagstaff on the tower. These forecasts having come this year by the Postal Telegraph and Cable Company, instead of the Western Union Telegraph Company, as formerly. Our telegraph line to the college has been out of service most of the year, and the predictions have been obtained by telephone, causing considerable inconvenience and delay in displaying the signals. Arrangements were finally made with the Postal Company, whereby they connect with our line to the college at the corner of Amity Street and Lincoln Avenue, they maintaining a line from their office to that point, and this division controlling the line from that point to the tower. The receipt of the forecasts by telegraph at the tower was resumed about December 1.

At the request of the section director of the Weather Bureau, the weekly snow reports are being sent to the Boston office, as in previous years.

Two standard thermometers, reading to one-fifth degree F., were purchased during the year, to replace others broken in use. Three new clocks for the Draper instruments in the tower were also bought, to replace others that were worn out.

REPORT OF THE BOTANISTS.

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

Besides the general correspondence work relating to the diseases of plants, which is constantly increasing each year, this division has continued its usual experimental work in the greenhouse on various market garden and floricultural problems.

During the past year this division has published two bulletins, entitled, "Cucumbers under Glass," issued as Bulletin No. 87; and "Injuries to Shade Trees from Electricity," which was issued as Bulletin No. 91.

From the pathologist's point of view, the past season has shown some resemblance to the preceding one. Both seasons have been peculiar, as demonstrated by the second blossoming of a large number of plants and the general upsetting of their seasonal habits. There has been an absence of some fungi, which usually occur more or less commonly, and a predominance of others which generally do not cause much damage. Some indications of the pink mold, a so-called attendant of apple scab, which made its appearance last year for the first time in this State, has shown itself again, although trouble from this fungus has not been serious in this State. The sooty mold of greenings, etc., has been unusually abundant the past two years where spraying has not been properly attended to, causing much disfiguration of the fruit. Considerable damage was done to pear trees by lice, which profusely secreted honey dew on the foliage and stems, thereby furnishing conditions for the luxurious development of a black mold on the stems and leaves, causing much injury to the latter.

The raspberry cane blight, recently described by Prof. F. C. Stewart,[1] has been noted in this State, and specimens have been sent to Professor Stewart, who has reported upon them. How common this disease is, or is likely to become, we are at present not able to say. There has been, moreover, an unusual amount of winter-killing of raspberry canes, resulting from the unusual conditions of the fall of 1902.

Some complaint has been made in regard to a potato stem rot, a disease which is apparently more common in Vermont, where it, with other potato diseases, is receiving serious attention by Prof. L. R. Jones.

An unusual leaf spot disease for this region was noted on corn. This was caused by the fungus *Helminthosporium inconspicuum* C. and E., which gave the leaves a badly spotted appearance, and in one instance rendered the crop practically useless. Probably the extremely abnormal corn weather during the past summer was responsible for this.

A fungus known as *Vermicularia trichella* Fr. caused considerable spotting and damage to the leaves of the English ivy (*Hedera helix*, L.). There has been a minimum number of the usual shade tree fungous blights, although the blight of the horse-chestnut leaves, caused by the fungus *Phyllosticta sphæropsoidea* Ell. and Ev., was troublesome, and a considerable amount of defoliation occurred to maples from sun scorch. The Norway maple leaves were also greatly lacerated by the winds at the time of unfolding, and they were literally covered with honey dew, which in some cases resulted in the development of a black mold on them.

The stem rot diseases of the carnation, aster, campanula, etc., have been rather common on out-of-door plants. The usual blights of the melon and cucumber were present, but these crops did so poorly that the fungus had little material to work on. The general consensus of opinion among growers of melons and cucumbers is that spraying does little or no good when the anthracnose and alternaria are present. This is especially true of the melon, where all attempts at spraying, even when frequently attended to, failed to hold these fungi in check.

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[1] Geneva, N. Y., Experiment Station, Bulletin No. 226, December, 1900.

The most general complaint, however, during the spring and summer, was in regard to winter-killing. It is seldom one finds so many varieties of plants injured from this cause, which can be traced back to the unusually prolonged warm weather, characteristic of the fall of 1902, and the sudden freeze following in early December. Among the plants that have suffered to a considerable extent are the following: —

The Californian privet (*Ligustrum ovalifolium*) and *Ligustrum ibota* were in many cases killed outright. Yellow and crimson rambler roses and certain honeysuckles were killed to the ground. The climbing ivy (*Ampelopsis veitchii*) was badly damaged, so much so, in fact, that buildings that were tolerably well covered with this beautiful ivy were almost bare in mid-summer. Wistarias, deutzia, spiræa thunbergii, spiræa vanhouttei and forsythia had their flower buds injured so severely that they made little show in the spring. The Japanese clematis was in most cases killed to the ground. Euonymus radicans suffered badly, as did many of the viburnums. Many of the choicer aquilegias were killed outright. The fruit buds of cherries, peaches and Japanese plums were practically killed; in some cases the wood was much injured. Grape vines were in some cases killed to the ground, and strawberries, blackberries and raspberries were much injured. Such wild plants as the beech, plum and buckthorn, and many of the wild roses, had their wood severely injured. Many of these plants appeared to come through the winter successfully, and threw out strong shoots in the spring, when they suddenly collapsed. Blackberries and raspberries showed a marked tendency to die back after having blossomed and fruited. In some other instances plants not supposed to be hardy, such, for example, as the crimson clover and alfalfa, have gone through the winter without trouble. It would appear that, while the severe frost in December, following the unusually prolonged warm spell, was the means of doing great injury to plants that are supposed to be tolerably hardy, those like the crimson clover, etc., which are not hardy, were not affected. The limited amount of frost in the ground, due to the snow cover, eventually proved advantageous to such plants as the crimson clover and alfalfa. It is probable that the unusually slight amount of moisture present in the soil during the past spring had much to do with weakening many plants which might have made some recovery under other conditions.

We append to this report some experiments relating to the influence of electricity on the growth of plants, which have been carried on by us and students in a minor way for some years. Notwithstanding the considerable accelerated growth that electrical stimulation is capable of giving rise to, these experiments are not presented with any idea in mind that they furnish evidence of legitimate lines of forcing, or that the matter will be taken up by practical growers as a means of increasing their crops, especially at the present time. There are many legitimate lines of increasing and improving crops of which growers have not as yet made full use, and, so long as such exist, the wisest policy to pursue is to pay little attention to the so-called freak farming methods. This subject is, moreover, an especially complicated one, and it is a question whether it would be of much value to those who are following commercial methods, even if considerable gain could be obtained. All stimuli to plants are by no means advantageous from the commercial point of view, inasmuch as they do not always induce acceleration in the right direction, since the law of correlation holds good in the plant kingdom, as elsewhere. Whether the scarcity of forcing elements or the development of more refined methods of the gardening of the future will induce gardeners to utilize the various cosmic forces which act as stimuli, and which are not employed at the present time, remains to be seen.

THE INFLUENCE OF CURRENT ELECTRICITY ON PLANT GROWTH.

BY G. E. STONE.

Since 1747, when Dr. Mainbray of Edinburgh electrified two myrtle plants, various experiments have been made to test the effects of electricity on the growth of plants. Many marvelous results have been reported from time to time that have arisen from electrical treatment, and, as a rule, the more ignorance the experimenter displayed in his knowledge of plant physiology, the more startling and marvelous have been the results.

At the time our experiments were undertaken we were unable to find instances where any attempt had actually been made to study, in a methodical way, the influence of current electricity on plants; and in practically all of the previously recorded experiments the data were scant and the scope of the work was extremely limited. In the various haphazard results that had been reported from time to time there had been no attempt made to measure the current or resistance, or to ascertain the electro motive force employed in any of the experiments from which remarkable deductions had been drawn. One of the criticisms which can be made in regard to all of the earlier work, as well as most of the later work, is that, with a very few exceptions, only a few plants were employed in experimenting, — frequently only one or two. As a consequence, the errors arising from individual variation were entirely ignored, since enough plants were not employed to eliminate them. Indeed, in numerous cases the results obtained were nothing more than would be obtained from individual variation, or would naturally arise from a slight difference in environment. The limited amount of current which we have shown to act as a stimulus to plant growth would indicate that in some cases they were not in the range of acceleration (see Fig. 1). That plants respond to electrical stimuli in various ways is well known. The effect, however, which electricity has upon the growth of plants has not been well understood, and the results obtained by various experiments have not been convincing, for reasons already pointed out. The fact has been definitely established that

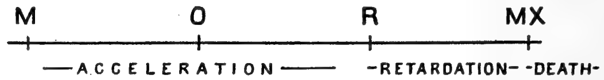

FIG. 1.—Diagram showing range of electric current affecting plants. M, minimum; O, optimum, or current producing greatest stimulus; MX, maximum, or death current; R to MX, retardation current.

electrical currents exist in the soil, and also in the plant; in fact, wherever chemical activity occurs electric currents are likely to be present, although these currents may be comparatively insignificant, and require delicate instruments for their detection.

The following experiments in stimulating plants with electricity have been carried on in this department for some years, and previous to undertaking this work many thousands of plants have been experimented with, and the minimum, optimum and maximum currents have been established by us in a general way. We therefore had more or less a definite idea in mind as to what strength of current we wished to apply at the beginning of our work. The experiments we are about to describe, therefore, represent only a small part of those which we have made, and these were made under conditions resembling those employed for commercial purposes. We shall, however, interpret the results of these experiments in the light of those obtained from our long study given to the subject, rather than from what these particular tables show.

The work was carried on in the greenhouse, during the summer months. The plants utilized were radishes and lettuce, which were selected for special reasons as being suitable for our work. The plants were grown in wooden boxes, 53 inches long, 32 inches wide and 7 inches deep. These boxes were placed on movable trucks, or in some cases on supports 18 inches from the floor. In all cases they were insulated. The soil employed was of a uniform quality and texture, and has been used for these experiments alone for some years. Previous to using the soil it was sifted through a sieve of $\frac{3}{8}$-inch mesh, and thoroughly mixed. After using the soil for a few experiments, it was taken out, resifted and thoroughly incorporated again ; and occasionally the boxes were shifted about, that is, the normal or untreated boxes were substituted or changed for those which had been treated. With a

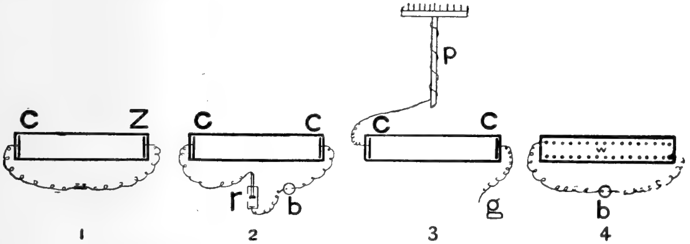

Fig. 2. — Longitudinal section of boxes employed in the electrical experiments, showing different methods of treatment. Size of boxes, 53 by 32 by 7 inches. 1, copper and zinc electrodes connected; 2, direct current with rheostat; 3, atmospheric; 4, wire electrodes. C, copper electrodes; Z, zinc electrodes; r, rheostat; b, gravity cells; w, wires; g, ground wire; p, collecting pole, 47 feet high.

few exceptions, copper or zinc plates were used for electrodes. These were made the same size as the ends of the boxes, and in a few exceptional cases two series of wires, strung on a frame about three inches apart, were employed instead of the plate electrodes. One of these frames of wires was buried near the surface, the other being buried near the bottom of the box. The current, therefore, had to pass from one frame to the other in a vertical direction through the soil. The strength of the currents was in most cases obtained with the aid of a Weston milammeter, capable of reading $\frac{1}{20}$ of a milliampere, or about $\frac{1}{20000}$ of an ampere. The interrupted induced currents were estimated, and represent only approximate determinations.

In the radish experiment the seed was sown directly in the treated boxes, whereas in the case of the lettuce the plants were transplanted into the treated boxes when of suitable size to make good growth ; the latter plants, therefore, were not stimulated during the whole period of development. Gravity cells were used in all cases except with the interrupted induced current, in which case sal-ammoniac cells were employed.

Experiments with Radishes.

Table I. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	Treatment.	Number of Plants.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Average of three normals, .	112⅔	4.83	10.55	-	-	-
1	Direct current; one gravity cell; copper plate electrodes, ...	81	4.89	12.58	.012	19.24	13.60
2	Direct current; three gravity cells; wire electrodes, .	110	4.63	9.26	[1] 4.140	[1] 12.22	[1] 9.68
3	Interrupted induced current; copper plate electrodes, .	114	5.85	11.22	21.110	6.35	10.98

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	4.83	5.12	6.00
Of tops, ...	10.55	11.02	4.45
Of whole plant, ...	15.38	16.14	4.93

In Table I., in which six experiments are shown, three normal and three treated, the results are not in every way satisfactory. The current strengths were determined only once or twice in each instance, and these were estimated by means of the electro-motive force of the cell and resistance of the soil, and also by a milammeter. The current strengths given, therefore, represent only those which were found at the time of the measurements; and, since the resistance of soil is constantly changing with the movements of the water currents and with the ever-changing moisture conditions, due to watering, the figures giving strengths of current must not be considered as averages. The strengths of current employed in the experiments shown in the first five tables vary, probably from .05 to 1 milliampere.

In the interrupted induced current experiments the current had a duration of only about ten seconds per hour. This was accomplished with a clock arrangement and with a Du Bois-Reymond induction apparatus. It should be pointed out, however, that with the use of this apparatus only approximate current strengths can be obtained, as it does not constitute a particularly favorable type of instrument for obtaining uniform currents of a definite strength. Our extensive use of the apparatus in other work has enabled us, nevertheless, to use it with some degree of certainty of securing optimum strengths of current. The three gravity cells with wire electrodes apparently furnish too much current, hence we obtained a loss with these. We were beyond the optimum and in the retardation zone (see Fig. 1). This method of applying current was not considered a satisfactory one, and it was subsequently abandoned.

Nos. 1 and 3 showed a gain in both roots and tops, the total gain being 13.60 and 10.98 per cent. respectively. At the bottom of the table is given the total gain from electrical treatment; for example, the weights of the plants from three treated boxes are compared with the weights of those in the three normal boxes. The total gain of 4.93 per cent. is of little significance.

TABLE II. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 39 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Average of three normals,	220⅔	5.29	5.55	-	-	-
4	Direct current; one gravity cell; copper plate electrodes,	205	6.22	12.65	17.58	127.92	74.07
5	Direct current; one gravity cell; wire electrodes,	250	5.88	7.47	11.15	34.59	23.15
6	Amospheric electricity; copper plate electrodes,	180	6.60	10.06	24.76	81.26	53.61
7	Copper and zinc plate electrodes, connected,	109	14.01	16.61	164.84	199.28	182.38
8	Interrupted induced current; copper plate electrodes,	220	6.17	6.17	16.63	11.17	13.83

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	5.29	7.77	46.88
Of tops,	5.55	10.59	90.85
Of whole plant,	10.84	18.36	69.54

In Table II. is shown a similar series of experiments, with modifications in the strengths of currents and methods of treatment. The currents, however, are reduced in all instances with favorable results. Nos. 6 and 7 received different treatment from those shown in the preceding table. In No. 6, termed atmospheric electricity, the current was obtained from a pole 35 feet above the ground; from the top of this pole there projected 24 small copper points, distributed in two circles, the outer arc having a radius of 30 inches. The arrangement was similar to that shown in Fig. 2, but not identical. The copper points were all connected with a single wire leading to the copper plate electrode of Box No. 3, the other electrode being grounded, as shown at G. The electrical potential was not determined in this experiment, but the deflection of the needle of a sensitive galvanometer showed that a current was present in the soil.

In No. 7, copper and zinc plate electrodes were simply connected together with a wire; this formed a cell in itself, and generated a current, usually about the optimum, which could be readily read with the milammeter. The results of the experiments are shown in the last column at the bottom of the table.

TABLE III. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	TOTAL WEIGHT, IN GRAMS, OF—		PER CENT. GAINED IN WEIGHT OF—		Total Per Cent. gained.
		Roots.	Tops.	Roots.	Tops.	
	Normal,	700	2,700	–	–	–
9	Direct current; one gravity cell; copper plate electrodes,	800	2,900	14.28	7.40	8.82
10	Amospheric electricity; copper plate electrodes,	900	3,000	28.59	11.11	14.70

Total weight, in grams:—	Normal.	Treated.	Per Cent. gained.
Of roots,	700	850	21.42
Of tops,	2,700	2,950	9.25
Of whole plant,	3,400	3,800	11.76

TABLE IV. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Normal, ...	291	3.09	2.74	-	-	-
11	Direct current; one gravity cell; copper plate electrodes, ...	294	2.65	2.72	[1] 14.23	[1] .72	[1] 7.89
12	Atmospheric electricity; copper plate electrodes, . .	281	3.20	4.27	3.55	55.83	28.13
13	Copper and zinc plate electrodes, connected, . .	289	2.94	5.53	[1] 4.85	101.82	45.28

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	3.09	2.93	[1] 5.50
Of tops, ...	2.74	4.17	52.19
Of whole plant, ...	5.83	7.10	21.78

[1] Loss.

TABLE V. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 40 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Normal, ...	273	3.29	4.02	–	–	–
14	Direct current; one gravity cell; copper plate electrodes, ...	275	4.00	4.18	21.58	3.98	11.90
15	Atmospheric electricity; copper plate electrodes, . .	277	3.61	3.97	9.72	[1] 1.24	3.69
16	Copper and zinc plate electrodes, connected, . .	278	3.74	3.95	13.67	[1] 1.74	5.19

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	3.29	3.78	14.86
Of tops, ...	4.02	4.03	.02
Of whole plant, ...	7.31	7.81	6.84

The experiments shown in tables III., IV. and V. followed one another in succession, and were conducted in a similar manner. Some of the data shown in Table III. was unfortunately mislaid or lost, hence it is incomplete.

No. 11, in Table IV., shows a loss, but the average percentage gained by treatment in other cases is important. The gain shown in Table V. as a result of treatment is comparatively small.

TABLE VI. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 30 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal,	241	-	5.1	3.2	-	-	-
17	Direct current; one gravity cell; copper plate electrodes,	215	.10 (.05-.24)	6.1	4.1	19.60	28.12	22.88
18	Direct current; two gravity cells; copper plate electrodes,	242	.43 (.22-.90)	5.9	5.5	15.68	71.87	37.34
19	Copper and zinc plate electrodes, connected,	198	-	7.4	5.2	45.09	62.50	51.80

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	5.1	6.46	26.66
Of tops,	3.2	4.93	54.06
Of whole plant,	8.3	11.39	37.22

TABLE VII. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Average Weight, in Grams, of — Roots.	Average Weight, in Grams, of — Tops.	Per Cent. gained in Weight of — Roots.	Per Cent. gained in Weight of — Tops.	Total Per Cent. gained.
	Normal,	217	-	10.80	4.14	-	-	-
20	Direct current; one gravity cell; copper plate electrodes,	264	.197 (.10-.33)	12.30	6.60	13.88	59.42	26.50
21	Direct current; two gravity cells; copper plate electrodes,	292	.516 (.23-1.0)	12.20	7.50	12.96	81.16	31.19
22	Copper and zinc plate electrodes, connected,	272	.305	11.20	4.96	3.71	19.80	8.16

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	10.80	11.90	10.18
Of tops,	4.14	6.35	53.14
Of whole plant,	14.94	18.25	22.15

The concluding experiments with radishes are shown in tables VI. and VII. In this series the atmospheric experiments were omitted, and two direct current experiments were run in each series, in which different strengths of currents were employed. In these experiments, and all others which follow, an attempt was made to regulate more carefully the current strengths, and to make daily readings of the same. For this purpose a water rheostat was introduced in the circuit in the two direct current experiments; this enabled us to modify resistance, and to maintain a tolerably uniform current throughout. Current records in all the remaining radish experiments are averages for the whole period, and are based on four readings each day. The minimum and maximum currents are given in parentheses. In the direct current series we endeavored to maintain .2 and .4 milliamperes respectively. In No. 17, however, it only averaged .1 milliampere; in Nos. 19 and 22 readings were made every three days, but no attempt was made to modify the current strengths, inasmuch as these boxes generally maintained the desired current.

The results shown in these tables are more uniform than in the preceding ones, as might be expected from the greater care we gave in maintaining a more or less uniform stimulus. No loss is shown by the treated ones; on the other hand, there is considerable acceleration shown by treatment.

SUMMARY. — *Showing the Results with Radishes (Raphanus sativus L.) given in Tables I., II., IV.–VII.*

TREATMENT.	Number of Plants.	PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
		Roots.	Tops.	
Direct current (weak); copper plate electrodes; Nos. 1, 4, 11, 14, 17, 20,	1,334	9.73	39.66	23.67
Direct current (stronger); copper plate electrodes; Nos. 18, 21,	534	14.32	76.51	34.26
Direct current; wire electrodes; Nos. 2, 5,	360	3.50	11.18	6.73
Interrupted induced current; copper plate electrodes; Nos. 3, 8,	334	18.87	8.76	12.40
Copper and zinc plate electrodes, connected; Nos. 7, 13, 16, 19, 22,	1,146	44.49	76.33	58.56
Atmospheric electricity; copper plate electrodes; Nos. 6, 12, 15,	738	12.67	45.28	28.47

Average per cent. of weight gained, in grams: —
Of roots, ... 17.26
Of tops, ... 42.95
Of whole plant, ... 27.34

The results of electrical treatment of various kinds and of different strengths of currents, in which 3,446 treated radish plants were compared with 2,022 normal or untreated ones, are shown in the summary. These comparisons are based on the growth of the normal plants with which the treated were grown, and not on the total normals, since the duration of experiments in one table does not correspond with those in another; or, in other words, there existed some difference in the degree of maturity of the various crops. This method of comparison is necessary, since the treatment varied in time, and the experiments in each table were not parallel throughout. The results show, however, appreciable gains; and, as they are averages, the percentages represent more accurately the influence of electrical treatment, the total gain for roots and tops being 27.34 per cent. A notable feature is seen in acceleration of tops, which showed about two and a half times more growth than that shown by the roots. In the case of the two interrupted induced-current experiments the reverse holds true, there being more than twice as much growth of roots as tops. This current exerts a different physiological effect on plants than the direct current.

Experiments with Lettuce.

The tendency of electrical stimuli to accelerate the growth of the tops of radish plants more than the roots suggested the idea of substituting lettuce. Lettuce possesses a different and more desirable habit of growth, it would seem, for electrical stimulation. The variety of lettuce grown in all cases was that known as the Boston head type, so commonly used by market gardeners in Massachusetts. The plants were grown according to the customary manner of growing lettuce; namely, the seed was sown in a small box of soil. When the seedlings were an inch or two high they were transplanted into larger boxes containing loam; and when they had formed three or four leaves two or three inches long, they were carefully selected, as regards vigor and size, and transplanted into the experimental boxes, as in the radish experiments. The loam in which they were started was of uniform quality and similar texture to that used in the boxes. Twenty-four plants were set in each box, which allowed room for their full development. In transplanting, however, there was little or no loam attached to their roots. We have handled lettuce so extensively in our greenhouse that we were familiar with its characteristic requirements, and usually had on hand an ample supply of material from which to select. The strengths of currents in all lettuce experiments where gravity cells were used are based on four daily records. The minimum and maximum currents are also given in parentheses in all cases. In the copper and zinc electrode connections the currents were recorded every three days and the tables show the averages obtained.

TABLE VIII. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa L.). Normal Plant taken as the Standard at 100.*

[Duration of experiment, 31 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	23	-	798	34.69	-
23	Direct current; copper plate electrodes,	23	.183 (.05-.25)	1,233	53.60	54.22
24	Direct current; copper plate electrodes,	22	.395 (.15-1.0)	1,226	55.72	60.62
25	Copper and zinc plate electrodes,	22	.286 (.1-.5)	1,126	51.18	47.53

Total average weight, in grams: —
Normal, . . . 34.69
Treated, . . . 53.50
Total per cent. gained, . . . 54.22

TABLE IX. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 42 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	-	681	28.12	-
26	Direct current,	24	.199 (.10-.35)	818	34.08	21.19
27	Direct current,	24	.342 (.20-.50)	816	34.00	20.91
28	Copper and zinc plate electrodes, connected,	24	.296 (.05-.60)	725	30.20	7.39

Total average weight, in grams: —
Normal, . . . 28.12
Treated, . . . 32.73
Total per cent. gained, . . . 16.39

In the two preceding tables are shown the results of electrical treatment upon lettuce. The current was set at .2 milliamperes in experiments 23 and 26, and at .4 milliamperes in experiments 24 and 27. The experiments in both tables show the effect of electrical treatment, and where the resistance was modified the results are tolerably uniform. The gain by all treatment is 16.29 and 54.52 per cent. respectively.

TABLE X. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 50 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	-	619	25.79	-
29	Direct current,	23	.171 (.02-.25)	575	25.00	3.06
30	Atmospheric electricity,	23	-	784	34.08	32.14
31	Copper and zinc plate electrodes, connected,	24	.06 (.01-.09)	688	28.66	11.13

Total average weight, in grams: —

Normal,	25.79
Treated,	29.24
Total per cent. gained,	13.37

TABLE XI. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 60 days.]

No.	TREATMENT.	Number of Plants.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	710	29.58	-
32	Direct current,	24	800	33.33	12.67
33	Copper and zinc plate electrodes, connected,	24	1,355	56.45	90.83
34	Atmospheric electricity,	24	1,000	41.66	40.83

Total average weight, in grams: —

Normal,	29.58
Treated,	43.81
Total per cent. gained,	48.10

Tables X. and XI. show experiments arranged similar to the two preceding tables, except that atmospheric electricity is substituted for one of the direct currents. The atmospheric experiments were conducted with some modification from those previously described with radishes. The principal difference, however, consisted in the pole being 47 feet from the ground, instead of 35 feet, and the number of copper points was 124, instead of 24. (See Fig. 2, No. 3.) In the latter case we also used a 28-inch metal bicycle wheel to support the points at the top of the pole; in the former arrangement an inverted umbrella frame was used. In No. 29 we endeavored to maintain a current of .2 milliamperes; Nos. 31 and 33 gave the usual current, but no attempt was made to obtain averages in the latter. A sensitive galvanometer usually showed a deflection of the needle when in circuit with the atmospheric electrodes; and when the wire from the pole was attached to a Thomson self-recording electrometer it was usually sufficient to deflect the needle and to charge slightly a glass case of 30 cubic feet capacity. Only occasional observations were made of the strength of the current in experiments shown in Table XI.

SUMMARY. — *Showing the Results with Lettuce (Lactuca sativa L.) given in Tables VIII.–XI.*

TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Total Per Cent. gained.
Direct current (weak); copper plate electrodes; Nos. 23, 26, 29, 32,	94	0.184	22.78
Direct current (stronger); copper plate electrodes; Nos. 24, 27,	46	0.367	40.76
Copper and zinc plate electrodes, connected; Nos. 25, 28, 31, 33,	48	0.214	36.48
Atmospheric electricity; copper plate electrodes; Nos. 30, 34,	47	–	39.22

Average per cent. of weight gained, in grams, ... 34.81

The average percentage of gain shown by lettuce is slightly higher than that given by radishes, although the acceleration is not so great as that shown in the growth of radish tops over roots. There are, however, no instances in the lettuce treatment where the normal plants have excelled in growth the treated ones, although in No. 21 there is a difference of only 3 per cent. between normal and treated.

Conclusions.

The foregoing experiments with lettuce and radish plants show, in all instances except two, a total gain by the use of electrical stimuli. Those experiments where an attempt was made to maintain a strength of current within narrow limits showed the best results from treatment. Could an absolutely definite strength of current be utilized throughout the period of duration much closer results could be obtained, and the optimum current be more closely determined. Such an arrangement suggested itself to us quite early in our work, but the necessary equipment was not at hand. Since the variations in current strength depend largely upon the variations in soil moisture, tolerably constant currents might be obtained by regulating the water supply; but some automatic resistance appliance would undoubtedly constitute the best mechanism for getting absolutely constant currents. The effect which electricity has in accelerating the growth of plants and on the germination of seeds is positive; and in hundreds of experiments, conducted in a different manner, we have seldom obtained any negative results. We have, moreover, conclusively shown from our experiments that the alternating current is much superior to the direct as a stimulator; therefore the alternating-current experiments, Nos. 3 and 8, given in this series, should by no means be considered as typical, as we have apparently failed to get the optimum strength in these cases.

The question naturally arises, in what manner does electricity stimulate plants; or, in other words, how are accelerated growth and accelerated germination to be explained? There are numerous agencies which act as stimuli to seeds and plants about which little is known in regard to how they stimulate the plant. There are, to be sure, many theories advanced for the purpose of explaining the response of plants to various stimuli.

We know perhaps as much about the rationale of electrical action on plants as we do about the effects of light in producing heliotropic bendings, or of gravity in producing geotropic bendings. Some of the various theories pertaining to electrical action, however, possess interest and are worthy of citation. Frecke held the idea that electricity was the great moving force of animate creation, and identical with nervous influence. Marat was of the opinion that electricity exerted a marked influence on the fertility of the soil, and similar ideas have been advanced by others in more recent times. Fichtner and Sohne claimed to have found that electricity rendered soluble the constituents of the soil; and the same opinion was advanced by Tschinkel, who believed that acceleration and growth were brought about by the action of electricity upon the salts and other constituents of the soil. Jodro attached a double function to the action of the soil current: first, it acts chemically on soil, in dissolving those constituents necessary for plant nourishment; and second, it acts mechanically, in setting the particles of the soil into a state of molecular vibration, thus loosening the earth. These views relating to the decomposition of the certain salts in the earth by passing a current of electricity through it have not been confirmed by Wollny. He made a series of careful analyses of soil, electrically treated and untreated, and found absolutely no difference, which could be attributed to the effects of electricity, in the percentages of potassium, ammonia, phosphoric acid, potassium nitrate and carbonic acid gas. The action of electricity upon oxygen, as is well known, gives rise to ozone; and some botanists have believed that the production of ozone in the seed by electric currents is the prime factor in accelerating germination and growth.

Most of these theories are very fanciful, and all inadequately explain the stimulating effect of electricity upon plants, nor is there any reason to believe that this phenomenon can be explained by simple mechanical theories. There may exist a fundamental basis for the theory that electricity is capable of decomposing certain constituents of the soil and rendering them more available, but in all probability the strength of current which is capable of advantageously stimulating plants would produce little effect on the soil; at any rate, it would produce little effect during the short space of time it requires to mature most crops. Moreover, when it is considered that moist seeds and seedlings respond to electrical stimuli in quite a remarkable manner when sown and allowed to develop on moist filter-paper cloth or in porous clay dishes, etc., the complicated soil theory of electrical action falls to the ground.

Electricity affects the protoplasm of the plant, and it is to the effect on the protoplasm that we must look for the solution of the problem, and not to its influence on the soil. This can be seen in plants that show protoplasm movements, such as Chara, etc. It has long been known that weak currents stimulate protoplasm, and induce an accelerated movement; whereas strong currents retard or stop such movements, or, if too strong, they kill the protoplasm.

