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TWENTIETH ANNUAL REPORT

OF THE

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION.

JANUARY, 1908.

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Approved by

The State Board of Publication.

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MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
PERLEY A. RUSSELL.
SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Honorary Director and Consulting Chemical Expert.*
WILLIAM P. BROOKS, Ph.D.,	*Director and Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
JOSEPH B. LINDSEY, Ph.D.,	*Chemist.*
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.*
JAMES B. PAIGE, D.V.S.,	*Veterinarian.*
E. A. WHITE,	*Florist.*
HENRY J. FRANKLIN, B.Sc.,	*Assistant in Entomology.*
ERWIN S. FULTON, B.Sc.,	*Assistant Agriculturist.*
GEORGE H. CHAPMAN, B.Sc.,	*Assistant Botanist.*
EDWARD B. HOLLAND, M.S.,	*Associate Chemist* (research division).
ROBERT D. MACLAURIN, PH.D.,	*Assistant Chemist* (research division).
HENRI D. HASKINS, B.Sc.,	*Chemist in Charge* (fertilizer division).
PHILIP V. GOLDSMITH, B.Sc.,	*Assistant Chemist.*
JAMES C. REED, B.Sc.,	*Assistant Chemist.*
PHILIP H. SMITH, B.Sc.,	*Chemist in Charge* (feed and dairy division).
LEWELL S. WALKER, B.Sc.,	*Assistant Chemist* (feed and dairy division).
WILLIAM K. HEPBURN,	*Inspector.*
ROY F. GASKILL,	*Assistant in Animal Nutrition.*
CARL S. POMEROY, PH.B.,	*Assistant Horticulturist.*
EDWIN F. GASKILL, B.Sc.,	*Assistant Agriculturist.*
T. A. BARRY,	*Observer.*

REPORT OF THE DIRECTOR.

The work of the Massachusetts Agricultural Experiment Station during the past year has in the main followed the usual lines, but in most directions with constantly broadening scope and material increase in amount. The completion of Clark Hall, which will amply accommodate both the educational and the experimental work in the department of botany and vegetable pathology, will materially increase our facilities for investigation in this subject; but the interruption to work, made unavoidable by the necessity of moving and reinstalling the large amount of scientific apparatus and material, has necessarily reduced the amount of work in this department during the past year. The interruption has proved especially serious in connection with the study of problems relating to hothouse crops, as such work on the removal of department headquarters was necessarily discontinued in the old houses, and the new will not be completed until next spring. With this single exception, the work in all departments of the station has been prosecuted under conditions affording all the usual advantages.

Changes in Organization and in Staff.

The retirement from active administrative duties on the 1st of July of Dr. C. A. Goessmann, who from the date of its passage in 1884 has been charged with the execution of the fertilizer control law, and who was at the head of that branch of our chemical department carrying on general analytical and research work in connection with soils, manures, fertilizers and fertilizer problems, rendered reorganization in that department desirable. The chemical work of the station during the preceding eleven years had been divided between two distinct and entirely independent divisions, and carried on in separate laboratories. These divisions were known as the division of fertilizers and fertilizer materials and the division of foods and feeding; the first, as has been stated, under Dr. C. A. Goessmann, and the second in charge of Dr. J. B. Lindsey. It was believed that organization under one head would secure a number of important advantages, as compared with the existing plan. Most important among the advantages which we have aimed to secure in reorganization were the following: —

1. Greater administrative economy.
2. Reduction in cost of equipment, apparatus and work.
3. The more complete separation of control from ordinary experimental and research work, thus making possible more accurate determination of the costs of each.
4. Improved facilities for research work in chemistry, through the creation of a research division, to which certain specially qualified men should give their entire time.
5. A saving in the time required for certain classes of control and analytical work, through concentration of forces alternately upon different branches of such work.

The organization adopted in the effort to realize these advantages is as follows: —

Department of Plant and Animal Chemistry.

Chemist: J. B. Lindsey, Ph.D.
Associate Chemist: E. B. Holland, M.S.
(*a*) Research division: E. B. Holland, M.S.
(*b*) Fertilizer division: H. D. Haskins, B.Sc.
(*c*) Feed and dairy division: P. H. Smith, B.Sc.

Besides the heads of divisions, four other analytical chemists, an inspector who collects samples of feeds and fertilizers and inspects dairy apparatus, a general laboratory assistant and one or sometimes two clerical assistants, one of whom is an expert stenographer, are regularly employed. The department also employs an assistant, who cares for the animals used in nutrition experiments and digestion work.

The chemist has general supervision of the entire work, and is responsible therefor, but is relieved of details, and will give most of his time to research problems. The associate chemist assists the chemist if required, or in his absence acts in his stead. The associate chemist, whose duties as such are usually nominal, was placed at the head of the research division. Mr. Holland, who received this appointment, had already had much and successful experience in chemical investigation.

Mr. Haskins, who was put in direct charge of the fertilizer control, with responsibility to the chemist, has for several years been looking after most of the details of this line of work, owing to the advanced age of Dr. Goessmann, and is well qualified for the position, both by training and experience.

Mr. Smith, who, with responsibility to the chemist, was put in charge of the feed and dairy control division, had had several years of experience in such work, for which he had shown especial fitness.

No other changes in organization have been made during the year, and the station at the present time makes provision for the various lines of work in which it engages under the following departmental organization : —

Departments.	*Heads of Departments.*
Agriculture,	The Director.
Horticulture,	F. A. Waugh, M.S.
Plant and animal chemistry,	J. B. Lindsey, Ph.D. E. B. Holland, M.S., associate.
Botany and vegetable pathology,	G. E. Stone, Ph.D.
Entomology,	C. H. Fernald, Ph.D. H. T. Fernald, Ph.D., associate.
Veterinary,	J. B. Paige, D.V.S.
Meteorology,	J. E. Ostrander, C.E.

The only change in staff affecting a position of prominence in the station during the past year has been the retirement of Dr. Goessmann from active administrative duties at the head of the fertilizer division of our chemical department, already referred to. The station is fortunate in still being able to avail itself of Dr. Goessmann's services in the capacity of consulting chemical expert. His broad chemical knowledge and richly cultured mind and his long and varied experience render his advice of great value.

Dr. Goessmann at the age of eighty years looks back upon a career the memory of which must be to him a source of unusual satisfaction. It excites the profound admiration of all those familiar with his life, his character and his achievements. The exercises held at the college last commencement in honor of his eightieth birthday made strikingly manifest the esteem and affection in which Dr. Goessmann is held by the alumni. The beautiful piece of stained glass, symbolizing some of the more prominent features of his life and work, which was then presented to him, though a triumph of affection and the designer's art, all too inadequately serves to express these sentiments.

An attempt to present an estimate of the value of Dr. Goessmann's service to the station and to the State and to set forth his part in the advancement of agricultural science would be out of place in this report; and yet brief mention of some of the more prominent features of his connection with this institution and the great agricultural movements with which his name has been identified seems appropriate. Dr. Goessmann took the chair of chemistry in the Massachusetts Agricultural College within a year of the date when its doors were first opened to students (1867), and this chair he filled, though of late with relatively few classes, until his retirement in June. Coming to this position with the best university training which Europe at that time could afford, he brought to his position the university spirit and method, and almost from the first he made his department in effect an experiment station in agricultural chemistry. Before Massachusetts had a regularly organized experiment station, Dr. Goessmann had carried out a large amount of experimental work, the results of which were published in reports of the college and those of the secretary of the State Board of Agriculture, as well as in numerous agricultural and scientific periodicals. Among the most important of these early investigations are those carried out to determine the possibilities of the beet sugar industry in this country. He was a pioneer in this field, and in his numerous publications clearly outlined the essentials for success. Of more general importance to the country at large was Dr. Goessmann's work in relation to fertilizers. He determined the manurial value of a large number of refuse substances and by-products. To him belongs the honor of having suggested and taken the most important part in the passage of the first law providing for fertilizer control passed in the United States. This law has been worth untold sums to the farmers, in the protection against fraud which it has afforded, while so wisely was it shaped that under Dr. Goessmann's administration it has almost equally served the interests of honest manufacturers and dealers. Among other important investigations conducted by Dr. Goessmann prior to the organization of the experiment station should be mentioned his studies as to the effects of special fertilization upon the composition of fruits, his determination of the effect of girdling upon the quality of grapes, his recognition of the possible relation of fertilizers to certain plant diseases, his work in connection with the reclamation of the Green River salt marsh in Marshfield, his determination of some of the chemical changes taking place in ensilage and his chemical examination of sorghum and its products. He was associated with Stockbridge in his investigations which led up to the theory of special fertilization which bears the name of the latter, and in the study of the results of fertilizer applications through observations upon a lysimeter and analytical work connected therewith.

Upon the organization of an experiment station in Massachusetts, in 1882, Dr. Goessmann was made director. This position Dr. Goessmann held until 1895, when the Massachusetts or State station was combined with the station established as a department of the college under the Hatch act. At this time Dr. Goessmann was made honorary director, and was placed in charge of the chemical fertilizer and fertilizer control work, in which position he continued to serve the station with distinguished ability until his retirement the 1st of July last. He has taken with him in his retirement the good will, affection and esteem of all who have been associated with him, and all share in the hope that he will have many years yet of health, usefulness and happiness.

A number of minor changes in the station staff have been made during the year. These changes in many cases have been made necessary by the resignation of men who have left us for positions of greater responsibility and reward. The changes in staff have been as follows: —

E. Thorndike Ladd, M.S., promoted to the position of first assistant chemist, fertilizer division, in place of Edward G. Proulx, B.Sc., resigned.

Walter E. Dickinson, B.Sc., in place of E. Thorndike Ladd, promoted.

Carl S. Pomeroy, B.Sc., Ph.B., assistant horticulturist, in place of Charles P. Halligan, B.Sc., resigned.

George H. Chapman, B.Sc., assistant botanist, in place of Neil F. Monahan, B.Sc., resigned.

Upon the reorganization of the chemical department, which has been outlined, an additional chemist in the research division was employed. The successful candidate was Robert D. MacLaurin, Ph.D., who comes to us after thorough post-graduate courses in chemistry, and a brief but successful record in research work in the Rockefeller Institute in New York.

During the year Howard A. Parsons, dairy tester in the division of foods and feeding, has resigned, and during the past month we have received the resignations of Walter E. Dickinson and E. Thorndike Ladd, assistant chemists, both of whom resign to accept positions offering superior inducements. The positions thus made vacant have not as yet been filled.

The Mailing List.

Revision. — The revision of the mailing list referred to in the last annual report has been completed. It was found, as anticipated, that many of the addresses carried in the old lists were dead, either because of decease or removal of individuals. The postmasters throughout the State with rare exceptions willingly and heartily lent their aid in revising the lists. As soon as the revision was completed, stencils for use with the Elliott addressing machine were procured. The stencils have been arranged by post offices, which are placed alphabetically in the files, and under each post office the names are alphabetically arranged. As a result of this arrangement, several important advantages are secured: —

1. Publications as addressed can be readily made into bundles for the several post offices. This saves a great amount of time in handling and sorting at the local post office and costs us but very little additional labor.

2. Publications can be much more promptly sent out than was possible previous to this arrangement by post offices.

3. If desired, as for example, in case of an outbreak of injurious insects in a certain locality, bulletins or cictulars can be readily sent to that locality.

The addresses of parties outside of Massachusetts are arranged alphabetically under the several states and countries.

Mailing List. — On completion of the revision, it was found that the number of live addresses was as follows: —

Residents of Massachusetts,	14,612
Residents of other States,	1,720
Residents of foreign countries,	169
	16,501

In addition, the station uses the Washington mailing list, which includes the addresses of those engaged in agricultural college and experiment station work. The total number of addresses in this list is about 2,000.

The station also uses the following special lists for meteorological reports, libraries, newspapers and exchanges: —

Meteorological,	260
Libraries,	158
Newspapers and exchanges,	520

During the past year an effort has been made to secure the addresses of all prominent cranberry growers. These addresses have for the most part been secured by writing to chairmen of the boards of selectmen in towns in the cranberry district, and to these men, most of whom prepared the lists promptly and without charge, the thanks of the station are due. The number of addresses in this list is 1,505.

During the past year we have added substantially 1,000 addresses to our general mailing list. These additions have been made in response to direct requests, and without solicitation on our part.

Publications.

Our rapidly growing mailing list has already greatly increased the costs of publication, and these costs must inevitably continue to increase with the constant additions to our lists. The time is not far distant when additional money for publications will be required. During the past year the publications of the station have been as follows: —

Publications during 1907.

Annual report: —

Contains reports of the director, treasurer and heads of departments, with papers on a large number of miscellaneous subjects. 207 pages.

Bulletins: —

No. 112. The Examination of Cattle and Poultry Foods, J. B. Lindsey. 60 pages.

No. 113. Analysis of Manurial Substances and Fertilizers and Trade Values, C. A. Goessmann. 30 pages.

No. 114. The Oriental Moth: a Recent Importation, H. T. Fernald. 15 pages.

No. 115. Preliminary Report on Cranberry Insects, H. J. Franklin. 15 pages.

No. 116. The San José Scale, H. T. Fernald. 22 pages.

No. 117. Trade Values and Fertilizer and Soil Analyses, C. A. Goessmann and H. D. Haskins. 22 pages.

No. 118. Molasses and Molasses Feeds for Farm Stock, J. B. Lindsey, E. B. Holland and P. H. Smith. 32 pages.

Technical, No. 3. Blossom End Rot of Tomatoes, Elizabeth H. Smith. 19 pages.

Complete Index to Bulletins and Reports of the Hatch Experiment Station, from 1888 to 1907. 48 pages.

Circulars: —

No. 1. Cotton-seed Meal, J. B. Lindsey and P. H. Smith. 8 pages.

No. 2. Cut Worms, H. T. Fernald. 2 pages.

No. 3. The Apple Maggot or Railroad Worm, C. E. Hood. 2 pages.

No. 4. Wire Worms, C. E. Hood. 2 pages.

No. 5. Root Maggots, H. T. Fernald. 2 pages.

No. 6. The Lecaniums, or Soft Scales, C. E. Hood. 2 pages.

No. 7. Ants, C. E. Hood. 2 pages.

No. 8. Bulletins of the Agricultural Experiment Stations in Massachusetts. 13 pages.

No. 9. Rules relative to Testing Dairy Cows. 6 pages.

No. 10. Sampling and Sending of Fertilizers, Soils and Feed Stuffs for Free Examination. 3 pages.

No. 11. Chemical Analysis of Soils, Wm. P. Brooks. 2 pages.

The complete index to the publications of the Hatch Experiment Station was very carefully prepared. It includes many cross-references, and will be found exceedingly valuable in connection with complete files of station publications from 1888 to 1907, inclusive. This bulletin will be sent, on application, to parties having files sufficiently complete to make it valuable.

Circular No. 8 gives a complete list of all the bulletins published both by the State and the Hatch Experiment Stations, as well as by the Massachusetts Agricultural Experiment Station, up to the date of its issue in July last. In this list publications which are still available for general distribution are indicated.

The other circulars are for the most part designed for use in answer to correspondence in relation to subjects with which they deal. They cover subjects on which the station receives frequent inquiries, and do so much more fully than would be possible within the limits of a letter.

The annual report of the station is printed by the State, and furnished only in an edition of 6,000. It will not be possible, therefore, to send this report even to all Massachusetts citizens whose names are on our mailing lists. Fifteen thousand copies of this report are, however, furnished to the secretary of the State Board of Agriculture, and are bound with his report, so that it is hoped the report in this form may reach all those who desire it. This plan of publication and distribution must, it seems, mean that many parties in the State receive duplicate copies of our reports. Clearly this is not economy, but we are for the present constrained by a State law to the method of publication outlined. An effort will be made during the coming session of the Legislature to secure a change in the law affecting our publications.[1]

Bulletins and Reports available for Free Distribution.

The supply of many of our reports and bulletins available for free distribution has been exhausted, but those in the following list will still be furnished on application: —

Bulletins: —

No. 33. Glossary of fodder terms.
No. 34. Fertilizer analyses.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 64. Analyses of concentrated feed stuffs.
No. 68. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.

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[1] Since writing the above report the Legislature has authorized the desired change.

No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 92. Fertilizer analyses.
No. 97. A farm wood lot.
No. 98. Inspection of concentrates
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.
No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.
No. 105. Tomatoes under glass; methods of pruning tomatoes.
No. 107. Analyses of manurial substances forwarded for examination; market values of fertilizing ingredients; analyses of licensed fertilizers collected in the general markets.
No. 109. Analyses of manurial substances forwarded for examination; analyses of Paris green and other insecticides found in the general markets; instructions regarding the sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients for 1906.
No. 113. Fertilizer analyses.
No. 114. The oriental moth; a recent importation.
No. 115. Preliminary report on cranberry insects.
No. 116. The San José scale.
No. 117. Trade values and fertilizer and soil analyses.
Technical Bulletin No. 2. The graft union.
Technical Bulletin No. 3. The blossom end rot of tomatoes.
Special Bulletin. The coccid genera *Chionaspis* and *Hemichionaspis*.
Index to bulletins and annual reports of the Hatch Experiment Station published previous to June, 1895.
Index to bulletins and reports, 1888–1907.
Annual reports for 1898–1907.

Of many of the other bulletins of the station, a few copies still remain. These will be supplied only to complete sets for libraries. Circular No. 8, which gives a complete list of bulletins published by this station, will be sent on application.

The co-operation and assistance of farmers, fruit growers and horticulturists, and all interested directly or indirectly in agriculture, are earnestly requested: Communications should be addressed to Massachusetts Agricultural Experiment Station, Amherst, Mass.

Asparagus Substation, Concord.

The work with asparagus in Concord, which is located on land leased from Mr. Charles W. Prescott, follows two distinct lines: (1) in co-operation with the Bureau of Plant Industry, of the United States Department of Agriculture, an effort to breed rust-resistant types of asparagus; (2) fertilizer experiments under the Adams fund in the effort to throw light upon the general question of the specific plant food requirements of this crop.

Breeding Experiments. — The Bureau of Plant Industry, through its agents in various parts of the world, has brought together a very large collection of varieties of asparagus. These have been drawn from all countries where the crop is grown. In most cases seed was procured. This seed was sown in a hothouse in Washington early last spring, and the young plants were sent in flats to Concord. This method of starting the plants was adopted in the belief that considerable time might thereby be saved. The number of varieties started was 36, but seed of several varieties was obtained from a number of sources, and 54 lots of seedlings were handled in this manner. The degree of success attending this method was only moderately satisfactory. The results varied widely with varieties, but in most cases there was a considerable percentage of loss, — greater no doubt than it otherwise would have been, on account of the extremely dry season. The young plants which survived made a fairly good growth. In addition to these varieties, our breeding plots now contain 35 other varieties, which have been brought together from various sources many of them having been collected by the Bureau of Plant Industry. Among the different varieties thus brought together in the same field may already be noted a very considerable variation in the apparent susceptibility to rust, and it may confidently be hoped that the objects in view in the experiment will ultimately, in large measure, at least, be attained.

Fertilizer Experiments. — The land selected for the fertilizer experiments lies in the Bedford Street district in the town of Concord. For a number of years previous to 1906 the field had been lying fallow, and was grown up with briers, small birches, weeds, etc. In preparation for the fertilizer experiments the field was cleared of brush and trees and plowed in the spring of 1906. It then received an application of fertilizers at the following rates per acre : —

Lime (tons),	[illegible]
Fine ground bone (tons),	1
Acid phosphate (pounds),	½
Muriate of potash (pounds),	600
Nitrate of soda (pounds),	350
[illegible]	150

These with the exception of the lime, were mixed, evenly spread and harrowed in. The lime was applied by itself. In order to subdue the witch grass and other weeds, the field was harrowed a number of times during the late spring, and on May 15 it was sown to buckwheat. The buckwheat made a heavy growth, and was plowed under when fully grown. The field was then harrowed and sown to winter rye. This was plowed under in the early spring of 1907, and the asparagus set. The field is laid out in forty twentieth-acre plots, separated by dividing strips 5 feet and 1½ inches in width.

The dimensions of the plots are 129 feet by 16 feet 10½ inches. Each plot contains five rows. Each dividing strip contains one row set in the middle. The distance between plants in the rows is 2 feet 6 inches. The plants were raised by Mr. Frank Wheeler of Concord, and were from seed of the Giant Argenteuil variety, specially selected by Mr. Wheeler on account of apparent vigor and capacity to resist rust. These plants were exceptionally large and strong, and one year old at the time of setting. Practically every plant started, and the growth throughout the season was remarkably strong. Many of the plants attained a height in excess of 6 feet. All the details of the work were superintended or carried out by Mr. Charles W. Prescott, to whose skill and faithful attention, in connection with the thorough preparation which the land had received, the fine growth of the plants must be largely attributed. Numerous interesting variations in growth on the different plots were noted during the season, but it is yet too early to present the details of treatment, or to discuss the effects of the different fertilizer applications.

Cranberry Substations.

The station is carrying on work with cranberries along two distinct lines and in two different localities: (1) the study of cranberry insects in Wareham; (2) fertilizer experiments with cranberries in Falmouth.