Current electricity likewise induces bendings in the roots (galvanotropism) when grown in water between electrodes. In such cases weak currents produce negative bendings, — that is, towards the cathode; while strong currents produce positive bendings, — towards the anode. Similar effects are seen in the movements exhibited by many microscopic animals, such as paramœcia and other protozoa.

Plants respond to light, gravity, moisture, etc., in a positive and negative manner; and it is also known that a negative electrotropic irritability exists in certain plants (Phycomyces in this case), or a sensitiveness to Hertz waves which induces negative bendings. The plant organism, whether in the embryonic or adult stage, responds in a positive and negative manner to various cosmic forces which act as stimuli. There is a positive geotropism which induces roots to grow downwards, and a negative geotropism which induces shoots to grow upwards. The force which accomplishes this is termed gravity. Our comprehension of gravity, however, is scarcely more intelligible than that of electricity, and for all we know they may be the same or similar manifestations of force. The results of electrical stimulation to plants are quite similar in their effects to those exhibited by other forms of stimuli.

There is a minimum, optimum and maximum current which gives rise to reactions similar to those obtained from other forms of stimuli. There is also a well-defined latent period, such as we find associated with heliotropic and geotropic stimuli, etc. Moreover, there exists a definite relationship between current intensity and perception, or reaction of the organism, as in chemotactic stimulation.

It was observed by early experimenters that there existed a difference in the growth of plants when subjected to what is termed positive and negative charges. Our limited experiments in this respect have shown that when seeds were treated with a positive charge the growth of the roots was greatly accelerated, while the stems were much less so; and conversely, when treated with a negative charge, the stem showed a greater accelerated growth than the roots. Germination — that is, radical development — was greatly accelerated when seeds were charged positively, although when charged with a negative charge germination at first was much less accelerated than in untreated seed. Thus we have a positive charge stimulating organs which react in a positive manner, and a negative charge stimulating organs which react in a negative manner; also the effect of a positive charge acting as a slight stimulus or retarding organs which act in a negative manner, and the negative only slightly stimulating or retarding positive reacting organs.

It would also appear as if positive charges had a tendency to produce attenuated or elongated root development. In regard to this point, it would be interesting to ascertain whether positive charges increase geotropic irritability. One of the recent conceptions of solutions is that they contain ions which are atoms or groups of atoms positively or negatively charged. It has been observed that solutions with a predominant positive charge, such as acids, and those with a predominant negative charge, bases and salts, have a certain definite effect upon protoplasm which is identical with those produced by positive and negative electrical stimulation. There is also reason to believe that protoplasm consists of particles which are charged positively and negatively. It is possible that in the protoplasm of roots and stems (hypocotyls, as well) of plants there exist opposite predominant charges, — the root carrying predominant negative charges, the stem predominant positive charges. When roots are stimulated with positive charges, acceleration results; and when stimulated with negative charges, acceleration is less marked. In other words, stimulation may arise by changing the predominant charge of the organ, and those organs respond most favorably to electrical stimuli in which opposite charges predominate. In subjecting roots to a positive charge, the predominant negative charges are overpowered or neutralized by the charges, and stimulation results; likewise, in subjecting stems to negative charges, the predominant positive charges are overpowered or neutralized by the negative charges, and stimulation likewise results; but reinforcing predominant positive or negative charges by electrical stimulation causes only a slight stimulus or retardation.

From these experiments it would appear that direct currents appear to stimulate most organs which possess predominant positive charges (radish tops), while interrupted induced currents appear to stimulate most organs which possess predominant negative charges. There is known to exist a difference between the "make" and "break." In the latter current, which is capable of giving rise to a modified physiological reaction, the effects of the opening are always more marked. The effects of the direct current noted above are not so readily accounted for on the basis of this theory.

These experiments have suggested other lines of investigation, and a further report will be made concerning them. It is possible that prolonged stimulation gives rise to different effects than brief stimuli. In prolonged stimulation with direct currents the positive electrode may have a toxic effect, causing inhibition, as is the case with solutions with positive ions. Physiologists have noted that the negative stimulates where the positive current prevents stimulation, although such does not hold in the case of plants, at least when charges of a brief duration are employed.

THE INFLUENCE OF THE ATMOSPHERICAL ELECTRICAL POTENTIAL ON PLANTS.

BY N. F. MONAHAN.

While electrical currents have such an important influence upon the growth and development of plants, as shown in the preceding pages, so also does the electrical potential of the atmosphere have an appreciable influence upon plant life. The atmosphere is always charged to a higher or lower electrical potential, either positive or negative. This has been clearly shown by experiments conducted by the Weather Bureau, United States Department of Agriculture, by Alexander McAdie of the Blue Hill Observatory, and by A. C. Monahan of this station. The conditions governing the amount of electrical potential of the air are not clearly understood, but Monahan found, in a series of experiments extending over nearly a year's time, that the air was charged positively about 90 per cent. of the whole time at a height of 30 feet from the ground. It is enough for us to know, however, that the air is always charged to a higher or lower potential. It is the purpose of this paper to show in a brief way some of the results of preliminary experiments on the effects of atmospherical electrical potential on germination, and the growth and development of plants. Fuller accounts will be published later.

Methods of Experiments and Apparatus used.

In all our experiments we have kept careful records of the exact electrical potential. These records were made by the use of a quadrant electrometer, designed by Sir William Thomson for observations in atmospherical electricity, and built by Eliot Bros. of London. In brief, the instrument consists of a delicate quadrant galvanometer and a self-registering apparatus. A full description of this instrument may be found in the twenty-eighth annual report of the Massachusetts Agricultural College, for 1891.

We used a large glass case, with a wooden frame, 4 feet 3 inches long, 2 feet 9 inches wide, and 2 feet 11 inches high, with a detachable door in the middle of one side, from which every part of the case was accessible. The door was made to fit tightly by a band of rubber around the edge, and was securely held in place by levers. When closed, the case was practically air tight, and was insulated from the stand by glass and rubber insulation. In one corner of the case a small water-dripping apparatus was placed. This apparatus consisted of a light eight-quart copper tank, with a projecting pipe which ended in a fine orifice; the water passing through the pipe immediately broke into drops, and was caught in a glass dish below. An insulated wire connected the case with the electrometer near by. A short time after the dripping started the tank was found to be electrified, presumably to the same potential as the air at the point of the projecting tube. The potential was imparted through the conductors to the electrometer, and a deflection of the needle ensued.

In the case was also placed a self-recording hygrometer (Richard Bros., Paris) and a self-registering thermometer. The case was charged in some instances through a wire at one end leading from a Holtz influence machine. Immediately after charging, the wire was withdrawn from the case, and the hole through which it was inserted was tightly plugged. At other times the case was charged from a Leyden jar through the same wire. This seemed necessary in order to get the required small potential. The air in the case would hold a part of its charge for about three hours; at the end of that time we could find no trace of any electrical potential. The growth of the plants was measured in some instances by a modified Pfeffer-Baranetzky self-registering auxometer, and in other cases by the use of a horizontal microscope with a micrometer scale attachment.

Effect on Germinating Seeds.

Two lots of one hundred seeds of each kind were taken. These seeds were placed in porous clay dishes and soaked for six hours. The first lot was placed in Case 1, and subjected to an electrical charge every eight hours, induced into the air of the case from the Holtz machine. The second lot was placed in Case 2, — a small glass case, where no electrical charge was allowed. In all instances the clay dishes were set in basins of water, so that the seeds were moist at all times. The conditions of the temperature and moisture were practically the same, the former varying from 18° to 20° C., the latter from 76 to 85 per cent. Both cases were closed, and under similar conditions.

Table 1. — *Showing Effect of a Positive Charge upon Germinating Seeds.*

[N, normal; C, charged.]

Kind of Seed.		Total Number of Seeds germinated in — 24 Hours.	48 Hours.	72 Hours.	96 Hours.	120 Hours.
White clover,	N,	–	–	56	67	76
	C,	2	59	72	79	80
Onion,	N,	5	23	30	34	40
	C,	3	41	47	51	51
Onion,	N,	–	3	13	18	44
	C,	–	5	17	28	37
Lettuce,	N,	–	34	48	56	77
	C,	–	55	82	85	85
Red clover,	N,	–	7	18	35	66
	C,	–	74	88	92	92
Total per cent. acceleration in charged seeds,		–	55.4	23.1	17.11	–

Table 2. — *Showing Effect of a Positive Charge upon Seeds that have lost Vitality.*

Kind of Seed.		Total Number of Seeds germinated in — 24 Hours.	48 Hours.	72 Hours.	96 Hours.	120 Hours.
Musk melon,	N,	–	–	–	–	–
	C,	–	1	1	1	1
Onion (Red Globe),	N,	–	1	–	2	2
	C,	1	2	2	3	3
Onion (Belden),	N,	9	25	33	33	33
	C,	7	18	20	20	20

Table 2 shows that atmospheric electricity does not increase the total number of seeds germinated over the total germination of those not charged, and that it does not bring to life seeds that have lost their vitality. Seed of a very low per cent. of germination were used.

The results obtained from these experiments confirmed the work done in 1896 at this station by Asa S. Kinney, on "Electro-Germination."[1] Kinney found that: first, electricity exerts an appreciable influence upon the germination of seeds; second, the application of certain strengths of current to seeds for a short period of time accelerates the processes of germination; third, the application of electrical currents to seeds does not increase the total percentage of germination. This latter result shows a direct opposition to the results obtained by Paulin. Paulin claimed that the application of electrical currents awakened to life seeds which had apparently lost vitality, and gave an increased percentage of germination in all seeds thus stimulated.

Effects on Plant Growth.

In some of our experiments three young tomato plants were placed in the large glass case and allowed to stand for eight hours. This was done in order that the plants might become accustomed to the changed conditions and to their new environment before being experimented upon. In these experiments the air in the case was charged every eight hours (at 7 A.M., 3 P.M. and 11 P.M.) to a potential of from 100 to 2,000 volts, as recorded by the electrometer and the growth of the plants recorded by the Pfeffer-Baranetzky self-registering apparatus. This method of measuring the growth proved unsatisfactory and was soon abandoned, and the following method, which proved more satisfactory, was tried. One plant at a time was placed in the case and allowed to stand for a few hours, as above; the plant was then set up near the glass on one side of the case, and the growth measured by means of a horizontal microscope with a micrometer scale attachment, the microscope being placed on the outside

[1] "Electro-Germination." Bulletin No. 43, Hatch Experiment Station.

of the case and focused upon the apex of the plant, measurements being taken every fifteen minutes.

The following figure shows the results of one experiment. A small tomato plant about four inches high was placed in the case, and treated as before described. Measurements of

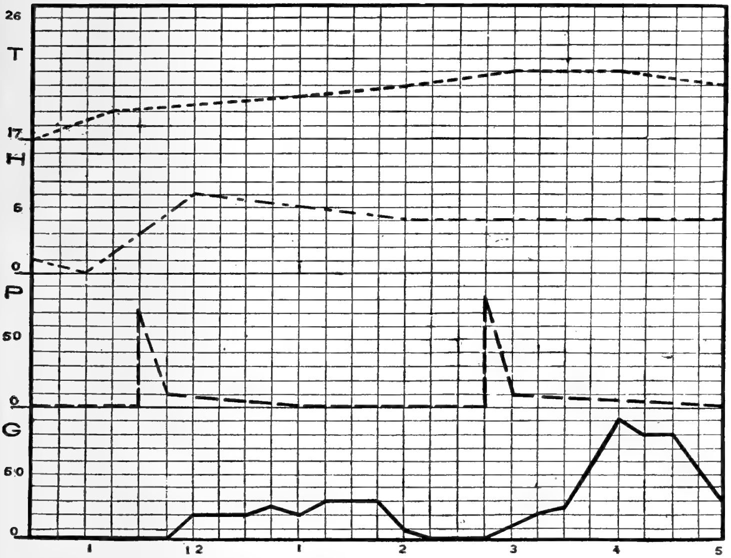

FIG. 1.—Growth curve of tomato plant. The horizontal divisions represent periods of fifteen minutes in time; the vertical divisions represent degrees of temperature, also humidity, electrical potential and increments of growth. T, temperature; H, humidity; P, electrical potential; G, growth.

growth were recorded every fifteen minutes, from 10.15 A.M. to 5 P.M. From 10.15 until 11.30 there was no perceptible growth. At 10.30 the air in which the plant was growing was charged to a potential of 70 volts. Half an hour later, at 12 o'clock, the plant had grown two spaces on the micrometer scale; and at 12.15 had grown two more spaces; and so on until 2.15, when no growth was recorded. At 2.45 the air in the case was recharged to 80 volts, and a greatly increased growth resulted, the maximum acceleration taking place at 1.15 and 4 o'clock respectively, as a result of the two stimuli.

This is but one of many similar figures showing the results of our experiments, tomato plants, corn cotyledons and bread moulds (*mucor* and *Phycomyces nitens*) being used. In all of these experiments the latent period varied from fifteen to thirty minutes.

In several of the experiments where the conditions of temperature and moisture were practically the same, and a large potential was employed, a serious retardation was shown, and in some instances death ensued ; in other cases, where a very small potential was employed, no appreciable acceleration was shown.

From these facts we are led to believe that there is a maximum, optimum and minimum voltage ; and, from the fact that different potentials were required to stimulate the growth of plants of different species, — and, in fact, of plants of the same variety and apparently of the same size, — it is evident that the maximum, optimum and minimum potentials vary with different varieties and species of plants, and also with plants of the same variety, depending upon the size, structural differentiation, development, etc., of the individual plant.

Summary.

1. Atmospheric electricity exerts an appreciable influence upon the germination of seeds.

(*a*) It accelerates the processes of germination. (In the experiments tried, those seeds charged with electricity show an acceleration in germination of 55.4 per cent. in forty-eight hours, 23.1 per cent. in seventy-two hours, and 17.11 per cent. in ninety-six hours.)

(*b*) It does not increase, to an appreciable extent, the total germination of charged seeds over the normal.

(*c*) It does not awaken to life seeds which have lost vitality.

2. Atmospheric electricity has an appreciable influence upon the growth of plants.

(*a*) From the results of these experiments we are led to believe that there is a maximum, optimum and minimum potential, but these have not yet been accurately determined.

(*b*) That the maximum, optimum and minimum voltages vary not only with the different varieties or species of plants, but with different individuals of the same varieties, and species depending largely upon the size, structural differentiation and degree of development of the plant.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH, W. E. TOTTINGHAM.
Inspector of Feeds, Babcock Machines and Dairy Tester: ALBERT PARSONS.
In Charge of Feeding Experiments: JOSEPH G. COOK.
Stenographer: MABEL SMITH.

PART I. — OUTLINE OF YEAR'S WORK.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Execution of the dairy law.
- F. Testing dairy herds.
- G. Work in progress and completed.
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PART II. — DAIRY AND FEEDING EXPERIMENTS.

- A. Effect of feed on the composition of milk and butter fat, and on the consistency or body of butter.
- B. Digestion experiments with sheep.
- C. Raising dairy calves without milk.

Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The correspondence of this department has considerably increased over previous years, due to the execution of the new feed law. The general character of the information desired has been much the same as heretofore. The total number of letters sent out during the year has been about 3,000.

B. Extent of Chemical Work.

The work in the laboratory has been of the same general character as formerly. The number of determinations of butter fat in cream has considerably increased.

There have been sent in for examination 132 samples of water, 229 of milk, 1,766 of cream, 8 of pure and process butter and 170 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 235 samples of milk and 585 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 772 samples of concentrated feed stuffs. This makes a total of 3,897 substances analyzed during the year, as against 3,240 last year and 3,622 in the previous year. Work on moisture, fiber and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists, and required considerable time for its proper execution. In addition, 17 candidates have been examined and given certificates to operate Babcock machines, and 2,240 pieces of glassware have been tested for accuracy, of which 57 pieces, or 2.54 per cent., were condemned.

C. Character of Chemical Work.

(a) Water.

In accordance with instructions from the experiment station committee, a charge of three dollars has been made for each sample of water examined by this department during the past year. The reasons for this charge were explained in a small circular sent to each applicant, a copy of which was printed in the last report, page 50. Most applicants have cheerfully paid the fee, while others have refused to send the sample for examination because of the charge. The number of samples examined has been 132, considerably less than formerly; but it is believed that the charge has resulted in holding in check those who have heretofore sent from 4 to 20 samples annually, as well as those who have sent largely out of curiosity, because an analysis could be had free of cost.

Instructions for securing an analysis of water: —

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. Lindsey,
Hatch Experiment Station.

(b) *Dairy Products and Feed Stuffs.*

The number of samples of milk and cream sent largely for the purpose of determining their butter fat content is increasing from year to year. The increase in the number of cream samples comes largely from creameries, while the milk comes from farmers desirous of ascertaining the quality produced by the several animals in the herd. This latter is a very satisfactory sign, and should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of the milk produced by different breeds, as well as full instructions relative to the best methods to be employed in determining the butter-producing capacity of dairy herds. Comparatively little analysis has been done for the Dairy Bureau, because of the pressure of other lines of work.

The number of feed stuffs sent for examination was about the same as usual. They are examined at once, and the results forwarded promptly, with such suggestions as circumstances may advise. Numerous samples are received from dealers, who avail themselves of the station facilities to make sure the materials they are offering are as claimed.

(c) *Chemical Investigation.*

So far as time and facilities permit, this department continues its work of investigating the various problems connected with the chemistry of dairying and animal nutrition. A good deal of attention has been given to the composition and digestibility of feed stuffs, as well as to the effect of feeds and feed combinations upon the quantity and quality of milk. A study of methods of analyses has been referred to elsewhere.

D. Cattle Feed Inspection.

In October and November, 1902, quite a thorough canvass of the State was made, some 320 samples of feeds collected, examined, and the results published in Bulletin No. 85. Because of the limited funds available, a few samples only — principally of cotton-seed meal — were collected in the late winter. The Legislature at its session of 1903 passed a new feed law (chapter 122, Acts of 1903); the full text of this law may be found in Bulletin No. 93, recently issued by this department. A brief synopsis of the law is as follows: —

Section 1 defines statements to be attached to all packages of feed stuffs.

Section 2 specifies feed stuffs included in the law.

Section 3 defines feed stuffs exempt from the law.

Section 4 states the penalty for violations of previous sections.

Section 5 mentions duties of director or deputy with reference to collecting and analyzing samples, and states penalty for interference.

Section 6 declares against the adulteration of whole or ground grain or standard by-products, and fixes penalty.

Section 7 requires the director to prosecute violations of the act.

Sections 8, 9 and 10 define the term importer, state the sum to be allowed for carrying out the provisions of the act, etc.

It is believed that the law will prove of great benefit to farmers, and they are to be congratulated upon its enactment. Similar laws are now in force in all of the other New England States, as well as in New York, New Jersey, Pennsylvania, Maryland, North Carolina and Wisconsin.

The new feed law went into effect July 1. Mr. Albert Parsons was appointed inspector, and has made a thorough canvass of the State, collecting some 700 samples. It is proposed to keep the inspector at work in different sections of the State a considerable portion of the year; in this way the station can be kept thoroughly informed concerning the character of the feeds offered. As would naturally be supposed, many feeds were found unmarked and without a guaranty, and it will require some time and considerable patience to bring about a complete conformity to the law. On the whole, it may be said that dealers appear ready and willing to conform to its requirements, and are constantly addressing letters of inquiry to the station concerning the character and value of the manifold feeds offered by manufacturers and jobbers. The station stands ready to co-operate with consumer, local dealer, jobber and manufacturer, to the end that all may be benefited.

The details of this inspection will be found in Bulletin No. 93.

E. Execution of the Dairy Law.

This department issued a special bulletin on the subject in July of the present year, entitled "The Dairy Law and its Results." The bulletin gave the text of the law, an account of the inspection of glassware, of the inspection of Babcock machines, very full information concerning the method of manipulating the Babcock milk test, together with as complete a list as possible of the creameries and milk depots in Massachusetts. This bulletin was sent in lots of from 10 to 100 to all milk depots and creameries in the State.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of sand blast. During 1902 there was examined 2,344 pieces, of which 56 pieces, or 2.39 per cent., were found incorrect. There have been examined the present year (1903) 2,240 pieces, of which 57 pieces, or 2.54 per cent., were not correctly graduated. Manufacturers are now very careful concerning the accuracy of the glassware put out by them.

Examination of Candidates. — Mr. E. B. Holland has continued as heretofore to have charge of this work. During 1901, 45 candidates were examined; in 1902, 13 candidates; and the present year, 17 have been given certificates of competency. It is believed that practically all parties now operating Babcock machines under the law have a good understanding of the principles of manipulation, and are capable of doing accurate work.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Albert Parsons, who makes the following report: —

The third annual inspection of Babcock machines was made in November and December, 1903. Fifty-two establishments were either visited or heard from, 37 being creameries and 15 milk depots. Twenty-four, or half the number, were co-operative, 18 were proprietary, and 10 were managed by stock companies. Forty machines were inspected. Of these, 1 was condemned and 6 needed slight repairs. A few overheated the tests, and a few required additional steam to warm them. All but two of the machines were run by steam power, one was run by hand and one by electricity. About three-fourths of the machines have frames of cast iron, while the other fourth is equally divided between galvanized iron and copper. Of the cast-iron machines, 22 are "Facile," and 9 are "Agos." As a rule, the glassware was found in good condition, although in some cases it was very dirty, in a few cases it was not tested, and a few pieces bore the mark of another State.

F. Testing Dairy Herds.

During the year this department has tested cows at the request of the Jersey, Guernsey and Holstein cattle clubs. Fifteen seven-day tests and 6 yearly tests have been completed and 38 yearly tests are in progress. The tests are made under the rule and regulations of the several clubs. It requires at the present time the services of a man during two weeks in each month, and in addition involves considerable clerical work.

G. Work in Progress and completed.

At the present time, experiments are in progress to note the value of specially prepared dried blood and digester tankage for milk production. It is believed that material of this kind will be used considerably in the near future as a source of protein for farm animals. Other experiments now in operation are: (*a*) to test the efficacy of a well-known condimental or medicated food, for which extravagant claims are made; (*b*) digestion experiments on a variety of coarse and concentrated feeds.

Experiments were also continued with summer-forage crops; but, owing to the very unusual summer conditions, definite results were not obtained, and they will be continued. An experiment is about to be undertaken to see if it is economically possible for the average dairy farmer to get along without the use of wheat bran, using silage as a diluter for the more concentrated by-products. Experiments have been completed with distillers' by-products, — malt sprouts, dried brewers' and distillers' grains, — and the results will soon be published in bulletin form. These experiments emphasize the nutritive and economical value of these several feeds as sources of digestible protein for milk production.

H. Addition to Staff.

Messrs. W. E. Tottingham, Albert Parsons and Joseph G. Cook have been recently added to the staff of this department. Mr. Tottingham serves as assistant chemist, taking the place made vacant by T. M. Carpenter, who secured a more lucrative and responsible position at the Pennsylvania experiment station. Mr. Parsons fills, in a sense, a new position, rendered necessary by the increasing work placed upon the department. He is acting as inspector of feed stuffs under the new feed law, as inspector of Babcock machines under the dairy law, and as dairy herd tester. Mr. Cook has charge of the experiments in animal nutrition at the feeding barn. These several young men have taken hold of the work earnestly and have proved themselves most efficient and satisfactory.

Part II. — Dairy and Feeding Experiments.

A. Effect of Feed on the Composition of Milk and Butter Fat, and on the Consistency or Body of Butter.

J. B. LINDSEY.[1]

Experiment VIII.

A general outline of experiments of a similar character will be found in the thirteenth and fourteenth reports of this station.

Object of the Experiment. — During the autumn and winter of 1901–02 a series of experiments was undertaken, for the purpose of noting, respectively, the effect of corn gluten meal with a minimum percentage of oil, of gluten meal with the addition of corn oil, and of corn meal, upon the relative proportions of the several ingredients in milk and butter fat, and upon the body of butter.

Plan of the Experiment. — Ten cows were divided into two lots of five each. Seven of the cows had calved in the late summer and early autumn, one in the preceding April, and two had been in milk about a year. The average milk product of each cow at the beginning of the trial was about 21 pounds daily. During the first period, both herds received the so-called standard grain mixture; during the three subsequent periods, Herd I. continued to receive the standard grain ration as in the first period; and in case of Herd II., a portion of the standard ration was replaced by gluten meal, by gluten meal and corn oil, and by corn meal, respectively.

[1] With E. B. Holland and P. H. Smith.

TABLE I. — *Duration of Experiment.*

PERIODS.	Character of Rations.	Dates.	Length of Periods (Weeks).
1, . .	Herd I., standard grain ration, Herd II., standard grain ration,	Oct. 20 through Nov. 9, .	3
2, . .	Herd I., standard grain ration, Herd II., gluten meal ration, .	Nov. 23 through Dec. 27,	5
3, . .	Herd I., standard grain ration, Herd II., gluten meal + corn oil,	Jan. 2 through Feb. 28, .	7
4, . .	Herd I., standard grain ration, Herd II., corn meal ration, .	Mar. 16 through Apr. 19,	5

Feeding and Care of the Animals. — The animals were fed twice daily. The corn oil was weighed out each day and carefully mixed with the grain ration, and was eaten without any trouble. Water was supplied constantly, by the aid of the Buckley self-watering device. Each cow was kept in a well-bedded, roomy stall, and was turned into a protected yard during the warmest part of each day when the weather was not actually stormy or severely cold. The feeding barn was heated to a temperature of 50–55° F. during the cold weather, kept clean and well ventilated. The animals were thoroughly cleaned daily, and before milking the udders were brushed and then wiped with a wet cloth. The milkers wore white duck suits.

Disturbances during the Experiment. — Just before the beginning of the second period, cow Folly of Herd II. was taken severely ill, and had to be permanently removed. It was thought best to continue the experiment as planned, using four cows in Herd II., rather than to begin again. In the third period, Red II. of Herd II. suffered an attack of indigestion. For this reason, samples of milk were not taken for two weeks, and butter making was omitted for one week. These interferences will be referred to again under "Composition of the milk," "Composition of the butter fat," etc.

TABLE II. — *Average Daily Rations for Each Cow (Pounds).*

First period: both herds, standard ration.

Herds.	Standard Grain Ration.	Chicago Gluten Meal.	Corn Oil.	Corn Meal Mixture.	First Cut Hay.	Rowen.
Herd I., . . .	8.6	–	–	–	12.4	10.1
Herd II., . . .	8.4	–	–	–	12.8	10.0
Second period: Herd I., standard grain ration; Herd II., gluten meal ration.						
Herd I., . . .	7.9	–	–	–	11.1	10.0
Herd II., . . .	5.3	2.7	–	–	11.5	10.0
Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.						
Herd I., . . .	7.9	–	–	–	10.9	9.9
Herd II., . . .	4.7	2.1	.6	–	9.2	9.8
Fourth period: Herd I., standard grain ration; Herd II., corn meal mixture.						
Herd I., . . .	7.2	–	–	–	10.9	10.0
Herd II., . . .	–	–	–	7	10.5	10.0

Character of the Rations and Feeds. — The standard grain mixture consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meals. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter.

The corn meal mixture was similar to the standard grain ration, excepting that the 5 pounds of ground oats were replaced by an equal amount of corn meal. It is to be understood that the figures given in Table II. represent the average feed consumed daily by each cow in each herd. For example, theoretically each herd in the first period was to consume an equal amount of feed per cow, namely, 8 pounds of grain, 10 pounds of rowen and 12 pounds of first cut hay; but, because of the individual requirements of the several cows, there was a slight difference in case of the average consumed by the two herds.

The spring wheat bran and cotton-seed meal were of good average quality. The oats were of standard quality, purchased whole and ground by the local miller. The Chicago gluten meal contained 40 per cent. of protein and 3.91 per cent. of fat in dry matter, thus furnishing a high percentage of corn gluten and a minimum percentage of corn oil. The corn was grown upon the station grounds, likewise the hay and rowen. The first cut hay was largely timothy, with a small admixture of red-top and clover. It contained 8.24 per cent. of protein in dry matter, and the rowen 14.20 per cent. The corn oil, procured of the Glucose Sugar Refining Company of Chicago, had a golden-yellow color, was clear, and had a marked odor of Indian corn. It was regarded as a very satisfactory sample.

TABLE III. — *Average Dry Matter and Digestible Nutrients in Ration of Each Cow.*

HERDS.	Total Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.			Nutritive Ratio.
		Protein.	Carbo-hydrates.	Fat.	
First period: both herds, standard grain ration.					
Herd I.,	27.37	2.55	13.33	.68	1:5.8
Herd II.,	27.12	2.52	13.22	.67	1:5.8
Second period: Herd I., standard grain ration; Herd II., gluten meal ration.					
Herd I.,	25.39	2.39	14.42	.63	1:6.6
Herd II.,	25.87	2.92	14.04	.59	1:5.3
Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.					
Herd I.,	25.34	2.39	12.32	.63	1:5.7
Herd II.,	23.41	2.55	11.13	1.14	1:5.4
Fourth period: Herd I., standard grain ration; Herd II., corn meal ration.					
Herd I.,	24.97	2.30	12.17	.61	1:5.9
Herd II.,	24.55	2.10	13.12	.59	1:6.9

TABLE IV. — *Average Quantity of Milk produced by Each Cow.* (*Pounds.*)

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
448.56	458.41	635.75	684.22	924.34	998.27	620.59	636.62

During the first period both herds produced essentially the same average quantity of milk per cow; during the second and third periods, presumably because of the increased supply of protein in the daily ration, Herd II. showed a slightly larger average yield.

Purity of the Milk. — A number of samples of the mixed milk were taken immediately after milking, placed in sterilized glass-stoppered bottles, and kept cold until examined for bacterial content. The number of bacteria varied from 200 to 3,600 to the cubic centimeter, showing the milk to be especially clean. Objectionable odor or flavor could not be detected.

Sampling the Milk. — Composite samples of the mixed milk from each herd were taken for five days in each week, and tested for total solids, fat and nitrogen. The solids were determined by drying in sand, the fat by extracting the dry material with ether, and the nitrogen by the Kjeldahl method. In securing a sample, the milk from each herd was carefully mixed, and a small dipperfull taken immediately.

TABLE V. — *Composition of Milk* (*Per Cent.*).

First period: both herds, standard ration.

Samples.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Oct. 26-30, . .	14.25	14.10	5.13	5.12	9.12	8.98	.573	.565
Nov. 1-4, . .	14.63	14.43	5.33	5.32	9.30	9.11	.584	.580
Nov. 4-9, . .	14.58	14.50	5.43	5.38	9.15	9.12	.576	.569
Average, . .	14.49	14.34	5.30	5.27	9.19	9.07	.578	.571

TABLE V. — *Composition of Milk* — Concluded.

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

Samples.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Dec. 11-16, . .	14.97	14.67	5.50	5.28	9.47	9.39	.594	.600
Dec. 17-22, . .	15.05	14.80	5.59	5.29	9.46	9.51	.599	.616
Dec. 22-27, . .	14.75	14.50	5.49	5.17	9.26	9.33	.600	.613
Average, . .	14.92	14.66	5.53	5.25	9.39	9.41	.598	.610

Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.