Work on Cranberry Insects. — The station was fortunately able to command once more the services of Mr. H. J. Franklin for the study of problems connected with cranberry insects. Mr. Franklin spent the entire season, from the middle of April to the middle of October, in the cranberry district, most of the time in the town of Wareham. As the result of the season's work, our knowledge of cranberry insects has been greatly extended at numerous points, and the tentative conclusions reached as a result of the first season's work have been in many cases confirmed. A bulletin presenting the results of the first season's work, and containing advice as to the treatment to be adopted for the prevention of injury from the more important cranberry insects, has been issued during the year. This has been sent to all cranberry growers whose addresses we were able to obtain, — about 1,500. It has been found that the injury due to many insects can be for the most part prevented by a thorough destruction of vegetation around the shores of the bog, and suitable control of the water in flooding. Methods of spraying have been found to be fairly effective in some cases. The bulletin on cranberry insects, which gives all details, can still be furnished on application.

Fertilizer Experiments. — The fertilizer experiments in Falmouth are located in what is known as the Red Brook bog, belonging to Mr. N. H. Emmons of Boston and Falmouth. The present is the second season that these experiments have continued, and results which are believed to be of considerable significance have been obtained. The possibility of making exact comparisons between different fertilizer treatments has been in considerable measure reduced, owing to the unfortunate breakage during last winter of one of the dikes, thus exposing a portion of the plots used in fertilizer experiments throughout the winter, while another portion of the plots was under water. It is not best, therefore, to undertake a discussion of the results in detail at this time. The following conclusions, however, appear to be warranted: —

1. The use of nitrate of soda greatly stimulates the growth of vines, and on bogs where vine growth is naturally free, this fertilizer should be used sparingly if at all. It has been noted, however, that the size of the berries is considerably increased wherever nitrate has been applied.

2. The application of acid phosphate appears to favor early maturity of the fruit, accompanied apparently by decrease in size. It would be premature to assert that this fertilizer element should not be used at all, but the indication is that the quantity needed is relatively small.

3. Among the fertilizer elements applied, the potash appears to have exerted the most favorable influence on the yield of fruit. Not only has it apparently increased the quantity, but it seems highly favorable to the development of a bright color, which gives the fruit an unusually attractive appearance. The fruit on the plots to which muriate of potash and acid phosphate were applied was characterized by experts as exceptionally solid and heavy, as well as of fine appearance.

4. The application of lime appears to have been unfavorable to fruitfulness.

Substation for Orchard Experiments.

Plans have been laid for extensive orchard experiments which will extend over a long period. A six-acre orchard of Baldwin trees set six years ago has been leased for ten years. The location is on the Bay Road in the southern part of the town of Amherst, on the farm of Myron C. Graves. The soil conditions throughout the entire tract appear to be exceptionally even for a tract of such size in this State, and it is believed the orchard affords very exceptional advantages for fertilizer, cover-crop and cultural experiments, which are the principal types of work in view.

Department Reports.

The reports of the heads of the different departments of the station will be found in later pages. The report of the agriculturist is elsewhere briefly summarized.

Department of Horticulture. — The report of the department of horticulture includes papers upon three distinct subjects: —

1. Notes on the propagation of apples. The experimental work upon which this paper is based was carried on with dwarf trees. The principal object of the experiment was to determine the influence of the scion on the character of the tree. The variety reported upon in greatest detail was the Baldwin, which was grafted upon three different stocks: the ordinary apple; Doucin; and Paradise. The method of measurement adopted shows a distinct influence apparently due to the variation in scion. The trees on the Doucin stocks were more uniform in shape and taller than those on the Paradise stocks; the trees on Paradise stocks were much stockier than on Doucin; while those on Doucin stocks were in turn much stockier than those on the ordinary stocks.

2. The physiological constant for the germination stage of cress. The methods which have been used in investigations for the determination of physiological constants are briefly outlined. The method reported upon, which is original, is described and compared with the earlier methods. The results with cress are reported in detail.

3. Variation in peas. This paper presents the results obtained by careful observations, and includes tabular records of a large number of observations which are carefully averaged. The results obtained are fruitful in suggestions as to the principles which should be followed in selection in breeding for improvement in any given direction.

Department of Plant and Animal Chemistry. — The report of the chemist presents first a numerical statement of the amount of analytical work accomplished during the year. This makes it apparent that the demands upon the station for work of this character are rapidly increasing.

The chemist in charge of the fertilizer control work, H. D. Haskins, reports the analysis of 45 more brands of fertilizers in connection with such work than in 1906. Three hundred and fifty-eight samples in all have been analyzed and nearly 500 collected. Forty-one per cent. of the samples analyzed proved to be below the guaranteed composition in some one or more of the fertilizer elements, but in many cases the deficiency in one element was made up by an excess in one or more of the others. Twenty-one samples of complete fertilizers showed a commercial shortage varying from 79 cents to $13.50 per ton. This section of the report of the chemist presents complete tabular statements, showing the extent to which the fertilizers analyzed equaled or fell short of the guarantees.

The next section of the report presents an account of the execution of the feed law. Samples of feeds analyzed, with the single exception of cotton-seed meal, the quality of which was unusually poor, were found in general to be substantially as guaranteed. The report calls attention to the large amount of analytical work which is done without charge for private individuals in determining the quality of samples of milk and feeds. The results of the execution of the dairy law are briefly presented: 6.62 per cent. of Babcock glassware tested was condemned on account of inaccuracy; of the Babcock machines inspected, 37 in all, 2 were condemned.

The chemist calls attention to the great increase in the amount of work connected with the carrying out of official tests of pure-bred cows. Such tests are now conducted with animals of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeds. During the past year thirty-five yearly records and seventy records for shorter periods have been completed. Sixty-three cows are now undergoing tests. This work consumes a large amount of time, and, while the station is reimbursed for its money expenditure, it is found to be somewhat of a burden. The work is, however, without doubt important and useful, and until it is provided for in some other way the station will continue to supervise it.

The report of the chemist briefly presents the results of experiments completed with a view to determining the value for different classes of live stock of molasses and molasses feeds. He does not regard molasses as possessing advantages for dairy cows over the more common feeds. For fattening cattle, the use of about 3 pounds daily can be recommended. For horses, a moderate amount of molasses is found to be useful as an appetizer and tonic; and the same is true for pigs. Molasses feeds are in general found to be rather high in price as compared with possible home mixtures, and would seem to possess no advantages as compared with such mixtures.

The results of experiments to determine the effects of soy beans minus the oil and of soy bean oil as food for dairy cows are presented. It was found that the meal, although exceptionally rich in protein, does not change the proportion of the different ingredients of milk. The oil temporarily increases the proportion of fat, and is found to affect the quality of the butter to a considerable extent, and on the whole unfavorably.

The report calls attention to experiments which are in progress on the effects of fat on milk secretion, and refers briefly to research work with soils from the different plots in Field A.[1]

It has been found that feeding molasses in large quantities depresses the digestibility of other foods used with it.

A section of the report of peculiar interest at this time, when the question of milk standards interests so many, deals with the chemical composition of milk. The average composition of the milk of most of the different prominent breeds, based upon a large number of analyses in different sections of the country as well as in foreign countries, is presented.

The effects of fat upon the composition of milk and butter fat and upon the consistency of butter are discussed by Dr. Lindsey. His experiments have shown that neither the proteid nor carbohydrate groups of nutrients when fed in normal amounts have any noticeable effect upon the proportion of different ingredients, nor on the character of butter fat. Any changes which occur as the result of variations in feed are usually consequent upon the kind and quantity of oil contained in the feeds used. Dr. Lindsey has found that when the feeds contain vegetable oils in excess of normal amounts the butter is soft. He finds that the flavor of butter depends primarily on cleanliness, the stage of lactation of the cow, the skill and care of the butter maker and the separator used.

[1] For an account of the experiments on Field A, see report of the agriculturist, page 32.

The concluding section of the report of the chemical department is a paper by E. B. Holland, on a "Standard for Babcock Glassware." This paper presents a summary of the results of the tests of Babcock glassware carried out at the station since the passage of the dairy law in 1901. A standard for such glassware is proposed and carefully drawn, and rules for testing are presented. The standard and rules proposed by Mr. Holland have not yet been officially sanctioned by the American Association of Agricultural Chemists, but both have met the approval of Dr. Babcock, and they will probably be adopted.

Department of Botany and Vegetable Pathology. — The report of Dr. Stone, the head of the department of botany and vegetable pathology, contains papers upon a considerable number of important topics. Of especial interest is Dr. Stone's report concerning methods of separating light and inferior seeds and dirt from commercial or home-grown samples of seeds. The apparatus perfected in the department for this work shows much ingenuity in design, and the work is accomplished with great rapidity and accuracy. The methods used here are especially important for such seeds as tobacco and onions. As a result of the rejection of the inferior seed, a better stand of plants, substantially all of which, coming from sound, heavy seeds, are strong, healthy and disease-resistant, is obtained than is possible when commercial samples are planted. Work of this character is for the present done without charge. There has been a considerable increase in the number of samples sent in to be tested for germination. This work also is done for the present without charge.

The report calls attention to the unusual extent to which sun scald and sun scorch have prevailed among different varieties of trees. These troubles appear to be due primarily in many cases to the loss of a considerable proportion of the fibrous rootlets, which the botanist believes has been due to the excessively cold winters of a few years ago; and these troubles have shown more largely than usual during the past summer on account of the severe drought which prevailed. The extensive defoliation of many species of trees, notably elms, in the late summer or early fall, is believed to have been the result of the same cause.

The report calls attention to two apparently new diseases: one affecting asparagus, and apparently caused by a species of fusarium; and another affecting the peony, the cause of which has not been determined. No remedy for either of these troubles can at present be suggested.

During the past year the botanist has made careful comparisons between a number of combinations of fungicides and insecticides for potatoes. These experiments were carried out in connection with fertilizer work of the agricultural department which is designed to throw light upon the relative value for different crops of seven different potash salts.[1] There was little or no blight during the season, and all of the combinations tried seemed to possess nearly equal merit as insecticides. From the standpoint, however, of their ability to adhere to the foliage and their qualities in other respects, the botanist ranks the different combinations used in the following order: —

1. Soda bordeaux and Paris green.
2. Bordeaux and sodium benzoate.
3. Bordeaux and disparene (arsenate of lead).
4. Bordeaux and Paris green.
5. Copper phosphate and disparene.

In connection with the variation in fertilizers for the potato crop in this series of experiments,[1] an important influence on the prevalence of scab was noted. The proportion of badly scabbed tubers was much greater where potassium-magnesium carbonate was the source of potash than on any of the other plots.[2] The proportion of scabby tubers was smallest where the muriate and nitrate were the potash salts employed; but the difference between the proportion of scabby tubers on these fertilizers and on the other potash salts was relatively small.

The report of the botanist discusses mosaic diseases of tobacco and the tomato. He finds an important difference between the two diseases in two respects. Healthy tobacco

[1] For a full account of these experiments, see report of the agricultural department, page 39.

[2] The fact that scab is more apt to prove serious in soils which are alkaline has been frequently noticed. The potash-magnesia carbonate is a strongly alkaline fertilizer. Dr. H. J. Wheeler has frequently called attention to this point in reports and bulletins of the Rhode Island Experiment Station and elsewhere.

plants set in soil which contains decaying rootlets of diseased plants usually become affected with the disease. In the case of the tomato, a similar result does not follow. The report gives an account of methods tried for the purpose of determining the cause of the mosaic disease in the tomato. The botanist believes his experiments show that the disease is not caused by an excess of any of the fertilizer elements. The mosaic disease of tobacco may be so caused. The disease can be produced in tomatoes by severe pruning, and is at least associated with a deficiency of both the soluble and insoluble forms of catalase in the foliage.

The report of the botanist includes a suggestive paper on the factors which underlie susceptibility and immunity to disease in plants. This paper emphasizes the necessity of as full and perfect knowledge of the conditions essential for perfect development as possible, and advances the view that when our knowledge is sufficiently complete at this point it will be found possible in large measure to avoid many diseases which at present often prove highly destructive. We find the highest development of cultural methods among American gardeners and hothouse men. In the hothouse, where the climatic conditions are largely under control, there is but little trouble from disease when the conditions are fully understood and the management skillful. In the case of out-of-door crops, control of the climate being impossible, we may not be able so fully to avoid disease ; but even with such crops, the most skillful adaptation of soil, manure and culture to the requirements of the crop will in large measure accomplish the same result.

Entomological Department. — The report of this department presents first a summarized statement showing the kind and amount of the work of the year. Brief accounts are also presented of some of the leading lines of experimental work. One of the most important of these is for the determination of the resistance of different crops to fumigation with hydrocyanic acid gas. These experiments are now complete for the cucumber, and similar tests for muskmelons have been begun.

Brief mention is made of experiments for the control of cabbage, turnip and onion maggots, concerning which, owing to causes beyond control, no definite results can yet be presented.

One of the most important lines of experiment during the past year has been the effort to determine the best methods of controlling thrips, which so often cause the blight of the onion. Spraying with kerosene emulsion appears to be the most promising method. The principal difficulty appears to be the production of a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. No perfectly satisfactory machine has yet been invented.

The report makes brief mention of experiments to determine better methods of destroying the San José scale, and the work with cranberry insects at Wareham. Further observations on the oriental moth are presented, and fortunately these indicate that this insect is not likely to become a serious pest. Attention is called to the fact that investigations have been begun to determine the exact geographical distribution of injurious insects. This work would seem to be particularly important, as Massachusetts is close to the northern limit of the distribution of some and near the southern limit of others. The report concludes with a presentation of observations upon the insects of the year.

Veterinary Department. — The report of the veterinarian presents an account of two serious outbreaks of disease among poultry. The first of these was European chicken cholera, which was found in two flocks. The identity of the disease was proved by careful microscopic investigations and inoculations. The owners of the affected flocks were promptly informed of the serious character of the disease, and, co-operating heartily with the veterinarian as they did, its prompt suppression was effected, and fortunately the disease did not spread from these flocks, which might easily have been centers of infection.

The other outbreak was found in a flock of chickens raised in brooders upon bare, sandy soil. It produced serious lesions of the feet and legs, and invariably proved fatal. The disease was found not to be infectious in character, and promptly disappeared when the chickens were moved to a more fertile location, where the growth of vegetation afforded some shade. It appears to have been due to the effects of the intense sunshine, aggravated by the character of the soil upon which the chickens were kept. The disease did not affect chickens brooded under hens, although kept on the same kind of soil.

Meteorological Department. — The report of the head of this department calls attention to a number of important improvements which have been made in the equipment of the department during the past year. One of the most important of these is the setting up of apparatus over one of the manholes of our heat distribution system for melting snow as it falls. By means of this apparatus it will be possible to secure a more accurate record of the total precipitation, while by means of connections with recording apparatus in the office of the department the time of beginning and ending of storms can be determined with much exactness.

WM. P. BROOKS,
Director.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1906.

The United States Appropriations, 1906–07.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1907, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$7,000 00
Cr.		
By salaries,	4,568 74	4,731 74
labor,	4,202 04	899 32
publications,	1,858 60	–
postage and stationery,	591 39	–
freight and express,	329 50	31 77
heat, light, water and power,	239 16	–
chemical supplies,	122 85	152 99
seeds, plants and sundry supplies,	542 31	163 02
fertilizers,	107 85	96 48
feeding stuffs,	495 80	176 55
library,	134 82	141 94
tools, implements and machinery,	259 80	8 70
furniture and fixtures,	371 55	–
scientific apparatus,	210 04	439 92
live stock,	36 50	–
travelling expenses,	648 73	80 57
contingent expenses,	28 00	2 00
buildings and land,	252 32	75 00
balance,	–	–
Total,	$15,000 00	$7,000 00

State Appropriation, 1906–07.

Cash received from State Treasurer,	$16,500 00	
from fertilizer fees,	4,745 00	
from farm products,	1,267 21	
from miscellaneous sources,	6,800 42	
		$29,312 63
Cash paid for salaries,	$12,619 97	
for labor,	2,925 76	
for publications,	840 00	
for postage and stationery,	537 29	
for freight and express,	174 13	
for heat, light, water and power,	474 02	
for chemical supplies,	576 47	
for seeds, plants and sundry supplies,	338 48	
for fertilizers,	71 07	
for feeding stuffs,	454 90	
for library,	108 61	
for tools, implements and machinery,	286 84	
for furniture and fixtures,	848 17	
for scientific apparatus,	369 78	
for live stock,	129 05	
for travelling expenses,	1,479 51	
for contingent expenses,	57 50	
for buildings and repairs,	1,122 69	
Balance,	5,898 39	
		$29,312 63

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work in the department of agriculture during the past year has covered the usual field of experiment, and has been devoted chiefly to an effort to throw light upon some of the many problems connected with the use of manures and fertilizers. The number of field plots used in this work has been 318; the number of closed plots, 153; and the number of pots in vegetation experiments, 330. In the majority of our experiments, repetition from year to year, extending over a considerable period, is desirable in order that accidental variations may be as far as possible eliminated, and in order to bring out the variation in results connected with the varying character of our seasons. A detailed account of the results will be presented for only a small proportion of the experiments in progress.

No inconsiderable share of the time of the agriculturist is occupied in answering the many questions which annually come to the station on all matters pertaining to the practice of agriculture. The number of such inquiries answered during the past year has been 824. Experience indicates that inquiries of the same general character are likely to be sent in many times during the year, and we are therefore adopting in this department, in so far as circumstances warrant, the plan of sending circulars, with such comments as the statement of individual conditions seems to require, which has been referred to in the report of the director.

The more important results of the experiments reported in detail may be briefly stated as follows: —

I. — Experiment to determine the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. This experiment was begun in 1890. The crop of this year was clover, sown in the standing corn in August of last year. On the basis of total yield (grass as well as clover included), the materials under comparison rank in the following order: nitrate of soda, dried blood, barnyard manure, sulfate of ammonia. The no-nitrogen plots gave a larger total crop than the sulfate of ammonia, and the clover in these plots was better than on any of the others. On the basis of increase in crop as compared with the product of the no-nitrogen plots, taking into account all the crops grown since the experiment began, the materials on a percentage basis rank as follows: nitrate of soda, 100; barnyard manure, 85.92; dried blood, 70.21; sulfate of ammonia, 45.36.

II. — Experiment to determine the relative value of muriate and high grade sulfate of potash. The crops on the basis of which comparison this year is possible were cabbages, rhubarb, raspberries, blackberries, asparagus, corn and squashes. The sulfate of potash gives the larger crops of raspberries and blackberries. For the other crops the muriate gives the larger crops; but the difference is unimportant except in the case of the asparagus, which is much better on the muriate than on the sulfate.

III. — Experiment to determine the relative value of different potash salts for field crops. The salts under comparison were kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The crop was potatoes. The salts, on the average of five trials for each, rank in the following order, as measured by the product of merchantable tubers: low-grade sulfate, muriate, nitrate, high-grade sulfate, silicate, carbonate, kainit. There was considerable scab, — a much greater amount on the carbonate than on the other potash salts.

IV. — Experiment to show the relative value for corn of special corn fertilizers, as compared with a mixture richer in potash. The special corn fertilizer gave a larger yield of sound corn. The fertilizer richer in potash excelled in the product of soft corn and stover. With an earlier spring and a hotter season, the proportion of sound corn produced on the fertilizer richer in potash would undoubtedly have been increased.

V. — Experiment to determine the relative value for production of corn of manure alone, as compared with a smaller application of manure and a moderate amount of sulfate of potash. The larger application of manure alone gave a slightly higher yield of sound corn. The combination of manure and potash gave the higher yields of soft corn and stover. There was not much money difference in the value of the crops produced under the two systems, while the cost of the smaller application of manure and potash was at the rate of about $6 per acre less than the cost of the larger application of manure alone.

VI. — Experiment to determine the relative value, as measured by crop production, of a considerable number of phosphates used in quantities to furnish equal phosphoric acid to each plot. The phosphates under comparison were: fine ground, — apatite, South Carolina rock and Tennessee rock phosphates; Florida soft phosphate, basic slag meal, dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. The crop of the past season was mixed hay. The yields on the different phosphates varied relatively little. Even the plots which have received no phosphates during the eleven years the experiment has continued gave a yield at the first crop at the average rate of about 4 tons to the acre, while the highest yield obtained on any of the phosphates at first cutting was only 9,240 pounds.

VII. — Soil tests. The past season was the nineteenth during which the south soil test reported upon has continued. The results show the surpassing importance for the production of satisfactory corn crops of a liberal supply of potash.

VIII. — Experiment in the application of manures and fertilizers for grass. The materials used are: first, barnyard manure; second, wood ashes; and third, a combination of fine-ground bone and potash. The average yield of hay during the past season was at the rate of 5,005 pounds. The average for the fifteen years during which the experiment has been continued has been 6,296 pounds.

IX. —Winter versus spring application of manure on a slope. The crop of the past year was mixed grass and clover. The experiment was a test simply of the residual fertility from previous applications, as no manure was applied this year, as it was feared it would cause serious lodging of the crop. This judgment was justified by the result. The crop was extremely heavy, and considerably lodged in spite of the fact that manure was not applied this year. The differences in yield were small, and did not indicate greater residual fertility where spring application of manure has been the rule than in the other plots.

X. — Experiment in the application of nitrate of soda for rowen. Owing to the deficiency of rainfall in the latter part of July and August, the rowen crop this year was small. The increase in crop resulting from the application of nitrate was not sufficient on the average to repay the cost of application.