Samples.	Total Solids, Herd I.	Total Solids, Herd II.	Fat, Herd I.	Fat, Herd II.	Solids not Fat, Herd I.	Solids not Fat, Herd II.	Nitrogen, Herd I.	Nitrogen, Herd II.
Dec. 28-Jan. 3,[1] .	14.79	14.64	5.40	5.43	9.39	9.21	–	–
Jan. 5-Jan. 10,[1] .	14.61	14.49	5.35	5.37	9.26	9.12	–	–
Jan. 12-17, . .	14.69	14.16	5.29	5.10	9.40	9.16	.586	.567
Jan. 19-24, . .	14.76	14.23	5.31	5.12	9.45	9.11	.604	.580
Jan. 16-31, . .	14.74	14.11	5.27	4.97	9.47	9.14	.597	.586
Feb. 2-7, . .	14.66	14.07	5.29	5.02	9.37	9.05	.597	.579
Feb. 9-14, . .	14.79	14.13	5.31	4.99	9.48	9.14	.599	.577
Feb. 23-28, . .	14.75	14.08	5.38	4.97	9.37	9.11	.587	.566
Average, . .	14.73	14.13	5.31	5.03	9.42	9.12	.595	.576

Fourth period: Herd I., standard ration; Herd II., corn meal ration.

Samples.	Total Solids, Herd I.	Total Solids, Herd II.	Fat, Herd I.	Fat, Herd II.	Solids not Fat, Herd I.	Solids not Fat, Herd II.	Nitrogen, Herd I.	Nitrogen, Herd II.
Mar. 3-8,[1] . .	14.68	13.69	5.25	4.43	9.43	9.26	.589	.576
Mar. 9-14,[1] . .	14.59	14.29	5.34	5.18	9.25	9.11	.590	.576
Mar. 16-21, . .	14.93	14.27	5.42	5.11	9.51	9.16	.606	.586
Mar. 23-28, . .	14.70	14.28	5.27	4.99	9.43	9.29	.597	.586
Mar. 31-Apr. 4, .	14.82	14.52	5.19	5.10	9.63	9.42	.610	.597
Apr. 6-11, . .	15.00	14.37	5.36	5.12	9.64	9.25	.620	.603
Apr. 13-18, . .	14.84	14.29	5.13	5.03	9.71	9.26	.619	.608
Average, . .	14.86	14.35	5.27	5.07	9.58	9.28	.610	.596

[1] Preliminary.

TABLE VI. — *Relation of Fat to Solids not Fat.*

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
1: 1.73	1: 1.72	1: 1.70	1: 1.79	1: 1.77	1: 1.81	1: 1.82	1: 1.83

It is desired at this point to again call attention to the important fact that cow Folly in Herd I. became suddenly ill between the first and second periods, and had to be permanently removed from the experiment. It was thought best, however, to continue the experiment as planned, rather than attempt to start again.

It will be seen, in observing the above tables of analyses, that in the first period, with five cows in each herd and both herds receiving the same ration, the composition of the milk was quite similar. This was, of course, due to the fact that the two herds had been evenly matched. The milk yield of both herds in this period was also essentially the same, namely, 2,243 pounds for Herd I. and 2,292 pounds for Herd II.

In the second period, because of the loss of Folly, it was not possible to make a comparison of the composition of the milk produced by the two herds; hence it was sampled only during the last three weeks, in order to secure a basis of comparison for the two following periods. In this period the relation of fat to solids not fat was 1 : 1.70 and 1 : 1.79 for herds I. and II. respectively.

In the third or corn oil period the composition of the milk produced by both herds is given for the two preliminary weeks as well as for the period proper, although the former is not included in the average. The results show that the milk produced by Herd I. remained quite constant in composition during the entire period. A slight decrease only in the fat percentage is noted, the relation of the fat to solids not fat being as 1 : 1.77. In case of Herd II. the fat percentage suddenly increased from an average of 5.25 to 5.40 during the preliminary period of two weeks, when the corn oil was being added to the ration. The relation of fat to solids not fat during the preliminary period was as 1 : 1.72. The effect of the corn oil appeared to have been lost after two weeks, for during the first week of the period proper the percentage of fat was 5.10, and it declined slightly during the period, with an average of 5.03 and a relation of fat to solids not fat of 1 : 1.81. While the total solids did not change during the preliminary period, they showed a decrease at the close of the period proper of .53 per cent. It is to be noted that the nitrogen during this period was .034 per cent. lower than in the previous period. A similar decrease was noticed when linseed oil was fed.[1]

The percentage of solid matter in both herds suffered a slight decline during the third period, possibly due to winter weather conditions; but it was greater in case of Herd II., due largely to the decrease of the solids not fat.

In the fourth or corn meal period the milk of Herd I. increased a little in total solids, perhaps due to advanced lactation or to warmer weather. In case of Herd II., the sudden removal of the corn oil caused a temporary decrease of .54 per cent. of fat and a slight increase in the nitrogen. The so-called fat equilibrium, however, was gradually restored; for in the second week of the preliminary period it was equal to that yielded during the last week of the former period, and the percentage continued quite regular during the entire period. The percentage of nitrogen gradually increased for several weeks, and during the last week of the period it was equal to the average percentage found during the second period. Similar conditions were observed in former experiments.[2]

Attention is called to the evenness in the composition of the milk produced by Herd I., which had the same feed for a period of six months, the only change worthy of notice being the gradual increase of the solids not fat from 9.19 to 9.58 per cent.

TABLE VII. — *Composition of the Butter Fat.*[3]

First period: both herds, standard ration.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	231.5	230.6	30.03	29.52	33.78	33.43	29.07	30.29
2 samples, . . .	231.1	231.0	29.74	29.56	34.43	33.70	29.31	29.75
2 samples, . . .	231.1	231.9	29.48	30.25	34.13	33.48	27.76	29.06
Average, . .	231.2	231.2	29.75	29.78	34.11	33.54	28.71	29.70

[1] Thirteenth report of this station, pp. 107–109. [2] *Loc. Cit.*
[3] Methods of the Association of Official Agricultural Chemists.

TABLE VII. — *Composition of the Butter Fat* — Concluded.

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

NUMBER SAMPLES, EACH HERD.	SAPONIFICATION EQUIVALENT.		REICHERT-MEISSL NUMBER.		MELTING POINT (DEGREES C.).		IODINE NUMBER.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	231.6	231.9	29.20	29.17	34.53	33.13	26.66	28.63
2 samples, . . .	232.2	232.3	29.52	29.91	34.40	33.43	27.42	29.50
2 samples, . . .	231.1	232.3	29.03	28.66	34.55	32.93	26.91	28.99
2 samples, . . .	232.7	233.7	29.39	28.48	34.58	33.08	26.95	29.59
Average, . .	231.9	232.6	29.29	29.06	34.52	33.17	26.96	29.18

Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.

2 samples, . . .	230.6	226.0	28.80	28.30	33.83	33.33	26.89	36.68
2 samples, . . .	230.2	224.7	30.20	27.80	33.90	32.93	27.47	37.35
2 samples, . . .	229.5	221.9	28.75	24.85	33.73	34.28	28.34	38.58
2 samples, . . .	230.5	219.6	28.55	23.20	34.05	34.40	28.18	40.23
2 samples, . . .	230.5	220.9	28.22	23.61	34.33	34.03	27.94	39.00
Average, . .	230.3	222.6	28.90	25.55	33.97	33.79	27.76	38.37

Fourth period: Herd I., standard ration; Herd II., corn meal ration.

2 samples, . . .	229.7	229.0	27.83	26.88	34.18	33.58	28.80	29.51
1 sample, . . .	227.8	229.4	26.64	27.47	34.15	33.70	29.55	29.14
1 sample, . . .	228.4	229.6	26.61	27.43	34.10	33.65	29.68	28.86
2 samples, . . .	229.6	232.4	27.35	27.17	34.28	33.58	29.02	28.84
2 samples, . . .	231.5	231.2	27.14	27.53	34.48	33.98	29.59	28.69
Average, . .	229.4	230.3	27.11	27.30	34.24	33.70	29.33	29.01

In the first period the butter fat produced by both herds showed a very similar composition, trifling variations only being noted in the melting point and iodine number.

In the second or gluten meal period it is difficult to note any change in the composition of the butter fat which may be attributed to the influence of the gluten meal. In a former experiment[1] no striking differences between the butter fat produced by the standard grain ration and a gluten meal ration could be noted. The iodine number of the fat produced by Herd I. showed a noticeable drop during this period, gradually returning during the next two periods to the number indicated in the first period. The reason for this temporary depression is difficult to explain. It is not to be overlooked that the cow Folly was removed during this

[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

period, and did not again enter the experiment; it is doubtful, however, if her loss in any way affected the composition of the fat.

In the third period Herd II. was still receiving a trifle over 2 pounds of gluten meal daily, so that the ration was essentially the same as in the second period, excepting for the addition of .6 pound of corn oil. It is in this period that a noticeable modification of the butter fat took place with Herd II., while the character of the fat produced by Herd I. remained constant. The difference consisted in the decrease of the saponification equivalent by 10 points, a decrease of the Reichert-Meissl number of $3\frac{1}{2}$ points, and an increase in the iodine number of a trifle over 9 points. The melting point of the fat, on the other hand, showed no marked change. Similar conditions were noted when cotton-seed and linseed oils were fed,[1] excepting that the two latter oils also raised the melting point of the fat.

In the fourth or corn meal period, when the rations of both herds were similar, excepting that corn meal took the place of ground oats with Herd II., the butter fat produced by the latter herd returned to its normal condition, *e.g.*, similar to that produced in the first and second periods, and closely resembling the fat produced by Herd I. during all four periods.

The only noticeable change in the fat of Herd I during the entire experiment,[2] extending from October 20 through April 19, — a period of six months, — consisted in the slight gradual decline in the Reichert-Meissl number, due to advancing lactation. It is interesting to observe the uniformity in the character of butter fat produced by a herd of five cows having the same feed during such a long period of time.

The Opinion of Experts on the Character of the Butter. — Two lots of cream from each herd, raised by the Cooley process, were ripened and made into butter each week. The ripening process generally lasted twenty-four hours, and some commercial starter was employed. The full details of

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[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

[2] Excepting the temporary depression in the iodine number in the second period already referred to.

the process are on file, but it is hardly considered necessary in this connection to publish them, other than to state that the most approved methods were followed.

Pound samples from each lot were sent to Mr. O. Douglass of Boston and Mr. W. A. Gude of New York, who scored them, each being entirely ignorant of the nature of the experiment or of the feeds employed.

TABLE VIII. — *Douglass Butter Scores.*

Flavor.		Body.		Color.		Salt.		Style.		Total.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds, standard ration.											
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
45.0	44.5	20	20	15	15	10	10	5	5	95.0	94.5
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
43.0	43.0	20	20	15	15	10	10	5	5	93.0	93.0
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
Av., 44.0	43.6	20	20	15	15	10	10	5	5	94.0	93.6
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
43.0	43.5	20	20	15	15	10	10	5	5	93.0	93.5
46.0	45.5	20	20	15	15	10	10	5	5	96.0	95.5
45.0	41.0	20	20	15	15	10	10	5	5	95.0	91.0
41.0	43.0	20	20	15	15	10	10	5	5	91.0	93.0
39.0	40.0	20	20	15	15	10	10	5	5	89.0	90.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.8
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.											
44.0	46.0	20	19	15	15	10	10	5	5	94.0	95.0
43.5	45.0	20	19	15	15	10	10	5	5	93.5	94.0
44.5	43.5	20	20	15	15	10	10	5	5	94.5	93.5
45.0	46.5	20	20	15	15	10	10	5	5	95.0	96.5
44.0	45.0	20	20	15	15	10	10	5	5	94.0	95.0
45.5	46.5	20	20	15	15	10	10	5	5	95.5	96.5
43.0	45.0	20	20	15	15	10	10	5	5	93.0	95.0
42.0	44.0	20	20	15	15	10	10	5	5	92.0	94.0
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
44.5	45.0	20	20	15	15	10	10	5	5	94.5	95.0
Av., 45.0	45.0	20	20	15	15	10	10	5	5	94.0	94.8
Fourth period: Herd I., standard ration; Herd II., corn meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
42.5	45.0	20	20	15	15	10	10	5	5	92.5	95.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
40.0	41.0	20	20	15	15	10	10	5	5	90.0	91.0
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
45.0	40.0	20	20	15	15	10	10	5	5	95.0	90.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
43.0	41.0	20	20	15	15	10	10	5	5	93.0	91.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.5

TABLE IX. — *Gude Butter Scores.*

First period: both herds, standard ration.

Flavor.		Body.		Color.		Salt.		Style.		Total.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
35.0	31.0	24.0	23.0	14.5	15.0	10	10	5	5	88.5	84.0
35.0	32.0	25.0	24.0	15.0	15.0	10	10	5	5	90.0	86.0
35.0	30.0	25.0	25.0	15.0	15.0	10	10	5	5	90.0	85.0
30.0	37.0	22.0	22.0	15.0	15.0	10	10	5	5	82.0	89.0
38.0	32.0	24.0	23.0	15.0	15.0	10	10	5	5	92.0	85.0
Av., 35.0	32.0	24.0	23.0	14.9	15.0	10	10	5	5	88.5	85.8

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

37.0	35.0	24.0	22.0	15.0	15.0	10	10	5	5	91.0	85.0
37.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	90.0
32.0	36.0	23.0	24.0	15.0	15.0	10	10	5	5	85.0	90.0
35.0	33.0	25.0	23.0	15.0	15.0	10	10	5	5	90.0	86.0
36.0	36.0	24.0	23.0	15.0	15.0	10	10	5	5	90.0	89.0
28.0	28.0	23.0	23.0	15.0	15.0	10	10	5	5	81.0	81.0
Av., 34.1	34.0	23.8	23.1	15.0	15.0	10	10	5	5	88.0	86.8

Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.

37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	38.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	92.0
39.0	40.0	24.0	25.0	15.0	15.0	10	10	5	5	93.0	95.0
42.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	96.0	90.0
38.0	41.0	24.0	25.0	15.0	15.0	10	10	5	5	92.0	96.0
38.0	40.0	23.0	25.0	15.0	15.0	10	10	5	5	91.0	95.0
38.0	38.0	23.0	23.0	15.0	15.0	10	10	5	5	91.0	91.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
Av., 37.8	39.1	24.2	24.2	15.0	15.0	10	10	5	5	92.0	93.3

Fourth period: Herd I., standard ration; Herd II., corn meal ration.

37.0	37.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	91.0
37.0	37.0	24.5	24.0	15.0	15.0	10	10	5	5	91.0	91.0
35.0	36.0	25.0	24.5	15.0	15.0	10	10	5	5	90.0	90.5
30.0	33.0	23.0	25.0	15.0	14.0	10	10	5	5	83.0	87.0
41.0	39.0	25.0	25.0	15.0	15.0	10	10	5	5	96.0	94.0
40.0	36.0	25.0	24.0	15.0	15.0	10	10	5	5	95.0	90.0
39.0	39.0	24.0	24.0	15.0	15.0	10	10	5	5	93.0	93.0
38.0	38.0	25.0	24.5	15.0	15.0	10	10	5	5	93.0	92.5
Av., 37.1	36.9	24.4	24.1	15.0	14.9	10	10	5	5	91.5	91.1

As will be seen from the above scores, Mr. Douglass considered the butter produced by both herds during the several periods of good average quality. The flavor he scored a trifle higher in the first and third periods. He found no fault with the body excepting in case of Herd II. in the third period; this butter he repeatedly pronounced as "light bodied, but acceptable in any market."

Mr. Gude appeared to have been much more critical. He often mentioned a "tainted off flavor, as from stale milk," in the butter produced by both herds during the first and second periods. This defect, in our judgment, was due to the starter, with which considerable trouble was experienced, and could in no way be attributed to the feed. The flavor of the butter produced by both herds during the third period was more satisfactory, although it was occasionally referred to as having only a "faint aroma." Mr. Gude several times mentioned the product of Herd II. during this third or corn oil period as having a "fine aroma," and the average score is rather higher than for Herd I. In the fourth period no particular difference in the flavor was observed.

The body of the butter made from Herd I. during all four periods was repeatedly pronounced "short and crumbly;" the body of that produced by Herd II. in the second and fourth periods was also frequently referred to as being crumbly; while that produced by the same herd in the third or corn oil period was sometimes spoken of as satisfactory and sometimes as rather light and rather soft, but suitable for market. It was evident that Mr. Gude liked the flavor and body of the butter produced by the corn oil ration. The same fact was noticed when King gluten meal, containing 14 per cent. of corn oil, was fed.[1]

Personal Observations on the Body of the Butter. — The writer made no attempt to pronounce critical judgment on the flavor of the butter, but endeavored to note particularly the character of the body. No difference could be observed in the body of the butter produced by both herds in the first period. It might be characterized as being hard and firm.

In the second period, pound samples of the butter produced by each herd were allowed to reach a temperature of 57° F. The butter from Herd I. at this temperature appeared noticeably harder and firmer than that produced by Herd II. This conclusion was reached as a result of pushing a glass rod into the mass at different points, and by

[1] Thirteenth report of this station, p. 120.

touching the same with the finger. The same differences were noted at a temperature of 70° F. As the temperature was gradually increased, Herd II. butter showed a tendency to lose form more quickly than Herd I. butter. When the interior of the lumps had reached 83° F., Herd II. butter had lost form, and collapsed into a shapeless, slushy mass; while Herd I. butter still stood up in print form, although showing a tendency to lose its shape. When the room temperature reached 95° F., and the interior temperature of the butter 85° F., Herd I. butter also lost form. It is quite possible that, if this latter butter had been held at 85° F., or even lower, for a considerable time, it would also have fallen into a slushy condition. It will be understood that it is quite difficult to control the exact temperature of a mass of butter. The temperature of the room may be 95° F., while the temperature of the interior of the lump of butter may be 10° lower.

Though the butter produced by Herd II. was softer, lost its form and became slushy more quickly than that produced by Herd I., but little of the fat actually melted until a higher temperature had been reached.

While the differences in the body of the butter produced by the two herds was quite marked, it was probably not sufficient to effect its commercial value, at least during the cooler portion of the year.

Similar observations to the above were made on the two lots of butter produced in the third or corn oil period, the results being even *more pronounced.* At a temperature of 44° F., Herd I. butter was very hard and firm; Herd II. butter, while being hard, had rather a greasy, salvy look, and yielded more easily to the touch. After standing over night at a temperature of 70° F., this difference was very pronounced, the Herd I. product being still firm, while the Herd II. was yielding and soft to the touch. At 82° F., Herd I. butter still retained its print form, while Herd II. butter lost form and was quite slushy. It is believed that the corn gluten and corn oil rations produced rather a softer butter than did the cotton-seed oil ration.[1]

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[1] Fourteenth report of this station, page 167.

But little difference could be noted in the body of the butter produced by both herds during the fourth or corn meal period. At an interior temperature of 60° F. it was not possible to detect any variation. After the butter had stood twenty-four hours in the same room, and showed an interior temperature of 76° F., Herd II. butter appeared to be a trifle softer than Herd I. butter. The difference was certainly not at all pronounced; both lots would be said to possess a hard, firm body.

TABLE X. — *Degrees of Penetration (Millimeters).*

[Each number represents results with one print.]

First Period (32° F.).		Second Period (65° F.).		Third Period (57° F.).		Fourth Period (67° F.).	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.35	4.05	8.39	11.70	6.45	13.30	12.10	13.17
4.15	4.65	8.60	10.80	6.40	13.15	13.96	14.05
4.35	4.50	9.45	11.90	5.95	12.60	15.50	19.08
4.40	4.55	9.10	12.55	5.95	15.10	16.20	15.75
4.25	4.85	11.00	13.10	7.40	14.65	16.15	16.15
–	–	11.10	16.30	7.05	14.70	15.25	16.50
–	–	10.20	15.50	6.30	14.20	15.79	18.46
–	–	–	–	6.55	13.25	16.40	17.75
–	–	–	–	6.00	13.05	–	–
–	–	–	–	6.95	16.15	–	–
Av., 4.30	4.50	9.69	13.12	6.50	14.02	15.17	16.36

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped for a definite height. Unfortunately, through a misunderstanding, the tests of the butter produced by the two herds in the first period were made a temperature of 33° F., so that the plunger had little opportunity to penetrate. In the other periods the butter was taken from the refrigerator and allowed to stand in the dairy room until it had acquired the room temperature. It will be seen that both in the second and third periods, and particularly in the latter, the butter produced by Herd II. was noticeably softer and more yielding than the product of Herd I. In the fourth period little difference was observed. This method of testing has been criticised, on the ground that different portions of the same lump or print would show widely different degrees of firmness. This claim may be to an extent true. In each case, however, a definite number of tests were made in different parts of each print, and results averaged. The variations were not wide, and the differences in the firmness of the butter are quite striking.

Effect of Feed on the Time of Churning the Cream and on the Quantity of Fat left in the Skim Milk and Buttermilk. — The only noticeable difference in the time of churning was in the third period. One-fifth more time was required to bring the butter from the cream produced by Herd II., receiving the corn oil, than from Herd I., receiving the standard ration.

A number of samples of cream, skim milk and buttermilk were taken in each period and the fat percentages determined, the results being tabulated below: —

TABLE XI. — *Fat in Cream, Skim Milk and Buttermilk.*

First Period.						Second Period.					
Herd I.			Herd II.			Herd I.			Herd II.		
Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.
15.50	0.11	0.11	16.88	0.07	0.10	18.88	0.23	0.02	16.13	0.34	0.05
17.13	0.08	0.02	16.38	0.13	0.02	17.63	0.24	0.06	16.63	0.34	0.06
18.50	0.18	0.05	16.88	–	0.05	18.50	0.18	0.04	16.88	0.33	0.08
–	–	–	–	–	–	–	–	0.10	–	–	0.12
Av., 17.12	0.12	0.06	16.71	0.10	0.06	18.34	0.23	0.06	16.55	0.34	0.08
Third Period.						Fourth Period.					
17.63	0.20	0.05	18.75	0.15	0.28	–	–	0.41	–	–	0.38
18.18	0.20	0.08	18.50	0.13	0.27	–	0.39	–	–	0.40	–
17.88	0.16	0.09	19.63	0.14	0.24	–	0.43	–	–	0.28	–
18.13	0.20	0.09	17.13	0.23	0.30	–	–	–	–	–	–
18.25	0.24	0.05	18.83	0.20	0.24	–	–	–	–	–	–
18.25	0.20	0.10	16.63	0.23	–	–	–	–	–	–	–
17.63	0.25	0.13	18.75	0.26	0.31	–	–	–	–	–	–
–	–	0.19	–	–	0.40	–	–	–	–	–	–
Av., 17.99	0.21	0.10	18.32	0.19	0.29	–	0.41	0.41	–	0.34	0.38

The results indicate that there was no particular difference in the percentage of fat left in the skim milk or buttermilk produced by the two herds, excepting in case of the buttermilk obtained from the butter produced by Herd II. in the third period, when .20 per cent. more fat was found than in that produced by Herd I. As the period of lactation became advanced, more fat was left in the skim milk produced by both herds. This, however, is a well-established fact with cream raised by the gravity process.

Conclusions. — The fact must not be overlooked that this experiment, on which the following conclusions are based, extended over a period of six months, with periods varying from three to seven weeks in length; the period proper was always preceded by a preliminary period of two weeks.

1. The immediate effect of the addition of .6 pounds of corn oil to the corn gluten meal ration was to increase the fat percentage in the milk .23 of 1 per cent. (5.17 to 5.40); at the end of two weeks the effect of the corn oil had disappeared, and the milk had returned to its normal fat content.

2. The removal of the corn oil from the daily ration caused a sudden drop of .54 per cent. in the fat (4.97 to 4.43), but after the first week the normal fat per cent. was again present.

3. Corn oil appeared to have depressed the nitrogen percentage in the milk by .034 per cent. (.610 to .576); the nitrogen gradually returned to its normal percentage after the feeding of the corn oil had ceased.

4. It is not considered practicable to feed large amounts of oil to cows, it having a tendency to derange the digestive and milk-secreting organs.

5. Corn meal was without effect on the composition of the milk.

6. There was but little change in the composition of the milk produced by Herd I. for a period of six months, during which time the herd received the same or so-called standard ration; a gradual increase in the percentage of solids not fat only was noted.

7. Corn gluten meal and corn meal were without noticeable influences on the chemical composition of the butter fat.

8. The addition of corn oil to the corn gluten meal ration caused a depression of 10 points in the saponification equiva-

lent, a decrease of 3½ points in the Reichert-Meissl number, and an increase of 9 points in the iodine number, while the melting point of the fat remained unchanged.

9. An analysis of the butter fat will seldom give positive knowledge concerning the firmness or body of the butter.

10. A high iodine number is indicative of a soft or "light-bodied" butter; but a high melting point is not a sure indication of a hard, firm butter.

11. It seems probable that neither the proteid or carbohydrate groups, when fed in normal amounts, have any noticeable influence in changing the proportions of the several milk ingredients, or in modifying the chemical character of the butter fat; such changes, so far as they occur, are due to the presence of the oil in the feed stuff.

12. Corn gluten meal with a minimum percentage of oil produced rather a soft, yielding butter; this condition was noticeably increased by the addition of corn oil to the ration.

13. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, method of butter manufacture, and especially upon the character of the starter employed. Normal feeding stuffs are of secondary importance in establishing butter flavor.[1]

14. The present and previous experiments indicate that starchy feeds produce a hard-bodied butter, vegetable oils a soft butter; some proteids a hard-bodied butter, others butter of a softer, lighter body.

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[1] A possible exception to the above may be made in the case of young, clean pasture grass.

B. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

Digestion experiments with sheep were begun at this station in 1893, and a full description of the method employed will be found in the eleventh report of the Massachusetts State Experiment Station. The following experiments were made in the autumn of 1902 and during the winter and spring of 1903. The full data is given in this report, with the exception of the daily production of manure and the daily water consumption, in which case, to economize space, averages only are presented.

The periods extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were fed each sheep daily, in addition to the regular ration. Water was before the animals at all times. Sheep III. throughout the series gave evidence of strong digestive powers, while Sheep II. and particularly Sheep I. showed at times evidence of weak digestion, and in several cases the results from these two latter sheep were omitted, and the tests will be repeated. The sheep were full-grown grade Southdown wethers, and have been used for a number of years.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

Feed Stuffs.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digestion hay,	7.63	12.03	31.60	45.89	2.85
Apple pomace,	3.93	5.06	16.17	70.00	4.84
Biles XXXX distillers' grains,	1.77	37.75	14.56	34.15	11.77
Merchants distillers' grains,	2.10	34.52	13.71	35.25	14.42
Brewers' grains,	3.83	26.02	17.48	45.30	7.37
Malt sprouts,	4.97	28.27	16.24	49.02	1.50
Soy bean meal,	5.18	41.93	4.40	29.43	19.06
Hominy meal,	3.38	12.23	4.97	69.43	9.99
Waste, Sheep III., Period XXV.,	7.63	12.03	31.60	45.89	2.85

[1] With E. B. Holland and P. H. Smith.

Composition of Fæces (Per Cent.).

Sheep I.

Period.	Fæces from—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	10.63	11.65	31.88	42.46	3.38
XXI., .	Apple pomace, ...	9.57	13.98	29.32	42.40	4.73
XXII., .	Biles XXXX distillers' grains,	10.26	18.28	26.85	41.40	3.21
XXIII., .	Merchants distillers' grains, .	10.63	18.34	27.04	40.81	3.18
XXIV., .	Brewers' grains, . . .	9.94	11.65	28.73	46.98	2.70

Sheep II.

Period.	Fæces from—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.08	12.10	28.74	43.45	3.63
XXI., .	Apple pomace, ...	10.58	14.23	26.89	42.70	5.60
XXII., .	Biles XXXX distillers' grains,	10.80	19.13	24.54	42.29	3.24
XXIII., .	Merchants distillers' grains, .	11.79	18.78	23.90	41.94	3.59
XXIV., .	Brewers' grains, . . .	11.46	12.59	26.14	46.78	3.03
XXVII., .	Soy bean meal, ...	13.41	14.22	24.83	43.40	4.14

Sheep III.

Period.	Fæces from—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.34	13.71	26.72	43.29	3.94
XXI., .	Apple pomace, ...	11.08	15.63	25.75	42.08	5.46
XXII., .	Biles XXXX distillers' grains,	10.88	19.60	23.92	42.25	3.35
XXIII., .	Merchants distillers' grains, .	11.64	19.53	23.61	41.76	3.46
XXIV., .	Brewers' grains, ...	11.18	12.29	25.19	48.00	3.34
XXV., .	Malt sprouts, ...	12.82	15.06	24.35	44.27	3.50
XXVII., .	Soy bean meal, ...	12.75	14.28	26.81	41.67	4.49
XXVIII., .	Hominy meal, ...	13.06	14.88	24.06	43.41	4.59

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

Sheep I.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	–	–	–	–	–	–	–	–	90.50
XXI., .	86.60	18.56	–	–	–	–	–	–	–	90.48
XXII., .	86.75	–	90.10	–	–	–	–	–	–	94.66
XXIII., .	87.22	–	–	91.23	–	–	–	–	–	93.24
XXIV., .	87.60	–	–	–	84.31	–	–	–	–	93.12

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

Sheep II.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	-	-	-	-	-	-	-	-	90.32
XXI., .	86.60	18.56	-	-	-	-	-	-	-	90.21
XXII., .	86.75	-	90.10	-	-	-	-	-	-	94.74
XXIII., .	87.22	-	-	91.23	-	-	-	-	-	93.15
XXIV., .	87.60	-	-	-	84.31	-	-	-	-	93.00
XXVII., .	87.82	-	-	-	-	-	-	-	-	93.23

Sheep III.

Period.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	-	-	-	-	-	-	-	-	90.12
XXI., .	86.60	18.56	-	-	-	-	-	-	-	89.78
XXII., .	86.75	-	90.10	-	-	-	-	-	-	94.02
XXIII., .	87.22	-	-	91.23	-	-	-	-	-	93.11
XXIV., .	87.60	-	-	-	84.31	-	-	-	-	93.32
XXV., .	89.12	-	-	-	-	85.55	-	-	73.50	93.56
XXVII., .	87.82	-	-	-	-	-	86.62	-	-	93.40
XXVIII., .	88.25	-	-	-	-	-	-	88.48	-	92.91

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

Period.	Character of Ration.	Sheep I.			Sheep II.			Sheep III.		
		Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.
XX.,	Digestion hay,	680	31.96	1,815	590	30.49	1,451	628	30.07	1,640
XXI.,	Apple pomace,	703	29.14	518	528	27.69	382	501	25.78	313
XXII.,	Biles XXXX distillers' grains,	654	28.38	1,690	595	27.98	1,097	671	27.41	1,410
XXIII.,	Merchants distillers' grains,	632	27.46	1,758	600	26.72	1,091	722	26.88	1,531
XXIV.,	Brewers' grains,	741	32.86	2,214	707	30.81	1,142	636	29.04	1,694
XXV.,	Malt sprouts,	1,090	31.33	1,623	933	31.51	1,053	721	26.83	1,286
XXVII.,	Soy bean meal,	674	27.78	2,500	617	24.58	2,208	638	26.05	2,316
XXVIII.,	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

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

Period.	Character of Ration.	Sheep I.		Sheep II.		Sheep III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
XX.,	Digestion hay,	158.75	155.00	150.25	146.25	140.00	139.00
XXI.,	Apple pomace,	153.00	152.00	144.75	146.25	138.00	138.50
XXII.,	Biles XXXX distillers' grains,	152.50	153.50	147.00	146.75	139.50	137.00
XXIII.,	Merchants distillers' grains,	152.50	153.00	148.50	148.25	136.75	139.25
XXIV.,	Brewers' grains,	161.25	155.75	153.25	150.50	144.75	142.75
XXV.,	Malt sprouts,	159.75	156.75	155.25	152.50	145.50	146.25
XXVII.,	Soy bean meal,	154.25	152.00	154.75	154.50	149.00	146.50
XXVIII.,	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Digestion Hay. — Period XX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
319.59 grams manure excreted,	289.23	30.75	33.70	92.21	122.81	9.78
Grams digested,	481.08	28.02	58.97	151.21	230.69	12.17
Per cent. digested,	62.45	47.68	63.63	62.12	65.26	55.44

Sheep II.

900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
304.86 grams manure excreted,	275.35	33.26	33.32	79.13	119.64	10.00
Grams digested,	494.96	25.51	59.35	164.29	233.86	11.95
Per cent. digested,	64.25	43.41	64.04	67.49	66.16	54.44

Sheep III.

900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
300.70 grams manure excreted,	270.99	33.44	37.15	72.41	117.31	10.68
Grams digested,	499.32	25.33	55.52	171.01	236.19	11.27
Per cent. digested,	64.82	43.10	59.91	70.25	66.81	51.34
Average per cent. digested (three sheep),	**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**

Average nutritive ratio of rations for three sheep, 1:7.29.

Apple Pomace. — Period XXI.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	519.60	39.65	62.51	164.19	238.44	14.81
1,200 grams apple pomace fed,	222.72	8.75	11.27	36.01	155.90	11.79
Total consumed,	742.32	48.40	73.78	200.20	394.34	26.60
291.36 grams manure excreted,	263.62	25.23	36.85	77.29	111.77	12.47
Amount digested,	478.70	23.17	36.93	122.91	282.57	14.13
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	146.16	5.33	–	12.90	125.20	6.13
Per cent. digested,	65.63	60.91	–	35.82	80.31	51.99

Sheep II.

Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
276.90 grams manure excreted,	249.79	26.43	35.55	67.17	106.66	13.99
Amount digested,	492.53	21.97	38.23	133.03	287.68	12.61
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	159.99	4.13	–	23.02	130.31	4.61
Per cent. digested,	71.83	47.20	–	63.93	83.59	39.10

Sheep III.

Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
257.81 grams manure excreted,	231.46	25.65	36.18	59.60	97.40	12.64
Amount digested,	510.86	22.75	37.60	140.60	296.94	13.96
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	178.32	4.91	–	30.59	139.57	5.96
Per cent. digested,	80.06	56.11	–	84.95	89.53	50.56
Average per cent. digested (three sheep),	**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**

Average nutritive ratio of rations for three sheep, 1:12.02.

Biles Distillers' Grains. — Period XXII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	563.88	43.02	67.83	178.19	258.76	16.07
250 grams Biles distillers' grains fed,	225.25	3.99	85.03	32.80	76.92	26.51
Total consumed,	789.13	47.01	152.86	210.99	335.68	42.58
283.76 grams manure excreted,	268.61	27.56	49.10	72.12	111.20	8.62
Amount digested,	520.52	19.54	103.76	138.87	224.48	33.96
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	159.64	–	61.03	19.48	53.70	25.28
Per cent. digested,	70.87	–	71.77	59.39	69.31	95.36

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
279.77 grams manure excreted,	265.05	28.63	50.70	65.04	112.09	8.59
Amount digested,	524.08	18.38	102.16	145.95	223.59	33.99
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	163.20	–	59.43	26.56	52.81	25.31
Per cent. digested,	72.45	–	69.39	80.98	68.66	95.48

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
274.09 grams manure excreted,	257.70	28.04	50.51	61.64	108.88	8.63
Amount digested,	531.43	18.97	102.35	149.35	226.80	33.95
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	170.55	–	59.62	29.96	56.02	25.27
Per cent. digested,	75.71	–	70.12	91.34	72.83	95.32
Average per cent. digested (three sheep),	**73.01**	–	**70.59**	**77.24**	**70.43**	**95.39**

Average nutritive ratio of rations for three sheep, 1:4.34.

Merchants Distillers' Grains. — Period XXIII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	566.93	43.26	68.20	179.15	260.16	16.16
250 grams merchants distillers' grains fed,	228.08	4.79	78.73	31.27	80.40	32.89
Total consumed,	795.01	48.05	146.93	210.42	340.56	49.05
274.64 grams manure excreted,	256.07	27.22	46.96	69.24	104.50	8.14
Amount digested,	538.94	20.83	99.97	141.18	236.06	40.91
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	176.10	1.36	57.00	21.15	64.35	32.18
Per cent. digested,	77.21	28.39	72.40	67.64	80.04	97.84

Sheep II.

Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
267.16 grams manure excreted,	248.86	29.34	46.74	59.48	104.37	8.93
Amount digested,	546.15	18.71	100.19	150.94	236.19	40.12
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	183.31	–	57.22	30.91	64.48	31.39
Per cent. digested,	80.37	–	72.68	98.85	80.20	95.44

Sheep III.

Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
268.76 grams manure excreted,	250.24	29.13	48.87	59.08	104.50	8.66
Amount digested,	544.77	18.92	98.06	151.34	236.06	40.39
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	181.93	–	55.09	31.31	64.35	31.66
Per cent. digested,	79.77	–	69.97	100.00	80.04	96.26
Average per cent. digested (three sheep),	**79.12**	–	**71.68**	**88.83**	**80.09**	**96.51**

Average nutritive ratio of rations for three sheep, 1:4.78.

Dried Brewers' Grains. — Period XXIV.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams hay fed,	438.00	33.42	52.69	138.41	201.00	12.48
400 grams brewers' grains fed,	337.24	12.92	87.75	58.95	152.77	24.85
Total consumed,	775.24	46.34	140.44	197.36	353.77	37.33
328.61 grams manure excreted,	306.00	30.42	35.65	87.91	143.76	8.26
Amount digested,	469.24	15.92	104.79	109.45	210.01	29.07
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	188.92	.88	71.60	16.72	77.35	22.33
Per cent. digested,	56.02	–	81.60	28.36	50.63	89.36

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
308.06 grams manure excreted,	286.50	32.83	36.07	74.89	134.02	8.68
Amount digested,	488.74	13.51	104.37	122.47	219.75	28.65
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	208.42	–	71.18	29.74	87.09	21.91
Per cent. digested,	61.80	–	81.12	50.45	57.01	88.17

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
290.43 grams manure excreted,	271.03	30.30	33.31	68.27	130.09	9.05
Amount digested,	504.21	16.04	107.13	129.09	223.68	28.28
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	223.89	1.00	73.94	36.36	91.02	21.54
Per cent. digested,	66.39	–	84.26	61.68	59.58	86.68
Average per cent. digested (three sheep),	**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**

Average nutritive ratio of rations for three sheep, 1:4.14.

Malt Sprouts. — Period XXV.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay fed,	623.84	47.60	75.05	197.13	286.28	17.78
42.14 grams waste hay,	30.97	2.36	3.73	9.79	14.21	.88
Total hay consumed,	592.87	45.24	71.32	187.34	272.07	16.90
200 grams malt sprouts fed,	171.10	8.50	48.37	27.79	83.87	2.57
Total consumed,	763.97	53.74	119.69	215.13	355.94	19.47
268.33 grams manure excreted,	251.05	32.18	37.81	61.13	111.14	8.79
Amount digested,	512.92	21.56	81.88	154.00	244.80	10.68
Minus hay digested,	379.44	20.36	44.93	125.52	179.57	9.13
Malt sprouts digested,	133.48	1.20	36.95	28.48	65.23	1.55
Per cent. digested,	78.01	–	76.39	102.50	77.78	60.31

Nutritive ratio of ration for Sheep III., 1:5.16.

Soy Bean Meal. — Period XXVII.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams hay fed,	614.74	46.90	73.95	194.26	282.10	17.52
200 grams soy bean meal fed,	173.24	8.97	72.64	7.62	50.98	33.02
Total consumed,	787.98	55.87	146.59	201.88	333.08	50.54
245.80 grams manure excreted,	229.16	30.73	32.59	56.90	99.46	9.49
Amount digested,	558.82	25.14	114.00	144.98	233.62	41.05
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	165.39	4.03	67.41	14.83	47.43	31.59
Per cent. digested,	95.46	44.93	92.80	194.62	93.04	95.67

Sheep III.

Total consumed as above,	787.98	55.87	146.59	201.88	333.08	50.54
260.47 grams manure excreted,	243.28	31.02	34.74	65.22	101.37	10.92
Amount digested,	544.70	24.85	111.85	136.66	231.71	39.62
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	151.27	3.74	65.26	6.51	45.52	30.16
Per cent. digested,	87.32	41.70	89.34	85.43	89.29	91.34
Average per cent. digested (two sheep),	**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**

Average nutritive ratio of rations for two sheep, 1:4.11.

Hominy Meal. — Period XXVIII.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal fed,	265.44	8.97	32.46	13.19	184.29	26.52
Total consumed,	794.94	49.37	96.16	180.51	427.28	41.61
231.44 grams manure excreted,	215.03	28.08	32.00	51.74	93.34	9.87
Amount digested,	579.91	21.29	64.16	128.77	333.94	31.74
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	241.03	3.11	24.03	16.67	173.57	23.59
Per cent. digested,	90.80	34.67	74.03	126.55	94.18	88.95

Nutritive ratio of ration for Sheep III., 1:8.32.

Summary of Coefficients.

Ration.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Hay,	Sheep I.,	62.45	47.68	63.63	62.12	65.26	55.44
	Sheep II.,	64.25	43.41	64.04	67.49	66.16	54.44
	Sheep III.,	64.82	43.10	59.91	70.25	66.81	51.34
Average,	. . . . .	**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**
Apple pomace,	Sheep I.,	65.63	60.91	–	35.82	80.31	51.99
	Sheep II.,	71.83	47.20	–	63.93	83.59	39.10
	Sheep III.,	80.06	56.11	–	84.95	89.53	50.56
Average,	. . . . .	**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**
Biles distillers' grains,	Sheep I.,	70.87	–	71.77	59.39	69.31	95.36
	Sheep II.,	72.45	–	69.39	80.98	68.66	95.48
	Sheep III.,	75.71	–	70.12	91.34	72.83	95.32
Average,	. . . . .	**73.01**	–	**70.59**	**77.24**	**70.43**	**95.39**
Merchants distillers' grains,	Sheep I.,	77.21	28.39	72.40	67.64	80.04	97.84
	Sheep II.,	80.37	–	72.68	98.85	80.20	95.44
	Sheep III.,	79.77	–	69.97	100.00	80.04	96.26
Average,	. . . . .	**79.12**	–	**71.68**	**88.83**	**80.09**	**96.51**
Dried brewers' grains,	Sheep I.,	56.02	–	81.60	28.36	50.63	89.36
	Sheep II.,	61.80	–	81.12	50.45	57.01	88.17
	Sheep III.,	66.39	–	84.26	61.68	59.58	86.68
Average,	. . . . .	**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**
Malt sprouts,	Sheep III.,	**78.01**	–	**76.39**	**102.50**	**77.78**	**60.31**
Soy bean meal,	Sheep II.,	95.46	44.93	92.80	194.62	93.04	95.67
	Sheep III.,	87.32	41.70	89.34	85.43	89.29	91.34
Average,	. . . . .	**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**
Hominy meal,	Sheep III.,	**90.80**	**34.67**	**74.03**	**126.55**	**94.18**	**88.95**

Discussion of the Results.

Digestion Hay. — The hay was largely Kentucky blue-grass (*Poa pratensis*), cut in bloom, and was employed in all of the several tests herein reported. It showed a high degree of digestibility.

Apple Pomace. — The pomace was taken fresh from the cider mill, and contained 18.56 per cent. of dry matter. It is the first digestion test of such material on record, either in Europe or the United States. The sheep did not digest it as evenly as could be desired, although they ate it satisfactorily, and no digestion disturbances were noted. The percentage of crude protein (5.06 in dry matter) was small, and no coefficients were obtained. This, in all probability, was partly due to the "digestion depression" known to take place when feeds especially high in carbohydrates are added to a hay ration, the effect being particularly noticeable in the protein, and to a less extent in the fiber. The pomace contained fully as much digestible matter as silage made from the smaller varieties of corn. Whether, per unit of dry matter, it is as valuable a feed as corn silage, is rather uncertain. This point will be ascertained later.

Distillers' Dried Grains. — Considerable has been said concerning the source, composition and digestibility of distillers' grains in the thirteenth report of this station. Briefly stated, these feeds represent the residue in the manufacture of alcohol, spirits and whiskey from the several cereals, and are composed chiefly of the hull, germ and protein matter of the grains. In the better class of such material, containing 28 or more per cent. of protein, the residue consists largely of corn. In the most modern plants, the distillery slop, hot from the stills, is dried immediately in especially constructed driers, and has a slightly sour taste and smell. One of the two samples herein reported — the merchants — had as lightly burned taste, which is not to be desired. The grains are now sold in Massachusetts markets under the following names: Biles XXXX Grains, Ajax Flakes, Merchants Grains, Hall's AAAA Grains, Atlas Gluten Meal and Corn Protegran.

Both samples here reported showed a high degree of digestibility. The sample of Merchants grains proved about 6 per cent. more digestible than the "Fourex" brand, due probably to the character of the cereals used in the mash. The difference was principally in the extract matter. Comparing the coefficients obtained with Sheep III., the difference in case of the total dry matter is reduced to 4 per cent. Marked differences are observed in the digestibility of the fiber. Such variations in fiber digestibility are characteristic of all grains and grain by-products. This matter will be referred to farther on.

In this connection it will doubtless prove of interest to summarize the results obtained at this station with 7 different samples of distillers' grains: —

Composition of the Grains (Per Cent.).

Brand.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Biles X,	8.91	1.68	29.15	9.58	40.03	10.65
Biles XX,	9.53	2.44	25.49	11.22	41.80	9.52
Biles XXX,	7.46	2.05	29.86	10.28	38.52	11.83
Biles XXXX,	8.83	1.70	34.76	11.40	33.50	9.81
Biles XXXX,	9.45	1.55	35.46	13.00	29.87	10.67
Merchants,	8.77	1.92	31.49	12.51	32.15	13.16
Atlas,	8.96	.94	38.80	8.86	28.08	14.36
Average,	8.84	1.75	32.14	10.98	34.85	11.43

The percentage of ash is low, as would naturally be expected. Its exact character has not been determined. The protein percentage is relatively high, and varies considerably, depending upon the material used. The brands offered in Massachusetts have been guaranteed to contain 33 and 34 per cent. Considerable fiber is present, as a result of the incorporated grain hulls. The fiber and extract matter must show a very considerable amount of pentosans, although determinations have not been made. The fat percentage is quite high, being similar in quantity to that contained in the corn gluten feed, before the corn oil was extracted.

Digestion Coefficients of Distillers' Dried Grains (Per Cent.).

[All experiments.]

Number of Sheep.	Brand.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	Biles X grains,	86.50	20.24	65.51	130.11	93.12	93.94
Sheep III.,	Biles X grains,	87.07	–	80.05	127.56	85.15	97.60
Sheep I.,	Biles XX grains,	88.53	13.91	79.94	122.75	88.22	94.45
Sheep VI.,	Biles XX grains,	79.77	–	76.50	97.22	79.77	94.87
Sheep II.,	Biles XXX grains,	79.88	–	73.41	108.91	78.03	91.78
Sheep VI.,	Biles XXX grains,	71.41	–	74.01	66.03	72.69	93.95
Sheep I.,	Biles XXXX grains,	79.82	–	72.08	102.77	81.12	96.99
Sheep VI.,	Biles XXXX grains,	73.47	–	69.22	81.78	76.73	98.45
Sheep I.,	Biles XXXX grains,	70.87	–	71.77	59.39	69.31	95.36
Sheep II.,	Biles XXXX grains,	72.45	–	69.39	80.98	68.66	95.48
Sheep III.,	Biles XXXX grains,	75.71	–	70.12	91.34	72.83	95.32
Sheep IV.,	Merchants grains,	77.21	28.39	72.40	67.64	80.04	97.84
Sheep V.,	Merchants grains,	80.37	–	72.68	98.85	80.20	95.44
Sheep VI.,	Merchants grains,	79.77	–	69.97	100.00	80.04	96.26
Sheep III.,	Atlas gluten meal,	79.53	–	73.04	94.88	84.00	92.43
Sheep IV.,	Atlas gluten meal,	79.75	–	72.56	116.50	84.91	90.06
Average,	. . . . . .	78.88	–	72.67	96.67	79.68	95.01

As a result of 16 single digestion trials with 6 different samples, several points may be noted: —

(*a*) The dry matter coefficients differed considerably, but the grains showed a high average digestibility.

(*b*) The ash was apparently little digested. Whether this was literally true, or whether a portion of it was substituted for the digestible ash of the hay, is not clear.

(*c*) The protein in the several brands was quite evenly digested, except in the first two samples.

(*d*) The fiber showed marked variations in digestibility, in common with all feeds of similar character. While it has been generally held that nitrogenous feed stuffs do not affect the normal digestibility of the coarse fodders they supplement, it certainly seems reasonable to conclude that the addition of 200 to 250 grams of the distillers' grains to the hay ration, giving a nutritive ration of 1 : 4, has resulted in increasing the digestibility of the fiber in the hay; which accounts, in the majority of cases, for the apparently very high digestion coefficients obtained. Admitting this to be the case, the fact still remains that, while the digestion coefficient for the fiber is rather of an uncertain quantity, it must be regarded as relatively high.

(*e*) The extract matter digested in the several samples differed to a noticeable extent, depending probably upon the nature of the material composing it, the way in which it is united with the crude fiber, and also upon the digestive capacity of the sheep. Other things being equal, animals in normal condition should digest substantially equal quantities of the same feed stuff, when fed under similar conditions. It often happens, however, that one or the other animal will be a trifle out of condition without giving any external evidence of it, and hence will digest rather more of one fodder group and less of another.

Attention is called to the fact that the higher the digestion coefficients obtained for the fiber, the higher are those obtained for the extract. This is undoubtedly due to the intimate chemical and physiological relations known to exist between these two fodder groups.

(*f*) The fat was quite evenly and largely digested.

Dried Brewers' Grains. — These were grains of good quality, and of a fresh, bright color. Sheep I. showed its inability to digest the fiber and extract matter as well as the other sheep, and even Sheep II. did not utilize the fiber as well as Sheep III. The average coefficients for the three sheep corresponded quite well with former experiments made at this station, and also with German experiments; excepting that in case of the American tests the coefficients for the protein and fiber are somewhat higher, and the extract matter 4 per cent. lower.

Malt Sprouts. — These were of average quality. They contained an exceptionally large portion of their nitrogen, 42.29 per cent., in the form of amids. The experiment was conducted with three sheep, but Sheep I. and Sheep II. digested so much less fiber and extract matter than is customary that the results with these two sheep were discarded, and the test will be repeated. Only one other American test with a single animal is on record, and showed considerably less fiber and extract matter digested than that obtained in the present experiment. The present single test agrees fairly well with the seven German trials reported.

Soy Bean Meal (*Brook's Medium Green*). — This variety is by far the best suited to northern conditions. The sample was grown upon the station grounds, and was coarsely ground before being fed. The seed is green in color, and similar in size to dwarf garden peas. The bean contained 61 per cent. of protein and fat, and these two ingredients are shown to be 91 and 93 per cent. digestible. The extract matter, 29.43 per cent., was 91 per cent. digested. The coefficients of digestibility obtained for the fiber are, of course, incorrect, due probably to the favorable influence of the soy bean, a nitrogenous feed stuff, in increasing the digestibility of the hay carbohydrates. It can be assumed that the fiber contained in the soy bean has a high rate of digestibility. The small amount present, 4.40 per cent., renders a knowledge of the exact percentage digestible of minor importance.

The three American digestion trials, with an unnamed variety, reported in Lindsey's compilation, show the protein and fat to have been nearly as well digested as those in the present trial. The fiber and extract matter, on the other hand, had noticeably lower digestion coefficients (33 and 71). In the two German trials reported the protein and fat are respectively 87 and 94 per cent., and the extract matter 62 per cent. digestible, while the digestibility of the fiber is not stated.

It is evident, from all trials thus far made, that the protein and fat, comprising from 50 to 60 per cent. of the bean is very fully digested. Whether the high digestibility of the fiber and extract in the present experiment is due to the variety of the bean, or is a peculiarity of the sheep employed, will be determined by further tests.

Hominy Meal, or Chop. — As used for cattle feeding this consists of the hull, germ and some of the gluten and soft starch. The sample tested for digestibility was of good average quality. The present trial was made with three sheep, but Sheep I. and Sheep II. digested so unevenly that the results were discarded, it being evident that their digestion powers had become weakened by continued use. The results with Sheep III. show the hominy to be fully as digestible as corn meal. The addition to the hay of even a carbohydrate feed, such as hominy, seemed to have increased the digestibility of the fiber in the hay, judging from the coefficients obtained for the hominy fiber.

C. Raising Dairy Calves without Milk.

J. B. LINDSEY.

With plenty of skim milk available, the rearing of calves intended for the dairy is a comparatively simple matter. There is, however, a constantly increasing demand in Massachusetts for whole milk, and the amount available for butter production is likely to diminish from year to year. With little or no skim milk at his disposal, the dairyman desirous of growing his own young stock is in need of a milk substitute to feed the calf during the first four to six months of its life. The brief experiment here reported was made to test the efficacy, for such a purpose, of Hayward's and Blatchford's calf meals.

(1) *Hayward's Calf Meal.*

Hayward of the Pennsylvania experiment station studied the question of providing a cheap and suitable milk substitute, and published his results in Bulletin No. 60 of that station. He succeeded in rearing ten unselected grade Guernsey calves without the aid of milk after the first fourteen to eighteen days. Most of the calves weighed from 150 to 250 pounds when from four to five months old, and were produced at a food cost of from $8 to $9 each. He concluded that the calf meal was a fairly satisfactory milk substitute, if used judiciously by careful feeders, but that it was not equal to whole milk.

The formula proposed by Hayward for the meal was as follows: —

	Pounds.
Wheat flour,	30
Cocoanut meal,	25
Nutrium,	20
Linseed meal,	10
Dried blood,	2

Hayward employed whole wheat, grown at the station and ground by the local miller. In the test about to be reported St. Louis flour at a cost of 2 cents a pound was used.

Cocoanut meal is a by-product in the manufacture of cocoanut oil, and was obtained of the India Product Food Company, 50 Chatham Street, Boston, Mass. It has a decided cocoanut odor, and tested 21.11 per cent. of protein and 19.23 per cent. of fat. Cocoanut oil is likely to become rancid after a brief period. Hayward believed it to have quite a favorable effect as a part of the calf meal.

Nutrium is a powder prepared by the National Nutrient Company of Jersey City, N. J., and is simply skim milk evaporated at a low temperature. It was very dry and fine, and kept well. This company also puts out the same article in granular form, but the powder is to be preferred.

Dried blood, especially prepared for feeding purposes, is offered by the Armour Fertilizer Works and by Swift & Co. of Chicago. It is also to be had of the agricultural warehouses in the large cities. It was employed by Hayward to check scours.

Cost per Pound of Each Ingredient and of the Mixture.

	Pounds.	Cost (Cents).	Total.
Wheat flour,	30	2	$0 60
Cocoanut meal,	25	1½	38
Nutrium,	20	10	2 00
Linseed meal,	10	1½	15
Blood,	2	4[1]	08
	87	-	$3 21

[1] In small quantities.

The cost per pound figures 3.7 cents, and to this must be added the freight charges on the nutrium, cocoanut meal and blood. Those who are desirous of trying this mixture would, of course, purchase these ingredients in larger quantities than the above, but it is doubtful if the meal could be prepared for much less than 4 cents a pound.

Method of Feeding the Meal. — This station tested the calf meal, using two unselected thrifty grade Jersey calves, a bull and a heifer. The several ingredients were in such good mechanical condition that it was not necessary to grind the mixture. It may not be out of place to add that the meal should be fine, and free from any coarse particles.

One pound was thoroughly stirred into 8 pounds of very hot water, and allowed to stand until milk-warm, in which condition it was fed. Hayward used 6 pounds of water to a pound of meal, and employed a calf feeder; but in our case it was considered better to teach the animals to drink at once.

The calves were fed whole milk for the first nine to fourteen days, and then skim milk and calf meal gradually substituted, whole milk being entirely taken away at the end of three weeks. Three quarts of skim milk were fed daily, in addition to the calf meal, until the calves were four or five weeks old, when both calves were placed upon an entire diet of calf meal. Hayward used the calf meal entirely after the first ten days, but it seemed wiser to the writer to allow some milk for a longer period, and thus give the animals a better start. Three-fourths of a pound of the meal was fed at first, and the amount gradually increased, until at the close of the experiment Calf I. was receiving 3 pounds and Calf II. 2 pounds of the meal daily.

Average Daily Record of Each Calf.

	Days entirely on Milk.	Average Amount Daily (Quarts).	Days partly on Milk, partly on Meal (Amount Daily).		
			Days.	Milk (Quarts).	Meal (Pounds).
Calf I., ...	14	5.7	19	4.3	1
Calf II., ...	9	5.3	15	4.3	1

Average Daily Record of Each Calf — Concluded.

	Days entirely on Meal (Amount).		Days partly on Milk after feeding Meal as Entire Ration.		Total consumed.	
	Days.	Amount (Pounds.)	Days.	Milk (Quarts).	Milk (Quarts).	Meal (Pounds).
Calf I., . .	143	2.50	2	4.0	152 [1]	374.0
Calf II., . .	101	2.20	44	2.6	229 [2]	306.5

[1] Whole milk, 93 quarts; skim milk, 59 quarts.
[2] Whole milk, 69 quarts; skim milk, 160 quarts.

Effect of the Calf Meal. — No serious trouble was experienced with either calf until February 12, when Calf II. suffered a bad attack of indigestion, which rendered it necessary to take away a considerable portion of the meal and substitute skim milk; and this animal was still receiving some milk when the experiment terminated, although she recovered and made good gains. On January 5 the supply of cocoanut meal became exhausted, and flour middlings was used in its place until March 10. The continued use of the middlings may have been a partial cause of the trouble. Calf I. was rather more robust, and experienced only a slight digestion disturbance about the middle of February, when a portion of the meal was replaced by skim milk for two days. While the calves did not have as sleek an appearance as animals raised on a whole milk diet, they were certainly in a thrifty growing condition, and at the close of the trial appeared especially vigorous.

Weekly Weights of Calves (Pounds).

DATES.	Calf I.	Calf II.	DATES.	Calf I.	Calf II.
November 10,	95 [1]	85 [2]	February 2,	190	182
November 17,	105	95	February 9,	203	191
November 24,	110	97	February 16,	210	177 [3]
December 1,	115	105	February 23,	222	185
December 8,	122	112	March 2,	235	185
December 15,	130	120	March 9,	247	197
December 22,	142	130	March 16,	252	218
December 29,	147	135	March 23,	263	225
January 5,	157	145	March 30,	277	235
January 12,	–	–	April 6,	295	250
January 19,	167	152	April 13,	310	260
January 26,	170	170			

[1] Just after beginning calf meal, three weeks after birth.
[2] Just after beginning calf meal, two and one-half weeks after birth.
[3] Ill with indigestion.

It will be seen from the above tables that the calves made a fair growth during the experiment, especially during the last month of the trial. Calf I. weighed 310 pounds when six months old, and made an average daily growth of 1.4 pounds while receiving the calf meal; while Calf II. weighed 260 pounds when five and one-half months old, and gained 1.1 pounds daily on the calf meal.

Cost of Feed Consumed. — Allowing 3 cents a quart for the whole milk, $\frac{1}{2}$ cent a quart for the skim milk and 4 cents a pound for the calf meal, the food cost in case of Calf I. was $20.20, and in case of Calf II. $15.11. If the calves had been fed largely calf meal at the end of the second week, this cost would have been somewhat reduced. Again, the calves might have been transferred a month earlier to a hay and grain diet. The object, however, in the present test was not to ascertain the minimum cost of raising the calf, but rather to note the effect of the calf meal during the first five or six months of the animal's life.

Conclusions. — 1. It is evident that, with reasonable care and cleanliness, calves can be successfully reared on Hayward's calf meal.

2. The meal is to be preferred only when a supply of skim milk is not available, or as a substitute for a portion of the milk.

3. The cost[1] is likely to be somewhat greater than when skim milk can be had at two cents a gallon. The expense of the meal is largely due to the nutrium, yet it is doubtful if a mixture as satisfactory for young calves could be obtained without the use of this substance.

4. The meal is evidently better utilized by calves after they are three months old than before that period.

5. The best method to be employed would probably be to allow the calf to suck the cow for the first two days, then feed whole milk for five days, to be followed by half whole and half skim milk for a week, gradually reducing the whole milk, so that at the beginning of the fourth week the diet may consist of 3 quarts of skim milk and $\frac{3}{4}$ to one pound of the meal, dissolved in the necessary hot water. At the end of the fourth week the skim milk may be dropped, and the calf put upon a diet of 2 pounds of the calf meal a day. Slight modifications may be made in this method depending on the condition of the animal.

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[1] The writer has grown seven unselected young calves, having an average weight when three days old of 73 pounds, to an average weight when ten weeks old of 173 pounds, on skim milk, together with such common grains as corn meal, wheat flour, flour middlings and gluten feed, at an average food cost of $4.80 each. By this method of feeding, calves ought to be produced that will weigh 200 to 300 pounds when five months old, at a food cost not exceeding $9 or $10. (See eleventh report of Massachusetts State Experiment Station, p. 125.)

6. It may be possible to modify the meal by replacing the cocoanut meal with some more common feeding stuffs, although Hayward did not succeed in finding a satisfactory substitute.

(2) *Blatchford's Calf Meal.*

This material, put out by the Barwell Mills, at Waukegan, Ill., is highly recommended by the manufacturers as a milk substitute. It is composed principally of linseed meal, beans, carob beans, cotton-seed meal and fenugreek, and retails at 3½ cents a pound. It has a very pronounced odor and flavor.

How the Meal was fed. — This article was tested by feeding it to one rugged grade Holstein calf, dropped Dec. 11, 1902. Unfortunately, the detailed record of the early part of this test has been lost, although some notes are on hand. The calf was first fed whole milk, a little later whole and skim milk, and at the end of two or three weeks the calf meal gradually substituted. The calf at first objected to the odor or taste of the meal, and never seemed to thoroughly relish it, although no serious difficulty was found in inducing the animal to take it. One pound of the meal was added to 6 pounds of hot water, thoroughly stirred and fed milk-warm. It was not possible to place the calf entirely upon the meal for a considerable time, hence the daily feed consisted of 4 quarts of skim milk and 2 pounds of the calf meal with the necessary water. On March 23, when a little over three months old, the calf was receiving 2¾ pounds of the meal daily, and continued to take this quantity without other food until the experiment terminated, May 4, the calf then being approximately four and one-half months old.