XI. — Experiments in feeding hens. These indicate the great value of animal protein and fat and the injurious influence of fibre in the ration.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The materials under comparison in this experiment, all of which are used in such quantities as to furnish equal nitrogen per plot, are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. The field includes eleven plots, of one-tenth acre each, and, with few and unimportant exceptions, each plot has been manured in the same way since 1890. Each receives equal and liberal amounts of phosphoric acid and potash, the former in the form of dissolved bone black, the latter in the form of muriate, to plots 1, 3, 6, 7, 8 and 9, and in the form of low-grade sulfate to plots 2, 4, 5 and 10. Three plots have had no nitrogen applied to them in any form since 1884. The various materials are used on the other plots in such quantities as to furnish nitrogen at the rate of 45 pounds per acre. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two.

From a period very early in the history of this experiment, the plots to which sulfate of ammonia has been applied have shown a tendency to comparative unproductiveness, due apparently to unfavorable chemical or biological conditions. It was thought probable that application of lime would correct these faulty conditions, and 50 pounds of unslaked lime were applied to plot 6 in 1896. The entire field has been twice limed (in 1898 and 1905) since that date, at the rate of about 1 ton to the acre. In spite of these applications, the yield on the sulfate of ammonia plots, as will be noted, is still much below the average of the other plots.

The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, and corn.

The crop the past year was alsike clover, considerably mixed, however, with grass, on all plots except those to which no nitrogen has been applied. The clover was sown in the standing corn on Aug. 6, 1906. When the corn was harvested in the fall of 1906, it was very apparent that the clover was relatively weak and unhealthy on all plots to which nitrogen has been applied during the progress of this experiment. The clover was thicker and more healthy on the three no-nitrogen plots than on any of the others. It was poorest on the sulfate of ammonia plots, and especially poor on the plots where sulfate of ammonia has been used in combination with muriate of potash. The relative condition of the clover on the different plots on the opening of spring was about the same as in the autumn, and as on most of the plots it was too thin for a good crop, 3½ pounds of alsike clover seed were sown per plot on April 3. This seed germinated fairly well, but of course the young plants from this seeding affected the rate of yield in the first crop but little. The rates of yield on the several plots and the sources of nitrogen and potash on each are shown in the following table: —

Yield of Hay and Rowen per Acre (Pounds).

Plots.	Nitrogen Fertilizers used.	Hay.	Rowen.
Plot 0,	Barnyard manure,	3,150	600
Plot 1,	Nitrate of soda (muriate of potash),	4,000	450
Plot 2,	Nitrate of soda (sulfate of potash),	3,900	600
Plot 3,	Dried blood (muriate of potash),	3,050	500
Plot 4,	No nitrogen (sulfate of potash),	3,400	650
Plot 5,	Sulfate of ammonia (sulfate of potash),	2,950	300
Plot 6,	Sulfate of ammonia (muriate of potash),	2,220	500
Plot 7,	No nitrogen (muriate of potash),	3,000	850
Plot 8,	Sulfate of ammonia (muriate of potash),	2,600	400
Plot 9,	No nitrogen (muriate of potash),	2,600	650
Plot 10,	Dried blood (sulfate of potash),	3,850	1,190

The fact that where the clover was relatively thin grasses came in to a considerable extent serves to obscure the effect of the different materials supplying nitrogen on the clover in the first crop. The second or rowen crop was very small on all plots. The principal reasons for this were two: (1) the first crop was cut late on account of bad weather; (2) there was but little rain during the latter part of the summer. The yield of rowen on the no-nitrogen plots, however, stands relatively much higher as compared with the yield on the other plots than was the case with the first crop. This difference was due to the fact that there was relatively little grass mixed with the clover in the rowen crop.

The average yields of this year on the several fertilizers are shown in the following table: —

Fertilizers used.	Pounds per Acre.	
	Hay.	Rowen.
Average of no-nitrogen plots (4, 7, 9),	3,000	717
Average of the nitrate of soda plots (1, 2),	3,950	525
Average of the dried blood plots (3, 10),	3,450	845
Average of the sulfate of ammonia plots (5, 6, 8),	2,590	400

As a result of all the experiments previous to this year, the materials furnishing nitrogen have produced crops in the following relative amounts: —

Relative Crop Averages.	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.63
Sulfate of ammonia,	91.08
Dried blood,	89.14
No nitrogen,	70.24

Similar averages for this year are as follows: —

	Per Cent.		
	Hay.	Rowen.	Hay and Rowen.
Nitrate of soda,	100.00	100.00	100.00
Barnyard manure,	79.75	114.29	83.71
Sulfate of ammonia,	65.57	76.19	66.81
Dried blood,	87.37	160.95	95.98
No nitrogen,	76.20	136.57	83.11

Combining the results of this year with those for previous years, on the basis of total yield per plot, the relative standing is: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	95.91
Dried blood,	91.35
Sulfate of ammonia,	84.13
No nitrogen,	70.96

Averaging our results on the basis of increase in crop as compared with the no-nitrogen plots, the relative standing for the entire period of the experiment, 1890–1907, inclusive, is as follows: —

Relative Increases in Yields (Averages for the Eighteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	85.92
Dried blood,	70.21
Sulfate of ammonia,	45.36

It will be noticed that, in spite of the fact that the mixture of grass with the clover, as has been pointed out, tends to obscure the effects of the fertilizer treatment on the latter, the combined yield of hay and rowen on the no-nitrogen plots this year is much greater than on the sulfate of ammonia, and practically the same as on barnyard manure. The yield of clover without doubt was actually greater on the no-nitrogen plots than it was on either the dried blood or the nitrate of soda. The fact has been for some time known that clovers, on account of their ability to draw nitrogen from the air under suitable conditions, are able to make relatively vigorous growth on soils to which no nitrogen is applied, provided these receive generous applications of such elements of plant food as lime, phosphoric acid and potash. Just why, however, the clover should do so much better, as was the case, on the no-nitrogen plots than on the other plots in this field is not at present apparent. It must be remembered that these other plots have received equal applications of lime, phosphoric acid and potash. It has been suggested that the failure of the clover to do well on these plots must be due to residual nitrogen, which during the progress of the experiment has gradually accumulated. Calculation, however, shows that the crops harvested from these plots during the years that the experiment has continued must have removed from the soil larger quantities of nitrogen than had been applied.

The fact that the soil has been so heavily limed twice within recent years seems to preclude the conclusion that the relative failure of the clover is due to an acid condition of the soil; and, indeed, careful chemical analyses of samples taken last spring show that the soil of these plots does not, as a rule, contain appreciable quantities of free acid. We are unable, then, at present to account for the results obtained; but careful chemical and biological investigations will be carried out, with a view to throwing light upon this most important question.

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

In this experiment, which was begun in 1892, muriate of potash is compared with high-grade sulfate, on a basis of such applications as will furnish equal actual potash per acre in connection with an annual application of fine-ground bone at the rate of 600 pounds per acre. Potash has been applied in different years in varying quantities. At first the applications were exceptionally heavy, — 350 to 400 pounds per acre of these salts were applied. Since 1900 each has been applied at the rate of 250 pounds per acre annually.

The crops during the progress of the experiment have embraced nearly all those common to this latitude. During the past year they have been: cabbages on two plots; asparagus, rhubarb, raspberries and blackberries, all on each of two plots; corn on four; and squashes on two. The rates of yield of the various crops on the different fertilizers are presented in the following table: —

Crops.	Fertilizers used.	Plot.	Yield per Acre (Pounds).		
Cabbages,	Muriate of potash,	11	39,522.70		
	Sulfate of potash,	12	38,461.50		
			Stalks.	Leaves.	
Rhubarb,	Muriate of potash,	13	30,733.90	24,526.00	
	Sulfate of potash,	14	30,685.30	26,168.20	
Raspberries,	Muriate of potash,	13	42.05		
	Sulfate of potash,	14	105.14		
Blackberries,	Muriate of potash,	13	365.38		
	Sulfate of potash,	14	738.76		
Asparagus,	Muriate of potash,	13	4,071.10		
	Sulfate of potash,	14	2,428.00		
			Hard.	Soft.	Stover.
Corn,	Muriate of potash,	15	63.56 bush.	6.05 bush.	7,943.80
	Sulfate of potash,	16	63.02 bush.	5.61 bush.	7,739.00
Corn,	Muriate of potash,	17	64.78 bush.	5.78 bush.	8,052.00
	Sulfate of potash,	18	64.94 bush.	7.10 bush.	7,781.40
Squashes,	Muriate of potash,	19	10,810.70		
	Sulfate of potash,	20	8,378.40		

Cabbages. — The yield of cabbages on the two potash salts this year is substantially equal. The crop on both was good. This result is not in agreement with results which we have usually obtained. As a rule, the sulfate of potash has given us larger crops of cabbages and better headed than muriate. The crop on this salt this year shows a slight inferiority in total yield. This difference is perhaps accounted for by the fact that the latter part of the summer was exceptionally dry. In seasons with less than normal rainfall and on light soils the muriate of potash often shows itself to be superior to the sulfate for crops which under opposite conditions give the best results with the sulfate.

Rhubarb. — With this crop, as with the cabbages, the results are substantially equal, whereas in earlier years the sulfate has given the larger yields. The explanation is perhaps that suggested in discussing the results with cabbages.

Asparagus. — It will be noticed that the yield of asparagus on the muriate of potash is much larger than on the sulfate. This is in accordance with the results which have previously been obtained with this crop. The customary practice of depending largely upon muriate as a source of potash would appear, therefore, to be wise.

Raspberries and Blackberries. — The yield of both these fruits is exceedingly small, as both were seriously winter-killed. This year, however, as in earlier years, the yield on the sulfate of potash is much greater than on the muriate. This difference in yield is undoubtedly mainly a consequence of the fact that the canes produced where sulfate of potash is applied are better ripened and go through the winter better than where muriate is used.

Squashes. — The variety of squashes grown, Delicious, was planted on June 29, having been put in after two failures to get a satisfactory start of carrots on the plots occupied. The date of planting was, of course, far later than is desirable. Autumn frosts, however, held off later than usual, and a moderate crop was secured. The yield on the muriate was considerably greater than on the sulfate.

Corn. — Plots 15, 16, 17 and 18 were occupied by a variety test of sixteen different kinds of corn, forwarded for trial by the Bureau of Plant Industry of the Department of Agriculture. The results for the different varieties have not yet been fully worked up, and the total yields only are presented in detail. On one of the pairs of plots the muriate gives a considerably larger crop of grain; on the other the crops are substantially even. The muriate gives the larger yield of stover in both cases. The latter result is in accordance with those which we have usually obtained where these potash salts have been compared for corn. Earlier experiments have not shown any considerable difference in the value of the two salts for grain production, and the results of this year, not being in agreement on the two pairs of plots, cannot be regarded as especially significant. They were possibly somewhat affected by the fact that so large a number of varieties was included in the experiment; although an effort to equalize conditions was made by running the rows of the different varieties across the plots, so that each plot included the same quantity of each of the several kinds.

As of possible interest, it may be here stated that among the different kinds grown in this experiment, which included some of those found in the experiments conducted by the department in various parts of the country to be the most promising, flint and dent varieties both being included, the largest yield was furnished by a variety of dent corn known as Minnesota No. 13 and the next largest by the Rustler White dent, a variety largely grown on the college farm in Amherst for the past two years, and obtained originally from a seedsman in Minnesota. Both of these varieties were fairly well ripened, although the cold, rainy spring and early summer months were highly unfavorable to the corn crop in this locality.

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

The general plan of this experiment is briefly stated in the nineteenth annual report, from which I quote : —

> This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash salts which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.

The experiment began in 1898, and the crops in the several years have been as follows : —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cow peas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.
1906. Potatoes.
1907. Potatoes.

As the results of last year indicated an important relation between the supply of potash in available form and the prevalence of blight, it was decided to plant the field to potatoes again in 1907, although it was recognized that this plan involved considerable risk that the crop would be seriously affected by scab, since, in spite of the fact that the seed planted in this field has always been thoroughly treated for destruction of the scab fungus, it had been noticed that the crop in a portion of the plots was somewhat affected by this disease. The amount of scab showing itself this year was unexpectedly serious, and this fact clearly indicates the soundness of the conclusion that potatoes should not as a rule be grown twice in succession upon the same field.

The variety of potatoes grown this year was Green Mountain. The seed was treated with formalin solution in the usual manner. On account of excessive rains throughout the early spring, planting was deferred until later than usual, — May 23. The crop was thoroughly cared for throughout the season, and sprayed twice with different combinations of fungicides and insecticides.[1] The yields per plot and the rates of yield per acre are shown in the following table : —

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 1, .	No potash, . . .	268.00	34.75	–	178.67	23.17	–
Plot 2, .	Kainit, ...	354.50	31.00	–	236.33	20.67	–
Plot 3, .	High-grade sulfate, .	367.00	33.50	–	244.67	22.33	–
Plot 4, .	Low-grade sulfate, .	369.50	23.00	–	246.33	15.33	–
Plot 5, .	Muriate, . . .	353.25	47.50	1.00	235.50	31.67	.67
Plot 6, .	Nitrate, ...	372.00	19.00	.75	248.00	12.67	.50
Plot 7, .	Carbonate, . . .	328.25	39.25	–	218.83	26.17	–
Plot 8, .	Silicate, ...	345.50	36.00	9.00	230.33	24.00	6.00
Plot 9, .	No potash, . . .	333.75	36.25	13.50	222.50	24.17	9.00
Plot 10, .	Kainit, ...	396.50	19.50	–	264.33	13.00	–
Plot 11, .	High-grade sulfate, .	386.50	27.50	.50	257.67	18.33	.33
Plot 12, .	Low-grade sulfate, .	400.00	27.75	.75	266.67	18.50	.50
Plot 13, .	Muriate, . . .	401.50	27.00	–	267.67	18.00	–

[1] For account of spraying experiments and results, see report of the botanist and vegetable pathologist, page 128.

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 14, .	Nitrate, ...	391.00	25.25	–	260.67	16.83	–
Plot 15, .	Carbonate, . . .	391.25	34.00	–	260.83	22.67	–
Plot 16, .	Silicate, ...	404.00	27.50	1.00	269.33	18.33	.67
Plot 17, .	No potash, . . .	301.25	33.00	1.50	200.83	22.00	1.00
Plot 18, .	Kainit, ...	339.50	13.00	.50	226.33	8.67	.33
Plot 19, .	High-grade sulfate, .	328.00	17.50	45.00	218.67	11.67	30.00
Plot 20, .	Low-grade sulfate, .	383.50	17.25	37.00	255.67	11.50	24.67
Plot 21, .	Muriate, . . .	333.00	15.25	56.00	222.00	10.17	37.33
Plot 22, .	Nitrate, ...	330.00	20.50	54.50	220.00	13.67	36.33
Plot 23, .	Carbonate, . . .	314.00	23.50	59.00	209.33	15.67	39.33
Plot 24, .	Silicate, ...	330.00	16.00	72.00	220.00	10.67	48.00
Plot 25, .	No potash, . . .	166.00	27.75	46.00	110.67	18.50	30.67
Plot 26, .	Kainit, ...	279.00	10.25	30.00	186.00	6.83	20.00
Plot 27, .	High-grade sulfate, .	370.50	11.50	29.00	247.00	7.67	19.33
Plot 28, .	Low-grade sulfate, .	366.75	23.00	6.00	244.50	15.33	4.00
Plot 29, .	Muriate, . . .	359.00	23.75	4.50	239.33	15.83	3.00
Plot 30, .	Nitrate, ...	336.00	24.25	2.00	224.00	16.17	1.33
Plot 31, .	Carbonate, . . .	340.00	37.00	–	226.67	24.67	–
Plot 32, .	Silicate, ...	372.50	28.50	–	248.33	19.00	–
Plot 33, .	No potash, . . .	198.00	25.00	–	132.00	16.67	–
Plot 34, .	Kainit, ...	284.00	14.50	–	189.33	9.67	–
Plot 35, .	High-grade sulfate, .	323.50	26.00	–	215.67	17.33	–
Plot 36, .	Low-grade sulfate, .	324.50	21.25	–	216.33	14.17	–
Plot 37, .	Muriate, . . .	297.50	33.00	–	198.33	22.00	–
Plot 38, .	Nitrate, ...	304.00	28.50	–	202.67	19.00	–
Plot 39, .	Carbonate, . . .	300.00	30.25	–	200.00	20.17	–
Plot 40,[1] .	Silicate, ...	226.00	33.25	–	150.66	22.17	–

The average yields of sound tubers under the varying fertilizer treatments were as follows: —

[1] Owing to a shortage in the available supply of silicate of potash, and the impossibility of procuring more, the quantity applied to this plot was only about one-sixth of the regular amount.

Potatoes.—Average Yields per Acre (Bushels).

Potash Salt.	Large.	Small.
No potash (plots 1, 9, 17, 25, 33),	168.93	20.90
Kainit (plots 2, 10, 18, 26, 34),	220.47	11.77
High-grade sulfate (plots 3, 11, 19, 27, 35),	234.73	15.47
Low-grade sulfate (plots 4, 12, 20, 28, 36),	245.90	14.97
Muriate of potash (plots 5, 13, 21, 29, 37),	236.57	19.53
Nitrate (plots 6, 14, 22, 30, 38),	235.07	15.67
Carbonate (plots 7, 15, 23, 31, 39),	223.13	21.87
Silicate (plots 8, 16, 24, 32, 40),	223.73	18.83

The no-potash plots this last year gave a yield much inferior to that produced on the plots receiving potash. The highest average yield was produced on the low-grade sulfate of potash: the lowest on the kainit. The differences between the different potash salts, exclusive of the kainit, are, however, relatively small. The full table showing the rates of yield per plot shows that there was considerable rot on about one-half of the plots. Dr. Stone failed to discover *Phytophthera infestans* on the foliage. The rot did not set in until the heavy rains of autumn. The variation in the proportion of decayed tubers in the different plots appears to be due to a difference in moisture conditions. There seems to be no well-defined influence on the proportion of decayed tubers which can be attributed to the potash salt employed. This year, as last, the foliage of the vines on the no-potash plots died much earlier than on any of the plots receiving potash. This premature death of the foliage may, however, have been due simply to lack of vigor consequent upon deficiency of potash in the soil, as Dr. Stone failed to find the characteristic fungi causing either the early or the late blight. It is probable, however, that in seasons with climatic conditions more favorable to the blight fungi they would attack the relatively weak foliage of plants growing where potash is deficient more seriously than they would the more vigorous foliage of better-nourished plants.

IV. — North Corn Acre. — Special Fertilizer *v.* Fertilizer Richer in Potash.

This experiment, which was begun in 1891, is designed to test the question whether the special corn fertilizers as offered in our markets are of such composition as seems to be best suited for the production of corn and mixed hay in rotation. The experiment occupies an acre of ground, and is divided into four equal plots, numbered from 1 to 4. Plots 3 and 4 were sown to millet during the first two years of the experiment, but with this exception their treatment has been the same as that of plots 1 and 2, 3 being a duplicate of 1 both as regards fertilizer application and crops produced, and 4 a duplicate of 2. The field has been in mixed grass and clover during three two-year periods, 1897–98, 1901–02 and 1905–06. With these exceptions, and with the further exception referring to millet noted above, corn has been the crop. Whenever the field has been put into grass and clover, it has been seeded in the standing corn of the previous year. Plots 1 and 3 have yearly received an application of fertilizers (a home mixture), furnishing nitrogen, phosphoric acid and potash at the rate per acre which would be supplied by 1,800 pounds of fertilizer having the composition of the average of the special corn fertilizers analyzed at this station. We have made but one change since 1899, as this average changes but little from year to year. The average composition of such fertilizers at that time was as follows: —

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

The fertilizer used on plots 2 and 4 has been a home mixture richer in potash and much poorer in phosphoric acid than the mixture representing the average corn fertilizers offered in the market. The difference in the application of the fertilizer elements is made clear in the following table: —

Fertilizer Elements applied annually.

Plots.	Rates per Acre (Pounds).		
	N	P_2O_5	K_2O
Plots 1 and 3,	42.6	180	77.4
Plots 2 and 4,	47.0	50[1]	125.0

The materials applied annually to the several plots are as follows: —

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

This field was limed in 1900 at the rate of 1 ton to the acre, and again this year at the same rate.

For the past two years the land has been in mixed grass and clover. The sod was plowed in May, and the corn, Rustler White dent, was planted on May 25. The rates of yield on the several plots and the averages for the two systems of manuring are shown in the following tables: —

Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (lesser potash),	59.75	4.24	6,400
Plot 2 (richer in potash),	56.00	7.10	7,060
Plot 3 (lesser potash),	57.75	5.75	6,760
Plot 4 (richer in potash),	52.00	8.25	6,720

[1] By mistake plots 2 and 4 received the same application of acid phosphate in 1906 as plots 1 and 3.

[2] Plot 4 this year received in addition 100 pounds of basic slag meal.