Weight of the Calf.

	Pounds.
March 23 (first record),	203.5
March 30,	205.0
April 6,	214.5
April 13,	221.0
April 20,	232.0
April 27,	242.0
May 14,	251.0

The animal did not suffer any serious digestion disturbances, and certainly grew well, as the above weights indicate, making an average increase of 1.15 pounds daily during the last forty-two days of the test.

Conclusions. — The above single trial is not sufficient to enable one to draw any absolute conclusions. The writer, however, observed the calf closely during the trial, and believes he is justified in making the following statements: —

1. Blatchford's calf meal is hardly as satisfactory as the Hayward mixture during the first three months of the calf's life, and it will probably prove necessary to feed one-third skim or whole milk and two-thirds meal during this period.

2. Used as above indicated, it proved quite satisfactory in the present single trial, can undoubtedly be depended upon as a partial milk substitute for calves under three months of age, and can be used as the entire food after that time and until the animal is ready for hay and the more common grains (five to six months).

3. It is possible that delicate calves would not thrive as well upon the meal as the one in the present trial.

4. The Blatchford meal was in good mechanical condition, and cannot be considered especially expensive.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, RICHARD H. ROBERTSON.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1903.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 35 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 2 in Ohio, 1 in Illinois and 1 in Arkansas.

Three hundred and six brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and eighty-four samples of fertilizer have thus far been collected in the general markets by experienced assistants in the station.

Five hundred and twelve samples were analyzed at the close of November, 1903, representing two hundred and ninety distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 90, July, and No. 92, November, 1903.

During the year 1903 a larger number of fertilizers have been licensed in the State of Massachusetts than for any previous year in the history of our fertilizer inspection laws. This necessitates an increased amount of work in the official inspection of commercial fertilizers. Twenty-three more brands of fertilizers were licensed and eighty more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1902 and 1903: —

	1902.	1903.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee, . . .	20	19
Number with one element above the highest guarantee, ...	83	91
Number with three elements between the lowest and highest guarantee,	183	207
Number with two elements between the lowest and highest guarantee,	87	118
Number with one element between the lowest and highest guarantee,	54	42
Number with three elements below the lowest guarantee, ...	3	2
Number with two elements below the lowest guarantee, ...	18	24
Number with one element below the lowest guarantee, ...	67	100
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	10	2
Number with one element above the highest guarantee, ...	22	17
Number with two elements between the lowest and highest guarantee,	16	31
Number with one element between the lowest and highest guarantee,	13	13
Number with two elements below the lowest guarantee, ...	4	1
Number with one element below the lowest guarantee, ...	19	14
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	9	11
Number between lowest and highest guarantee, ...	14	13
Number below lowest guarantee, ...	20	18

From the above table it will be seen that there is no material change in the quality of the fertilizers which have been examined, when compared with the results of the previous year. Where a discrepancy has occurred between the results of analysis and the manufacturers' guarantee, we are of the opinion that poor mixing is responsible, rather than a disposition on the part of the manufacturer to furnish an inferior article. As proof of this, we find in most cases that wherever a fertilizer shows a low test in any one ingredient, a corresponding high test is shown on some other element of plant food in the same brand; this usually corrects any difference in commercial value of the fertilizer.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1902 and 1903 (Cents per Pound).

	1902.	1903.
Nitrogen in ammonia salts,	16.50	17.50
Nitrogen in nitrates,	15.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.50	17.00
Organic nitrogen in fine bone and tankage,	16.00	16.50
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	4.50
Phosphoric acid soluble in ammonium citrate,	4.50	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values of fertilizing ingredients for the years 1902 and 1903 shows a higher market cost of nitrogen in form of ammonia salts and in the higher grades of organic substances for the year 1903 than for the previous year; this is, however, largely offset by a corresponding decrease in the market cost of the better forms of phosphoric acid.

The schedule of trade values for 1903 was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of March, 1903; it is based on the condition of the fertilizer market in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1903, and refers to the current market prices of the leading standard raw materials which furnish nitrogen, phosphoric acid and potash, and which enter largely into the manufacture of our commercial fertilizers.

Table A, following, gives the average analysis of officially collected fertilizers for 1903; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential elements of plant food in so-called special crop fertilizers put out by different manufacturers.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1903.*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.70	2.96	2.77	4.43	3.81	2.33	10.57	8.87	8.24	7.44	5.48	5.19
Ground bones,	7.69	3.23	2.85	-	9.88	14.86	24.74	22.54	9.88	-	-	-
Tankage,	8.04	4.59	3.93	-	10.68	7.54	18.22	17.96	10.68	10.00	-	-
Dissolved bone-black,	12.80	-	-	12.09	3.21	1.56	16.86	16.00	15.30	15.00	-	-
Acid phosphate,	10.30	-	-	14.90	1.70	-	16.60	-	16.60	-	-	-
Wood ashes,	13.05	-	-	-	-	-	1.44	1.50	-	-	5.56	5.00
Cotton-seed meal,	7.41	6.73	7.00	-	-	-	-	-	-	-	-	-
Flax meal,	9.42	5.73	6.08	-	-	-	-	-	-	-	-	-
Nitrate of soda,	2.06	15.41	15.41	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.78	20.40	19.00	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.15	-	-	-	-	-	-	-	-	-	48.88	48.12
Muriate of potash,	2.69	-	-	-	-	-	-	-	-	-	48.98	-
Kainit,	2.70	-	-	-	-	-	-	-	-	-	11.20	12.00

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1903.*

Name of Fertilizer.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	10.70	3.70	1.25	2.24	14.82	8.92	11.29	12.88	5.34	8.85	9.56	1.52	3.64
Fruit and vine fertilizer,	9.94	2.69	2.00	2.48	12.98	9.10	10.99	10.34	7.24	8.78	11.28	6.06	8.11
Grain fertilizer,	10.28	8.13	1.25	3.94	18.04	7.52	11.74	12.88	4.32	8.69	14.60	2.06	5.78
Grass fertilizer,	9.03	8.13	2.23	4.24	18.04	4.22	9.88	11.84	2.68	6.86	14.60	2.18	6.04
Market-garden fertilizer,	9.82	4.54	2.08	3.45	13.90	6.12	10.63	10.85	5.32	8.06	10.82	2.30	6.81
Potato fertilizer,	10.25	5.02	1.07	2.51	13.90	7.08	10.43	9.69	5.02	8.24	10.58	2.12	5.51
Tobacco fertilizer,	9.42	5.94	.59	3.41	13.38	4.22	10.00	10.56	2.94	7.54	17.34	1.66	7.96
Onion fertilizer,	9.26	4.36	1.16	2.64	12.26	6.38	8.72	9.70	5.10	6.56	7.76	4.04	5.76

A careful study of Table B teaches the following lessons. The trade name of a fertilizer is a poor criterion in ascertaining the efficiency of a fertilizer. Many farmers depend too much on trade names in making their selection of fertilizers. With the great variety of fertilizers now found upon the market, it becomes no easy matter for the average farmer to make an intelligent and judicious selection of his fertilizers, unless he is in possession and makes use of the fertilizer bulletins which are issued from time to time. In making a selection of a fertilizer for growing special crops, the needs of the soil and the requirements of the crop should receive careful consideration, and a fertilizer should be selected which will supply the wants of the soil in the most suitable and economical manner. In deciding what brands of fertilizers to purchase for general use, it is self-evident that those fertilizers should be selected which furnish the greatest amount of nitrogen, phosphoric acid and potash in a suitable and available form for the same money.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1903, to May 1, 1904) and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- High-grade Fertilizer with Ten Per Cent. Potash.
- Grass and Lawn Top-dressing.
- Tobacco Starter and Grower.
- Brightman's Fish and Potash.
- Fine-ground Bone.
- Columbia Fish and Potash.
- Abattoir Bone.
- Dissolved Bone-black.
- Muriate of Potash.
- Double Manure Salt.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dry Ground Fish.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass. — *Con.*
- Bradley's Complete Top-dressing for Grass and Grain.
- Bradley's X L Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Church's Fish and Potash.
- Bradley's Seeding-down Manure.

American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A A Ammoniated Superphosphate.
- Baker's Complete Potato Manure.

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

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass. — *Con.*
Clark's Cove Potato Fertilizer.
Clark's Cove King Philip Guano.

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

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

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

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

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

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

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
Quinnipiac Market-garden Manure.
Quinnipiac Phosphate.
Quinnipiac Potato Manure.
Quinnipiac Potato Phosphate.
Quinnipiac Corn Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass. — *Con.*
Quinnipiac Climax Phosphate.
Quinnipiac Havana Tobacco Grower.
Quinnipiac Onion Manure.

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

The American Agricultural Chemical Co (Standard Fertilizer Co., branch), Boston, Mass.: —
Standard Complete Manure.
Standard Fertilizer.
Standard Special for Potatoes.
Standard Guano.

The American Agricultural Chemical Co. (H. F. Tucker & Co., branch), Boston, Mass.: —
Tucker's Original Bay State Bone Superphosphate.
Tucker's Special Potato.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
Williams & Clark's High-grade Special.
Williams & Clark's Americus Potato.
Williams & Clark's Potato Phosphate.
Williams & Clark's Potato Manure.
Williams & Clark's Corn Phosphate.
Williams & Clark's Royal Bone Phosphate.
Williams & Clark's Prolific Crop Producer.

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

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

Abbott and Martin Rendering Co., Columbus, O.: —
Harvest King.
Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Grain Grower.
- Bone, Blood and Potash.
- High-grade Potato.
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Baker's Pure Castor Pomace.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

T. H. Bunch, Little Rock, Ark.: —
- Cotton-seed meal.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Universal Brand.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Manure.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash (D Brand).
- Bowker's Corn Phosphate.
- Bowker's Bone, Blood and Potash.
- Bowker's Early Potato Manure.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Market-garden Manure.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Bowker's Kainit.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Bristol Fish and Potash.
- Bowker's Fine-ground Fish.
- Bowker's Tobacco Ash Elements.
- Bowker's Ground Bone.
- Bowker's Wood Ashes.
- Bowker's Superphosphate.
- Sulfate of Ammonia.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.

Chicopee Rendering Co., Springfield, Mass.: —
- Pure Ground Bone.
- Tankage.
- Complete Animal Fertilizer or Lawn and Garden Dressing.

Chas. M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Excelsior Potato Fertilizer.
- E. Frank Coe's Fish Guano and Potash (F. P.).
- E. Frank Coe's Columbian Corn Fertilizer.
- E. Frank Coe's Columbian Potato Fertilizer.
- E. Frank Coe's New Englander Corn Fertilizer.
- E. Frank Coe's New Englander Potato Fertilizer.
- E. Frank Coe's Columbian Ammoniated Bone Superphosphate.
- E. Frank Coe's Red Brand Excelsior Guano.
- E. Frank Coe's Ground Bone.
- American Farmers' Market-garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Chemicals for Imperial Liquid Plant Food.
- Chemicals for Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Ashes (Star Brand).

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Canada Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.
- Hardy's Complete Manure.

Hargraves Manufacturing Co., Fall River, Mass.: —
- Fine-ground Bone and Tankage.

C. W. Hastings, Jamaica Plain, Mass.: —
- Ferti Flora.

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

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

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

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Potato Manure.
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Animal Brand.
- Swift's Lowell Ground Bone.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market-garden Manure.
- Swift's Lowell Nitrate of Soda.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Potato Manure.
- Tobacco Starter Improved.
- Tobacco Manure Wrapper Brand.
- Economical Potato Manure.
- Average Soils Complete Manure.

Mapes Formula and Peruvian Guano Co., New York, N. Y. — *Con.*
- Vegetable Manure or Complete Manure for Light Soils.
- Corn Manure.
- Complete Manure (A Brand).
- Cereal Brand.
- Complete Manure Ten Per Cent. Potash.
- Top-dresser Improved, Half Strength.
- Tobacco Ash Constituents.
- Grass and Grain Spring Top-dressing.
- Complete Manure for General Use.
- Fruit and Vine Manure.
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.

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

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

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

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

The Ohio Farmers' Fertilizer Co., Columbus, O.: —
- Corn, Oats and Wheat Fish Guano.
- Tobacco and Potato Special.
- High-grade Truck Guano.

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

R. T. Prentiss, Holyoke, Mass.: —
- Complete Fertilizers.

Benjamin Randall, Boston, Mass.: —
- Randall's Market Garden.
- Randall's Farm and Field.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- High-grade Complete Corn and Grain.
- Fish and Potash Fertilizer.
- High-grade Soluble Tobacco and Potato.
- High-grade Fertilizer for Oats and Top-dressing.
- High-grade Grass and Grain.
- High-grade Soluble Tobacco Fertilizer.
- Pure Fine-ground Bone.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Oats and Top-dressing.
- Hubbard's Grass and Grain.
- Hubbard's Soluble Corn Manure.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Potato Phosphate.
- Hubbard's '02 Top-dressing.
- Hubbard's Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Ross Brothers, Worcester, Mass.: —
- Ross Brothers' Lawn Dressing.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex Corn Fertilizer.
- Essex A. I. Superphosphate.
- Essex X X X Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Tobacco Starter.
- Essex Special Tobacco Manure.
- Essex Rhode Island Special Fertilizer.
- Essex High-grade Sulfate of Potash.
- Essex Nitrate of Soda.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Pure Ground Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sulfate of Potash.
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Corn Superphosphate,
- Sanderson's Special with Ten Per Cent. Potash.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

W. H. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Wilcox Potato, Onion and Tobacco Manure.
- Wilcox Potato Manure.
- Wilcox Complete Bone Superphosphate.
- Wilcox Fish and Potash.
- Wilcox High-grade Tobacco Fertilizer.
- Wilcox Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Pure Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- All Crops.
- Potato Plowman.
- Corn Success.
- Ground Bone.

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

A. H. Wood & Co., South Framingham, Mass.: —
- Special Fertilizer for Corn, Potatoes, etc.
- Special Manure for Market Gardening, Top-dressing, etc.

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

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on soil analyses.
3. Notes on wood ashes and lime ashes.
4. Notes on Peruvian guano.
5. Notes on sugar-beet refuse.
6. Notes on city garbage products.

1. Analyses of Materials forwarded for Examination.

During the season of 1903, 235 samples of fertilizing materials and miscellaneous substances have been received from farmers within our State for analysis. Many of these materials are refuse or by-products from some manufacturing industry. Some of these by-products contain only nitrogen, some contain phosphoric acid or possibly potash compounds, others contain two, and many of them contain all, of the essential elements of plant food. In either case the material possesses a distinct commercial value, which can be ascertained only by a careful chemical analysis.

As in the past, the investigation of materials for general fertilizing purposes has been carried on free of charge to farmers within our State. Our practice has been to analyze this class of materials in the order in which the samples arrive at this office. Beginning about April 1 and continuing through the summer and early fall, work of this nature has to give place to our official inspection work on commercial fertilizers. For this reason we would advise those sending samples for analysis free of charge to send as early in the season as possible. The winter season usually offers more time to attend to this kind of work, and therefore enables us to furnish results of analysis more promptly than at any other period of the year.

During the year we have taken an active part in the work of the Association of Official Agricultural Chemists, which aims to investigate any new modes of analysis in agricultural chemistry. The result of our labors along this line, as well as other investigation work of a technical nature, does not appear in our publications, as its chief value is in the establishment of new methods of analysis.

Following is a list of materials received during the past season: —

Wood ashes,	41	Dry ground fish,	6
Complete fertilizers,	34	Ground bones,	6
Soils,	70	Minerals,	12
Lime ashes,	10	Phosphatic slag,	4
Cotton-seed meal,	8	Nitrate of soda,	4
Dissolved bone-black,	2	Peat,	2
Tankage,	3	Tannery lime waste,	2
Cotton hull ashes,	2	Muriate of potash,	3
Superphosphate,	1	Cotton-seed dust,	1
High-grade sulfate of potash,	2	Cotton-seed droppings,	1
Cocoanut fiber pith,	1	Refuse ashes,	1
New York horse manure,	1	Sulfate of ammonia,	1
Sheep manure and wool waste,	1	Belgian phosphate,	1
Lime refuse,	1	Cassava waste,	1
Garbage tankage,	1	Manure,	1
Waste lime, plastering,	1	Mill refuse,	1
Acid phosphate,	1	Peruvian guano,	1
Coal and wood ashes,	1	Granite,	1
Sugar-beet refuse,	1	Bat guano,	1
Cotton waste,	1	Dried blood,	1
Lime,	1	Wool waste,	2

2. Notes on Soil Analyses.

In the above list of materials which have been forwarded for analysis during the season we would call attention to the increased number of samples of soil which have been received, as compared with previous years. The information desired by parties sending soil samples for analysis is, in most cases, What are the necessary fertilizing ingredients to be applied to this particular soil, and in what proportion in order to produce successfully any given crop? We are trying to aid in answering this inquiry by every means within our power, and shall continue, as in the past, to analyze samples of soil; yet we must insist that the samples of soil forwarded for investigation are taken according to our instructions, which are of late published in every March bulletin of this division (see Bulletin No. 89, March, 1903), otherwise the analysis can be of little practical value. The information furnished by a chemical analysis of soil is still of an arbitrary nature, and furnishes only the amount of the various ingredients of plant food present in the soil, without reference to their availability to any particular plant. Knowing that our present methods for the determination of the availability of plant food in soils is not as satisfactory as could be desired, we are studying the subject continually, believing that more satisfactory ones can be secured only by a constant attention to the questions involved.

3. Notes on Wood Ashes and Lime Ashes.

(*a*) *Wood Ashes.* — During the season of 1903, 17.4 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 24 per cent. for the year previous. The following compilation shows their general chemical character: —

Analysis of Wood Ashes.	Number of Samples.
Moisture from 1 to 10 per cent.,	11
Moisture from 10 to 20 per cent.,	14
Moisture from 20 to 30 per cent.,	9
Moisture above 30 per cent.,	3
Potassium oxide above 8 per cent.,	2
Potassium oxide from 6 to 7 per cent.,	4
Potassium oxide from 5 to 6 per cent.,	8
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	8
Potassium oxide below 3 per cent.,	3
Phosphoric acid from 1 to 2 per cent.,	34
Phosphoric acid below 1 per cent.,	3
Average per cent. of calcium oxide (lime), 29.39.	
Insoluble matter below 10 per cent.,	7
Insoluble matter from 10 to 15 per cent.,	12
Insoluble matter from 15 to 20 per cent.,	9
Insoluble matter above 20 per cent.,	8

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

	Maximum.	Minimum.	Average.
Moisture,	37.34	2.27	15.23
Potassium oxide,	8.15	1.68	4.76
Phosphoric acid,	1.80	.46	1.37
Calcium oxide,	35.75	22.33	29.39
Insoluble matter,	28.85	1.40	15.07

We advise farmers, before buying ashes, to ascertain if the party of whom they are to purchase is on record as having complied with our State laws, and holds a license for the sale of his article in Massachusetts. Protection by our State laws is only secured by patronizing dealers and importers who have complied with our laws for the regulation of the trade in commercial fertilizers.

There are indications that more care is taken by some of our importers in the collection and shipment of ashes than has been the case in the past. In some cases as high as 8 and 9 per cent. of potassium oxide has been guaranteed in carloads of ashes imported from Canada; this is 3 or 4 per cent. higher than the usual guarantee of this element. The importance of buying ashes on a specified guaranteed composition of each of the essential elements, — potash, phosphoric acid, and also lime — cannot be too strongly urged upon our farmers.

(*b*) *Lime Ashes.* — Judging from the increased number of samples of lime ashes that have been received during the season for analysis, this material is used more commonly than heretofore to furnish lime to those soils which require an application of this ingredient. Although being a valuable source of lime, it is well to remember that lime ashes are a refuse product in the production of burned lime, and are therefore apt to vary widely in chemical composition (see following table), depending largely upon the mode of handling as well as exposure to the weather. Lime ashes should therefore be bought on a statement of guarantee of the quantity of lime, potash and phosphoric acid which they contain. The small quantity of phosphoric acid in lime ashes is derived from the wood that is used in charging the kiln; the potash is derived partially from this same source and partially from the limestone; both of these elements are therefore apt to vary widely in different samples.

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

	Maximum.	Minimum.	Average.
Moisture,	23.16	10.47	15.66
Potassium oxide,	3.32	.76	1.86
Phosphoric acid,	1.66	.03	.63
Calcium oxide,	55.44	32.42	41.15
Insoluble matter,	26.50	1.10	6.46

4. Notes on Peruvian Guano.

Analysis of Peruvian Guano recently introduced into our Markets.

	Per Cent.
Moisture,	17.10
Total phosphoric acid,	21.26
Soluble phosphoric acid,	2.81
Reverted phosphoric acid,	10.47
Insoluble phosphoric acid,	7.98
Potassium oxide,	4.20
Nitrogen,	3.23

The above-stated article has of late been again introduced into our markets; it is evidently a genuine sample of Peruvian guano, and of a valuable composition as a general fertilizer. As Peruvian guanos are known to vary more or less in regard to their chemical composition, they should always be bought and sold on a statement of their guaranteed composition. A detailed discussion of the occurrence of Peruvian guanos, their merits as a fertilizer and their historic importance with reference to the introduction of commercial fertilizers, will be found in the annual report of the inspector of commercial fertilizers to the Massachusetts State Board of Agriculture for the years 1875–76.

5. Notes on Sugar-beet Refuse.

Analysis of Sugar-beet Refuse forwarded for Investigation.

	Per Cent.
Moisture,	7.70
Phosphoric acid,	none
Total potassium oxide,	9.72
Water soluble potassium oxide,	8.36
Total nitrogen,	6.39
Nitrogen as nitrates,	3.86
Nitrogen as ammoniates,	.05
Nitrogen in organic form,	2.48
Calcium oxide,	none
Sodium oxide,	7.00
Sulphuric acid,	2.82
Chlorine,	1.87
Carbonic acid,	none

The above material is a waste product from the sugar-beet industry; it is produced in the process of manufacturing alcohol from the beet-sugar molasses; it is rich in potash and nitrogen, and deserves special attention in the production of tobacco and other industrial crops. The successful introduction of the beet-sugar manufacture as a home industry already benefits our agricultural interests in many ways, as was predicted by the friends of the sugar-beet industry years ago.

6. Notes on City Garbage Products.

Sample No. 1 represents what is known as garbage tankage; sample No. 2 represents the ashes from the cremation of city garbage.

Analysis of Garbage Products.

	Per Cent.	
	Sample No. 1.	Sample No. 2.
Moisture,	7.42	3.01
Potassium oxide,	none.	5.13
Total phosphoric acid,	6.06	8.77
Available phosphoric acid,	4.40	– *
Insoluble phosphoric acid,	1.66	– *
Nitrogen,	5.96	none.

* Not determined.

The above-mentioned materials are products obtained by hygienic treatment of city garbage. Sample No. 1 was obtained by heating the selected garbage in vats under pressure; by this method the fats are recovered; and the organic nitrogenous matter is preserved for use as a nitrogen source in fertilizers. In this process, however, the greater part of the potash and other salines are leached out. Sample No. 2 represents the product obtained by the cremation of city garbage. In this material the nitrogen has been sacrificed, but the potash is retained in the ashes. The products from both of these processes furnish valuable material for fertilizing purposes; they should always be bought and sold on a statement of guaranteed composition.

REPORT OF THE ENTOMOLOGISTS.

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

The entomological division during 1903 has continued its work along lines similar to those of preceding years. The correspondence has received careful attention, but has been less than usual, probably because fewer insects have made their presence felt, owing to the peculiar weather conditions of the spring and summer.

The experiments to determine a simple and successful treatment for the San José scale have been continued according to a plan which promises well, and which, so far as can be learned, has not been tried elsewhere in this country. Certain difficulties have arisen, however, and whether it will be possible to proceed with these experiments during 1904 cannot now be determined.

Much attention has been given to the collections of insects at the insectary during the year, and, as a result, they are now more nearly expressive of our present knowledge than ever before.

The card catalogue has now entirely outgrown the cases intended to contain it, thus rendering it less useful for reference, but it is hoped that this difficulty may be soon overcome.

It is a generally recognized fact that original investigation and publication are among the most important functions of an experiment station. That the entomological division of the station has not fallen behind in this portion of its duties is seen by the following list of articles on entomology published during the present year by persons working at the insectary, either for the station, or by those fitting themselves for that work: —

C. H. FERNALD: "The Brown-tail Moth" (with A. H. KIRKLAND), under direction of the State Board of Agriculture, Boston, March, 1903; "Colour Blindness in Entomologists," Canadian Entomologist, July, 1903.

H. T. FERNALD: "Orchard Treatment for the San José Scale," Bulletin No. 86, Hatch Experiment Station, February, 1903; "How shall we arrange our Collections?" Entomological News, April, 1903; "First Annual Report of the State Nursery Inspector," Agriculture of Massachusetts for 1902, June, 1903; "Plant Lice," Nature Leaflet No. 18, Massachusetts Board of Agriculture, July, 1903; "Some Important Scale Insects," Massachusetts Crop Report for September, October, 1903; "Notes on the Species of Isodontia," Canadian Entomologist, October, 1903; "The Plum Webbing Saw Fly" (with E. A. BACK), Entomological News, November, 1903; "Two New Species of Sphex," Psyche, October–December, December, 1903.

Mrs. M. E. FERNALD: "Notes on the Coccidæ," Canadian Entomologist, January, 1903; "Lepidosaphes *versus* Mytilaspis," Canadian Entomologist, April, 1903; "Catalogue of the Coccidæ of the World," Bulletin No. 88, Hatch Experiment Station, July, 1903.

H. J. FRANKLIN: "Notes on Acanthothrips," Psyche, October–December, December, 1903.

A. W. MORRILL: "Life History and Description of the Strawberry Aleyrodes," Canadian Entomologist, February, 1903; "Notes on some Aleyrodes from Massachusetts, with Description of New Species," Psyche, April, 1903; "Notes on the Early Stages of Corylophodes marginicollis Lec," Entomological News, May, 1903; "New Apoidea from Montana," Canadian Entomologist, August, 1903; "Notes on the Immature Stages of Some Tingitids of the Genus Corythuca," Psyche, August, 1903; "The Greenhouse Aleyrodes and the Strawberry Aleyrodes," Technical Bulletin No. 1, Hatch Experiment Station, August, 1903.

Besides these, several other papers are either in press or well advanced in preparation, and will soon be published.

INSECTS OF THE YEAR.

The present year has seen the great abundance of a few kinds of insects, but taken as a whole the season has been unfavorable for their rapid increase. The early spring was apparently normal in its character, but about the first of May a period of drought began, which continued well into June. During this period the grass dried up and in many places became brown and dead, and large numbers of insects were found clinging to it, having seemingly died of starvation. The result was that the hay crop, though late, was but little affected by insects; and similar results were more or less evident with nearly all crops, as regards their insect foes.

In a few cases, however, these weather conditions were favorable to insect life. The plant lice, which are usually destroyed in large numbers by cold spring rains, were this year almost entirely unchecked, and, increasing rapidly, did much injury to trees and plants already suffering from the lack of rain. The damage caused by plant lice was particularly noticeable on fruit stock, elms and maples, many of which suffered severely; and even when the heavy rains came later, destroying myriads of the lice, so many were present that large numbers survived, thus continuing the injury to more than an ordinary amount till quite late in the fall.

The spring weather also seemed to be unusually favorable for root maggots of various kinds, the onion maggot causing a large amount of loss to the onion growers in the Connecticut valley in particular, while the work of the cabbage maggot was seen everywhere. During the year more inquiries were received by this division about maggots than during the preceding eight years taken together.

The apple-tree tent-caterpillar was more abundant last spring than for a number of years, but whether the peculiar season has had the effect of destroying these insects sufficiently to prevent their appearance in large numbers in 1904 cannot now be determined.

The elm-leaf beetle began the season actively, and by May 21 their egg clusters were very abundant everywhere, but particularly on those trees which were not treated in 1902. Later in the season, however, their work was less noticeable than usual, and, in fact, there were many places where spraying seemed unnecessary. Whether the nature of the season or factors yet undiscovered were the cause of their slight importance is not known.

The San José scale has increased rapidly during the year, wherever it occurs. Crawling young were found last spring on June 9, nearly two weeks earlier than the year before, and during the summer and fall this insect seemed to increase in abundance more rapidly than usual.

During the year 1902 a new plum pest appeared in the Connecticut valley, spinning its webs entirely over the trees in May and early June. On investigation it proved to be a saw fly hitherto known only from South Dakota and Manitoba. Of this insect, which is known as *Neurotoma rufipes* Marl., the life history has been worked out at this station during the present year and published. While this insect has already shown great possibilities as a serious pest on the plum, it is too soon to predict that it will actually become such; but the results of the studies made here show that, if treated when it first appears, it should be easily controlled.

The plum curculio is always in evidence on the plums, and to some degree on the apples; but this year it has paid particular attention to the latter fruit, and by its punctures has reduced many thousands of bushels of apples from first class to a lower grade. Whether the unusually large amount of injury to apples by the curculio this year was due to a greater number of the insects which succeeded in passing through the preceding winter alive, or whether it was due to an insufficient supply of plums for them to attack last spring, is difficult to determine; possibly both factors occurred.

For several years the imported willow-borer (*Cryptorhynchus lapathi*) has been present in great abundance. The injuries which it causes to willows, poplars and similar soft-wooded trees are frequently serious; and it is now almost impossible to raise these trees in some localities, thus greatly reducing their value for planting as holders of the soil in such places as on sandy beaches. No satisfactory method of combating this insect has as yet been discovered.

The brown-tail moth has continued to enlarge its area of occupation, and it is only a question of time how soon it will be a pest all over New England.

The gypsy moth has now to a considerable extent recovered from the attacks made upon it by the State, which ceased in 1899, and in many places is as abundant as it ever was. A careful examination of a large part of the infested territory shows one change from former conditions; then, in towns not generally badly infested, the insect would be found in colonies, while elsewhere the trees and plants were not infested; at the present time the colonies in such towns are not as populous perhaps as formerly, but the insects are generally scattered, a few here and a few there, thus producing what may be termed a general distribution. This probably settles the possibility of extermination in the negative for the future. The State has lost its opportunity, and must abide by the results. No new important parasitic or predaceous foes have appeared thus far, and man must depend almost entirely on his own exertions to control this pest.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, F. R. CHURCH.

The agricultural department during the past season has followed up the main lines of inquiry pertaining to the selection of manures and fertilizers for the various crops of the field and garden previously undertaken. It is recognized that the inevitable variations due to seasonal and other conditions beyond control make necessary numerous repetitions of an experiment before results justify general conclusions. It is comparatively easy, for example, to determine whether a given fertilizer is useful to a given crop upon a given field in any one year. One is not, therefore, justified in concluding that it will prove useful every year; one does not know that it will prove useful in other combinations of fertilizer materials, nor even that its continued use may not ultimately prove harmful in certain directions.