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash), ...	58.75	5.00	6,580
Plots 2 and 4 (richer in potash), ...	54.00	7.68	6,890

It will be noticed that the combination of fertilizers representing the special corn fertilizer gives an average yield of sound corn at the rate of about 4¾ bushels per acre more than plots 2 and 4. The yield of soft corn and of stover is, however, larger on plots 2 and 4. We have here an illustration of the well-known effect of a liberal supply of soluble phosphoric acid in hastening maturity, — an effect which was especially important during the past season, on account of the cold and rainy spring and the low average summer temperature. The greater weight of stover (field cured) on plots 2 and 4 may be in part a consequence of the fact that the crop was not so fully matured, although it has been repeatedly noted in our experiments that a liberal supply of potash promotes a heavy yield of forage. The addition of the basic slag meal to plot 4 has produced no apparent benefit during the past season.

V. — South Corn Acre. — Manure Alone *v.* Manure and Potash.

The objects in view in this experiment and the general plan are stated in the following quotation from my last annual report: —

The object in view in this experiment is to compare the crop-producing capacity of manure alone applied in fairly liberal amounts with a combination of a lesser amount of manure and a moderate quantity of a potash salt. An acre of land is used in the experiment. It is divided into four plots, of one-quarter acre each. Two of the plots (1 and 3) have received applications of manure only; the other two plots (2 and 4) have been fertilized by applications of lesser amounts of manure, together with a potash salt.

This experiment was begun in 1891. The crop for the first six years was corn. Corn was raised also in 1899 and 1900, and in 1903 and 1904. The field has been put into mixed grass and clover three times, being seeded in the summer preceding the first year of cutting in the corn crop.

Each time that the land has been seeded it has been cut twice annually for two years. The sod has then been broken in the fall for the corn crop of the following year. The years when the field has been in mowing are 1898 and 1899, 1901 and 1902, and 1905 and 1906.

Manure has been applied to plots 1 and 3 every year, at the rate of 6 cords per acre, with the following exceptions. No manure was applied in 1897, 1902 and 1905, and in 1898 the amount applied was at the rate of 4 cords per acre. The reason for the omission of manure in the years mentioned and for the smaller amount in 1898 was that experience indicated that its application would cause the grass and clover to lodge badly.

Manure has been applied to plots 2 and 4 as follows: in 1891 and 1892, at the rate of 3 cords per acre; in 1898, at the rate of 2 cords per acre; while in 1897, 1902 and 1905 no manure was applied. In all other years the application has been at the rate of 4 cords per acre. Potash has been applied to plots 2 and 4 at the rate of 160 pounds per acre of high-grade sulfate annually, except in the years when no manure was applied. In these years the potash also was withheld.

The entire field was limed in 1900 at the rate of 1 ton per acre. The manure used has been from well-fed milch cows, and has usually weighed about 3 tons per cord. Both manure and fertilizer were applied broadcast after plowing, and harrowed in.

The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields per Acre, 1907.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	65.50	6.00	7,080
Plot 2 (manure and potash),	60.40	7.78	7,508
Plot 3 (manure alone),	64.25	6.00	7,380
Plot 4 (manure and potash),	62.25	8.25	7,120

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	64.88	6.00	7,230
Plots 2 and 4 (manure and potash),	61.33	8.02	7,314

It will be noticed that the yield of sound corn is somewhat larger on the heavier application of manure alone than on the combination of a lesser quantity of manure and the potash. On the other hand, the average yield of soft corn and of stover is greater on the combination of manure and potash. This result is in some respects analogous to that obtained with fertilizers on the north corn acre. In a more favorable season, the combination of manure and potash is likely to make a better relative showing. In estimating the significance of the results actually obtained, however, it should be kept in mind that, assuming the farmyard manure to cost $5 per cord applied to the field, the annual difference in cost of materials applied under the two systems of manuring has amounted to about $6 per acre, the application of the lesser amount of manure and the potash costing about that amount less than the larger application of manure.

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

This experiment, comparing different phosphates, has been in progress eleven years. The phosphates under comparison are as follows: apatite (fine ground[1]), South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. Each is applied in such quantities as to furnish phosphoric acid at the rate of 96 pounds per acre. Three plots have received no phosphoric acid during the entire period of the experiment. All plots have annually received an application of materials furnishing nitrogen and potash and in equal amounts, nitrogen being furnished at the rate of 52 pounds and potash at the rate of 152 pounds per acre. In the case of a few crops requiring especially high manuring (onions and cabbages), a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. The crops grown in this field in the order of succession have been as follows: corn, cabbages, corn, — in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, cabbages, and mixed grass and clover for two years. The plots were seeded to mixed grass and clover in the spring of 1905; the present is therefore the third year that they have been in grass. The yields and the gain or

[1] Not used either in 1906 or 1907, as it is not offered by dealers.

loss as compared with the no-nitrogen plots are shown in the following table : —

Plots.	Fertilizers used.	Yield per Plot (Pounds).		Yield per Acre (Pounds).		Gain or Loss (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	No phosphate, ...	1,050	50	8,400	400	-	-
Plot 2,	Apatite, ...	1,100	63	8,800	504	867	+71
Plot 3,	South Carolina rock phosphate,	1,060	62	8,480	496	547	+163
Plot 4,	Florida soft phosphate, . .	1,060	50	8,480	400	547	+67
Plot 5,	Phosphatic slag, . . .	1,045	52	8,360	416	427	+83
Plot 6,	Tennessee phosphate, . .	1,005	41	8,040	328	107	—5
Plot 7,	No phosphate, ...	1,020	30	8,160	240	-	-
Plot 8,	Dissolved bone black, . .	1,150	61	9,200	488	1,267	155
Plot 9,	Raw bone, ...	1,155	63	9,240	504	1,340	171
Plot 10,	Dissolved bone meal, . .	1,145	63	9,160	504	1,227	171
Plot 11,	Steamed bone meal, . . .	1,040	70	8,320	560	387	227
Plot 12,	Acid phosphate, . . .	1,005	75	8,040	600	107	267
Plot 13,	No phosphate, ...	905	45	7,240	360	-	-

It will be noted that the first crop was exceptionally heavy. The large yield was without doubt due in considerable measure to the weather conditions, which were exceptionally favorable for hay in this locality. Such yields, however, must have been impossible but for the liberal fertilization which the field has received.

It will be noticed that even the no-phosphate plots have given a yield averaging nearly 4 tons per acre at the first cutting. The highest yields were afforded by the dissolved bone black, raw bone and dissolved bone meal, between which there was relatively little difference ; but the fact that the yield on the plot receiving apatite was but little inferior to the yield on these best plots, while with such crops as cabbages in past years it has been hardly one-half as great, taken in connection with the relatively large yield of the no-phosphate plots, sufficiently emphasizes the relative unimportance of supplying phosphoric acid in soluble form for such a crop as mixed grass and clover. The soluble phosphates in this experiment when cabbages were the crop gave yields about two to five times as great as the no-phosphate or the insoluble phosphate plots, while this year the differences are comparatively insignificant. The yield of rowen this year was exceptionally small, and for the same reasons as those which have been mentioned in discussing the results on Field A, viz.: late cutting of the first crop, and protracted drought during the latter part of the summer.

VII. — Soil Tests.

Soil test work has been continued upon the two acres which have been used so long in work of this description. The plan is the co-operative method adopted in convention in Washington in 1889. The crops of this year have been, on one acre, corn; on the other, mixed grass and clover. The latter was sown this spring, and the crop, which was considerably mixed with weeds, was not weighed separately for the different plots. No detailed report will be made, therefore, for this acre. In this soil test work the kinds of fertilizers and the rates of application 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, 800 pounds.
Lime, 800 pounds.
Manure, 5 cords.

Soil Test with Corn (South Acre). — This acre has been used in soil tests for nineteen years, beginning in 1889. The field was limed, each time at the rate of 1 ton per acre, in 1899 and 1904. Early in the spring of the present season it received another application of lime, at the rate of 1,000 pounds per acre of R. R. agricultural lime, manufactured by the Rockland-Rockport Lime Company. This was spread after plowing, as in previous years, and harrowed in. The crops for the successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover. The crop for the present season was corn, which is, therefore, the ninth corn crop grown in the field since the experiment began in 1889. Three times during this period the field has been put into mixed grass and clover, each time for two years. The third grass and clover period ended last year. The sod, however, was not turned until last spring. The soil was well prepared, but, owing to the cold and rainy spring, the crop, Rustler White dent, was not planted until June 1. The character of the past season, as has been pointed out in another section of this report, was rather unfavorable for corn. The following table shows the fertilizers used on the several plots, the rates of yield and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1907.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels).	Stover (Pounds).	Corn (Bushels).	Stover (Pounds).
Plot 1, .	Nitrate of soda, ...	1.00	720	—1.00	—280
Plot 2, .	Dissolved bone black, . . .	.81	700	—1.19	—300
Plot 3, .	Nothing, ...	2.00	1,000	-	-
Plot 4, .	Muriate of potash, ...	23.31	6,000	+21.23	+4,967
Plot 5, .	Lime, ...	1.25	900	—.92	—167
Plot 6, .	Nothing, ...	2.25	1,100	-	-
Plot 7, .	Manure, ...	72.50	6,900	+70.25	+5,800
Plot 8, .	Nitrate of soda and dissolved bone black.	10.06	2,500	+6.25	+1,400
Plot 9, .	Nothing, ...	3.81	1,100	-	-
Plot 10, .	Nitrate of soda and muriate of potash.	31.13	5,400	+27.46	+4,400
Plot 11, .	Dissolved bone black and muriate of potash.	30.13	6,500	+26.61	+5,600
Plot 12, .	Nothing, ...	3.38	800	-	-
Plot 13, .	Plaster, ...	7.75	1,200	+4.37	+400
Plot 14, .	Nitrate of soda, dissolved bone black and muriate of potash.	38.31	5,500	+34.93	+4,700

It will be noticed that the yield on the nothing plots is excessively small, amounting on the average to but little more than 2½ bushels of shelled corn per acre and about 1,000 pounds of stover. The use either of nitrate of soda or of dissolved bone black alone gives absolutely no increase; indeed, the crops on these single fertilizer materials were smaller than on the nothing plots. On the other hand, the use of muriate of potash at the rate of 160 pounds per acre (for this, the nineteenth year during which the land has been fertilized only with this material) gives an increase at the rate of rather over 20 bushels of corn and nearly 2½ tons of stover per acre. The tables which follow bring out the effects of the different fertilizer elements when used alone or in different combinations with great clearness : —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	−1.00	+7.44	+6.23	+8.32	+5.25
Stover (pounds),	−280.00	+1,700.00	−567.00	−900.00	−11.75

Value of increase,	$3 89[1]
Financial result (loss),	11

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels),	−1.19	+7.25	+5.38	+7.47	+4.73
Stover (pounds),	−300.00	+1,680.00	+633.00	+300.00	+578.00

Value of increase,	$5 89
Financial result (gain),	3 01

	Results of the Addition of Potash to —				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels),	21.23	28.46	27.80	28.68	26.54
Stover (pounds),	4,967.00	4,680.00	5,900.00	3,300.00	4,712.00

Value of increase,	$38 75
Financial result (gain),	35 15

[1] The financial calculations in these tables were based on the following prices: —

Nitrate of soda,	$50 00 per ton.
Muriate of potash,	45 00 per ton.
Dissolved bone black,	18 00 per ton.
Lime,	6 00 per ton.
Plaster,	10 00 per ton.
Manure,	5 00 per cord.
Corn,	75 per bush.
Stover,	8 00 per ton.

	Results of the Addition to Nothing of —			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels), ...	—.92	+70.25	+4.37	34.93
Stover (pounds), ...	—167.00	+5,800.00	400.00	4,700.00
Value of increment, . . .	-	$75 89	$4 88	$45 00
Value of decrease, ...	$1 36	-	-	-
Financial result, ...	3 76 (loss).	50 89 (gain).	88 (gain).	34 52 (gain).

The first of these tables shows that, although nitrate of soda, when used alone, does not increase the crop, it gives a small increase when used in connection with either of the other fertilizer materials alone or with the two together. The nitrate when used in connection with either potash alone or with potash and dissolved bone black has apparently at the same time increased the yield of grain and decreased that of stover. No explanation of this result can be offered. We have, however, figured results on the weights of field-cured stover, and it is possible that variation in moisture content obscures real effects, although this is not believed to be the case, as similar results have been obtained in other years.

The second of these tables shows that, while phosphoric acid used alone gives no increase, it gives a moderate increase both in grain and in stover when used with either of the other fertilizer materials or with both. It will be noticed that on the average the value of the increase in crop due to the use of the phosphate exceeds the cost of that fertilizer.

The third table shows the results obtained by the use of potash. The fact is at once evident that this is the dominant element for the corn crop in this soil. It will be noted that even when used by itself it gives a large increase. It seems surprising that the increase produced when the potash is used in connection with both the other fertilizer elements does not compare more favorably with the increase when it is used alone. We have, it is true, a somewhat larger increase in grain. On the other hand, the increase in stover is not as great as that produced when the potash is used alone. The value of the increase produced by the use of potash greatly exceeds the cost of this fertilizer element.

The last of the four tables under consideration shows the results, as compared with the nothing plots, of the use respectively of the lime, the manure, the plaster and the complete fertilizer. The lime used alone proves absolutely valueless. The manure gives a heavy crop, and its use is highly profitable. Plaster produces a small increase. Complete fertilizer produces a fair crop, and is moderately profitable.

Attention is here called to the fact, previously noted in referring to this field, that the object in view is not to demonstrate the possibility of producing large crops, but to bring out the specific effects of long-continued use of the different fertilizer elements and fertilizer combinations. A more profitable crop could undoubtedly be produced on fertilizers by making a more liberal application. The possibility of doing this is sufficiently demonstrated by the results obtained in raising corn in alternation with mixed mowings on fertilizers alone on the north corn acre,[1] where highly profitable crops have been yearly produced. This soil test work, taken in connection with other experimental work, a part of which is referred to in this report, and in connection with results obtained in various parts of the State, certainly indicates the desirability of a more general and larger use of fertilizers rich in potash in the production of the corn crop.

VIII. — Experiment in Manuring Grass Land.

The plan of this experiment will be understood from the following outline, quoted from my sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year, fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

[1] See page 43.

The past season in this part of Massachusetts was in general favorable to a large yield of hay at the first cutting, but the rowen crop was in most fields much smaller than usual, on account of the deficiency of rainfall during the latter part of July and August. It will be noted, however, that the yields in this field during the past season were considerably under the general average for the entire period of the experiment. The results for each of the systems of manuring is shown in the table: —

Fertilizers used.	Yield per Acre.		
	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,517	1,205	4,722
Bone and potash,	3,903	1,728	5,631
Wood ashes,	3,083	1,579	4,662

The average for the entire area this year was 5,005 pounds. The average from 1893 to 1906, inclusive, was 6,389 pounds of well-dried hay per acre annually. The average to date, including the crop of the past season, is 6,296 pounds. A comparison of the average yield throughout the entire period for each of the several systems of manuring will be of interest. These averages are as follows: —

	Pounds per Acre.
When top-dressed with manure,	6,525
When top-dressed with wood ashes,	5,965
When top-dressed with bone and muriate,	6,284

In each of plots 1 and 2 two different mixtures of grass seeds are under comparison on equal areas. One of the mixtures in each plot is the usual farmer's mixture of timothy, redtop and clovers. The other mixture contains a considerable variety of seeds, but tall and meadow fescues are the predominating species. These plots were seeded in 1902. During the first few years the timothy mixture gave the larger yields. During the past season the fescue mixture has given the larger total yields on both plots. The differences, however, are not large.

IX. — Experiment in the Application of Manure.

Full details with reference to the plan followed in this experiment will be found in the nineteenth annual report. Briefly stated, the object is to compare results obtained through spreading manure as it is removed from stables during the winter with the practice of storing in a heap in the open air until spring and then spreading. The field which is used in this experiment slopes quite rapidly toward the west. The experiment was begun in 1899; the past season, therefore, is the ninth during which the experiment has continued. The crop this year was mixed grass and clover, sown in the standing corn of the previous year. No manure was applied either in winter or spring this year, as it was apparent that the land, which has been manured annually at the rate of 6 cords to the acre for the past eight years, would produce as rank a growth as was desirable. The rates of yield per acre and the relative standing of the several plots are shown in the following table: —

Grass and Clover. — Actual Yields (Pounds per Acre).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	6,885	973.3	6,903	1,081.5
Plot 2,	6,885	1,261.7	6,795	1,135.5
Plot 3,	5,948	1,279.7	6,363	1,117.5
Plot 4,	6,633	973.3	6,164	1,027.4
Plot 5,	6,327	558.8	6,020	973.3

Grass and Clover. — Relative Yields (Per Cent.).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	100	100	100.26	111.12[1]
Plot 2,	100	100	98.69	90.32
Plot 3,	100	100	106.98	87.32
Plot 4,	100	100	92.93	105.56
Plot 5,	100	100	95.15	174.18

[1] These yields of rowen less accurately measure the fertility than the first crop, for the grass and clover both were unevenly killed in spots by the lodging of the first crop.

The crops of this year are of course a measure only of the residual fertility from previous manuring. The yield was heavy, but, as will be noticed, it was not uniformly favorable to either system of application, although on the whole the plots to which the manure has been applied during the winter gave the heavier yields. These experiments to date do not support the view that the waste following winter application of manure is sufficiently serious to offset the saving in labor, as compared with the system of double handling which storing in heaps to be spread in the spring involves. Our records indicate that spring application costs at the rate of about $4.80 per acre more than the single handling, where the manure is spread when hauled during the winter.

X. — Nitrate of Soda for Rowen.

This experiment was designed to determine whether the application of nitrate of soda made soon after the first crop is cut will give a profitable increase in rowen. The field, although originally seeded to pure timothy in 1897, now gives crops largely mixed with clover. The total area is a little more than three acres. For the first crop we apply fertilizers at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds.

For the purpose of the experiment with nitrate of soda, eight equal plots have been laid off, each containing almost exactly one-third of an acre. Alternate plots have annually received a top-dressing of nitrate of soda after the removal of the first crop during the past seven years. For the past four years, in order to facilitate the more even distribution of the nitrate, it has been mixed with sufficient basic slag meal to furnish an application of the latter at the rate of 400 pounds per acre; and to equalize conditions on the alternate plots to which no nitrate is applied, the slag meal is applied to all of these at the same rate. The results obtained the past season are presented in the table: —

Nitrate of Soda for Rowen.

Plots.	Fertilizers used (Rates per Acre).	Yields (Pounds).	Increase per Acre (Pounds).
Plot 1, .	Slag meal, 400 pounds, ...	1,295	–
Plot 2, .	Slag meal, 400 pounds; nitrate of soda, 150 pounds, .	1,584	312
Plot 3, .	Slag meal, 400 pounds, ...	1,249	–
Plot 4, .	Slag meal, 400 pounds; nitrate of soda, 150 pounds, .	1,493	160
Plot 5, .	Slag meal, 400 pounds, ...	1,417	–
Plot 6, .	Slag meal, 400 pounds; nitrate of soda, 200 pounds, .	1,712	417
Plot 7, .	Slag meal, 400 pounds, ...	1,173	–
Plot 8, .	Slag meal, 400 pounds; nitrate of soda, 250 pounds, .	2,285	1,112

The differences this year, although indicating a beneficial effect in every instance from the application of nitrate, are comparatively small except on plot 8. This is doubtless accounted for in large measure by the extreme drought which prevailed during the latter part of the summer. At current retail prices for nitrate during the past season its application did not prove profitable in any instance.

XI. — Poultry Experiments.

The poultry work of the past year has consisted in a repetition of the experiments in feeding for eggs which were carried out during the two preceding years. The general results of these experiments cannot perhaps be better expressed than in the following words, quoted from the nineteenth annual report: —

> The experiments had indicated: first, that, provided fat is abundant in the ration, high protein content is not essential; second, that, if the fat content of the ration is low, a large proportion of protein in the feeds used appears to be much more essential; and third, that a large proportion of fiber in the ration used is unfavorable to a good egg product.

The fowls used in the experiments of the past year were, as in previous years, pullets of our own raising. Carefully matched flocks were kept, as in former years, each in a house by itself, all of the houses being precisely similar in general dimensions and construction. The results of the past season's work are confirmatory in every particular of the results previously obtained. A somewhat full account of our experiments will be published in a bulletin which will be issued in the near future. I call attention here, therefore, only to what seem to be some of the more important practical conclusions. In estimating the reliability of these conclusions, it should be remembered that they are based upon results (on the whole in exact agreement throughout) which have been obtained in these long-continued experiments. These practical conclusions are as follows: —

1. When fat is abundant in the rations used in feeding fowls, a satisfactory egg product can be obtained by the use chiefly of grains which are relatively low in protein and high in carbohydrates. This means that corn may safely constitute a large proportion of the grain fed to laying fowls, and that it is not necessary, in order to secure a satisfactory egg product, to pay the higher prices usually demanded for wheat. It seems wiser to depend chiefly upon animal foods, such as beef scraps of good quality, to supply a fairly liberal proportion of protein and to enrich the ration in fat, using corn in connection with the scraps as the chief whole grain. A little wheat may be desirable, for the sake of variety, but to feed wheat as a source of protein seems unnecessary. Vegetable protein is not equal in value for egg production to protein derived from animal substances.

2. If, on the other hand, the combination of feeds used is low in fat, then a ration which furnishes abundant protein will prove considerably superior to one low in protein. If, for example, a dried animal meal from which the fat has been largely extracted, or such material as milk meal (milk albumen) made by the evaporation to dryness of separator skimmed milk low in fat, be used as sources of animal protein, then the combination of foods, including wheat in large quantity and therefore supplying protein in relative abundance, will give more eggs than a combination of foods in which corn, which furnishes less protein, is the principal grain. It has been clearly shown in investigations with domestic animals that in the process of digestion and assimilation the protein of the food may undergo changes resulting in the production of fat. If, as seems probable, the laws controlling metabolism in the digestive and assimilative processes of our domestic fowls are similar to those in the larger domestic animals, we find in this fact an explana-

tion of the difference in relative importance of wheat and corn in the rations of fowls with high and with low fat content. The body temperature of the domestic fowl is much higher than that of the larger domestic animals. To maintain this higher temperature, the oxidation in the body of relatively large quantities of heat producers must be essential. Among food heat-producers fat possesses not only the highest unit value, but is lowest in cost in proportion to value. It seems wise, therefore, in feeding fowls to introduce this nutrient into the ration as largely as is consistent with health. Beef scraps which have been carefully prepared, so that they are free from all bad odors or rancidity, and which contain a fairly large proportion of fat should be freely fed to laying fowls. They may not only with safety, but with positive advantage, be kept before such fowls all the time ; and if such scraps are so fed, then corn may safely be the principal grain used.

3. The domestic fowl has little or no ability to digest fiber. Our experiments have shown that a large proportion of fiber in the ration is unfavorable to egg production, other things being equal. The practice, therefore, of using such grains as oats, barley or buckwheat largely in the rations of laying fowls would seem to be unwise. Here again it may possibly in some cases be an advantage to use these grains in small amounts occasionally, for the sake of variety. The writer, however, is not a believer in this practice. He is able to obtain exceedingly satisfactory egg product while depending almost wholly upon corn, cracked or whole, as a grain ration, in connection with a mash including bran or middlings, linseed meal, corn meal and beef scraps.

REPORT OF THE HORTICULTURAL DIVISION.

F. A. WAUGH, HORTICULTURIST; CARL S. POMEROY, ASSISTANT HORTICULTURIST; E. A. WHITE, FLORIST.

The work in horticulture has followed the same lines as in recent years. Some additional problems have been undertaken, particularly in plant breeding, but there has been no change of general policy.

The experiments in pruning and in grafting have been continued, and have been combined with rather interesting results in the production and management of dwarf fruit trees. This subject just now commands a widespread interest, and the station has been able to be of considerable assistance to suburban residents, fruit growers, nurserymen and other planters of dwarf fruit trees. It has been thought best not to put out a special bulletin on this subject for the present, though a book on dwarf fruit trees, giving the results of our experience, has been published privately.

The station work in horticulture has been greatly strengthened during the year by the addition of some new men to the staff. Mr. C. S. Pomeroy of the University of Vermont has been placed in direct charge of all experimental work, and Prof. E. A. White of Storrs Agricultural College, Connecticut, has taken charge of the work in floriculture.

Notes on the Propagation of Apples.

F. A. WAUGH.

For several years the division of horticulture has been conducting experiments on the propagation of fruit trees, especially apples. For various reasons the so-called dwarfing stocks for apples (Doucin and Paradise) have been largely employed and carefully observed. Two objects have been kept most prominently in mind in these experiments : —

1. To observe as accurately as possible the effects of stock on cion, a field of study which has long been of great interest to horticulturists.

2. To determine the practical merits of different methods of propagation, with especial reference to the production of dwarf fruit trees.

While we have had a considerable quantity of material under study, and have been able to draw fairly satisfactory conclusions of a practical nature, it has been difficult to secure proper quantities of material under suitably uniform conditions for making exact scientific comparisons. The following data, however, seem to be safe and worthy of credit.

Comparison of Standard, Doucin and Paradise Stocks.

It should be explained at this point that "standard" apple stocks are the kind almost always employed in this country. They are grown mostly in the west and south, from seeds taken from apple pomace. These seedlings are then sold to nursery men in every part of the country, and are used as stocks for budding or grafting all varieties of apples.

Doucin stocks are mostly imported from France, where they are grown, not from seeds, but from mound layers or cuttings. They are somewhat slower growers than standard stocks, and when budded with common varieties produce trees of a semi-dwarf stature.

Paradise stocks are also grown chiefly in France, and in the same manner as the Doucin stocks. They are still dwarfer in character, and when budded with ordinary varieties produce very small trees. Some of these trees bear fruit abundantly at two or three years old, and appear to be mature at a height of 8 feet, or even less.

This difference in growth may be seen in the nursery to some extent, though usually the dwarfing effect of the Doucin and Paradise stocks is less obvious there than after the trees are planted in the orchard. This reservation is especially necessary in the case of the Baldwin apple, which shows a special aptitude for the Doucin stock. Yet the general influence of the different stocks is seen in a comparison of the growth of two-year-old nursery trees given below: —

Comparison of Baldwin Trees, Two Years Old.

	On Standard.	On Doucin.	On Paradise.
Number of trees, ...	89	47	37
Average height (centimeters), ...	166	116	98
Ratio of height to diameter, ...	103.8	82.9	70.0

The last of these figures, ratio of height to diameter, is the most significant. A small ratio indicates what the nurseryman calls a "stocky" tree. All the figures, however, indicate that considerable differences exist between the three lots of Baldwin trees propagated in the three different kinds of stocks.

However, averages are apt to be misleading, and they never tell the whole story. More information can be conveyed if we adopt the graphic method, as in Figs. 1, 2 and 3, in which each entire group of trees is represented. Here the very different characters of the curves, as well as their differing positions in their enclosing rectangles, indicate the very striking differences in the three lots of nursery trees. The tall, narrow, smooth curve in No. 2 shows that the trees on Doucin stocks were much more uniform than on the other two. As the short, stocky trees are placed at the left of each curve with the tall, slim ones at the right, it is easily seen that the trees on Paradise were much stockier than those on Doucin, and those on Doucin were in turn shorter and stockier than those on ordinary stocks.

BALDWIN APPLE TREES. — Two years old.

Number of Individuals.

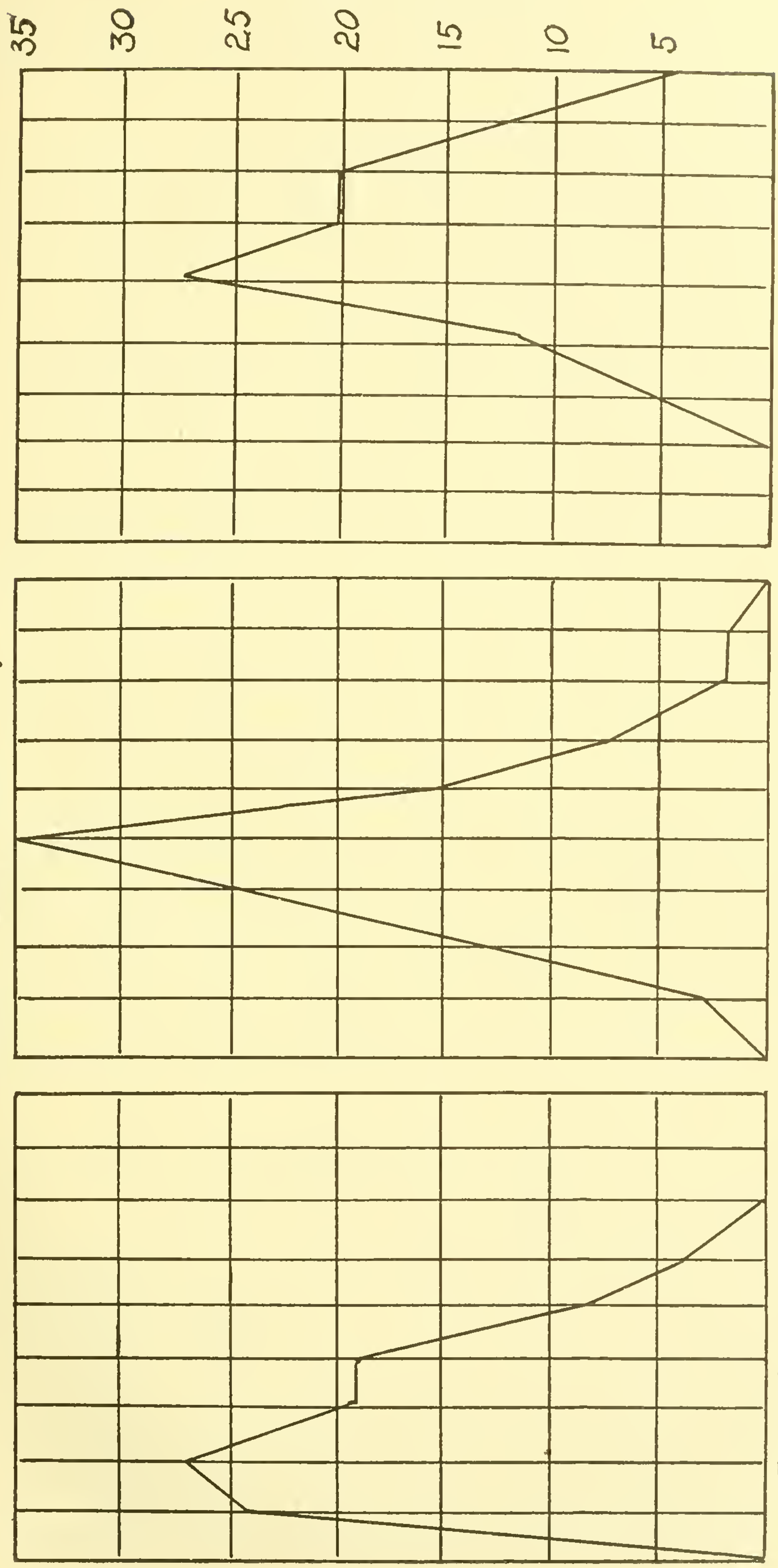

Fig. 1. — On Paradise stocks.

Fig. 2. — On Doucin stocks.

Fig. 3. — On standard stocks.

Diagrams showing the variation in Baldwin apple trees as grown on different stocks. Each curve represents the distribution of 100 trees into classes, according to the ratio of diameter to height. The smaller ratios are at the left, beginning with a ratio of 50 (height ÷ diameter = 50), progressing by 10's and ending with a ratio of 140. Horizontal lines represent numbers of individuals in each class.

These results agree with the common belief regarding the influences of the different stocks ; but so far as we know these influences have never before been carefully demonstrated and measured.

The same differences are shown between trees of other varieties, such as Wealthy, McIntosh, Greening, etc., when grown on the different kinds of stocks. Unfortunately, we do not have a series of varieties growing on all three stocks, under uniform conditions and of the same age, so as to make an extended comparison. However, the following averages of two additional lots on Paradise and Doucin stocks will indicate the generally uniform character of the influence of these stocks : —

Comparison of Two-year-old Nursery Trees.

	On Doucin.	On Paradise.
Wealthy : —		
Number of trees,	84	51
Average height (centimeters),	165	128
Ratio of height to diameter,	110.0	98.5
McIntosh : —		
Number of trees,	73	50
Average height (centimeters),	148	154
Ratio of height to diameter,	106.4	96.2

Variation in Peas.

F. A. WAUGH; C. S. POMEROY.

Two new ideas, of the magnitude of great discoveries, recently brought to the front in the scientific world have developed an entirely new interest in plant breeding. This new interest has manifested itself both in practical plant-breeding work and in renewed scientific investigation. The two ideas here referred to are: (1) Mendel's law, so called; and (2) the statistical method of studying variation and heredity.

The horticultural division of the Massachusetts Agricultural Experiment Station has been engaged for several years in certain investigations in both these fields. On account of the length of time required to secure definite results, no report has yet been made of these experiments, but a brief report of some of the partial figures may be of interest at this time, particularly by way of illustrating the modern methods of study.[1]

For the purposes of this particular study, one row of peas was staked off in the middle of a field. A careful record was kept of each vine, showing its length, the number of pods borne, the length of the pods and the number of peas in each pod. The variation is shown by the following figures: —

Variation in Peas.

	Minimum.	Maximum.	Average.
Number of vines,	179	–	–
Length of vines (centimeters),	20	88	54.70
Number of pods per vine,	1	13	4.68
Length of pods (centimeters),	2	9.5	6.88
Number of peas per pod,	–	9	3.46

[1] The statistical methods of study and graphic methods of presenting data have been developed especially in England by Francis Galton and Prof. Karl Pearson. In this country the same methods have been presented by C. B. Davenport and by E. Davenport, dean of the Illinois College of Agriculture, in his recent book, "Principles of Breeding." It seems better to refer the student of plant breeding to these works, rather than to attempt a more extended explanation of these somewhat complicated methods in this report.

These figures, however, give only very meager information as to the whole range of variation, even in the qualities studied. If we wish to know the facts more accurately, we should refer to the graphic presentation on pages 66, 67 and 68.

Let us study first Fig. 1, showing the variation in length of vine. The spaces along the bottom of the figure represent different lengths of vine, in centimeters. The vertical spaces

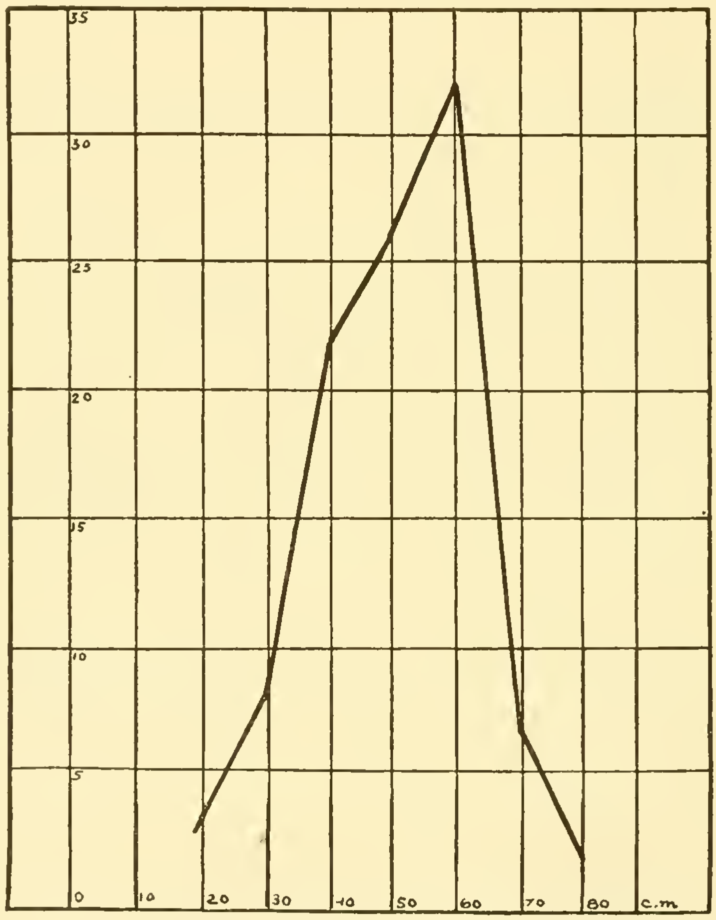

FIG. 1.

represent the number of vines of each length, the whole being represented on a percentage basis; *i.e.*, 179 vines as 100. It will be seen that in each 100 vines there were 3 having a length of 20 centimeters, 8 with a length of 30 centimeters (26–35 centimeters), 22 with a length of 40 centimeters, 32 with a length of 60 centimeters, 7 with a length of 70 centimeters and 2 with a length of 80 centimeters. The figure thus shows the composition of the entire row (the "population," as it is technically called) with respect to height.

One of the most important facts brought out by this graph is that, while the average length of vine is 54.7 centimeters the largest number of vines have a height of 60 centimeters. This shows that the typical Excelsior pea vine in this field was nearly 10 centimeters taller than the average; or, to put the matter another way, a relatively large number of vines run below the typical height.

We may now direct our attention to the number of pods to

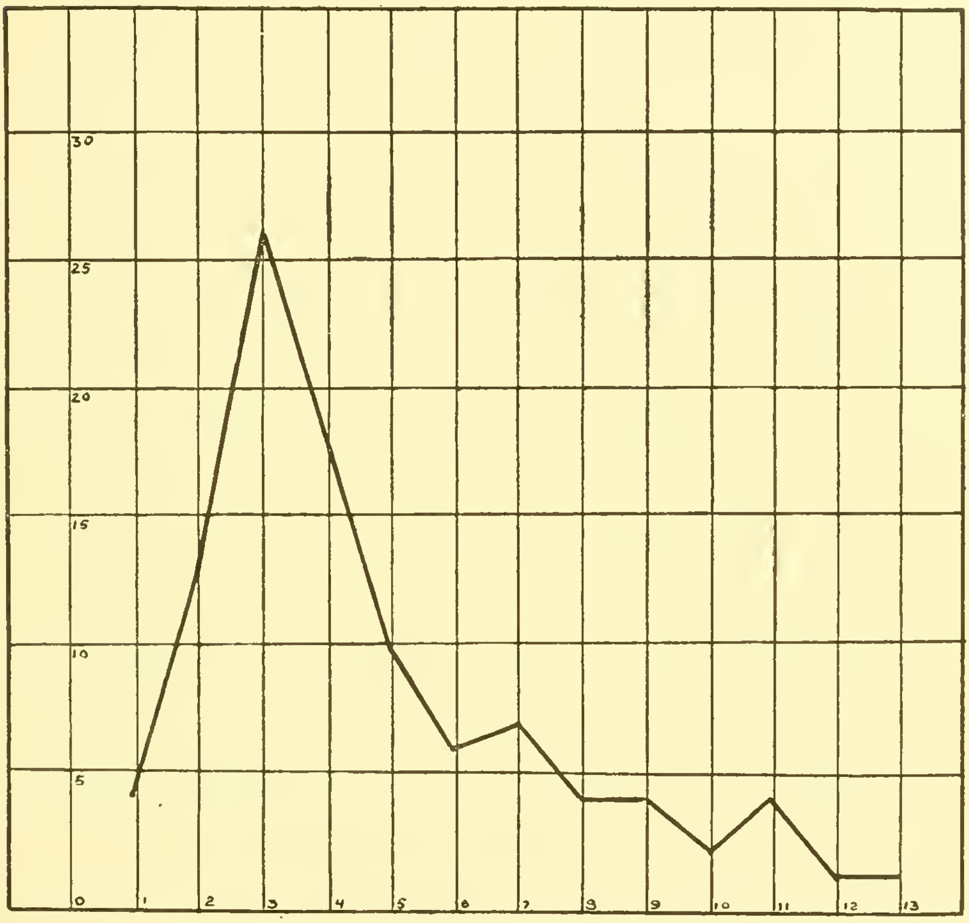

FIG. 2.

the vine. These are shown by Fig. 2. From this we see at once that the typical vine in this field (*i.e.*, the kind of vine most frequently found) contains 3 pods, while the average number is 4.68. This average is brought up by a few vines, represented at the right of the curve, bearing an unusually large number of pods.

At this point it might be suggested that the practical plant breeder, in an endeavor to improve this variety of peas, would naturally select seed from those vines bearing 8, 9, 10 or more pods.

Fig. 3 gives the curve representing the variation in number of peas, to the pod. Two pods in each 100 at the average had no peas, while one in 100 had 8 and one had 9. The average was 3.46, but the typical pod contained 4 peas, — distinctly more than the average.

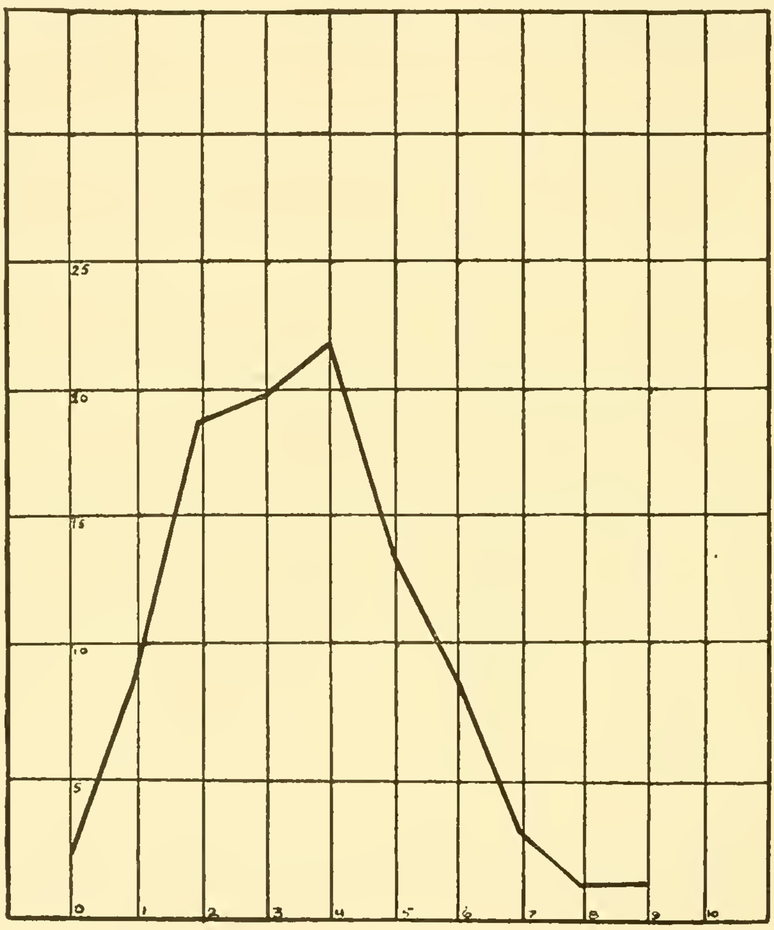

FIG. 3.