Results must be tested by experiments again and again, and yet again, before the conditions affecting them can be estimated at their true value, safe deductions drawn therefrom that will be generally useful, or advice founded upon them. The past season, so exceptional in character, affords striking illustration of the necessity of such repetition in the nature of the results from the use of a number of materials which it was believed we quite fully understood. As a means of testing the results in plot experiments in the open field, where numerous conditions are beyond control, we have the past season continued the system of closed plot and vegetation experiments.

We have begun a series of experiments with asparagus, for which we have been making preparation for the past two years, having laid out forty-two plots for that purpose, with a view to seeking light as to the manurial needs of the crop, both as regards the selection and amount of materials required and the time of application. One-year-old plants of our own growing were set last spring, and have made a good start.

Forty-eight new varieties of potatoes have been given a preliminary trial, but will not be reported until after another year.

Our grass garden, with forty-eight species and seven varieties, has been thoroughly cared for, and one-half the plot of each species lawn-mowed throughout the season.

Exclusive of these plots of grass, our work has involved the care of two hundred and twenty-three plots in the open field and one hundred and fifty closed plots, while our vegetation experiments have required the care of two hundred and fifty-four plots.

The work with poultry has been of practically the same amount as in recent years, as we some time ago reached the limit with our present equipment. The study of the relations of feeds to egg production has engaged the greater share of the time devoted to this line of work.

In this report will be presented a statement of results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers. Other results are reserved for discussion in bulletins which it is hoped may be published within the near future. A brief statement only will be made in this report of the general results obtained in our experiments with poultry.

The nature of the principal subjects of inquiry and the more important conclusions will be made clear by the following statement: —

I. — The relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. Soy beans, the crop of this year, gave yields on the basis of which the materials rank in the following order: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate of soda ranks relatively lower this year than in most previous years, but the general average to date ranks the materials as follows, on the basis of increases in the crops as compared with the no-nitrogen plots: nitrate of soda, 100; barnyard manure, 77.8; dried blood, 65.1; sulfate of ammonia, 63.6.

II. — The relative value of muriate and high-grade sulfate of potash for field crops. The results of this year indicate the sulfate to be superior to the muriate for potatoes. For the soy beans the two salts gave nearly equal yields, while the crops of cabbages and onions were practical failures on both salts, largely, it is believed, because of the unfavorable season.

III. — *A*. The relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure, as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank for this year in the following order: for the early crops, — including dandelions, strawberries, peas and beets, — dried blood, nitrate of soda, sulfate of ammonia; for the late crops, nitrate of soda ranks first, followed by dried blood and sulfate of ammonia. *B*. Relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for strawberries, tomatoes, cucumbers, celery and turnips; while the muriate has given slightly superior results with dandelions, peas and beets.

IV. — The relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate and silicate. The crop of this year was clover, mixed with timothy. As indicated by the yields of clover, the best results were obtained on the high-grade sulfate; while the silicate, carbonate, low-grade sulfate and nitrate gave results almost as good. The yield of timothy was heaviest on the kainite and muriate. As last year, one of the most striking results of the experiment was the injury to the clover due to potash salts containing chlorine, — especially to the kainite.

V. — The relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was cabbages, and those which gave satisfactory growth and yield in the order of their rank are: dissolved bone meal, South Carolina rock phosphate, raw bone meal, phosphatic slag, steamed bone meal, and dissolved bone-black. Three phosphates gave results much inferior to any of the others, viz., Tennessee phosphate, apatite, and Florida soft phosphate.

VI. — *A.* Soil test with corn. The crop of this year was very small on all plots, owing to the unfavorable season; but the potash increased the crop to a far greater extent than any other plant-food element. *B.* Soil test with mixed grass and clover. The results demonstrate the close dependence of the grass crop upon the supply of nitrate of soda. They indicate also the increased tendency of continued use of nitrate and muriate of potash to bring the soil into an acid condition. Another marked result is the effect of an application of lime in increasing the proportion of timothy in a mowing sown to a mixture of timothy, red-top and clover.

VII. — To determine the economical result of using in rotation on grass lands: the first year, barnyard manure; the second year, wood ashes; and the third year, ground bone and muriate of potash. The average yield of hay, all three systems of manuring being represented, is at the rate of 8,104 pounds per acre in two crops. The average on that portion of the field reseeded last summer is on one plot at the rate of 8,546.5 pounds for the reseeded portion; for the portion not reseeded, 6,243 pounds. On another plot the average yield on the reseeded portion is at the rate of 10,003 pounds, and on the portion not reseeded 5,642 pounds, per acre.

VIII. — Winter compared with spring application of manure. The field where this experiment is tried slopes moderately lengthwise of the plots. The crop this year was soy beans, and the crops under the two systems of application were not far from equal, but with the advantage slightly in favor of the winter over spring application. This result appears to have been due to the fact that the ground beneath its covering of snow remained unfrozen throughout the winter, and that there was practically no wash over the surface.

IX. — To determine the best nutritive ratio or the best mixture of feeds for laying hens. The results of the year appear to indicate that it is not essential to feed a mixture of feeds giving a narrow nutritive ratio for satisfactory egg production. They indicate, further, that the proportion of fat in the ration is a matter of much importance, a large proportion favoring egg production; and that, on the other hand, a large proportion of fiber in the ration, such as would be furnished when grains like oats and barley are largely used, is unfavorable to egg production. A ration in which corn is prominent has given results considerably superior to those obtained with the ration in which wheat is prominent; and the economic results in feeding corn largely in connection with a suitable amount of animal food are much superior to the similar results with wheat.

I. — Manure and Fertilizers furnishing Nitrogen compared. (Field A.)

A full description of the plan of the experiment on Field A was given in the twelfth annual report of the Hatch Experiment Station. There are two objects in view: first, to compare the efficiency (as measured by crop production) of a few of the standard materials that may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a crop belonging to the clover family is capable of rendering the application of nitrogen to a succeeding crop of another family unnecessary. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. There are eleven plots in the field, and with few and practically unimportant exceptions each has been manured in the same way since 1899. All plots are liberally manured each year with materials supplying phosphoric acid and potash, and in quantities to furnish these elements in equal amounts. Manure or fertilizers supplying nitrogen are applied yearly to eight of the eleven plots, and in quantities to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three, and dried blood to two plots. Three plots have had no nitrogen applied to them since 1884. The potash applied to these plots is supplied in the form of muriate to six plots, viz., 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, viz., 2, 4, 5 and 10. The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes. The crop of this year was the medium green soy bean.

It will be generally understood that, if the object in view in an experiment should be simply the determination of the relative value of different materials applied as sources of nitrogen, such a crop as the soy bean (which belongs to the clover family, and which therefore under the right conditions can draw upon the air for a portion or perhaps for all of its nitrogen) would not be selected; but we are testing not simply the relative value of the different nitrogen manures, but also the effect of the legume grown on the no-nitrogen plots upon the succeeding crop. Accordingly, the soy bean, which is one of the most successful of the legumes grown as a hoed crop, was our choice, as it has been several other years, during the progress of this experiment.

The crop was planted on May 20, and was well cared for throughout the season. No accident or inequality in extent of insect or other damage on the several plots interfered with the normal results of the experiment; but the season was highly unfavorable to the growth of the crop, which is one requiring protracted warm weather.

Although the yield on the plots to which the nitrate of soda was applied was fairly satisfactory, attention is here called to the fact that this fertilizer seems to exert an adverse influence upon the early development of the soy bean. It has been repeatedly noticed that where nitrate of soda is the source of nitrogen, the leaves, especially in the early stages of growth, assume a crinkled or wrinkled appearance, and fail to reach full size and normal development. This crinkling appears to be due to the death of the marginal tissues of the leaf, and such death is supposed to be due to an accumulation of nitrates in injurious amounts in these tissues. The margin of the leaf ceasing to grow, while its main body still continues to develop, the inevitable consequence is the crinkling effect which has been alluded to. As the season advances, the soy bean plants as a rule show a more normal leaf development; and, although the crinkling this season was excessive, the yield on the nitrate of soda plots does not appear to have been materially decreased, as a consequence.

Attention is here called, with regret, to the fact that there was undoubtedly an error made in determining the weight of the straw on Plot 10. Close observation throughout the season leads to the conclusion on the part both of my assistant and myself that the relative growth of vines as compared with seed on this plot was quite as large as on any other in the field, and yet the weight as reported shows it to have been in proportion to seed less than on any other plot.

The yields obtained on the several plots and the sources of nitrogen on each are shown in the following table: —

Yield of Soy Beans per Acre.

Plots.	Nitrogen Fertilizers used.	Beans (Bushels).	Straw (Pounds).
0, .	Barnyard manure (most of potash used contained in the manure).	23.8	2,010
1, .	Nitrate of soda (muriate of potash), ...	20.5	1,700
2, .	Nitrate of soda (sulfate of potash), ...	24.8	2,080
3, .	Dried blood (muriate of potash), ...	16.7	2,015
4, .	No nitrogen (sulfate of potash), ...	17.1	1,705
5, .	Sulfate of ammonia (sulfate of potash), ...	16.9	1,480
6, .	Sulfate of ammonia (muriate of potash), ...	11.6	1,160
7, .	No nitrogen (muriate of potash), ...	11.1	1,125
8, .	Sulfate of ammonia (muriate of potash), ...	14.8	1,390
9, .	No nitrogen (muriate of potash), ...	8.8	745
10, .	Dried blood (sulfate of potash), ...	21.7	1,225

It will be noticed that the crop, even on the best plot, this year is small. In 1901, when the same crop was grown, the yield on the poorest plot was at a higher rate (25.86 bushels of seed) than that on the best plot this year; while the average yield on all plots, including those to which no nitrogen was applied, was at the rate of 29.9 bushels per acre in 1901. The inferiority of the crop of this year was undoubtedly largely the consequence of the unfavorable season, although there is some evidence that this soil may once more need an application of lime. It has received no lime since 1898, when this material was applied at the rate of one ton to the acre. An abundance of lime in the soil is well known to be highly important to nearly all legumes.

The average yields of this year, as affected by the fertilizers used, are clearly shown in the following table: —

FERTILIZERS USED.	Beans (Bushels).	Straw (Pounds).
Average of the no-nitrogen plots (3),	12.3	1,192
Average of the nitrate of soda plots (2),	22.7	1,890
Average of the dried blood plots (2),	19.2	1,620
Average of the sulfate of ammonia plots (3),	14.4	1,343

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	93.10
Sulfate of ammonia,	92.00
Dried blood,	90.80
No nitrogen,	73.80

Similar averages for this year are shown below: —

FERTILIZERS USED.	Beans (Per Cent.).	Straw (Per Cent.).
Barnyard manure,	100.00	100.00
Nitrate of soda,	95.38	94.03
Dried blood,	80.67	80.60
Sulfate of ammonia,	60.50	66.82
No nitrogen,	51.68	59.30

The nitrate of soda, as last year, stands relatively lower than it usually has done. It is believed that the excessive rains of the past two seasons have caused the loss of some of the nitrate of soda; which may well have washed through the soil and been carried away in the drainage waters.

The average yield of all the nitrogen plots, as compared with the average of those receiving no nitrogen, is shown below: —

	Beans (Bushels).	Straw (Pounds).
Average, 8 nitrogen plots,	18.85	1,633
Average, 3 no-nitrogen plots,	12.33	1,192

It will be noticed that the no-nitrogen plots give only about 65 per cent. as much seed as the plots receiving nitrogen, and about 73 per cent. as much straw. The nodules in which are found the bacteria connected with the assimilation of atmospheric nitrogen were very abundant upon the roots of the plants upon all plots, as was determined by frequent examination. In spite of this fact, the supply of nitrogen at the disposition of the plants on the no-nitrogen plots appears to have been inadequate for even fairly vigorous growth. No reason can be assigned, unless it be that the acid condition of the soil prevented the normal action of the agencies connected with the assimilation of atmospheric nitrogen.

In conclusion, attention is called to the fact that nitrate of soda must be regarded as one of the most desirable of the materials that can be purchased as a source of nitrogen. The cost of nitrogen in this form is lower than in most other materials, and in this as well as in other experiments upon our grounds it usually shows itself to be more effective than any other nitrogen fertilizer. Its superiority to the other materials used in this experiment is made more evident if in place of comparing total yields we compare the increases in yields produced by the several nitrogen fertilizers. On this basis, including all crops raised to date, but taking into account the seed only for this year, the different materials rank as follows: —

Relative Increases in Yields, Average for Fourteen Years.

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	77.80
Dried blood,	65.10
Sulfate of ammonia,	63.60

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

The experiments on this field are in continuation of work which has been in progress since 1892, and I cannot do better in introducing what is to be reported for this year than to quote from my last annual report. The object of this experiment "is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Most of these crops have been grown during several years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done much the best on sulfate of potash; the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash."

The crops of the past year have been potatoes, cabbages, onions, and soy beans, while on two plots perennial garden crops and small fruits, viz., rhubarb, asparagus, raspberries and blackberries have been started. The crops both of onions and cabbages were practically failures; in both cases, it is believed, largely on account of the abnormally cold and otherwise very unfavorable season. The onion crop throughout this entire section was in general the poorest known for years. The cabbages made a healthy growth, but, as the season proved, were started much too late. With average summer temperatures the crop would have matured, but under the conditions of the past season few heads reached marketable development. The number of such heads on the muriate of potash was considerably more than on the sulfate, and the total weight of the crop on the muriate was at the rate of about 4,400 pounds per acre greater than on the sulfate. In the case of the onions the total weight of crop produced, including scallions and tops, was at the rate of about 1,000 pounds per acre greater on the muriate than on the sulfate, but there were only 5 bushels more of good onions. In view of the nature of the results with these two crops, further details concerning them will not be given.

1. *Soy Beans (Sulfate v. Muriate of Potash).*

The variety of soy beans grown in this experiment was the medium green. This crop occupied two plots (17 and 18), which last year produced a crop of cabbages. The yield of cabbages last year on the sulfate of potash was at the rate of about 5 tons to the acre more than on the muriate. The crop this year suffered from no accidental conditions affecting results, but owing to the unfavorable season the yields were very small. The results are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Medium Green Soy Beans, Yields per Acre.

FERTILIZERS USED.	Beans (Bushels).	Straw (Pounds).
Muriate of potash,	11.20	1,000
Sulfate of potash,	10.73	689

It will be noted that the yield of beans is slightly greater on the muriate than on the sulfate; the difference, however, is exceedingly small, and no especial significance can be attached to it. In previous years the sulfate of potash has usually given the better crop of this variety of beans, and I am still inclined to advise its selection. The greater depletion of the soil as a result of the heavy yield of cabbages last year on the plot receiving the sulfate of potash may in part account for the fact that the sulfate of potash this year fails to show its usual superiority.

2. *Potatoes (Sulfate v. Muriate of Potash).*

The potatoes in this experiment were of the Beauty of Hebron variety; the seed was grown in northern Maine. This crop occupied two plots (11 and 12), which last year produced a mixed crop of timothy and clover. The sod was broken this spring, and the seed, which had been previously treated with formalin for destruction of scab spores, and budded, was planted on May 16. An effort was made to protect the crop from insects and blight by the use of prepared insecticides and fungicides offered in our markets. These proved fairly satisfactory in the destruction of the potato beetle, but were not entirely effective in preventing blight. The vines began to show signs of blight on July 18, but its progress was slow; there was but very little rot, and the yield was fairly satisfactory. The potatoes were dug after the vines were entirely dead, and the yields were as shown below.

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

Fertilizers used.	Merchantable.	Small.
Muriate of potash,	171.71	29.94
Sulfate of potash,	194.58	29.09

It will be noticed that the yield of small tubers was practically identical on the two potash salts, but that the sulfate of potash gave a yield of merchantable tubers at the rate of nearly 23 bushels per acre greater than the muriate. This result is in exact agreement with the results of many other experiments which have been tried upon our grounds; and it seems to be impossible to doubt that sulfate of potash should be generally selected for the potato, rather than the muriate, for all soils which have a fair capacity to retain moisture.

Farmers raising the crop on such soils should demand potato fertilizers in which this salt has been used as the source of potash. Not only is the crop almost invariably larger on the sulfate, but it is of superior eating quality. Previous experiments here have shown that it almost invariably contains from 2 to 3 per cent. more starch, and that when cooked the potatoes are whiter, of better flavor, and more mealy.

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

The object in this experiment is to study the influence of a few standard fertilizers used continuously upon the same land upon the yield of garden crops. The experiments were begun in 1891, and from that date to 1897 inclusive fertilizers alone were applied to the land. During the past six years stable manure also has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the fertilizers have been used in the same amounts and applied to the same plots as at first. The original number of plots in the experiment was six, of about one-eighth of an acre each. On all of these fertilizers were used. When we first began to apply manure as well as fertilizers, we introduced into the experiment a seventh plot of the same area as the others, but which had had different previous manurial treatment. To this we have since applied manure only at the above-named rate. This plot was introduced in order that we might have a basis for determining whether the materials used were in any degree beneficial when added to the somewhat liberal quantity of manure employed. It was found that at first the yields of almost all crops on the manure alone were almost as good as those where the fertilizers also were used. In a few cases the manure alone gave the better crops. It is not believed that we are justified in concluding that the fertilizers have been used without beneficial effect, for the no-fertilizer plot introduced in 1898 had, previous to that year, been more heavily manured than the other plots. The superiority of the plot receiving manure alone seems to be gradually decreasing, and this plot will doubtless ultimately serve as a basis for making fair comparisons between the results obtainable with manure alone and results obtained with equal manure and fertilizers. Up to the present time it is not considered to have furnished such a basis, and no reference accordingly will be made in this report to the yields upon this plot.

All the prominent out-door garden crops in this locality have been grown in rotation upon each plot, and each crop during several years. The list of crops so far grown includes spinach, lettuce, onions, garden peas, table beets, early and late cabbages, potatoes, tomatoes, squashes, cucumbers, turnips, sweet corn, celery, and one small fruit, — strawberries. Asparagus and rhubarb were set in 1902, but no cuttings have yet been made, and these will not therefore be referred to in this report.

As stated in my last annual report, these "experiments have been planned with reference to throwing light especially upon two points: *A.* The relative value of nitrate of soda, sulfate of ammonia and dried blood used as sources of nitrogen. *B.* The relative value of sulfate of potash and muriate of potash. These two points will be separately discussed."

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

The three fertilizers compared as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot (at the rate of 60 pounds per acre), and each fertilizer is always applied to the same plot. An application supplying per acre the amount of nitrogen above named requires the annual application of materials at about the following rates per acre: —

	Pounds.
Nitrate of soda,	375
Sulfate of ammonia,	300
Dried blood,	850

Each of these nitrogen fertilizers is used on two plots, on one with sulfate of potash, on the other with muriate, — in both cases in such quantities as to furnish equal actual potash.

The results with some of the crops, especially where sulfate of ammonia is the source of nitrogen, have been widely different on these two potash salts, the yields on the sulfate being greatly superior to those on the muriate. The potash salts are applied in such quantities as to furnish potash at the rate of 120 pounds per acre, which requires the use of about 240 pounds of commercial muriate or high-grade sulfate of potash. Dissolved bone-black is used on all plots as the source of phosphoric acid, and in such quantity as to furnish phosphoric acid at the rate of about 50.4 pounds per acre. To furnish this, dissolved bone-black is applied at the rate of about 320 pounds per acre.

The results previous to this year may be summarized as in our last annual report. For the early crops, *i.e.*, the crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, spinach, early cabbages and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers, as measured by the total yields, including leaves, vines and tops as well as the marketable product, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	93.70
Sulfate of ammonia,	57.30

For the late crops, including late cabbages, turnips, celery, tomatoes and squashes: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	99.00
Sulfate of ammonia,	78.40

The crops grown in this experiment this year for which results will be reported include strawberries, followed by celery; dandelions, followed by cucumbers; tomatoes; beets; and garden peas, followed by turnips. The weather conditions have been highly unfavorable to the normal growth and development of some of these crops, especially tomatoes, but a small proportion of which ripened, and cucumbers. The excessively dry weather of the month of May, followed by the equally excessively wet weather of the month of June, gave us conditions no doubt extremely unfavorable to the action of all the nitrogen fertilizers, but apparently particularly so in the case of the nitrate of soda. Moreover, considerable damage was done both to dandelions and strawberries through the burning of the leaves, caused by the application of the nitrate of soda and the sulfate of ammonia. The application of either of these chemicals as a top-dressing to a growing crop requires the utmost care. It was not the belief of the assistant applying the materials that these chemicals adhered to the leaves when applied in such quantity as to prove injurious; but the result proved that he was mistaken in his judgment, for the injury through burning of the leaves both of the dandelions and the strawberries where nitrate of soda and sulfate of ammonia were applied was very serious. Doubtless as a consequence chiefly of the conditions to which attention has been called, the dried blood, as compared with the other nitrogen fertilizers, ranks this year relatively higher than in any previous year.

The average rate of yield per acre obtained with each of the nitrogen fertilizers, used it will be remembered in addition to the manure, for the present season is shown in the following table: —

Nitrogen Fertilizers for Garden Crops. — Rate of Yield per Acre (Pounds), Average of Two Plots.

Fertilizers used.	Dandelions.	Strawberries.	Peas.		Beets.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Sulfate of ammonia,	37,857	5,010	11,210	9,758	37,866	43,507
Nitrate of soda,	35,098	5,489	9,880	8,710	44,319	49,643
Dried blood,	48,312	10,072	11,694	11,129	46,429	41,689

Nitrogen Fertilizers for Garden Crops, etc. — Concluded.

Fertilizers used.	Tomatoes.			Cucumbers.		Celery.	Turnips.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Sulfate of ammonia.	8,613	26,891	18,293	2,772	5,979	16,870	33,442	12,662	29,221
Nitrate of soda,	8,293	24,726	16,768	4,701	8,016	34,553	44,351	7,598	33,442
Dried blood,	8,171	23,842	12,805	2,718	4,076	24,797	48,701	3,896	27,923

The relative influence of the nitrogen fertilizers has differed widely for the different crops, as is evident on examination of the above tables, and each must therefore be separately discussed.

Dandelions. — This crop was started in the summer of 1902. The fertilizers this year were applied evenly on April 14. The leaves, as above stated, were badly burned where-ever nitrate of soda or sulfate of ammonia was used. The crop was cut May 6, at which time it was judged that the leaves had reached their maximum development. The plants were in blossom, and of course somewhat beyond the stage at which the crop is commonly cut for market. On the basis of the yields obtained, the relative standing of the different nitrogen fertilizers was as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	78.36
Nitrate of soda,	72.66

There can be no doubt that, as a result of the burning effect alluded to, both the sulfate of ammonia and nitrate of soda actually decreased the yield.

Strawberries. — The vines from which the fruit harvested this year was picked were set in the spring of 1902. The fertilizers used were evenly spread broadcast on April 14. Within a few days the leaves began to show marked injury on the nitrate of soda and sulfate of ammonia plots. On the basis of total weights of ripe fruit, the nitrogen fertilizers ranked in the following order: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	54.50
Sulfate of ammonia,	49.74

Without doubt both the nitrate of soda and the sulfate of ammonia proved actually injurious.

Garden Peas. — The fertilizers applied to this crop were spread broadcast after plowing on April 30, and harrowed in. On the basis of weights of pods and vines harvested, the nitrogen fertilizers take the following relative rank: —

FERTILIZERS USED.	Pods (Per Cent.).	Vines (Per Cent.).
Dried blood,	100.00	100.00
Sulfate of ammonia,	95.86	87.68
Nitrate of soda,	84.55	78.26

The yields on the sulfate of ammonia were slightly greater than where no fertilizer was added to the manure. On the nitrate of soda they were considerably less, and there is no evidence that the latter benefited the crop.

Table Beets. — The fertilizers for this crop were applied at the same time and in the same manner as for the peas. As indicated by the yields, the relative standing of the different nitrogen fertilizers for this crop is as follows: —

FERTILIZERS USED.	Beets (Per Cent.).	Tops (Per Cent.).
Dried blood,	100.00	83.97
Nitrate of soda,	95.47	100.00
Sulfate of ammonia,	83.50	87.62

The fertilizers were apparently moderately beneficial to this crop, but the nitrate of soda stands relatively much lower than in previous years.

Tomatoes. — Fertilizers were applied as in the case of garden peas. The relative standing of the nitrogen fertilizers, as indicated by the yields (ripe and green fruit and vines), is as follows: —

FERTILIZERS USED.	Ripe Fruit (Per Cent.).	Green Fruit (Per Cent.).	Tops (Per Cent.).
Sulfate of ammonia,	100.00	100.00	100.00
Nitrate of soda,	96.28	91.97	91.67
Dried blood,	94.86	88.66	70.00

Cucumbers. — The cucumbers were planted on June 30, being put in to replace squashes, which had been killed by too heavy an application of kerosene emulsion. The relative standing of the nitrogen fertilizers, as indicated by the weights of the fruit and vines, is as follows: —

FERTILIZERS USED.	Fruit (Per Cent.).	Vines (Per Cent.).
Nitrate of soda,	100.00	100.00
Sulfate of ammonia,	58.96	74.53
Dried blood,	57.80	50.81

The vines in this experiment were somewhat affected by fungi, which doubtless influenced both yield of fruit and growth. The nitrate appears to have exerted a very favorable influence, but the reasons, in view of the character of the season and the lateness of the crop of cucumbers, are not evident. Both the amount of fruit, however, and the weight of the vines produced where the nitrate was used were materially greater than where no fertilizers were employed.

Celery. — This crop followed the fruiting strawberries, and the manure applied this year to these plots was turned in with the strawberry vines. The fertilizers called for on the several plots had been applied in the spring as a top-dressing to the strawberries. The relative standing of the different nitrogen fertilizers, as indicated by the total weight of the crop when dug in the fall and the roots freed from earth, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	71.76
Sulfate of ammonia,	48.94

Turnips. — This crop was sown on July 30, following garden peas. The variety was the White Egg. The relative standing of the nitrogen fertilizers, as indicated by the weights of roots of the different qualities and leaves, is as follows: —

FERTILIZERS USED.	Merchantable (Per Cent.).	Culls (Per Cent.).	Leaves (Per Cent.).
Dried blood,	100.00	30.61	83.33
Nitrate of soda,	91.20	60.20	100.00
Sulfate of ammonia,	68.80	100.00	87.21

The relative standing of the different nitrogen fertilizers for the early crops of this year, including dandelions, strawberries, peas and beets, as indicated by the combined weights of merchantable products, tops and vines, is: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	83.13
Sulfate of ammonia,	82.67

For the late crops, including tomatoes, cucumbers, celery, cabbages and turnips, the relative standing determined in the same manner is: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.20
Sulfate of ammonia,	85.74

Combining the results of 1903 with the twelve previous years, the relative standing of the nitrogen fertilizers is: —

	Per Cent.
For the early crops: —	
Nitrate of soda,	100.00
Dried blood,	95.42
Sulfate of ammonia,	60.03
For the late crops: —	
Nitrate of soda,	100.00
Dried blood,	98.76
Sulfate of ammonia,	78.96

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

The general conditions under which these experiments have been tried have been already outlined. It will be remembered that these salts are under trial in connection with the sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen when used in addition to manure for garden crops. The crops grown on these two potash salts, therefore, are the same as those which have been named in discussing the relative value of the different nitrogen fertilizers. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results for the past year are shown by the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Acre (Pounds), Average of Three Plots.

Fertilizers used.	Dandelions.	Strawberries.	Peas.		Beets.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Muriate of potash,	41,385	6,531	11,586	9,570	44,502	45,541
High-grade sulfate of potash,	39,459	7,183	10,269	10,162	41,840	44,351

Sulfate and Muriate of Potash compared, etc. — Concluded.

Fertilizers used.	Tomatoes.			Cucumbers.		Celery.	Turnips.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Muriate of potash.	8,069	24,797	14,431	2,699	4,982	24,119	42,208	7,143	28,918
High-grade sulfate of potash.	8,648	25,508	17,480	4,094	7,065	26,694	42,121	8,961	31,472

Examination of the table reveals the fact that the results for this season are the precise opposite of the results which have been obtained in most of our previous experiments. The muriate of potash gives the greater yield in the case of all the early crops, and the sulfate of potash the larger yield in the case of all the late crops. It is well understood that muriate of potash dissolves and diffuses through the soil somewhat more readily than sulfate, and, further, that it makes soils more retentive of moisture; and it may be that the great deficiency in rainfall which prevailed during the season until early in June left the soil so dry that the sulfate of potash did not become sufficiently dissolved and diffused to become available to the early crops.

The relative average standing of these two salts, as indicated by the total yields of all crops grown previous to this year, is shown in the following table: —

Fertilizers used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.00	100.00
Muriate of potash,	93.20	102.90

The relative average standing for this year, determined upon the same basis, is as follows: —

Fertilizers used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Muriate of potash,	100.00	92.66
Sulfate of potash,	98.36	100.00

Combining these results with those of the twelve previous years, the average standing, as indicated by total yields, is as shown in the following table: —

Fertilizers used.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.00	97.97
Muriate of potash,	93.84	100.00

The total rainfall during the past season from April 17, the date when the fertilizers were applied to the dandelions and strawberries, to June 7 was .48 inches. Such a rainfall must have been quite insufficient to bring the less soluble fertilizers into circulation, and the failure of the sulfate of potash to produce its usual effect on the early crops is not surprising. It has been repeatedly noticed in experiments here that in excessively dry seasons the muriate of potash usually excels the sulfate for all crops, even those which ordinarily do better on the sulfate. Following this period of excessive drouth came a period extending from the 7th of June to the end of the month with equally excessive rainfall, the total precipitation for that period amounting to 7.79 inches. July was also a comparatively rainy month, and it seems probable that the more soluble muriate of potash may have been largely carried into the subsoil. In this position it would not be equally available to the late crops as the less soluble sulfate.

It is not the belief of the writer that the fact that the relation of the two potash salts for this season to early and late crops respectively is exactly the reverse of what it has been in previous years, should lead to a modification of the advice which has been previously given, viz., that the sulfate should generally be preferred for the early crops and the muriate for the late on all soils with a fair capacity to retain moisture.

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

The experiment for comparison of different potash salts was begun in 1898. The field contains forty plots, of about one-fortieth of an acre each. The plots are fertilized in five series of eight plots each, each series including a no-potash plot and one plot for each of the potash salts under comparison. Those salts are kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such amounts as to furnish equal potash to each plot. In the quantities employed the different salts supply annually actual potash at the rate of 165 pounds per acre. All plots are equally manured with materials furnishing fairly liberal amounts of nitrogen and phosphoric acid. The crop of the past season was mixed clover and timothy. This is the second year that this crop has occupied the land. The table which follows, showing yields, does not quite accurately show the effect of the fertilizers. It was out of the question to separate weeds and grasses from the clover in an experiment conducted on the scale of this. Most careful examination often repeated during the season made the following points self-evident: —

1. That on the no-potash plots the clover was very thin, but the weeds of various kinds were relatively abundant.

2. That on the plots to which kainite was applied the clover was weaker than on any of the other plots receiving potash. The timothy, on the other hand, was more abundant and apparently more vigorous on the kainite plots than on the others.

3. On the muriate of potash plots the clover was inferior to all other plots receiving potash except the kainite, and here also timothy was relatively abundant and vigorous.

4. The clover on the low-grade sulfate of potash plots was distinctly inferior to that on the high-grade sulfate.

The fact that the differences above noted were repeated with little variation in each of the series of plots leaves no room to doubt the highly unfavorable influence on the development of the clover of the kainite and the muriate, and the moderately unfavorable effect of the low-grade sulfate.

The field was cut twice, the hay carefully cured, to a considerable extent in cocks, and without much loss of leaf or head. The table shows the rates of yield per acre for both first and second cut, as well as the total for each plot: —

Clover. — Yield per Acre (Pounds).

Plots.	Potash Salt.	Hay.	Rowen.	Total.
1,	No potash,	3,462	1,653	5,115
2,	Kainite,	3,462	3,592	7,054
3,	High-grade sulfate,	3,307	1,586	4,893
4,	Low-grade sulfate,	3,150	2,100	5,250
5,	Muriate,	3,441	2,368	5,809
6,	Nitrate,	2,927	2,234	5,161
7,	Carbonate,	2,882	2,011	4,893
8,	Silicate,	3,128	2,279	5,407
9,	No potash,	3,239	1,698	4,937
10,	Kainite,	4,424	2,435	6,859
11,	High-grade sulfate,	4,021	2,011	6,032
12,	Low-grade sulfate,	3,977	1,921	5,898
13,	Muriate,	3,753	2,055	5,808
14,	Nitrate,	3,977	2,100	6,077
15,	Carbonate,	3,462	2,011	5,473
16,	Silicate,	4,155	1,988	6,143
17,	No potash,	3,753	1,720	5,473
18,	Kainite,	4,357	1,698	6,055
19,	High-grade sulfate,	4,066	1,698	5,764
20,	Low-grade sulfate,	4,200	2,190	6,390
21,	Muriate,	4,379	2,145	6,524
22,	Nitrate,	3,843	1,899	5,742
23,	Carbonate,	4,021	1,609	5,630
24,	Silicate,	3,999	1,966	5,965
25,	No potash,	2,458	1,609	4,067
26,	Kainite,	4,021	2,122	6,143
27,	High-grade sulfate,	3,753	1,519	5,272
28,	Low-grade sulfate,	4,446	1,966	6,412

Clover. — *Yield per Acre* (*Pounds*) — Concluded.

Plots.	Potash Salt.	Hay.	Rowen.	Total.
29,	Muriate,	3,820	1,765	5,585
30,	Nitrate,	3,664	1,430	5,094
31,	Carbonate,	3,664	1,452	5,116
32,	Silicate,	4,021	1,787	5,808
33,	No potash,	3,619	1,519	5,138
34,	Kainite,	4,088	1,921	6,009
35,	High-grade sulfate,	3,709	1,631	5,340
36,	Low-grade sulfate,	4,111	1,564	5,675
37,	Muriate,	3,932	1,832	5,764
38,	Nitrate,	3,441	1,698	5,139
39,	Carbonate,	3,753	1,810	5,563
40,	Silicate,	3,887	1,787	5,674

The influence of the different potash salts is somewhat more clearly brought out by the table below, which gives the average results for each of the potash salts employed : —

Clover. — *Average Yield per Acre* (*Pounds*).

Potash Salt.	Hay.	Rowen.	Total.
No potash (plots 1, 9, 17, 25, 33),	2,066	1,025	3,091
Kainite (plots 2, 10, 18, 26, 34),	2,544	1,471	4,015
High-grade sulfate (plots, 3, 11, 19, 27, 35),	2,357	1,056	3,413
Low-grade sulfate (plots 4, 12, 20, 28, 36),	2,485	1,218	3,703
Muriate (plots 5, 13, 21, 29, 37),	2,416	1,271	3,687
Nitrate (plots 6, 14, 22, 30, 38),	2,232	1,170	3,402
Carbonate (plots 7, 15, 23, 31, 39),	2,223	1,112	3,335
Silicate (plots 8, 16, 24, 32, 40),	2,399	1,226	3,625

The average yield on the plot receiving no potash is much lower than on the other plots, in spite of the fact that weeds helped to a considerable extent to make up the deficiency in clover and timothy. The kainite gives the highest total yield of hay. This was doubtless in part due to the fact that the large mixture of timothy enabled the crop to stand up better during the heavy rains of the month of June than on those plots where the clover so largely predominated. The plots receiving high-grade sulfate of potash lodged very badly, — more seriously than any other plots in the field; and, as bad weather necessitated cutting the crop somewhat late, the vigor of the plants was undoubtedly lowered, as shown by the relatively low yield of rowen on these plots. They without doubt exhibited the highest average development of clover during the early part of the season, and with a more normal season should have given the heaviest rowen.

What is true of the high-grade sulfate of potash plots is doubtless also true in somewhat lesser degree of the plots manured with the silicate, carbonate and nitrate.

The experiment of this year lends additional support to the advice which has previously been given, viz., that "on soils with good retentive qualities sulfate of potash should generally be preferred to muriate or kainite for clovers," in spite of the fact that the total yields, including timothy, are heavier on these plots.

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

In this experiment, which has now been in progress seven years, we are endeavoring to determine by means of the growing crops the relative availability of a number of different phosphates. Those under comparison are as follows: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone, and acid phosphate.

All phosphates under comparison are used in amounts sufficient to furnish actual phosphoric acid at the rate of 96 pounds per acre, and each is applied annually in finely ground form to the same plot. The field contains thirteen plots, of about one-eighth of an acre each. Three of these plots have received no application of phosphoric acid since the beginning of the experiment. One of these is at either end, and the other in the middle, of the field. All plots are supplied alike with materials furnishing nitrogen and potash in available forms in liberal amount and in equal quantities to each. The materials used as sources of nitrogen and potash furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some crops a supplementary application of a quick-acting nitrogen fertilizer has been made to all plots alike. The crops which have been grown in this field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, and onions. With the exception of the onions, all the crops previously grown in this field have given good yields, even on the three plots in the field which have received no phosphate.

The soil of the field at the beginning of the experiment was not quite even in quality throughout. Plot 1 surpassed any other in the field in fertility at the start, and on the whole (although the difference is not very marked) there appears to be a gradual natural decline in productiveness from this end of the field toward the other.

The crop of the present season was cabbages. The variety is the Danish Ball-head. The seed was sown at the usual time for the crop in this locality, but so abnormally cold was the season that the crop was far from mature when cold weather set in. Still, the yields (which include weight of stumps, loose leaves and soft heads, as well as the weight of hard heads and totals) make it possible to estimate the relative availability of the different phosphates to the crop grown. The rates of yield per acre are shown in the following table: —

Cabbages on Plots with Equal Amounts of Phosphoric Acid.

Plots.	Fertilizers used.	Number of Hard Heads.	Hard Heads (Pounds).	Soft Heads, Leaves and Stumps (Pounds).	Total Crop (Pounds).
1,	No phosphate,	1,184	4,040	9,360	13,400
2,	Apatite,	776	3,560	17,360	20,920
3,	South Carolina rock phosphate,	2,928	12,040	24,480	36,520
4,	Florida soft phosphate,	816	3,840	21,840	25,680
5,	Phosphatic slag,	2,232	9,920	28,040	37,960
6,	Tennessee phosphate,	440	1,720	29,160	30,880
7,	No phosphate,	104	400	14,120	14,520
8,	Dissolved bone-black,	2,336	8,392	31,520	39,912
9,	Raw bone,	2,304	11,800	32,440	44,240
10,	Dissolved bone meal,	2,384	12,760	29,320	42,080
11,	Steamed bone meal,	1,632	8,720	28,200	36,920
12,	Acid phosphate,	1,296	6,200	24,120	30,320
13,	No phosphate,	120	440	8,080	8,520

The most important points to which it seems desirable to call attention are the following: —

1. The no-phosphate plots give very low yields both of hard heads and total, indicating the marked dependence of the cabbage upon the supply of phosphoric acid.

2. Apatite and soft Florida phosphate are the least effective among the phosphates employed.

3. South Carolina rock gives a surprisingly good return, being exceeded in yield of hard heads by only one plot, — the one receiving dissolved bone, — while in total yield it is materially exceeded by but few.

4. The phosphatic slag ranks among the best of the phosphates used. It is exceeded in yield of hard heads by the dissolved bone-black, the South Carolina rock and the raw bone, in the order named; while in total weight of crop it is exceeded by the dissolved bone, the raw bone and the dissolved bone-black.

5. The most valuable crop in the field is that produced by the dissolved bone, although it is slightly exceeded in total yield by the crop on the raw bone.

6. Particular attention is called to the fact that this year, as in preceding years, the raw bone meal gives a crop much superior to that obtained by the use of steamed bone meal.

The differences in the development of the cabbages on the different plots in the field, as affected by the phosphates applied, became manifest at a very early date. The plants were scarcely a week old before marked differences could be seen; and the relative development throughout the season, as recorded after several examinations, was in about the order indicated by the final yields, although most observers ranked the crop on the phosphatic slag while growing relatively higher than indicated by the final result.

In estimating the significance of the results upon this field, it is important to keep in mind the facts as regards the character of the soil. It is what would be called a strong and moderately heavy loam, and has great capacity to retain moisture. The relatively insoluble phosphates are known to give better results on soils of this character than on those which are lighter and drier.

Our experiments indicate that the cabbage is one of those crops most closely dependent upon the supply of available phosphoric acid, and yet this crop gives us a good return upon phosphates ordinarily regarded as very slowly available. The opinion in general held concerning the necessity for acidulated phosphates may need modification. We have not, it is true, raised on the South Carolina rock or the raw bone crops of the highest rank, as measured by the number and weight of hard heads. The total yields are excellent, and the weights of hard heads in a more normal season would without doubt have been much higher. It appears reasonable to believe that on soils of the character of this field the farmer may safely depend for a considerable portion at least of the phosphoric acid needed by his crops upon the cheaper natural phosphates, such as finely ground South Carolina rock and finely ground bone, while phosphatic slag also promises to prove a most useful fertilizer upon soil of this character.

VI. — Soil Tests.

Two soil tests, both upon our own grounds and both in continuation of previous work upon the same fields, have been carried out during the past season. Fertilizers have been applied in accordance with the co-operative plan for soil tests, with one or two small exceptions. Lime and plaster have been applied to the plots calling for these fertilizers in double the usual soil test amounts. Each plot annually receives an application of the same kind or kinds of fertilizers. Such experiments are not adapted to securing the production of heavy crops, but rather to throwing light upon the general question as to the particular plant food requirements of different crops. By study of the results, the effects of the different leading elements of plant food on the several crops can be determined with much accuracy.

Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Both fertilizers and manure (where the latter is introduced for purposes of comparison) are always applied broadcast after plowing, and harrowed in. The kinds and the amounts per acre are as follows: —

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

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

This acre has been used in soil tests for fifteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, and corn. Since 1889 this field has therefore borne seven corn crops, and during this time it has been four years in grass. The crop last year was corn, following grass; this year, corn follows corn. The season was the most unfavorable for this crop which has been known within the lifetime of most men now living, and the crop of this year was exceedingly poor, even on the land which has for fifteen years received an annual application of manure at the rate of 5 cords per acre. Last year, although the season then also was somewhat unfavorable, this plot gave a yield almost double that of this year. It is not surprising, therefore, that the yield on most of the plots receiving fertilizers was very low. Four of the plots have received neither manure nor fertilizer throughout the entire fifteen years, and these now show a degree of exhaustion amounting to almost absolute sterility. Allowing 90 pounds of ears as husked to the bushel of shelled grain, the average product of these plots was at the rate of about $1\frac{1}{2}$ bushels to the acre. The average yield of stover on these plots is at the rate of 560 pounds per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1903.

Plots.	FERTILIZERS USED.	YIELD PER ACRE.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels 90 Pounds).	Stover (Pounds).
1,	Nitrate of soda,	.56	360	—.44	—390
2,	Dissolved bone-black,	.94	360	—.06	—390
3,	Nothing,	.94	300	-	-
4,	Muriate of potash,	16.61	1,880	15.61	1,130
5,	Lime,	.15	160	—.85	—590
6,	Nothing,	1.06	1,200	-	-
7,	Manure,	37.39	3,600	36.39	2,850
8,	Nitrate of soda and dissolved bone-black.	3.89	800	2.36	430
9,	Nothing,	1.28	340	-	-
10,	Nitrate of soda and muriate of potash.	18.00	2,200	16.47	1,830
11,	Dissolved bone-black and muriate of potash.	20.39	2,320	18.86	1,950
12,	Nothing,	1.78	400	-	-
13,	Plaster,	2.06	400	.53	30
14,	Nitrate of soda, dissolved bone-black and muriate of potash.	25.56	3,040	24.03	2,670

In view of the highly unfavorable season, the development of the corn was far from normal, and extended discussion of the results does not seem called for. It will be noticed that, as in previous years, the potash among the fertilizer elements used is the one exercising by far the greatest effect in increasing the crop. The addition of either nitrate of soda or phosphoric acid, as shown by the results on plots 10 and 11, does not very materially increase the yield produced on potash alone (Plot 4). The addition of nitrate of soda to the mixture of potash and dissolved bone-black used on Plot 11 caused a considerable increase, — greater this year than in previous years, as shown by the yield on Plot 14. This difference in effect may very well be due to the gradual exhaustion of the supply of humus in the soil on these plots, which for so many years have been manured with fertilizers alone, and subjected to tillage throughout most of the time.

Though no combination of fertilizers gives what can be considered a good crop, the lesson is just as clear this year as in previous years, viz., that fertilizers for corn should be rich in potash.

B.— Soil Test with Mixed Grass and Clover (North Acre).

The field on which this test was carried out has been used in similar tests with various crops for fourteen years, beginning in 1890. The fertilizers have been applied in accordance with the system regularly used in soil tests, save as regards amounts. During the years when potatoes or onions have been grown, double the usual quantities have been employed. One other peculiarity in treatment must be reported. In the spring of 1899 one-half of each plot received an application of freshly slaked lime, at the rate of 1 ton per acre. This lime was spread after plowing, and worked in with a harrow. The crops in order of succession have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions for four years (1898 to 1901 inclusive), potatoes, and grass and clover. The crop upon which we are reporting followed potatoes. The seeds sown included the following varieties: timothy, red-top, and mammoth red and alsike clover. The seeds of the timothy (18 pounds), red-top (8 pounds), red clover (5 pounds) and alsike clover (4 pounds) were mixed and sown broadcast Sept. 15, 1902. The date of sowing was so late that the grass made relatively little growth during the autumn months and the clover winter-killed. The winter was, however, favorable for the grasses, and they came through without injury, and 15 pounds of red clover seeds were sown on April 4.

As has been pointed out in another connection, there was less than one-half inch of rain from the middle of April to the 7th of June. The conditions, therefore, were most unfavorable for the germination of the clover and for the growth of the young and therefore very shallow-rooted grass plants. The yields, therefore, were small, but the results are nevertheless of considerable interest. The fertilizers applied to the several plots and the rate of yield per acre with the gain or loss where the different fertilizers were employed are shown in the following table: —

Grass and Clover. — *North Acre Soil Test, 1903.*

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing, ...	360	1,150	–	–
2, .	Nitrate of soda, ...	1,520	3,140	1,096.7	2,036.7
3, .	Dissolved bone-black, . .	950	1,560	463.3	503.3
4, .	Nothing, ...	550	1,010	–	–
5, .	Muriate of potash, . . .	660	950	135.0	50.0
6, .	Nitrate of soda and dissolved bone-black.	1,830	3,180	1,330.0	2,390.0
7, .	Nitrate of soda and muriate of potash.	1,820	2,190	1,345.0	1,510.0
8, .	Nothing, ...	450	570	–	–
9, .	Dissolved bone-black and muriate of potash.	620	920	177.5	207.5
10, .	Nitrate of soda, dissolved bone-black and muriate of potash.	2,330	2,830	1,895.0	1,975.0
11, .	Plaster, ...	430	480	2.5	—517.5
12, .	Nothing, ...	420	1,140	–	–

Examination of the table makes the fact evident that it is the nitrate of soda chiefly which determined the rate of yield. It is further evident that this is able to exert its full influence only on the half of the plot which received the application of lime that has been referred to. Nitrate of soda alone on the limed half of the plot after fourteen years continuous use still gives a crop of hay at the rate of rather over 1½ tons per acre; used with dissolved bone-black, it gives almost exactly the same yield; used with muriate of potash, it gives a smaller yield, — only a little over 1 ton to the acre.

Much evidence is afforded, by a study of the relative proportions of the different species on the different plots and on the limed and unlimed portions of the several plots, that the soil in some parts of this field is once more becoming acid. It is likely that this is the case on Plot 7, for to that plot have been applied large quantities both of muriate of potash and nitrate of soda, both of which tend to aggravate the conditions leading to development of a sour condition of the soil. To Plot 10 dissolved bone-black has been added, as well as the nitrate of soda and muriate of potash, and this, because of the lime it contains, has helped to lessen the tendency to the development of acidity; but even on this plot the yield is less than on the nitrate of soda alone, and probably because of the acid condition induced by the continued use of the fertilizers the plot has received.

A careful determination of the relative proportions of the timothy, red-top and clover in the product of a square yard on both the unlimed and limed portions was made. On the unlimed portion of every plot the red-top was more abundant than the timothy. There was practically no clover on the unlimed portion of any plot. Timothy exceeded red-top on the limed portion of all plots except Plot 7. This is the plot to which both the nitrate of soda and muriate of potash have been applied; and here, in spite of the lime which was put on in 1899, the soil is undoubtedly again acid, as shown by the fact that the red-top exceeds the timothy. Clover was found in appreciable quantities only on the limed portion of plots 9 and 10. The lessons of the experiment, it seems to me, are clear, the following being the most important points: —

1. Nitrate of soda, as in many previous experiments, proves the controlling element in the production of grass; but this exerts the full effect of which it is capable only on soils which are not excessively acid.

2. Whenever, in a mowing seeded with a mixture of timothy and red-top, the latter largely predominates, it is an evidence that the productivity of the field would be increased by an application of lime.

3. Clover cannot be made to thrive in a soil unless it is free from acidity; and in those cases where on seeding clover fails, acidity may reasonably be looked for.

VII. — Experiment in Manuring Grass Lands.

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about nine acres. It is divided into three approximately even plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall, ashes and the bone and potash in early spring. A portion of the land was broken up as described in the annual report for last year, on account of having become somewhat infested with weeds, and reseeded. That portion which was plowed after the removal of the first crop in the summer of 1902, repeatedly harrowed, and then seeded on August 15, has this year produced a very heavy crop. This, no doubt, may be in part attributed to the very thorough preparation which the land received before seeding, although the liberal manuring which it has received for so many years was no doubt also a most important factor. The past season, although it promised at the start, on account of the excessively dry weather from the middle of April to about the 10th of June, to be a very poor one for the hay crop, eventually proved decidedly favorable, as the frequent rains during the last three weeks in June produced a heavy growth. Conditions for the rowen crop were also exceptionally favorable. The yields of hay and of rowen and the totals for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	5,886	2,664	8,550
Bone and potash,	4,648	3,333	7,981
Wood ashes,	5,188	2,591	7 779

The average total yield of the entire area for this year is 8,104 pounds. The average for the entire period (1893 to the beginning of the present year) was 6,413 pounds. The average to date is 6,597 pounds. The average yield when top-dressed with manure has been 6,827 pounds; when top-dressed with wood ashes, 6,427 pounds; when top-dressed with bone and potash, 6,562 pounds. The average yields for this year, as will be seen, are much above the general average to date.

Old and New Seeding compared.

As has been stated, the yield on the part of the land reseeded last summer was very exceptionally heavy. The advantage of reseeding is made evident by comparison of the yields on that portion of plots 1 and 2 not reseeded with the yield on the portion which was reseeded. These comparisons are shown by the following table: —

	Yield per Acre (Pounds).		
	Hay.	Rowen.	Totals.
Plot 1, wood ashes: —			
Not reseeded,	4,305.0	1,938.0	6,243.0
Reseeded portion,	5,629.5	2,917.0	8,546.5
Plot 2, barnyard manure: —			
Not reseeded,	3,966.0	1,676.0	5,642.0
Reseeded portion,	6,845.5	3,157.5	10,003.0

The yields obtained on the reseeded portion, amounting to rather over 4¼ tons on one plot and to almost exactly 5 tons on the other, are certainly exceedingly satisfactory.

The Seed sown.

An effort is being made to render the results of the experiments on this land more valuable by comparing two different mixtures of grass seeds. As the result of experience, it has been found that on this land, under the system of manuring followed, timothy, and to a lesser degree red-top, tend to die out, and are replaced to a considerable extent by Kentucky blue-grass, — a species far less valuable for mowings. Tall and meadow fescue will, it is believed, prove more persistent, and it is hoped they may be able to hold the ground against the Kentucky blue-grass. With a view to testing these species as regards this point, equal areas of the reseeded portions of plots 1 and 2 have been sown with each of the two mixtures shown below: —

Fescue Mixture (Pounds per Acre).

Timothy,	6
Red-top,	8
Red clover,	5
Alsike clover,	4
Kentucky blue-grass,	4
Meadow fescue,	6
Tall fescue,	4

Timothy Mixture (Pounds per Acre).

Timothy,	18
Red-top,	8
Red clover,	5
Alsike clover,	4

These mixtures may be for convenience called respectively fescue mixture and timothy mixture. The relative yields in the first year on the two different seed mixtures is shown below: —

	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Plot 1: —			
Fescue mixture,	5,042	2,648	7,690
Timothy mixture,	6,217	3,186	9,403
Plot 2: —			
Fescue mixture,	6,521	2,921	9,483
Timothy mixture,	7,129	3,394	10,523

It will be seen that the timothy mixture has given the larger crops this year on both plots, both at the first and second cuttings. During the past dozen years many mixtures of grass seeds have been tried on different parts of the college estate, but none has been found which, everything considered, exceeds in value a mixture substantially that which is so generally used of timothy, red-top and clover. This mixture in the first year is clearly superior to the other, but whether it will maintain its superiority cannot of course be determined at present.

VIII. — Experiment in the Application of Manure.

The experiment upon which the results for the past year are to be reported was begun in 1899. The object in view is to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large heaps, to be spread just before plowing the land in the spring. A full account of the plan of this experiment will be found in the thirteenth annual report of this experiment station. The field contains five plots, each subdivided into two sub-plots, on one of which the manure is spread when hauled out during the winter and on the other put into a large heap from which it is hauled out and spread in the spring. We have in reality five parallel experiments yearly, the area of each sub-plot being about one-quarter of an acre. The crop last year was ensilage corn. On three plots the yield where the manure was spread in the spring was considerably greater than where it was spread in the winter; on the other two plots the yields under the two systems of application were practically equal. Rye was sown in the standing corn on August 20, to furnish winter cover. This rye had made considerable growth, which was fairly even on all the plots when it was plowed under, the middle of May. The crop of this year was soy beans, five different varieties being planted, each kind in equal area on all the plots. Owing to the cold weather, the growth was not altogether satisfactory, and the yield even of the earliest varieties was small. It was seen that one variety would not ripen, and accordingly it was cut when in ensilage condition and put into the silo. We have, therefore, to report for each plot the rate of yield per acre of dry beans and straw, and of green forage for the silo. The rates of yield per acre and the relative standing of the several plots are shown in the tables: —

Actual and Relative Yields of Green Forage.

Plots.	Manuring previous to 1889.	Actual Yields (Rates per Acre, Pounds).		Relative Yields (Per Cent.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	10,785	9,729	100	90.21
2, .	Wood ashes, . . .	9,821	8,811	100	89.72
3, .	No manure, ...	9,041	9,408	100	104.06
4, .	Fine-ground bone and muriate of potash.	9,546	11,519	100	120.67
5, .	Fine-ground bone and sulfate of potash.	10,509	11,840	100	112.66

Actual and Relative Yields of Soy Beans and Straw.

Plots.	Manuring previous to 1889.	Actual Yields (Rates per Acre).			
		Beans (bushels).		Straw (pounds).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	14.56	15.56	1,021	1,212
2, .	Wood ashes, . . .	16.27	15.50	1,272	1,319
3, .	No manure, ...	15.04	14.42	1,232	1,119
4, .	Fine-ground bone and muriate of potash.	15.22	12.55	1,284	1,045
5, .	Fine-ground bone and sulfate of potash.	14.26	15.21	1,252	1,269

Actual and Relative Yields of Soy Beans and Straw — Concluded.

Plots.	Manuring previous to 1889.	Relative Yields (Per Cent.).			
		Beans.		Straw.	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	100	106.87	100	118.71
2, .	Wood ashes, . . .	100	95.27	100	103.69
3, .	No manure, ...	100	95.88	100	90.83
4, .	Fine-ground bone and muriate of potash.	100	82.46	100	81.39
5, .	Fine-ground bone and sulfate of potash.	100	106.66	100	101.36

In previous years the south half (spring manured) of each plot has, with two insignificant exceptions, above noted in the case of the ensilage corn of last year, given a greater yield than the north half. The yield of the winter-manured portion for each year being considered 100 for the several plots, the yields of the spring-manured portion of the same plots has varied in the different years as follows: in 1900, from 103 to 125; in 1901, from 118 to 177; in 1902, from practical equality in two cases to 150. This year, it will be noted, there is but little difference in the yields under the two systems of manuring, and the advantage is on the side of the winter application. The winter application considered as 100 as in previous years, the yields for the spring application of manures has varied as follows: for the beans, 82.46 to 106.87; for the straw, 81.39 to 118.71; and for the green forage, 89.72 to 120.67.

In attempting to understand the reasons for such differences as have been noted in the different years, we find, on a study of the weather conditions, that those of the winter of 1902 and 1903 were for this locality quite exceptional. A heavy snowfall came during the first week in December, at which time the ground was not frozen. This snow, with occasional additions from time to time, though sometimes wasting to some extent, lay upon the ground throughout the winter in sufficient amount to prevent the ground from freezing. The winter was without those frequent sudden thaws, accompanied by heavy rains, which with frozen ground lead to excessive washing. So remarkable was the winter that the roots of one of our exceptionally hardy summer crops, dwarf Essex rape, came out in the spring uninjured, and with the approach of warm weather sprouted and made vigorous growth. Under such conditions it is not strange that loss of the soluble plant food constituents of the manure spread upon the surface took place to a very slight extent, if at all. Could we depend upon such winters as the last, the practice of spreading manure and leaving it upon the surface during the winter would undoubtedly be wise, as it saves on the cost of handling; but, as every one familiar with our climate understands, such winters cannot be depended upon, and accordingly the weight of evidence in our experiments is still in favor of hauling the manure into heaps, to remain over winter and to be spread in the spring.

IX. — Poultry Experiments.

In our experiments with poultry during the past year our attention has been confined almost exclusively to questions connected with the feeding of fowls for eggs. We are endeavoring to obtain light on the question as to the proper relation between the different nutrients in the ration fed. Our work during the year may be summarized as follows: —

1. We have compared two rations, in one of which corn is prominent, in the other wheat, using animal meal as a source of animal food. The nutritive ratio of the ration including wheat has been 1 : 4.34; for the one including corn, the ratio has been 1 : 6.24.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food in each, and with an addition of corn oil as a source of fat, in which the milk albumin is very poor. The nutritive ratio of the ration including wheat is 1 : 4.44; for the ration including corn, 1 : 6.48.

3. We have compared two rations in one of which wheat is prominent, in the other rice, with milk albumin as the source of animal food in each. Both of these rations were very low in fat. The nutritive ratio of the first (in which wheat is prominent) is 1 : 4.3; of the second (in which rice is prominent), 1 : 6.4.

The most important points in connection with the results appear to be as follows: —

1. In the comparison of wheat with corn, where animal meal was the source of animal food, the egg production for the entire period from December 14 to September 4 was practically equal. For the winter period, December 14 to April 1, the corn ration produced eggs at an average rate of .3005 per hen day; the wheat ration, at the rate of .2792 per hen day. In other words, 100 hens on the corn ration would have given an average daily yield of a slight fraction over 30 eggs, while the wheat ration would have given from the same number of hens almost 28 eggs per day. For the summer period, April 1 to September 4, the corn ration gave an average of .4365 eggs per hen day; the wheat ration,

.4541; or, in other words, the average daily product from 100 hens would have been for the wheat ration 44.4 eggs; for the corn ration, about 43.7. The average food cost per egg produced was on the wheat ration, a very slight fraction over 1 cent; on the corn ration it was .85 of a cent.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food in each, and with corn oil added as a source of fat, the egg product was considerably better than in the first experiment. For the entire period the hens receiving corn produced more eggs, — an average at the rate of .4166 eggs per hen day. For the wheat the similar average was .3570. For the winter period, December 14 to April 1, similar averages were: for the wheat ration, .2606; for the corn ration, .2862. For the summer period, April 1 to September 4, the averages were: for the wheat, .4251; for the corn, .5107. For the entire period the average food cost per egg laid was for the wheat ration 1 cent, for the corn ration .8 cent. The product obtained in this experiment, at the rate respectively for the wheat of 35.7 eggs per day and for the corn at the rate of 41.66 eggs per day, for 100 hens is considered good, for fowls kept in close confinement, especially in view of the fact that the pullets used in the experiment were rather late hatched, and laid but few eggs until the first of February, viz., 125 for the fowls receiving wheat and 48 for the fowls receiving the corn ration.

3. In the comparison of wheat with rice, with milk albumin as the source of animal food in each, the results were decidedly in favor of the ration including the rice. For the entire period the product of these fowls was at the rate of .3732 eggs per hen day; for the fowls receiving the wheat, at the rate of .3328 eggs per hen day. For the winter period, December 14 to April 1, the averages were: for the rice ration, .3097; for the wheat ration, .2241 eggs per hen day. For the summer period, April 1 to September 4, similar averages were: for the rice, .4188; for the wheat, .4080. The production in this experiment is inferior on both rations to that obtained in either of the other experiments; and, although the yield on the rice is fairly good, this cannot be

regarded as a practical food for ordinary use, on account of its high cost. The food cost for the eggs produced in this experiment was at the rate of about $1\frac{1}{5}$ cents for the wheat ration, and nearly 2.1 cents per egg for the rice ration.

As the result of experiments in previous years, corn had been found superior to wheat rations when animal meal was used as the source of animal food, while with scraps the two rations gave nearly equal numbers of eggs. In previous experiments, with milk albumin as the source of animal food, the egg production has usually been unsatisfactory when wheat has been the principal grain. These facts had led to the belief that possibly the amount of fat in the ration played an important part in determining the egg yield; and the experiments of this year were planned with a view to throwing light upon this point. In some particulars they seem to confirm this theory. The production of eggs on milk albumin, which is very low in fat, has in previous years been quite unsatisfactory. This year, with the addition of fat, more eggs have been produced. Further, in other experiments the egg production where corn is the principal grain has much exceeded that where wheat is the principal grain, when animal meal is used as the source of animal food. The results this year were very similar. On the other hand, the ration lowest in fat of all, viz., that including rice, has given many more eggs than the ration including wheat, which furnishes a far greater quantity of fat.