Turning once more to the requirements of the practical plant breeder, we see that he would wish to grow the largest number of peas to the pod, as well as the largest number of pods to the vine; and the question arises immediately, whether these two qualities are compatible. Do the vines bearing the largest number of pods bear also the largest number of peas to the pod? or are the pods with the largest number of peas borne on the vines having relatively few pods?

Studies in Correlation.

These questions bring us immediately to the study of correlation in variation, — one of the most important fields of plant study. In no field, moreover, is the value of the statistical method more conspicuous than in this.

There are two algebraic methods of answering the questions just asked, the first known as Yule's method,[1] and the second may be called Pearson's method [2] or the method of compound series. In applying the former method it is necessary to separate the plants into four groups, according to the two characters to be compared.

If we select those vines which bear 8 pods each or more, putting them in one class, with those bearing 7 pods or less in another class, and if we then subdivide each of these classes according to the average number of peas per pod on each vine, we shall have the following groups and figures: —

	8 Pods or More.	7 Pods or Less.
3.6 peas per pod or more, ...	9	66
3.5 peas per pod or less, ...	19	85

From which the following computation is made according to Yule's formula: —

$$\frac{(66 \times 19)-(9 \times 85)}{(66 \times 19)+(9 \times 85)}=\frac{489}{2019}=+0.242.$$

Showing a correlation of character in these groups of over 24 per cent.

Now, if the arbitrary division is made between vines bearing 7 pods or over and those bearing 6 pods or less, the rest of the computation following as before, we find the coefficient of correlation reduced to — 0.067; or with the division made between vines bearing 5 pods and those bearing 4, the coefficient of correlation becomes — 0.0126, showing a very little or slightly negative correlation in these groupings.

[1] See E. Davenport, "Principles of Breeding."
[2] See C. B. Davenport, p. 456, 1907, "Statistical Methods."

In plain language, it appears that the few vines bearing an abnormally large number of pods bear also an abnormally large number of peas to the pod. These would certainly be the vines which the pea grower would select in improving his stock toward greater prolificacy.

If the whole number of vines is studied in one view, without arbitrary division into classes, by the method of compound series, the correlation coefficient is found to be — 0.0176,[1] a number so small as to be entirely negligible.

While the results involved are of less practical interest, it may be worth while to give the results of other correlation studies with this same material. For instance, we may study the correlation existing between the length of vine and the number of peas per vine.

Of course we would expect the taller vines to bear the largest number of pods and of peas; and, in fact, the mathematical computation shows a correlation coefficient of +0.668[2] when it is understood that a coefficient of +1.0 shows the highest correlation that can exist, and indicates two characters absolutely dependent on one another, it will be seen that +0.668 indicates very close relationship between length of vine and number of peas borne.

If we compute in a similar manner the relation existing between the number of pods per vine and the total number of peas per vine, we find a correlation coefficient of +0.897.[3]

These peas will be made the basis of further breeding experiments, and a comparison of future generations with the crop of 1907 may be expected to develop new points of interest.

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[1] Standard deviation, pods per vine, 2.64; peas per pod, 1.14.

[2] Standard deviation, length of vine, 10.5; peas per vine, 10.3.

[3] Standard deviation, pods per vine, 2.64; peas per vine, 10.3.

The Physiological Constant for the Germinating Stage of Cress.

F. A. WAUGH; C. S. POMEROY.

The subject of physiological constants was studied several years ago by the senior writer, and a report of certain investigations made, to which the reader is referred for summaries of the theories advanced by various investigators.[1] A brief statement of the present accepted belief is here given, that the subject may be properly understood by all.

A physiological constant may be defined as the amount of heat required to carry a plant through some certain stage of its growth. Thus each species of plant and each phase of development for each species would have its own physiological constant.

De Candolle,[2] writing over fifty years ago, set forth two fundamental principles which are accepted as sound to-day: "1. The active heat is the product of the degree of temperature and its duration. A more intense heat in a short time produces the same effect as a less intense heat in a longer time. This is true, provided the range of temperature and the space of time are limited. 2. Every plant requires a certain minimum of heat for each of its physiological functions, as germinating, leafing, flowering, etc. The temperatures below freezing point have no effect on plants, or at a certain low degree a destroying one; but there are many species on which the lower degrees above the freezing point have no effect. There is a starting point of vegetation for every species at a certain degree of temperature; every species requires a certain sum of heat above a certain degree of temperature, distributed over a certain space of time between a minimum and a maximum of

[1] F. A. Waugh, Vermont Agricultural Station report, II. (1898), pp. 263–272.
[2] Alphonse De Candolle, "Géographie Botanique" (1855).

duration." This minimum of temperature, which must be reached before any development takes place, has been called the critical temperature. De Candolle considered 43° as the critical temperature for all plants. Previously it had been placed at the freezing point. Now it is known that this point varies for different species and varieties, and for different functions.

The theory as above stated assumes as the constant the sum total of temperatures above a certain minimum point for the elapsed time. Such a constant is of use in places having similar climates, but obviously is not suitable for comparisons between places having different lengths of growing seasons; for plants of the same species come to maturity in northern latitudes with a very much less sum of heat than in more southern locations. In order to correct this inaccuracy, Linsser[1] proposed the aliquot idea. To determine the aliquot for any physiological function, the sum temperature for the given phase is divided by the sum temperature for the entire year, as observed at the same station. Thus, instead of depending upon the production of a certain constant *sum* of heat, certain stages are considered as due to be completed when the sum temperatures above the critical temperature equal a definite *fraction* of the sum temperature of the year. Linsser called this fraction the physiological constant.

Another question is presented by this study of the aliquot, namely: Is the critical temperature constant for a given function and species in different latitudes? No investigations are known which have sought to determine this point, but theoretically it must be answered in the negative, as a little thought will show. If we consider this constant to be the same in all latitudes, how can we conceive of certain trees and shrubs having any dormant periods in locations where the temperature rarely falls as low as that at which they bloom in our northern climate? That is, the temperature is continually above the critical temperature, and no chance is offered for the plants to rest.

Heretofore all investigations of this subject have depended upon thermometer readings for their measurements of the sum temperatures. These readings were taken two or three times a

[1] Carl Linsser, "Die Periodische Erscheinungen des Pflanzenlebens in ihrem Verhaeltniss zu den Waermeerscheinungen." Mem. Acad. Sci., St. Petersb., sev. VII., 11 (1867), No. 7, p. 35.

day, their mean found, and that figure employed as the temperature of the day. This method has given results which were obviously very inaccurate as to the sum of heat for the time, and much more variable on some days than on others. However, in comparing different sets of observations taken in this same manner, the variations have averaged up with each other fairly well and relatively correct comparisons could be made.

For several years the division of horticulture has been carrying forward a series of investigations in this field by methods not hitherto applied to this interesting subject. The novelty and value of our methods consist in their being very much more accurate than any previously employed. Instead of depending on public meteorological reports for the computation of accumulated temperatures, we have employed the recording thermograph. This instrument makes a complete and continuous record, showing exactly the quantities of heat to which it has been exposed.

Greater accuracy was secured, secondly, by placing the thermograph in close proximity to the plants under observation. The temperatures recorded are therefore the exact temperatures to which the plants were subjected. When it is understood that previous investigators have been forced in many cases to accept meteorological records taken many miles from the plants under observation, it will be seen that this feature of our work constitutes a considerable improvement.

In the third place, much greater accuracy was secured in methods of computing sum temperatures. Having a perfect record from the thermograph, there remained only the problem of securing an exact measurement of the heat quantities thereon represented. This problem was solved by the use of the planimeter. The thermograph record appears in the form of an irregular line having a generally horizontal direction. If the height of this line, representing degrees of temperature, be measured from some base line (as, *e.g.*, the zero of the thermometer), we may readily construct a figure which offers an exact geometrical representation of the quantity of heat which we seek to measure. Such figures are shown in Fig. 1. Horizontal distances represent degrees of heat; so that the product of length by height, giving the area of the figure, gives also the quantity of accumulated heat.

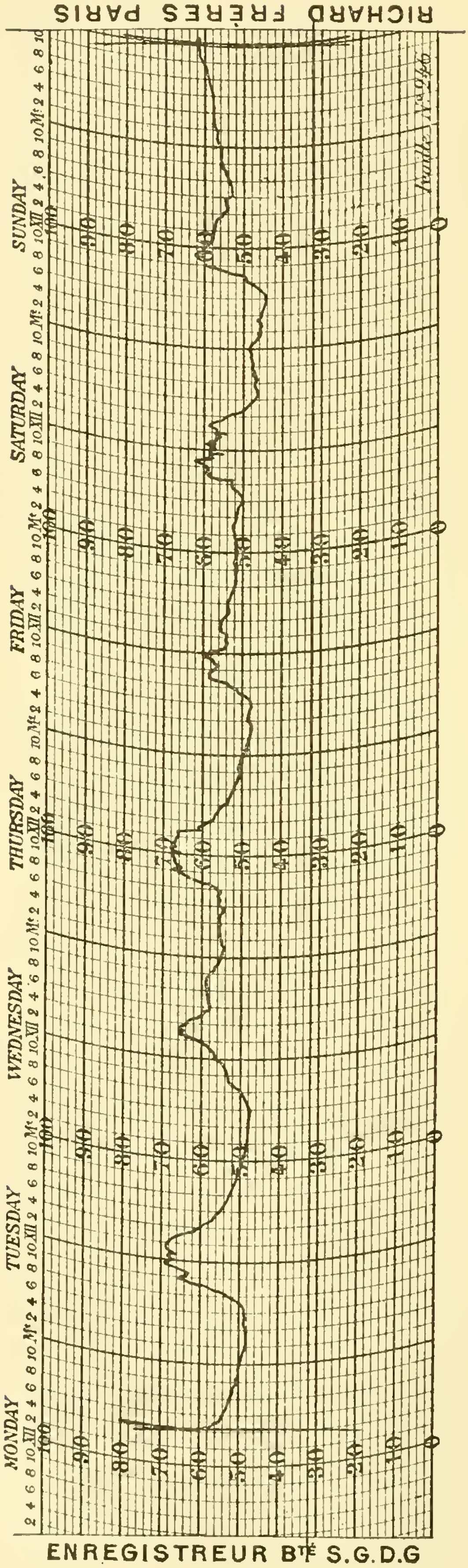
RICHARD FRÈRES PARIS
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
ENREGISTREUR Bté S.G.D.G

FIG. 1.

In our work we have used a Coradi rolling sphere planimeter, which is one of the most reliable and accurate styles of planimeter in the market.

In seeking to apply the method here outlined to the actual determination of specific physiological constants, the first requisite was a plant which would pass through its various stages rapidly, so that a number of observations could be made in a comparatively short time; the phase in question must be one easily reproduced, and several individuals of the same age should be under observation at the same time, in order that the length of time required for the completion of the phase may be noted for a greater number. The germination stage of common curled cress was chosen for observation, as it seemed to satisfy the required conditions. Germination is rapid at ordinary temperatures, and is very uniform, and the phase can be studied at all seasons of the year, out of doors or in the greenhouse.

During the past few months 77 thermograph records have been obtained of this phase, and tabulated for study. In these records the sum temperatures above 32° have varied from 2,714 to 4,286, and the time occupied for the completion of the stage from 70 to 210 hours. The problem now, with these figures before us, is to determine at once two unknown quantities: first, the critical temperature; and second, the constant quantity of heat above that temperature required to complete the germination phase in the cress plant.

The method of making this computation will be readily

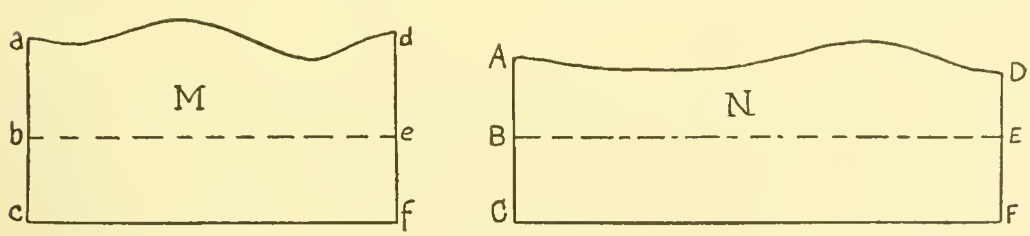

FIG. 2.

understood from the diagram (Fig. 2). The figure M represents one thermograph record for one experiment, and the figure N another record for another experiment. The lines c f and C F represent the 32° or base line. The irregular lines a d and A D represent the temperature trace. The lines b e and B E represent the critical temperature. Temperatures below b e and B E are assumed to have no effect on the germination of the cress seeds. It is required first to determine the height of b e above c f, which height is assumed to be the same as the height of B E above C F.

According to our assumptions, the area of the figure a b e d is equal to the area of the figure A B E D. If we let the height b c = B C = x; and if we let the elapsed time in hours for figure M represented by c f = y; and let the elapsed time in hours for figure N be represented by C F = y'; then allowing m to represent the total sum temperature for the figure M = (a c f d), and n to represent the total sum temperature above zero recorded in the figure N (A C F D), we may form the following algebraic equation : —

$$m - yx = n - y'x$$

$$(y - y')x = m - n$$

$$x = \frac{m - n}{y - y'}.$$

As the quantities m, n, y and y' are all directly measurable on any two thermograph records thus compared, x may be easily computed in concrete numbers.

Some difficulty arises in the use of this formula for determining the value of x, as when any single thermograph record is compared successively with several others taken at random, decidedly irregular results follow. Values for x can be found varying all the way from —1° to + 60°; and though the majority of values lie between 5° and 10°, there is still too great variation to make the result satisfactory. This comparatively great variation is due, however, not to any essential inaccuracy in the method, but the smallness of the numbers employed.

In order to get rid of the relatively great variations shown in individual comparisons and to find a reliable average for the whole body of records, these records were plotted as shown in Fig. 3. Here each dot shows the result of a single experiment, referred to a horizontal axis for time and to a vertical axis for accumulated temperature. The distribution of these dots demonstrates at once the practically uniform character of the results.

It is now an easy matter to draw the line A B, forming the axis along which these dots cluster, and which may be assumed to be the theoretical locus of them all.

Having now this average of values shown in the line A B, we may take any time values, as 100 hours and 150 hours, and find immediately the corresponding sum temperatures, — 3,140

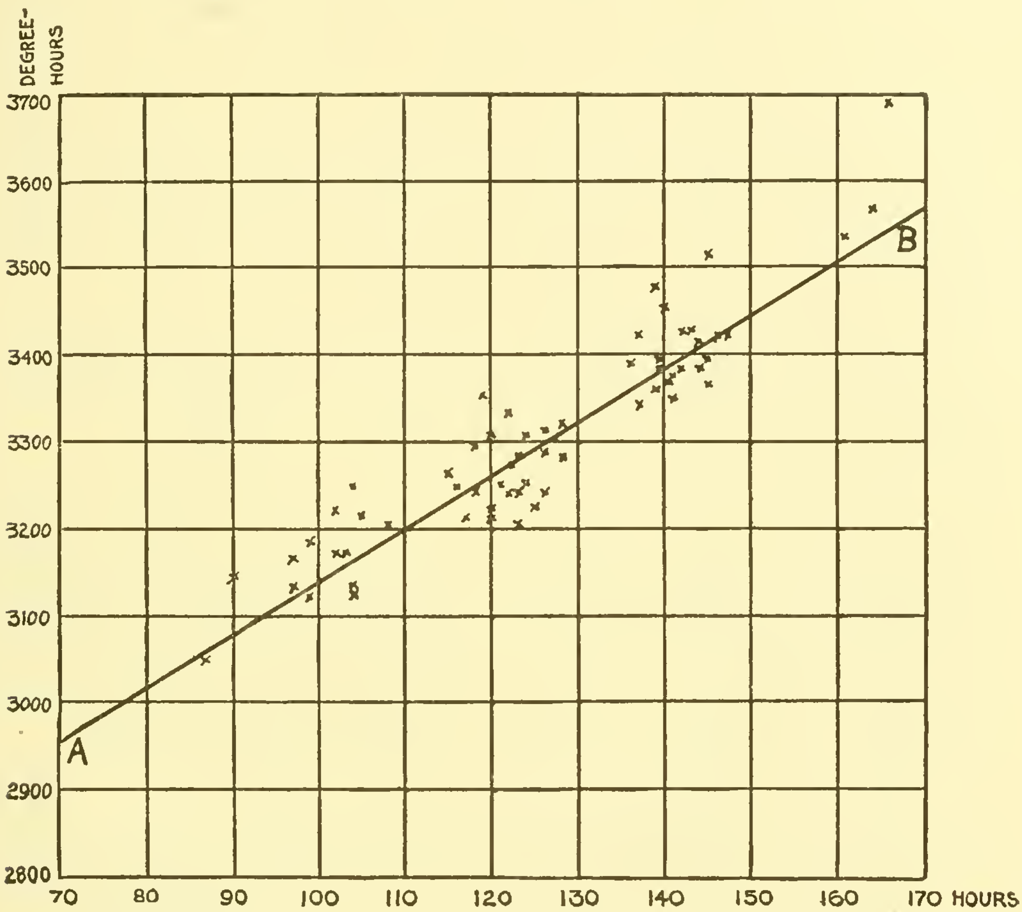

FIG. 3.

and 3,445 degree-hours. Substituting these values in the equation already formed, we find the value of x to be 6.2°. Adding this amount to 32°, the base from which we are computing, we have 38.2°, the critical temperature for the germination phase of cress.

The constant sum temperature above 38.2° required for the germination of cress should now be easily found by subtracting from each sum temperature as taken the amount of temperature intervening between 32° and 38.2°. This is secured simply by multiplying the elapsed time by 6.2°.

Applying this method to the records in hand, we find that fairly constant results are secured, according to our expectations. The records at the extreme ends of the scale, especially at the upper end, deviate considerably from the average, but this was to have been expected, and for present purposes these records may fairly be excluded. It seems proper further to throw out three or four other records which on account of excessive deviation are open to suspicion. With these apparently abnormal records temporarily eliminated (they are to be studied further in additional experiments), we secure results which are rather remarkably uniform. Thus, the constant sum temperature being computed to be 2,530 degree-hours, the extreme deviation is less than 100, and the standard deviation is only 36.6°. The probable error is only 24.7°.[1]

Thus, the temperature being known, and lying within reasonable limits, the germination period of cress can be computed in advance within a range of approximately two hours.

The tabulated records used in these computations are appended to this report.

A few abnormal records have been reserved for further study, and there have arisen one or two intricate questions relating to the whole theory of the physiological constant which must be investigated further; but as the figures stand they seem to represent a considerable advance in this interesting field.

Tabulation of Thermograph Records.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
87,	3,054	2,516
90,	3,148	2,590
97,	3,135	2,533
97,	3,164	2,562
98,	3,126	2,518
99,	3,186	2,572
100,	3,127	2,507
102,	3,221	2,589
103,	3,173	2,535

[1] "Standard deviation" is the geometric mean of deviations. "Probable error" is defined as that departure from the mean, on either side, within which exactly one-half the variates are found.

Tabulation of Thermograph Records — Continued.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
104,	3,253	2,608
104,	3,126	2,481
105,	3,217	2,566
108,	3,205	2,536
115,	3,263	2,550
116,	3,249	2,530
117,	3,216	2,491
118,	3,245	2,513
118,	3,296	2,564
119,	3,352	2,614
120,	3,311	2,567
120,	3,214	2,470
120,	3,217	2,473
121,	3,253	2,503
122,	3,241	2,485
122,	3,336	2,570
123,	3,246	2,484
123,	3,206	2,444
123,	3,283	2,521
124,	3,309	2,541
124,	3,285	2,517
124,	3,258	2,490
125,	3,228	2,463
126,	3,290	2,509
126,	3,241	2,460
126,	3,316	2,535
128,	3,286	2,492
128,	3,310	2,516
136,	3,394	2,550
137,	3,341	2,491
137,	3,427	2,577
139,	3,479	2,617
139,	3,385	2,523
139,	3,398	2,536
139,	3,362	2,500
140,	3,376	2,508

Tabulation of Thermograph Records — Concluded.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
140,	3,451	2,583
141,	3,350	2,476
141,	3,372	2,498
142,	3,428	2,548
142,	3,381	2,501
143,	3,431	2,545
144,	3,417	2,524
144,	3,384	2,491
145,	3,397	2,538
145,	3,367	2,508
146,	3,425	2,520
147,	3,423	2,511
161,	3,536	2,538

Constant sum temperature, ... 2,530 degree-hours.
Standard deviation, ... 36.6°
Probable error, ... 24.7°

REPORT OF THE CHEMIST.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

JOSEPH B. LINDSEY.

Research division: E. B. HOLLAND and R. D. MACLAURIN.
Fertilizer division: H. D. HASKINS, E. T. LADD,[1] W. E. DICKINSON.[2]
Feed and dairy division: P. H. SMITH and L. S. WALKER.
Inspection of fertilizers, feeds and Babcock machines: W. K. HEPBURN.
In charge of feeding experiments: R. F. GASKILL.
Clerk and stenographer: HARRIET M. COBB.