A study of the rations of this year shows an apparent relation between the quantity of fiber in the food and the egg production. The rations furnishing exceptionally large amounts of fiber, derived principally from such grains as oats and barley, have given very inferior yields of eggs.

In conclusion, we are justified in saying that our experiments do not lend support to the belief that the nutritive ratios of rations fed to hens must necessarily be narrow to produce a satisfactory product. We have obtained more eggs in winter in all experiments this year on the combinations of foods with the wider nutritive ratios, and in two out of three experiments the result was the same for the summer period. I am still inclined to the belief that the amount of fat in the ration is a matter of much importance. I believe, further, that care should be taken that the ration does not include too large a proportion of fiber, as this without doubt increases the labor of digestion, and probably decreases the proportion of the various nutrients digested and assimilated. It is well understood that animal matter of some kind is essential to good egg production. Our earlier experiments have shown the great superiority of animal to vegetable protein in rations for laying hens. It is believed, however, that suitable animal feeds, under which class may be included all such as are well preserved and sweet and palatable, may be wisely used in connection with a large proportion of our cheapest grain, — corn.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

F. A. WAUGH, HORTICULTURIST; GEO. O. GREENE, ASSISTANT.

The work of the department of horticulture during the year just closing has been devoted largely to reorganization, and to the beginning of new lines of experiment and new systems of record. The various experiments undertaken will be reported upon as fast as valuable results develop. Meanwhile, the department continues to find a large part of its public service in answering various inquiries from all over Massachusetts and neighboring States. Such inquiries, touching all the subjects connected with fruit and vegetable growing, arboriculture and landscape gardening, are answered promptly, and as fully as circumstances permit.

The work of testing new and old varieties of fruits and vegetables has been considerably abated, but has not been suddenly nor inconsiderately abandoned. The comparison of varieties of strawberries, for example, which has long been a feature of the department work, has been continued for the present on a somewhat different plan, and some report of results is a part of the present publication.

Mr. George A. Drew, who has been assistant horticulturist and in charge of various lines of experimental work for several years, resigned that position in September, to take up more remunerative work elsewhere. The vacancy was filled October 1 by the appointment of Mr. George O. Greene, assistant horticulturist of the Kansas Experiment Station. The high character of the service performed by Mr. Drew during his term as assistant should be a matter of special recognition and record here.

Strawberry Experiments.

Experiments with strawberries, which have been carried on for many years in the department of horticulture, have been continued for the present. This work has been under the direct charge of Mr. George A. Drew, and the following notes have largely been made up by him.

Season and Soils.

The season of 1903 was a disappointment in many respects to strawberry growers. To start with, a number of the early varieties were damaged by spring frosts; then, when the later fruit was about ready to mature, a severe drought set in, lasting practically throughout the fruiting season, and very naturally reducing the yield.

While disappointing from the commercial grower's standpoint, the season was not without some instructive features as regards behavior of varieties and the ability of certain soils to retain moisture. Where the soil had been very thoroughly prepared, and there was an abundance of vegetable matter present, the strawberry plant withstood the dry weather without very serious damage; on the other hand, where the soil was of a gravelly nature, and the amount of vegetable matter limited, the plant easily succumbed to the effects of the drought.

It cannot be emphasized too much or repeated too often how great a part thorough preparation of the soil takes in the yields obtained. The strawberry naturally has a very limited root system, and any means that will induce the fibers to penetrate deeper is labor well spent.

A medium deep loam is, all things considered, about the ideal soil. If one depends on a sandy or gravelly soil, irrigation facilities must be provided, and, taken one year with another, some system of irrigation will undoubtedly pay. If one does not feel justified in the outlay this would necessitate, and one has several kinds of soil to choose from, it is well to select two different types: one gravelly, light and early; the other more loamy, heavier and later. Then, after a series of years, one could balance up accounts, so to speak, and find which was the most profitable in the long run.

Notes on Varieties.

Many new and old varieties have been compared on different soils, ranging from rather dry gravel to fine rich loam. Those varieties which, on account of their novelty, their special value or other interest, seem worthy of report, are described and commented on below.

August Luther. — Fruit: oblong; size, small; core, melting; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early; calyx, small, loose; texture, medium; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, many; rust, none.

Sets a large amount of fruit, but has no special points of merit.

Belmont. — Fruit: oblong, flattish, irregular; size, very large; core, slightly hollow; external color, crimson; color of flesh, red to core; flavor, slightly acid; season, medium to late; calyx, large, loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; runners, numerous; rust, very slight.

Not very productive, but attractive in appearance, and one of the good old kinds.

Bismarck. — Fruit: roundish; size, medium large; core, small, hard and closed; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, prominent; quality, very good; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A good home berry, and fairly productive.

Blonde. — Fruit: conic, regular; size, medium large; core, slightly open; external color, light crimson; color of flesh, reddish; flavor, acid; season, late; calyx, large, loose; texture, firm; seeds, brownish, prominent; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, good; runners, numerous; rust, slight.

Brandywine. — Fruit: round, conic, tapers to sharp point; size, large; core, slightly open; external color, dark crimson; color of flesh, red throughout; flavor, acid; season, medium to late; calyx, green, loose and prominent; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, fair. Blossom, a good pollenizer, perfect; plant, vigorous; foliage, dark, large and regular; runners, numerous; rust, slight.

Productive generally, but the fact of berry turning black where exposed to the air proves a great drawback; erratic in different localities.

Brunette. — Fruit: round, conic; size, large; core, slightly hollow; external color, crimson; color of flesh, crimson; flavor, insipid; season, medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A valuable home variety.

Bubach. — Fruit: flat, conical; size, large; core, hollow; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, early to medium; calyx, medium; texture, medium; seeds, greenish, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium dark, medium large; runners, medium; rust, slight.

Deficient in vigor, and, like the Marshall, succeeds only in favored localities, where one can get a fine healthy stock of plants.

Bush Cluster. — Fruit: usually conical; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, acid; season, medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, poor; shipping quality, fair. Blossom, imperfect; plant, fairly vigorous; foliage, large, medium dark; runners, numerous; rust, slight.

A disappointment in all respects.

Clyde. — Fruit: irregular, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, early; calyx, loose, large; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium, large, light; runners, very numerous; rust, slight.

Extremely productive, and tends to set more fruit than it is capable of maturing; somewhat subject to disease.

Cobden Queen. — Fruit: round, irregular, conic; size, medium large; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, prominent outside; quality, good; shipping quality, good. Blossoms, rather few, imperfect; runners, numerous; rust, slight.

Foliage unhealthy; fruit seedy.

Corsican. — Fruit: round to roundish, conic; size, medium; core, slightly hollow; external color, scarlet; color of flesh, pinkish; flavor, insipid; season, early to medium early; calyx, medium; texture, soft; seeds, yellow, outside; quality, fair; shipping quality, poor. Blossom, perfect; plant, vigorous; foliage, inclined to discolor; runners, fair; rust, slight.

Too soft for commercial use; always a disappointment here.

Darling. — Fruit: round, conic; size, medium; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, medium; texture, medium; seeds, yellow, prominent; quality, fair. Blossom, perfect; plant, deficient in vigor; rust, slight.

Too poor for commercial use.

Delaware. — Fruit: flat, conical, irregular; size, medium; core, medium to large; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather prominent; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, very good. Blossom, perfect; plant, medium in vigor; foliage, medium; runners, medium; rust, little.

Rather unproductive, but set some fine fruit of good color and shipping quality.

Dewey. — Fruit: long, conic; size, medium large; core, small, hard; external color, scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, medium; rust, slight.

Inclined to be deficient in vigor, and nothing of special merit to recommend it.

Dole. — Fruit: irregular, conical; size, medium large; core, medium large; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, medium; calyx, medium; texture, rather soft; seeds, yellow, imbedded; quality, good; shipping quality, poor. Blossom, imperfect; plant, vigorous; foliage, good; runners, many; rust, little.

Unproductive; possesses no special advantage over others.

Drought King. — Fruit: round, conical, and irregular; size, medium; core, slight, hard; external color, scarlet; color of flesh, whitish; flavor, very acid, sour; season, medium; calyx, medium; texture, firm; seeds, brownish, prominent; quality, very good; shipping quality, good. Blossom, imperfect; rust on plant, slight.

Unworthy of its name; very poor.

Gibson. — Fruit: flat, conical; size, large to very large; core, small, hollow; external color, dark crimson; color of flesh, red throughout; flavor, slightly acid; season, medium; calyx, medium large; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, healthy, vigorous; runners, few; rust, slight.

Unproductive here, but very fine fruit, and worthy of further trial.

Gladstone. — Fruit: irregular, conic, like Glen Mary; size, large to very large; core, hard; external color, scarlet; color of flesh, pinkish; flavor, acid; season, medium; calyx, loose medium; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, medium green; runners, numerous; rust, slight.

Resembles Glen Mary closely.

Glen Mary. — Fruit: irregular, conical; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, good. Blossom, perfect; plant, very vigorous; foliage, large, vigorous; runners, numerous; rust, slight.

Greatest fault in uneven ripening of tips of berries, but large and productive.

Haverland. — Fruit: long, conical; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, slightly imbedded; quality good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, large, long; runners, many; rust, slight.

Very productive, and one of the best for commercial and domestic use; one of the leaders still.

Hawaii. — Fruit: long, conic; size, medium; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, yellow, slightly imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, resembles Haverland; runners, numerous; rust, slight.

Resembles Haverland closely, but not so productive nor so large fruit.

Hero. — Fruit: flat, conical; size, medium large; core, medium; external color, dark scarlet; color of flesh, red to core; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, good; runners, few; rust, slight.

Not very vigorous or productive, and a disappointment here.

Howard 7. — Fruit: irregular, inclined to be in two parts; size, large; core, large, open, hollow; external color, crimson; color of flesh, crimson to core; flavor, acid; season, medium; calyx, large, upturned; texture, firm; seeds, yellow, imbedded; quality, poor; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, dark, medium large; runners, average; rust, slight.

Worthy of further trial.

Howard 14. — Fruit: very long, tapering at each end; size, large; core, slight, slightly hollow; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, medium large; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, very tall, long leaf stalks; runners, many; rust, little.

Inclined to run small after first few pickings.

Howard 36. — Fruit: long, flat, conical, somewhat tapering at point; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, slightly acid; season, medium to early; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium large, vigorous; runners, many; rust, little.

One of the most productive and profitable varieties on our ground.

Howard 103. — Fruit: round, conical; size, large; core, closed, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, very early; calyx, medium, rather loose; texture, rather soft; seeds, yellow, deeply imbedded; quality, fair; shipping quality, fair.

Blossom, imperfect; plant, fairly vigorous; foliage medium, dark and vigorous; runners, medium; rust, none.

A good, productive, very early berry, and for this purpose excels.

Howard's Clyde 3. — Fruit: round, conic, slightly irregular, often divided; size, large; core, slight, closed; external color, scarlet; color of flesh, scarlet; flavor, slightly acid; season, early; calyx, medium large, loose; texture, slightly soft; seeds, light yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, medium dark, large; runners, numerous; rust, none.

Does not set as much fruit as Clyde, but matures it better; an improvement on Clyde, and valuable.

Joe. — Fruit: round, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, medium; calyx, loose, medium large; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossoms, medium in number, large, perfect; plant, vigorous; foliage, large, dark; runners, fair; rust, slight.

Not very productive, but promising as a large, juicy berry; fancy.

Jucunda. — Fruit: roundish; size, large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, green; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, dark, on short stalks; runners, medium; rust, slight.

Still worthy of cultivation, though deficient in vigor.

Kansas. — Fruit: round, conic; size, medium; core, slightly hard; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, medium vigorous; runners, very numerous; rust, slight.

Not to be recommended, according to its behavior on our grounds.

Klondike. — Fruit: irregular, conic; size, very large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, medium; calyx, large; texture, medium; seeds, brown, imbedded; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, light; runners, numerous; rust, slight.

Inclined to ripen unevenly, and too soft for transportation a long distance; valuable home variety.

Latest. — Fruit: irregular, conic; size, large to very large; core, hard; external color, dark scarlet; color of flesh, whitish; flavor, insipid; season, late; calyx, loose; texture, medium firm; seeds, brown, deeply imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, medium vigorous; foliage, medium; runners, few; rust, slight.

Plants stock up well and are fairly productive; promising late variety.

Leheman 2. — Fruit: irregular, conical; size, large; core, hard; external color, dark scarlet; color of flesh, light scarlet; flavor, acid; mid-season; calyx, small; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, leaves long, medium large; runners, numerous; rust, slight.

Productive and reliable.

Lester. — Fruit: conical; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, large, loose, prominent; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, thick; runners, fair; rust, none.

Lyon. — Fruit: long, conic; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, loose; texture, medium; seeds, prominent; quality, good; shipping quality, good. Blossom, thrifty, imperfect; plant, vigorous; runners, numerous; rust, slight.

Very productive, medium-sized berries.

M. A. C. Seedling 24. — Fruit: round, conic; size, large to very large; core, inclined to be hollow; external color, crimson; color of flesh, light crimson; flavor, insipid; season, early to medium; calyx, medium; texture, rather soft; seeds, brown, imbedded; quality, fair; shipping quality, fair. Blossom, not very vigorous, perfect; plant, only fair in vigor; foliage, medium large; runners, fair; rust, considerable.

Inclined to be soft for long transportation, but otherwise very good.

Margaret. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, pinkish; flavor, sweet; season, early to medium; calyx, loose, prominent; texture, very firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, fair; rust, slight.

Not very productive, but occasionally to be recommended.

Marshall. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, loose, prominent; texture, firm; seeds, yellow, prominent; quality, standard; shipping quality, good. Blossom, perfect; foliage, large, dark, heavy; rust, slight.

Not productive, but fine for home use; success with this variety depends mainly on selection of plants and favored localities and on high cultivation.

McFarland's Seedling. — Fruit: elongated; size, very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, large, loose; texture, firm; seeds, brownish, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, large, dark; runners, numerous; rust, slight.

Very productive and promising, where large fancy fruit is desired.

McKinley. — Fruit: irregular, long, flat; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, loose, large, prominent; texture, rather soft; seeds, golden, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, vigorous; runners, fair; rust, slight.

Greatest fault is soft fruit and uneven ripening; similar to Meggansett Dew Drop.

Mead's Seedling. — Fruit: round, conic; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, medium; calyx, medium, loose; texture, medium; seeds, yellow; quality, fair; shipping quality, fair or rather poor. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Originated by H. O. Mead of Lunenburg, Mass. Inclined to become soft on standing.

Meggansett Dew Drop. — Fruit: long, irregular, conical; size, large to very large; core, slight; external color, scarlet; color of flesh, whitish; flavor, insipid; season, early to medium; calyx, loose; texture, medium fine; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very vigorous; foliage, dark; runners, numerous; rust, none.

General tendency to color unevenly, and rather soft for shipping; resembles McKinley somewhat; productive.

Morgan. — Fruit: long, flattish; size, large to very large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium early; calyx, large, rather loose; texture, medium firm; seeds, yellow, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Greatest fault is general tendency to color unevenly; productive.

Nettie. — Fruit: long, irregular, conic; size, very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, loose, large; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, dark, large; runners, fair; rust, slight.

Appears to be a promising late variety, where size and appearance count; fancy.

New York. — Fruit: long, irregular, conic; size, large; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; calyx, medium loose; texture, medium firm; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, fair; rust, slight.

Inclined to be too light colored, otherwise a productive fancy berry.

Nick Ohmer. — Fruit: roundish; size, large; core, slight; external color, scarlet; color of flesh, whitish; flavor, sweetish; season, medium; calyx, medium, rather loose; texture, firm; seeds, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, diseased; runners, numerous; rust, slight.

Plant deficient in vigor, and not productive; some very good fruit, but not to be relied upon.

Pacific. — Fruit: broad, flattish, conical; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, acid; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium; runners, numerous; rust, slight.

Productive, and a good early berry.

Paris King. — Fruit: long, irregular, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, rather acid; season, early; calyx, medium loose; texture, firm; seeds, yellow; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, numerous; rust, slight.

A good, productive, early berry.

Parson's Beauty. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, early to medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossoms, numerous, perfect; plant, vigorous; foliage, dark, medium thick; runners, very numerous; rust, slight.

Productive, but berries not uniform, and hence not very attractive in appearance.

Pennell. — Fruit: flattish, irregular, conic; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, very prominent, numerous; quality, rather poor; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Prominent seeds on outside give unattractive appearance, otherwise a valuable addition.

Plymouth Rock. — Fruit: roundish; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sweet; season, medium; calyx, loose; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, vigorous; plant, fairly vigorous; foliage, fair; runners, fair; rust, slight.

Fairly productive, but fruit not uniform.

Pocomoke. — Fruit: irregular, conical; size, large to very large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, vigorous, perfect; plant, has good vigor; foliage, medium large; runners, fair; rust, slight.

Productive and promising; a good commercial variety, to be recommended.

Pomona. — Fruit: round, conic; size, medium large; core, slight;

external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, early to medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, full, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Averages favorably with the commercial sorts.

Porto Rico. — Fruit: long, conical, small neck; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sub-acid; season, medium; calyx, loose, upturned; texture, firm; seeds, brownish; quality, good; shipping quality, very good. Blossoms, medium in number, imperfect; plant, fairly vigorous; foliage, fair; runners, average, or below; rust, slight.

Parker Earle type; productive, and worthy of more extended trial.

Premium. — Fruit: conical; size, medium large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, early to medium; calyx, medium; texture, firm; seeds, imbedded; quality, rather poor; shipping quality, good. Blossom, imperfect; plant, fairly vigorous; foliage, medium dark; runners, numerous; rust, slight.

Good average berry, but inclined to run small by mid-season.

Pride of Cumberland. — Fruit: round, conic; size, medium large; core, slight; external color, light crimson; color of flesh, light crimson; flavor, sub-acid; mid-season; calyx, medium loose; texture, very firm; seeds, yellow, protruding; quality, very good; shipping quality, very good. Blossoms, medium in number, perfect; plant, fairly vigorous; foliage, fair; runners, comparatively few; rust, slight.

Not very productive on our soil, but otherwise a good commercial berry.

Putnam's Seedling X. — Fruit: round, conic; size, large; core, medium; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, large; texture, very firm; seeds, yellow, slightly imbedded; quality, good; shipping quality, very good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium; runners, average; rust, slight.

Fine, firm, regular late berry.

Rochester. — Fruit: irregular, conic; size, medium large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, medium; texture, firm; seeds, yellow, protruding; quality, poor; shipping quality, good. Blossoms, many, perfect; plant, fairly vigorous; foliage, medium; runners, numerous; rust, slight.

Not to be recommended for commercial planting, from its behavior on our grounds.

Rough Rider. — Fruit: irregular; size, medium large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather loose, medium; texture, firm; seeds, yellow, imbedded; quality, rather poor; shipping quality, good. Blossoms, medium in number, perfect; plant, poor in vigor; foliage, fair; runners, fair; rust, slight.

Nothing to recommend it, according to its behavior here.

Sample. — Fruit: round, conic, regular; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; mid-season; calyx, medium; texture, medium; seeds, brownish; quality, fair; shipping quality, fair to good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium green; runners, numerous; rust, slight.

A fine, productive, uniform commercial berry, inclined at times to be a little soft; still the most reliable. under various conditions.

Sawyer's Seedling. — Fruit: round, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, medium to late; calyx, medium; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, fairly vigorous, perfect; plant, very good in vigor; foliage, large, vigorous; runners, average; rust, slight.

Satisfactory on our grounds; productive and valuable.

Shuster's Gem. — Fruit: round, conic; size, large; core, slight; external color, crimson; color of flesh, lightish; flavor, sub-acid; mid-season; calyx, large; texture, medium; seeds, yellow, protruding; quality, fair; shipping quality, fair. Blossom, perfect; plant, has good vigor; foliage, medium dark; runners, average; rust, slight.

An old reliable berry, and worthy of culture.

Springdale Beauty. — Fruit: irregular, roundish; size, medium to large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, loose; texture, medium; seeds, yellow, slightly imbedded; quality, fair; shipping quality, fair. Blossom, vigorous, perfect; plant, vigorous; foliage, medium dark; runners, average in number; rust, slight.

A good general-purpose berry.

Uncle Jim. — Fruit: long, conical; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very good in vigor; foliage, resembles Marshall; runners, numerous; rust, none.

Sets moderate amount of fruit, and matures it; one of the most promising newly introduced varieties; fancy.

Uncle Sam. — Fruit: round, conic; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium late; calyx, large, loose; texture, firm; seeds, brown, imbedded; quality, fair; shipping quality, good. Blossom, perfect, and good pollenizer; plant, vigorous; foliage, dark; runners, comparatively few; rust, slight.

Stocks up well in hill system, but rather light color for a market berry, and only moderately productive.

Cultural Methods.

The department has constantly experimented with methods of cultivation; and, since this work has covered many years and a diversity of soils, some general remarks on the management of strawberry plantations may appear to be in place. While the cultural methods of growing the strawberry vary widely, and each system has its special devotees, nearly all methods have merits and demerits worth considering.

Shall the strawberry plant be allowed to fruit one or two years? Nearly all the best growers now practise the former method. By this quick rotation fungous and insect pests are avoided to a greater extent, and the fruit is generally considered enough better to warrant the extra labor and expense.

Shall the plants be set in the early spring, or in autumn? Generally speaking, our experience has shown that spring setting is best, as the root system gets a better chance to develop, and the crown to store up nutriment for fruit bearing the following year. However, in special cases good results are obtained by selecting vigorous plants in July and August, setting in beds close together, and allowing no runners to form.

There are four general systems, modified more or less to suit special conditions; these are commonly practised with spring setting: the hill system, hedge-row system, narrow matted row and wide matted row systems.

The hill system is more generally advocated by amateur than commercial growers. The plants should be set out about two and one-half by two feet, and no runners allowed to form. Everything that will aid the crown to increase in size and strength should be provided. The larger and more vigorous the crowns, the greater the results; the strength of the plants goes to building up a fruit-producing organism alone. Another great advantage is the exposure to air and sunlight on all sides, and the consequent production of better-colored, better-flavored and firmer fruit, worthy of a fancy price.

The hedge-row system is a modification of the hill system in many respects. The plants should be set out about the same distance apart, or possibly in rows three feet apart. The first vigorous runners are then trained in a line with the parent plants, but not detached from them. When this line is filled out so as to make one continuous row, with plants about four or five inches apart, no more runners should be allowed to form. This system possesses nearly all the advantages of the former, and besides gives larger yields. Some varieties, like Clyde, which are naturally light-colored and rather soft, gave surprisingly better results as regards color and firmness the past season when grown in this way. The mass of fruit on one side of the rows, fully exposed to the air and sun, was a sight worth seeing.

The wide matted row and narrow matted row are really a modification of one system. By this plan the plants are set some three and one-half or four feet wide by one and one-half feet in the rows. No runners are allowed to grow until the parent plant has become well established, and then all or a limited number of runners, according to the wide or narrow row system, are allowed to root. The general tendency of this system is to grow vines at the expense of the fruit. Large yields are sometimes obtained, but generally of smaller and poorer fruit.

Whatever the system adopted, or the character of the soil on which the plants are grown, it is of the utmost importance to start with plants of unimpaired vigor, and keep them thus. Feed liberally, and spray with Bordeaux mixture occasionally. Cultivate frequently. Experiment, and study the varieties and adaptation to soil.

Marketing Apples in Boxes.

A feeling has been steadily gaining ground among the growers of good apples that some package smaller and neater than the common barrel should be used in marketing the fruit. It seems unnecessary to here review all the considerations which have influenced fruit growers in coming to this conclusion. There are many things to be said in favor of smaller packages. There are also some few objections and many qualifications to be made. The movement toward the use of boxes has been emphasized during the shipping season of 1903 by the great scarcity and unreasonably high price of barrels. Inquiries regarding the use of boxes have accordingly been frequent; and on this account it has been thought that a brief note of our experience in the department of horticulture would prove of general interest.

Bushel boxes of two common patterns have been used during the two shipping seasons of 1902 and 1903, though not in large numbers. Both early apples and winter varieties were shipped in these packages. In every case the results were gratifying. The apples always brought as much money, or more, than the same quantity of fruit in barrels; in fact, the cash returns were nearly always greater, and sometimes surprisingly so. In one instance, in 1902, Gravensteins were shipped both in barrels and in bushel boxes on the same day and to the same dealer, the fruit being from the same trees, and graded precisely the same throughout; the apples in boxes, however, were wrapped in papers. In this instance the barrels sold at $2 each, and the boxes at the same price. Since the boxes hold very nearly one-third of a barrel, the price was approximately three times as much for the fruit in boxes.

This case, however, is extreme; no such greatly disproportionate price was secured in any other instance for box apples. Still, every shipment of apples in boxes showed a fair margin in favor of the package, and several times the difference was a handsome one.

According to our experience, it seems that the bushel box is especially advantageous for early apples, — say up to the end of the Gravenstein season. Fancy grades of all varieties, however, may be expected to show good results in boxes. Sutton Beauty, shipped as late as Christmas time, realized high prices.

Our experience also favors the use of wrapping papers on fancy apples, more especially on highly colored and on soft-fleshed early varieties. These papers are best bought ready cut for the purpose, and are supplied by various dealers.

There are several forms of boxes in use. Those which we have specially examined are as follows: —

The vegetable box in use throughout the State for potatoes, beets and similar garden truck has been considerably tested for apples. We have used it ourselves to some extent, but do not consider it suitable. This box is 18 inches square and 8 inches deep, thus having a capacity of 2,592 cubic inches, or considerably more than a standard bushel (United States standard bushel contains 2,150.42 cubic inches). The ends of this box are of $\frac{3}{4}$-inch lumber, and the sides, top and bottom of $\frac{1}{2}$-inch stuff.

The box most used and recommended by large apple shippers is represented in our collection by samples bought from a New York manufacturer. This is the box which we have chiefly used, and which we prefer. The inside dimensions are 10 by 11 by 20 inches, thus giving a capacity of 2,200 cubic inches, — very nearly the exact measure of the standard bushel. It weighs a trifle over 50 pounds, filled. The ends are of $\frac{7}{8}$-inch stuff, and the sides, top and bottom of $\frac{1}{4}$-inch stuff. It will be seen that the sides, top and bottom are very light, thus allowing a considerable spring. There is a difference of opinion among shippers as to whether this elasticity is desirable, or objectionable. Some favor it strongly; others insist that a perfectly rigid box is better. Our own opinion is that the rigid box is better for long shipments, as, for example, to Europe; but that the box with plenty of spring is better for near-by markets.

Another box, having exactly the same interior dimensions, is manufactured in Wisconsin, and is represented in our collection by a sample. We have not used this box, but are pleased with its appearance. It is better made and more attractive than the New York box, just described. The ends are of $\frac{7}{8}$-inch stuff, the top and bottom are of $\frac{1}{4}$-inch stuff, and on the sides at each corner is a strip of $\frac{3}{8}$-inch lumber, about $2\frac{1}{2}$ inches wide. This holds in place a sheet of thin veneer, which forms the principal portion of the side. The box is light and strong, as well as good looking.

These boxes can all be bought in the knock-down, and made up at home. The price is about $15 per hundred.

Another box, used in Ontario, Can., is very well made and attractive, but too expensive for the domestic trade. It measures $10\frac{1}{2}$ by $11\frac{1}{2}$ by 22 inches inside, giving a capacity of $2,656\frac{1}{2}$ cubic inches, or considerably over a bushel, — in fact, more nearly five pecks. This box is made with ends of $\frac{1}{2}$-inch lumber, sides, top and bottom of $\frac{3}{8}$-inch wood, the whole being firmly dovetailed at the corners. It forms a fine package for the foreign trade, though it is larger and more expensive than necessary.

We would not recommend any one to undertake the use of the bushel box for apples on a large scale without considerable preliminary experiment; but we consider it well worth trying. We shall be glad to answer any inquiries on this subject, so far as our experience and information allow.

Notes on Quinces.

One of the most profitable crops during the last two years on the farm of the horticultural department has been furnished by the quince orchard. This consists of about 250 trees, of all sizes, ages and varieties. The larger part of them are growing on a springy slope at the base of a hill. The soil is good, rich alluvium, excellent for garden crops when dry enough. The particular spot where these trees stand has been partially drained by tile some time ago, but these drains have now become so much clogged that the land is quite wet during a considerable part of the year.

Under these conditions the plantation gave an abundant crop of very fine fruit in 1902, and a very fair crop of nearly as good quality in 1903. These were sold mostly at wholesale, — that is, to market men and dealers, or through commission men in Boston, Worcester and Springfield.

In 1902 the No. 1 fruit, which constituted by far the bulk of the crop, sold for $2 a bushel. In most cases this price was received for the fruit *f. o. b.* at Amherst, though that shipped on commission to the three cities named sold for $2 in those markets, and charges had to be deducted. The No. 2 fruit sold for 75 cents, $1, $1.25 and $1.50 a bushel, averaging about $1.25.

In 1903 quinces were very scarce, but at the same time the crop on the trees was not so large nor of quite such good quality. The No. 1 fruit brought $2 and $2.25 (mostly the latter figure), net. The No. 2 fruit brought various prices, averaging about $1.25.

In both years the profit from the trees was considered very satisfactory. The good prices secured were attributed largely to the method of marketing the fruit. In the first place, it was well ripened; the fruit was allowed to remain on the trees until it had attained a bright, rich color. In the second place, it was very rigidly graded, only prime specimens being put into the first grade. Next, each specimen was carefully wrapped in clean fruit paper, specially cut for the purpose. These fruits were then packed in fresh, clean, attractive bushel boxes. A few were sold, some wrapped and some unwrapped, in 16-quart peach baskets, but the box was thought to be much the better package.

The use of the bushel box, or some similar small package, and the wrapping, are thought to be essential points in marketing fancy quinces, except when the fruit is delivered direct to the consumer. Quinces bruise very easily, and even the slightest bruise on a ripe quince quickly becomes discolored, and the fruit presents a highly unattractive appearance. Quinces packed in barrels and shipped some distance to market come out with nearly every specimen bruised; but the wrapping and the small package both prevent such injury.

The small package is desirable on another account, namely, because very few customers care for more than a bushel of quinces at a time; even market men with a very fair trade prefer to buy in bushel lots.

The character of the soil on which the college quince trees grow has been mentioned. Wet clay land is frequently recommended for quinces, but the trees do better on well-drained soil. Even fairly light loam will sometimes support thrifty trees for some years, though the ideal soil is moderately heavy clay. Light and sandy soils give small prospect of success.

The quince tree grows slowly, and does not require rigorous pruning. If only reasonable and seasonable attention is given to keep the head open and well balanced, nature will do the rest.

No diseases or insects of any consequence have troubled us. The trees have been sprayed with Bordeaux mixture, and this has probably helped to hold in check the scab, a fungous disease which attacks the leaves and fruit to some extent nearly every year, but which, with us, does not assume serious proportions.

The principal varieties grown are Orange, Champion and Rea (Rea's Mammoth). All succeed perfectly, and we have found them all equally acceptable in the market.