PART I. — THE WORK OF THE YEAR BRIEFLY OUTLINED.

1. Correspondence.
2. Numerical summary of laboratory work.
3. Execution of the fertilizer law.
4. Miscellaneous fertilizers, soils and by-products for free analysis.
5. Execution of the feed law.
6. Milk, cream and feeds sent for free examination.
7. Execution of the dairy law.
8. Sanitary analysis of drinking water.
9. The testing of pure-bred cows.
10. Special chemical work.
11. Work completed.
12. Work in progress.

PART II. — DAIRY AND CHEMICAL STUDIES.

1. The chemical composition of milk.
2. The effect of food on the composition of milk and butter fat, and on the consistency or body of butter.
3. Standard for Babcock glassware.

[1] Resigned Jan. 1, 1908. [2] Resigned Dec. 1, 1907.

Part I. — The Year's Work briefly outlined.

J. B. LINDSEY.

On July 1, the division of foods and feeding and the fertilizer division were united, and termed the department of plant and animal chemistry.

A new division was created, to be known as the research division. This latter division will devote itself to the study of problems in animal nutrition and investigations in plant and animal chemistry.

The fertilizer division takes charge of the annual inspection of commercial fertilizers, examines samples of fertilizers, refuse manurial substances and soils sent to the station, and will devote the remainder of its time to other problems either of a control or research nature.

The feed and dairy division has charge of the execution of the feed and dairy laws, examines samples of water, supervises the testing of pure-bred cows, analyzes samples of feed stuffs and dairy products connected with experiments in progress at the station as well as those sent in for examination.

A brief outline of the work follows, and includes that of the two separate divisions *previous* to the reorganization.

1. Correspondence.

The enactment of an amendment to the fertilizer law, requiring the publication of station valuations, the local dealer's retail cash price and the percentage difference between the two, has noticeably increased the correspondence during the past year. In addition to the above, a large number of letters has been received and answered relative to problems connected with fertilizers, feed stuffs and dairying. Numerous analyses of fertilizers, feed stuffs, dairy products and water have been reported directly to the manufacturers, local agents and private persons. The estimated number of letters of all kinds sent out from Dec. 15, 1906, to Dec. 1, 1907, — eleven and one-half months, — approximated 5,395.

2. Numerical Summary of Laboratory Work.

From Dec. 15, 1906, to Dec. 1, 1907, there have been received and examined 99 samples of water, 529 of milk, 1,732 of cream, 135 of feed stuffs, 176 of fertilizers and fertilizer materials, 48 soils and 21 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 338 samples of milk, 40 samples of cream, 52 samples of butter, 68 samples of butter oil, 111 samples of cattle feeds, 336 samples of agricultural plants, 31 samples of soils and 32 samples of fertilizers. There have also been collected and examined 841 samples of cattle feeds in accordance with the requirements of the feed law, and 513 samples of fertilizer in accordance with the fertilizer law. The total for the year has been 5,102.

In addition to the above, twenty-one candidates have been examined and given certificates to operate Babcock machines, and 3,082 pieces of Babcock glassware have been tested for accuracy of graduation, of which 204, or 6.62 per cent., were inaccurate.

3. Execution of the Fertilizer Law (Acts of 1896, Chapter 297, and 1907, Chapter 289).

Since July 1, Mr. H. D. Haskins has assumed charge of this work, and has carried it forward with energy and perseverance. Mr. Haskins submits the following report: —

A new fertilizer act, passed by the State Legislature and approved April 11, 1907, reads: —

Be it enacted, etc., as follows:

Section 1. The bulletins or other publications of the Massachusetts agricultural experiment station containing information about fertilizers shall, in all cases, state the dealers' cash price per ton for such fertilizers, the value per ton of the ingredients of the same, and the percentage of difference between the said price and the said value.

Section 2. This act shall take effect upon its passage.

In compliance with the above act, the necessary data have been collected, and fertilizer Bulletin No. 119 gives, in detail, the required information as well as the method employed in obtaining the same.

During the season 513 samples, representing 358 distinct brands, have been analyzed and the results have been published. (See Bulletin No. 119, December, 1907.) Forty-five more licensed brands were analyzed than during the previous year. Seventy-seven manufacturers, importers and dealers have secured licenses for 317 distinct brands of fertilizer during 1907.

Samples were taken in about 80 different towns and cities in the State. Of the 358 brands analyzed, 275 were complete fertilizers; 38 were materials furnishing nitrogen and phosphoric acid, such as ground bone, tankage and dry ground fish; 14 were potash compounds; 9 were phosphoric acid compounds; 15 were compounds furnishing nitrogen; and 7 were compounds furnishing potash and phosphoric acid.

Trade Values of Fertilizing Ingredients for 1907.

	Cents per Pound.
Nitrogen: —	
In ammonia salts,	17½
In nitrates,	18½
Organic in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers,	20½
Organic nitrogen in fine bone and tankage,	20½
Organic nitrogen in coarse bone and tankage,	15
Phosphoric acid: —	
Soluble in water,	5
Soluble in ammonium citrate (reverted),	4½
In fine bone and tankage,	4
In coarse bone and tankage,	3
In cotton-seed meal, linseed meal, castor pomace and wood ashes,	4
Insoluble (in neutral citrate of ammonia in mixed fertilizers),	2
Potash: —	
As sulfate, free from chloride,	5
As muriate (chloride),	4¼
As carbonate,	8

The above prices were made up from quotations obtained for the six months preceding March 1, 1907, and actually show the price at which the various ingredients were retailed in markets at centers of distribution in New England, New York and New Jersey.

The average comparative commercial value of the 275 brands of complete fertilizer analyzed was $24.19, the average retail cash price $35.40 and the percentage of difference 44.85.

Of the 275 brands, 113, or about 41 per cent., failed to meet the manufacturers' guaranty in some one or more of the essential elements; many of these deficiencies were made up by an excess of some one or more of the other essential ingredients. Twenty-one of the samples of complete fertilizers, however, showed a commercial shortage ranging from 79 cents to $13.50 per ton.

Eighty-six brands were deficient in one, 23 in two and 4 in all three of the essential elements of plant food. Seventy were deficient in nitrogen, 43 in potash and 28 in phosphoric acid.

Among the 38 brands of ground bone, tankage and dry ground fish, 16 failed to meet the guaranty in nitrogen and 4 in phosphoric acid; only a few of these brands, however, show a commercial shortage. The average retail cash prices, valuations and percentages of difference of the ground bones, dissolved bones, tankages and dry ground fish were as follows: —

	Retail Cash Price.	Valuation.	Percentage Difference.
Ground bone,	$29 46	$27 45	7.32
Dissolved bone,	25 50	25 03	1.88
Tankage,	21 67	29 93	27.60 [1]
Dry ground fish,	39 00	39 89	2.23 [1]

[1] Valuation in excess of selling price.

In case of chemicals and other raw materials, it may be said that 2 samples of nitrate of soda, one sample of dried blood and 5 samples of cotton-seed meal failed to meet the nitrogen guaranty. Two samples of muriate of potash and one sample of carbonate of potash did not meet the potash guaranty. One sample of superphosphate, 1 sample of dissolved bone black and 2 samples of dissolved phosphates and potash fell below the phosphoric acid guaranty.

Cost of One Pound of Nitrogen, Phosphoric Acid and Potash in Raw Materials.

	Cents.
Nitrogen: —	
From nitrate of soda,	19¼
From dried blood,	22½
From cotton-seed meal,	23⅗
From linseed meal,	24⅖
From castor pomace,	23¼
Potash: —	
From carbonate of potash,	8
From sulfate of potash,	5⅖
From muriate of potash,	4½
Available phosphoric acid: —	
From dissolved bone black,	7½
From acid phosphate,	5⅕

A pound of total phosphoric acid in "Thomas slag phosphate" has cost the consumer on the average about 5 cents.

Summary of Analyses of Complete Fertilizers, 1907.

The table below shows the comparative quality of the brands of complete fertilizer analyzed during the year, and gives the following information concerning each manufacturer: (*a*) the number of brands of complete fertilizer collected and analyzed; (*b*) the number of brands in which all three of the essential ingredients of plant food are equal to the lowest guaranty; (*c*) the number which do not show a commercial shortage, including those fertilizers where a deficiency of any one element is offset commercially by an excess of some of the other essential ingredients; (*d*) the per cent. of the whole number of complete fertilizers sold by each company not having a commercial shortage. The last three columns indicate the number of brands deficient in one, two and in all three of the essential elements of plant food.

TABLE I.

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
W. H. Abbott,	3	1	3	100.00	2	–	–
American Agricultural Chemical Company.	61	45	58	95.08	14	2	–
Armour Fertilizer Works,	10	8	10	100.00	1	1	–
Beach Soap Company,	3	1	2	66.66	2	–	–
Berkshire Fertilizer Company,	4	2	4	100.00	2	–	–
Bonora Chemical Company,	1	–	1	100.00	1	–	–
Bowker Fertilizer Company,	33	19	29	90.00	8	6	–
J. Breck & Son,	4	1	1	25.00	3	–	–
Buffalo Fertilizer Company,	4	–	1	25.00	3	1	–
Coe-Mortimer Company,	7	2	3	42.85	4	1	–
Eastern Chemical Company,	1	–	1	100.00	1	–	–
Eureka Liquid Fertilizer Company,	1	–	–	–	–	–	1
R. & J. Farquhar & Co.,	5	4	4	80.00	–	1	–
Fertilizer Products Company,	1	1	1	100.00	–	–	–
C. W. Hastings,	1	–	–	–	1	–	–
Lister's Agricultural Chemical Works,	7	5	6	85.71	2	–	–
Mapes Formula & Peruvian Guano Company.	16	12	16	100.00	4	–	–
Mitchell Fertilizer Company,	1	–	1	100.00	1	–	–
National Fertilizer Company,	15	8	13	86.66	5	2	–
New England Fertilizer Company,	7	4	6	85.71	2	1	–
Olds & Whipple,	4	3	4	100.00	1	–	–
Parmenter & Polsey,	2	2	2	100.00	–	–	–
R. T. Prentiss,	3	–	–	–	–	1	2
Benjamin Randall,	2	1	2	100.00	–	1	–
W. W. Rawson & Co.,	3	3	3	100.00	–	–	–
Rogers & Hubbard,	8	4	8	100.00	4	–	–
Rogers Manufacturing Company,	8	5	7	87.50	3	–	–
Ross Brothers,	1	–	1	100.00	1	–	–
N. Roy & Son,	1	–	–	–	1	–	–
Russia Cement Company,	11	7	11	100.00	4	–	–
Sanderson Fertilizer Company,	4	1	1	25.00	2	1	–
M. L. Shoemaker,	1	1	1	100.00	–	–	–
Smith Agricultural Chemical Company.	8	1	4	50.00	4	2	1
Sterling Chemical Company,	1	–	1	100.00	–	1	–

TABLE I — *Concluded.*

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
Swift's Lowell Fertilizer Company, .	14	3	12	85.71	10	1	–
Tavender Process Company, . .	1	1	1	100.00	–	–	–
Whitman & Pratt, ...	4	3	4	100.00	1	–	–
Wilcox Fertilizer Works, . . .	6	6	6	100.00	–	–	–
A. H. Wood & Co., ...	1	1	1	100.00	–	–	–

Summary of Analyses of Ground Bone, Dissolved Bone, Tankage and Dry Ground Fish, 1907.

The following table presents the same information as the previous one, with the exception of the column giving the percentage number which do not show a commercial shortage; this was omitted on account of the small number of brands of these raw materials licensed by each manufacturer.

TABLE II.

MANUFACTURER.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
W. H. Abbott, ...	1	1	1	–	–
American Agricultural Chemical Company, . .	1	–	–	1	–
Armour Fertilizer Works, ...	1	1	1	–	–
Beach Soap Company, ...	1	–	1	1	–
Bowker Fertilizer Company, ...	4	2	4	2	–
Buffalo Fertilizer Company, ...	1	–	–	–	1
John C. Dow & Co., ...	1	1	1	–	–
R. & J. Farquhar & Co., ...	1	–	1	1	–
Thomas Hersom & Co., ...	2	2	2	–	–
Home Soap Company, ...	1	1	1	–	–
Geo. E. Marsh Company, ...	1	–	1	1	–
D. M. Moulton, ...	1	–	–	–	1

TABLE II — *Concluded.*

Manufacturer.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
National Fertilizer Company,	2	–	1	2	–
Olds & Whipple,	1	1	1	–	–
Parmenter & Polsey Fertilizer Company,	1	–	1	1	–
W. W. Rawson & Co.,	1	1	1	–	–
Rogers & Hubbard Company,	2	1	2	1	–
Rogers Manufacturing Company,	1	1	1	–	–
Russia Cement Company,	1	1	1	–	–
Sanderson Fertilizer and Chemical Company,	1	–	–	1	–
Springfield Rendering Company,	2	1	2	1	–
Swift's Lowell Fertilizer Company,	4	2	3	2	–
T. L. Stetson,	1	–	1	1	–
A. L. Warren,	1	1	1	–	–
Whitman & Pratt Rendering Company,	1	–	1	1	–
Wilcox Fertilizer Works,	1	1	1	–	–
Sanford Winter & Son,	1	1	1	–	–
J. M. Woodard & Bro.,	1	1	1	–	–

4. Miscellaneous Fertilizers, Soils and By-products for Free Analysis.

During the past season 208 samples of fertilizer and refuse by-products used for fertilizing purposes, 79 soils and 25 miscellaneous substances have been fowarded for analysis by farmers and others interested in agriculture. The greater part of these samples have been taken according to printed instructions forwarded from this office. It is the usual custom, when application is made for free analysis, to send the applicant the necessary directions for taking an average sample. This is of the utmost importance, for unless an average sample is furnished, a representative analysis cannot be obtained. As a general thing, these samples are analyzed in the order of their arrival. During the season of the inspection of commercial fertilizers we are not able at all times to promptly attend to the requests for the analysis of this class of materials. Samples are, however, tested as promptly as possible, and reported together with whatever information has been asked for by the applicant. Samples received during the fall and winter months can be examined more quickly, and will ordinarily be reported in a few days after they are received.

5. Execution of the Feed Law (Acts of 1903, Chapter 122).

Since July 1, Mr. P. H. Smith has been charged with carrying out the provisions of this act, and has proved his ability to handle the work to the complete satisfaction of the writer. At the beginning of the year 1907 the inspector made a complete canvass of the State, and collected 477 samples, all of which were examined during the winter and early spring months. It was not possible to publish the results in bulletin form, but the analyses of those falling substantially below the guaranty, or in which any inferior condition was noted, were reported to the manufacturer, with such comments and suggestions as the circumstances seemed to warrant.

The chief result of the inspection was the discovery of numerous lots of inferior cotton-seed meal. Because of heavy rainfalls in the autumn of 1906, large quantities of cotton-seed were considerably damaged, and as a result much of the meal was seriously off grade in color, texture and chemical composition. Of the 75 samples examined, 65 were guarantied to contain 41 or more per cent. protein; and of this number 75 per cent. fell below the guaranty, some very much more so than others. Those samples put out by Kaiser & Brown, Memphis, Tenn., bore a 41 per cent. guaranty and tested 20 to 21.50 per cent. of protein, and were unquestionably fraudulent. Of the 18 lots of Star Brand put out by the J. Lindsey Wells Company, Memphis, Tenn., only 3 met their guaranties; 8 fell nearly 5 per cent. of protein below the minimum, and 7 showed a deficit of 5 to 7 per cent.

While it was naturally beyond the power of man to control the weather conditions, it is believed that many southern brokers were decidedly lax in their method of dealing, and attached a 41 per cent. protein guaranty to whatever meal they shipped, without any particular regard to its quality.

The writer is also convinced that certain northern jobbers soon discovered that the meal they were receiving was inferior to the guarantied representations. They proposed, however, to take their chances, and, in case they were found out, plead ignorance and bad weather; and, if absolutely necessary, settle with the local dealer with the least loss to themselves. The station, by all means in its power, endeavored to keep both the dealer and consumer informed regarding the true conditions. A special circular of 8 pages was prepared and sent to every important feed dealer in the State. All samples of meal received from local dealers and private parties were examined and the results reported within two or three days.

Beginning in late August, 1907, the inspector canvassed the State, and completed his work about the middle of October, collecting 364 samples, all of which have been examined chemically and many also submitted to a microscopic analysis. Concentrated feeds have ruled exceptionally high in price, and many dealers were carrying very limited stocks, some of the ordinary brands being temporarily out of the market. Comparatively few violations of the law were noted, and these were mostly of a technical character. The results of the autumn inspection are now in press (December, 1907), and will appear in bulletin form.

Only one new feed was found during the present autumn. It is known as flax feed, and is composed substantially of one-third small and imperfectly developed flax seed and two-thirds of a variety of ground weed seeds. It has an extremely bitter taste. It has been fed to several cows in the station herd, and no objectionable taint was noted in the milk. The cows ate it rather grudgingly when fed by itself, but consumed it readily when mixed with other grains. The price asked — $26 a ton — is considered high.

6. Milk, Cream and Feeds sent for Free Examination.

Many dairymen frequently send samples of milk and cream to be tested for total solids and fat, in order to ascertain the quality of the product yielded by the cows composing their herds. The State and local boards of health, as well as the large milk contractors, keep a watchful eye over the composition and condition of the milk supply of the State, and many producers frequently receive warning that their product is deficient in one or more particulars. This induces them to send samples to the station for examination and to ask for advice. The milk is examined promptly, and the results, together with the necessary comments, are forwarded without delay. The station is always ready, to the full extent of its resources, to lend a helping hand to such as ask. One creamery sends all of its samples to the station to be tested for butter fat, and two others send a number of samples every two weeks. A charge is made in such cases, to cover the necessary expense.

Samples of feeds are constantly received from farmers, local dealers and jobbers, who wish to ascertain not only if the materials sent are as represented, but also regarding their particular feeding value. In most cases a partial chemical or microscopic analysis only is necessary to enable one to furnish the desired information. There is a constant tendency on the part of some jobbers to use the station in place of private chemists. It must be distinctly understood that, while it is the aim of the station to furnish all parties with whatever special information its equipment makes possible, its laboratory cannot be continually at the call of those engaged in private business operations.

7. Execution of the Dairy Law (Acts of 1901, Chapter 202).

This law requires the station (*a*) to test, for accuracy of graduation, all glassware used in connection with the Babcock test or any other test in determining the value of milk and cream; (*b*) to examine for competency all parties operating such tests; and (*c*) to inspect yearly all machines thus used. The station is given authority to collect, from the parties for whom the work is done, sufficient money to cover the actual expense involved.

It is believed that the law could be improved by the addition of an amendment providing a small yearly appropriation ($400), to enable the station to make semiannual inspections of machines and operators, and by giving it authority to remove all operators who employed dirty glassware and who were not conscientiously performing their duties. The result of the year's work may be summarized as follows: —

(*a*) *Testing of Glassware.* — Each piece of glassware found to be correct has the words "Mass. Ex. Sta." etched on. There were examined 3,082 pieces, of which 204, or 6.62 per cent., were condemned.

(*b*) *Examination of Candidates.* — Twenty-one candidates were examined during the year 1907. Most of those presenting themselves for examination had a fair understanding of the process, although it was frequently necessary to refuse certificates, insist on further preparation and a second examination. It is believed that the station would be false to its trust if it allowed candidates to pass who did not have a satisfactory theoretical and practical understanding of the method of procedure.

(*c*) *Inspection of Babcock Machines.* — The annual inspection of Babcock machines was made in November of 1907. Of the 36 places visited, 22 were creameries, 11 milk depots, 2 city milk inspectors and 1 a chemical laboratory. Sixteen of the creameries were co-operative and 5 were proprietary or managed by stock companies. The 11 milk depots in operation were in every case proprietary.

Thirty-seven machines were inspected, of which 2 were condemned and 1 was found needing additional heat. The machines in use are 14 Facile, 9 Agos, 6 Wizard, 5 Electrical and 2 Stoddard.

The glassware as a whole was clean, but a few still use very dirty bottles and 3 were found using untested glassware. Following is a list of creameries and milk depots now in operation that pay by the Babcock test: —

1. Creameries.

Location.	Name.	President or Manager.
1. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
2. Belchertown,	Belchertown Co-operative,	M. G. Ward, president.
3. Brimfield,	F. N. Lawrence,	F. N. Lawrence, proprietor.
4. Cheshire,	Greylock Co-operative,	C. J. Fales, president.
5. Cummington,	Cummington Co-operative,	W. E. Partridge, manager.

1. Creameries — Concluded.

Location.	Name.	President or Manager.
6. Egremont,	Co-operative,	E. A. Tyrrell, manager.
7. Easthampton,	Hampton Co-operative,	W. H. Wright, superintendent.
8. Heath,	Cold Spring,	F. E. Stetson, manager.
9. Hinsdale,	Hinsdale Creamery Company.	W. C. Solomon, proprietor.
10. Lenox,	Lenox Creamery,	P. A. Agnew, manager.
11. New Salem,	New Salem Co-operative,	W. A. Moore, president.
12. Monterey,	Berkshire Co-operative,	F. A. Campbell, manager.
13. North Orange,	North Orange Co-operative,	C. E. Dunbar, manager.
14. Northfield,	Northfield Co-operative,	L. R. Smith, superintendent.
15. Shelburne,	Shelburne Co-operative Creamery.	Ira Barnard, manager.
16. Shelburne Falls,	Shelburne Falls Creamery,	T. M. Totman, proprietor.
17. Springfield,	Tait Bros.,	Tait Bros., proprietors.
18. Westfield, P. O. Wyben Springs.	Wyben Springs Co-operative,	C. H. Wolcott, manager.
19. West Newbury,	West Newbury Co-operative,	R. S. Brown, manager.
20. Williamsburg,	Williamsburg Creamery,	D. T. Clark, manager.
21. Worthington, P. O. Ringville.	Worthington Co-operative,	M. R. Bates, superintendent.

2. Milk Depots.

Location.	Name.	President or Manager.
1. Cambridge,	C. Brigham Company,	J. R. Blair, manager.
2. Cheshire,	Ormsby Farms,	E. B. Penniman, proprietor.
3. Beverly,	Cherry Hill Farm,	Henry Fielden, superintendent.
4. Dorchester,	Elm Farm Milk Company,	J. H. Knapp, manager.
5. Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
6. Southboro,	Deerfoot Farm,	S. H. Howes, manager.
7. Boston, P. O. Charlestown.	D. W. Whiting & Sons,	George Whiting, manager.
8. Boston, P. O. Charlestown.	H. P. Hood & Sons,	Wm. Brown, manager.
9. Boston,	Boston Dairy Company,	W. A. Graustein, president.
10. Boston,	Walker-Gordon Laboratory,	Merrill B. Small, manager.
11. Boston, P. O. Roxbury,	Alden Bros.,	Alden Bros., proprietors.

8. Sanitary Analysis of Drinking Water.

The experiment station has made sanitary examinations of drinking water since its establishment in 1882. Since January, 1903, because of the abuse of the privilege of free analysis and because of the increase of other important lines of work, a charge of $3 a sample has been made. Special jars are furnished, together with full instructions for collecting and forwarding the samples. An analysis of water sent in shipper's jar will not be made, neither will bacteriological nor mineral analyses be undertaken. A sanitary analysis is made to determine whether the water is contaminated with bad drainage from privy vaults, barns or sinks. A mineral analysis is usually undertaken to ascertain the amount of the several mineral ingredients contained in the water, and thus to gain information relative to its supposed medicinal properties. Parties wishing such information are referred to private chemists.

The water examined the past year was of the usual quality. It was derived largely from springs and wells which had frequently become polluted from the ordinary sources. After the soil once becomes contaminated, it requires considerable time to purify itself, and the water is likely to be rendered unfit for use for a number of years. Too great care cannot be exercised by parties depending for their supply upon wells and springs located close to dwelling houses, barns or other buildings. Samples are sometimes found contaminated with lead. It is strongly advised that all lead pipe be removed and replaced with iron coated with asphaltum or with galvanized-iron pipe. Lead is a poison, and if it once enters the system it is very difficult to eradicate it.

9. The Testing of Pure-bred Cows.

This department continues its work in testing pure-bred cows under the rules and regulations of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeders' associations. The work for Jersey and Guernsey breeders is confined almost exclusively to consecutive monthly tests for the purpose of securing yearly records. Sixty-three cows are now in the test, which requires the services of one man nearly the entire month. Holstein breeders require, as a rule, seven-day tests, although in some cases the time limit is set at fourteen and thirty days, and in occasional instances ninety days, should the animals under test be making phenomenal records. At times between the months of December and May four or five men are thus employed.

Only one Ayrshire breeder (G. E. Stone of Littleton) is at present making a yearly test of his herd.

The station has issued a special circular, giving breeders full information relative to the making of such tests; the circular also states the rules and regulations governing the same. All records, after being verified and sworn to, are forwarded to the several cattle clubs and a duplicate copy kept on file at this office. There have been completed during the year 5 Guernsey and 30 Jersey yearly records and 70 Holstein records (53 of which were of seven days' duration, 10 for fourteen days and 7 in excess of fourteen days).

It hardly seems that it is the proper function of the experiment station to do work of this kind, but it will continue to give such matters attention until other facilities are provided for the accommodation of breeders.

10. Special Chemical Work.

The station has co-operated with the association of official agricultural chemists in studying the accuracy of methods for the determination of nitrogen and in ascertaining the most suitable methods to be used in the analysis of condensed milk. These results were reported to several referees of the association.

Mention may also be made of a study to ascertain the best methods to be employed in determining water and the several sugars in molasses, also of a determination of the fat constants of soy bean oil. These investigations will be published as a part of this report or elsewhere.

11. Work Completed.

Molasses and Molasses Feeds.

The station has made a study of the value of molasses and molasses feeds for dairy cattle, horses and swine, and has published its findings, together with the most important results secured by German and French investigators, in Bulletin No. 118, which is now ready for distribution.

The value of molasses was discussed under the following headings: composition, effect of molasses on digestibility of other feed stuffs, digestion coefficients for molasses, relative values of molasses and corn meal, and the uses of molasses as a component of the daily rations for the several important kinds of farm animals. The conclusions may be summarized briefly as follows : —

For Dairy Cattle. — No particular advantage is to be gained under ordinary conditions by the northern farmers, from the use of molasses as a food in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition, to induce a temporary maximum food consumption and for facilitating the disposal of unpalatable and inferior roughage and grain, two to three pounds daily of molasses undoubtedly would prove helpful and economical.

For fattening Cattle. — Some three pounds daily may be fed advantageously, especially during the finishing process, when the appetite is likely to prove fickle. The object at such times should be to make the food especially palatable, and thus induce a maximum consumption and also to secure a bright, sleek appearance.

For Horses. — In spite of the many reports favorable to the use of molasses for horses, the writer is not inclined to recommend to northern farmers its indiscriminate use in place of the cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive and for improving the palatability of rations, two to three pounds daily of molasses would undoubtedly prove productive of satisfactory results.

For Pigs. — These animals will consume reasonably large quantities of cane molasses daily without ill effects (one pound per one hundred pounds live weight). Small amounts (two to three ounces daily) must be given at first and gradually increased. Molasses must be fed with foods reasonably rich in protein. If skim milk is not available, a combination by weight of two parts bran, one part gluten feed, one part corn meal and one part molasses, or one part tankage, four parts corn meal and one part molasses, ought to prove satisfactory. It is believed that no particular advantage is to be gained by employing molasses for pig feeding other than an appetizer.

The residuum molasses from Porto Rico (blackstrap) is brought in tank steamers and offered in Boston at 14 cents a gallon of 12 pounds in barrel lots. It contains about 1,100 pounds of digestible organic matter in one ton, and as a food has about 75 per cent. of the value of corn meal. The particularly favorable effect of molasses as an appetizer, etc., naturally is not included in the above estimate of its worth; neither does its lack of protein as compared with corn meal nor the extra cost and bother of handling enter into the calculation.

The value of molasses feeds was summarized under composition, digestibility, for milk production and as compared with home-mixed grain rations.

It was shown that these feeds were composed of oat and barley residues, partly ground grain screenings and malt sprouts in many cases, one-fourth to one-third molasses, and sufficient gluten feed and cotton-seed meal to supply the protein guarantied.

The total digestible organic nutrients contained in molasses feeds are in excess of those contained in wheat bran, but noticeably below those contained in flour middlings and gluten feed. The amount of protein contained in bran, middlings and gluten feed is decidedly greater than in the average of the several molasses feeds. The latter class of feeds may be said to be only moderately digestible.

No advantage is to be gained from feeding molasses feeds in place of home mixtures of standard concentrates. Digestible protein in the former feeds is decidedly more expensive, and digestible matter can generally be purchased for less money in the home mixtures.

The fact that many of the prepared molasses feeds contain considerable quantities of unground weed seeds is a decided argument against their use. Weed seeds pass through the animal undigested, and are distributed with the manure and greatly increase the cost of subsequent cultivation.

The Digestibility of Proprietary Cattle Feeds.

A considerable number of mixtures of various by-products are offered as ready rations for dairy stock. Among these may be mentioned Buffalo creamery feed, Chapin's alfalfa meal, Biles union grains, H. O. and Quaker dairy feeds, Protena, Schumacher's stock feed, Sucrene, Green Diamond and Holstein sugar feeds. In addition to an analysis, the *degree of* *digestibility* is quite necessary in order to form an accurate opinion of the true nutritive value of a feed stuff. The station has tested the digestibility of all of the above-mentioned feeds, and intends publishing the detailed results.

The requirements of any ready ration, either mixed at home from standard by-products, or purchased in the form of a proprietary mixture, may be briefly stated as follows: —

1. It should be bulky, palatable, and free from mold and rancidity.

2. It should contain at least 16 pounds of digestible protein in 100.

3. It should contain substantially 70 pounds of digestible organic nutrients in 100, and not over 9 per cent. of total fiber.

The results of our observations and digestion studies have shown that only one proprietary feed — Biles union grains — substantially conformed to the above requirements. This feed contained 17.8 pounds of digestible protein, 66.7 pounds of digestible organic matter and 9.6 pounds of total fiber in 100 pounds. The other feeds showed from 7.5 to 16.1 pounds of digestible protein, from 52 to 62 pounds of digestible organic matter and from 10 to 18 pounds of total fiber in 100. Most of the above feeds are quite expensive as sources of digestible protein, and furnish digestible organic matter at a higher cost than it can be had in the ordinary standard by-products.

The Effect of Soy Beans minus the Oil, and of Soy Bean Oil on the Composition of Milk and Butter Fat, and on the Consistency or Body of Butter.

An experiment was in progress during the winter of 1906-07 to study the physiological effect of this legume upon milk and butter. The experiment is one of a series planned to ascertain the feeding effect of the various groups of substances — protein, carbohydrates and fat — upon milk secretion in general. The beans were shipped to a western oil mill to secure the removal of the oil, the percentage being reduced from 16 to 8. It was hoped that after the extraction the residue would not show over 3 per cent., but this result was not secured. It is intended to publish and discuss the experiment in detail at a future time. The most important results only are now mentioned: —

1. Soy bean meal, after the extraction of oil, had no effect in changing the relative proportions of the several milk ingredients, did not noticeably modify the chemical composition of the butter fat, and exerted no marked influence on the body of the butter.

2. Soy bean oil temporarily increased the percentage of fat in the milk, modified the composition of the butter fat by decreasing the saponification number, the percentage of soluble fatty acids and the percentage of volatile fatty acids; it increased the iodine number from 32 to 40, and hence the olein percentage, but did not change the melting point of the fat. The oil likewise produced a softer, more yielding butter, that would not stand up well at 70° F. and above.

12. Work in Progress.

Studies in Milk Secretion.

Two grade Holstein cows are being fed a continuous hay diet during an entire lactation period; two similar cows a hay and moderate grain diet during an entire period of lactation; two Jersey cows — a high grade and a pure bred — are also receiving a hay and moderate grain diet during a period of lactation.

The objects sought are: (*a*) the variations in the chemical composition of the milk and milk fat; (*b*) the milk fat constants; (*c*) the comparative composition of the milk fat from Holstein and Jersey cows under similar conditions of feed and care. It is also intended to observe, so far as possible, the general character of the butter resulting from the hay and from the hay and grain diet. This work will continue until the autumn of 1907.

Studies in Soil Analysis.

Samples of soils from Field A, which is divided into eleven different plots, and which has been under continuous treatment since 1889, are being submitted to a careful examination, to ascertain the chemical variations in the soil resulting from different methods of fertilization. The results thus far secured show very slight differences in the amount of the several constituents present. This work is a part of an experiment under the management of the agricultural department of the station.

Effect of Molasses on Digestibility.

It is a well-known fact that the addition of considerable quantities of starch, sugar and similar substances causes a distinct depression in the digestibility of the substances with which they are fed. By digestion depression is meant the checking of the digestion and an assimilation of the other substances. A number of experiments have been made and others are still in progress to study the influence of Porto Rico molasses on the digestibility of the other ingredients of different rations. The results thus far secured may be stated briefly: —

1. When molasses fed together with hay constituted from 10 to 15 per cent. of the total dry matter of the ration, little if any depression was noted.

2. With molasses composing some 20 per cent. of the dry matter of the hay ration, a depression of 4.5 per cent. was noted in the digestibility of the hay, the digestibility of the dry matter of the latter being 58 per cent. without the molasses, and 55.4 per cent. with the molasses.

3. Molasses and hay would not make a satisfactory combination for any kind of farm stock. A more suitable ration would consist of hay, together with one or more protein concentrates and molasses. Consequently, the effect of the molasses was tested upon a combination of hay and gluten feed. The results of six single trials, in which molasses composed from 17 to 24 per cent. of the dry matter of the ration (average 20 per cent.), show that the dry matter of the combination of hay and gluten without molasses was 72.3 per cent. digestible and 66.5 per cent. digestible when fed with the molasses, hence the molasses caused a depression of 8 per cent. in the digestibility of the hay and gluten.

Early Amber Sorghum.

This plant has again proved its usefulness as a forage crop. Observations have been continued relative to the quantity of seed to be sown broadcast to the acre. Last season as satisfactory results were secured from 60 pounds as from 100 pounds of seed to the acre. The present season three 20-acre plots were each fertilized alike as heretofore and on June 11 the seed was sown broadcast at the rate of 50, 40 and 30 pounds to the acre. In spite of the late seeding and dry August, the crop grew fairly well, and when cut, September 12, was just beginning to head out. The yields, on the basis of one acre, were as follows: —

Seed per Acre.

	50 Pounds Seed to the Acre.		40 Pounds Seed to the Acre.		30 Pounds Seed to the Acre.	
	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).
Plot 1,	32,000	6,944.0	–	–	–	–
Plot 2,	–	–	29,400	6,556.2	–	–
Plot 3,	–	–	–	–	28,800	6,278.4

The yields were not as heavy as were obtained the year previous (20,000 pounds to the acre), owing to the cool, dry August, which did not permit as advanced a development of the crop. From two years' observations it may be concluded that 50 to 60 pounds of seed to the acre are sufficient when sown broadcast for forage purposes. More than this is not necessary; smaller amounts permit a too coarse development of the individual plants, and also gives opportunity for the growth of weeds, especially during the early life of the sorghum plants.

Alfalfa in Massachusetts.

Observations have been continued relative to the suitability of alfalfa as a forage crop in this State. Last year three cuttings were secured from a one-sixth acre plot, equivalent to 3.65 tons of dry hay to the acre (basis of 15 per cent. moisture). The two small plots referred to in the previous report have been combined in one plot one-third of an acre in area. A growth of some 6 to 8 inches was allowed to remain during the autumn of 1906, to serve as a mulch. The plants came through the winter of 1906–07 in excellent condition, and started well in the spring, although the season was some ten days to two weeks late.

The first cutting contained considerable grass in spots, but yielded at the rate of 2.35 tons to the acre. Unfortunately, through an oversight, the weight of the second cutting (made in early August) was not taken. The third cutting (made September 19) stood about 2 feet high and yielded at the rate of 1 ton to the acre. The weather was very bad during the curing of this cutting, the hay standing in cocks under hay caps for two weeks, being shaken out once during that time. In spite of the bad weather condition, it was fairly well cured and the animals ate it readily. The entire yield for the season, on the basis of 15 per cent. water, must have been at the rate of nearly 4½ tons to the acre. In view of the results thus far secured, the writer is inclined to advise farmers to try alfalfa in a small way, to study its peculiarities carefully, and not to be discouraged if success is not attained at the first trial.

Cost of Rearing Dairy Stock.

The station raises one or two dairy calves yearly to keep up its herd which is being used for experiment purposes. An account has been kept of the food cost involved, and, while the data is not sufficiently complete for publication, it may be said that from $40 to $45 represents the cost of food consumed, when figured at market prices, until the animal reaches two years of age. The animals have been pastured during the summer and for the remainder of the year fed on first and second cut hay, some silage and not over two or possibly three pounds of grain daily. The grain ration has usually consisted of a mixture of bran and fine middlings.

Part II. Dairy and Chemical Studies.

1. The Chemical Composition of Milk.

J. B. LINDSEY.

The larger part of milk consists of water, which contains a variety of substances in suspension and solution. The substances largely dissolved in the water are casein and albumen, milk sugar and the ash or mineral matter, which together form the milk serum.[1] The fat is suspended in the milk in microscopic globules, which are semisolid, and with the serum form what is termed an emulsion.

The multitudinous analyses of milk have shown it to vary widely in composition, depending upon the breed and individuality of the cow, stage of lactation and weather conditions. Food, as a rule, has little effect in permanently changing the proportions of the several ingredients. Numerous authorities state that 100 pounds of milk of average quality should contain the following amounts of the different ingredients : —

		Pounds in 100, or Percentage.
Water,		87.00
Fat,		4.00
Albuminoids	Casein,	3.00
	Albumen,	.50
Milk sugar,		4.80
Ash,		.70
		100.00

The term "total solids" is meant to include all of the ingredients excepting water. For ordinary purposes the chem-

[1] That portion of the casein which can be removed by filtration through filter paper is not generally included in normal serum.

ist determines only the total solids and fat, and obtains the solids not fat by difference. The former two serve as an index of the chemical composition of the milk.

Composition of Milk of Pure-bred Cows.

The following data have been tabulated from authentic sources, in the hope that they will throw light on the composition of milk produced by distinct breeds of dairy cows : —

(*a*) American Data.

1. *Jerseys.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months,	Chicago Exposition,[1]	14.00	4.78	9.28
5	6 months,	Pan-American Exposition at Buffalo.[2]	13.90	4.58	9.32
25	4 months,	Louisiana Purchase Exposition, St. Louis.[1]	13.50	4.70	8.80
3	One lactation period.	New York Experiment Station.[3]	15.40	5.61	9.80
3	8 months,	New Jersey Experiment Station.[4]	14.34	4.78	9.56
		Average, 61 cows,	13.87	4.77	9.12

2. *Guernsey.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months,	Chicago Exposition,[5]	13.78	4.61	9.17
25	6 months,	Pan-American Exposition at Buffalo.[2]	13.90	4.60	9.30
2	One lactation period.	New York Experiment Station.[3]	14.60	5.12	9.47
3	8 months,	New Jersey Experiment Station.[4]	14.48	5.02	9.46
2	Probably 7 days.	Wisconsin Experiment Station.[6]	14.46	5.39	9.07
		Average, 57 cows,	13.92	4.67	9.25

3. *Holsteins.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months,	Pan-American Exposition at Buffalo.[2]	12.00	3.25	8.75
15	4 months,	Louisiana Purchase Exposition, St. Louis.[1]	11.30	3.40	7.90
70	Generally 7 days.	Wisconsin Experiment Station.[6]	11.78	3.33	8.45
1	One lactation period.	New York Experiment Station.[3]	12.39	3.46	9.07
3	Eight months,	New Jersey Experiment Station.[4]	12.12	3.51	8.61
		Average, 94 cows,	11.73	3.34	8.39

[1] The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638. This paper gives 13.71 as the total solids for Jerseys.

[2] DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).

[3] Tenth report, p. 141.

[4] Report for 1890, p. 223.

[5] Furnished by W. H. Caldwell, secretary, American Guernsey Cattle Club. Hoard's Dairyman gives 13.41 per cent. solids and 4.51 per cent. fat for Guernseys.

[6] Twentieth report, p. 158.

4. *Ayrshires.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months,	Pan-American Exposition, Buffalo.[1]	12.60	3.60	9.00
4	One lactation period.	New York Experiment Station.[2]	13.06	3.57	9.35
3	Eight months,	New Jersey Experiment Station.[3]	12.70	3.68	9.02
		Average, 12 cows,	12.78	3.61	9.12

5. *Shorthorns.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
24	3 months,	Chicago Exposition,[4]	12.41	3.64	8.77
5	6 months,	Pan-American Exposition, Buffalo.[1]	12.80	3.57	9.23
25	4 months,	Louisiana Purchase Exposition, St. Louis.[4]	12.20	3.60	8.60
2	Probably 7 days.	Wisconsin Experiment Station.[5]	12.60	3.52	9.08
		Average, 56 cows,	12.36	3.61	8.75

6. *Brown Swiss.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months,	Pan-American Exposition, Buffalo.[1]	12.70	3.63	9.07
5	4 months,	Louisiana Purchase Exposition, St. Louis.[4]	12.50	3.60	8.90
		Average, 10 cows,	12.60	3.62	8.98

7. *Devons.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
2	One lactation period.	New York Experiment Station.[2]	13.77	4.15	9.60

Summary American Data.

Breed.	Number of Cows.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys,	61	13.87	4.77	9.12
Guernseys,	57	13.92	4.67	9.25
Holsteins,	94	11.73	3.34	8.39
Ayrshires,	12	12.78	3.61	9.12
Shorthorns,	56	12.36	3.61	8.75
Brown Swiss,	10	12.60	3.62	8.98
Devons,	2	13.77	4.15	9.60

[1] DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).
[2] Tenth report, p. 141.
[3] Report for 1890, p. 223.
[4] The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638.
[5] Twentieth report, p. 158.

In addition to the above, F. W. Woll[1] gives the following: —

Summary of American Analyses for Butter Fat in Milk of Pure-bred Cows.

Breed.	No. of Cows.	Butter Fat (Per Cent.).
Jerseys,	491	4.98
Guernseys,	191	4.77
Holsteins,	679	3.28
Ayrshires,	108	3.84
Shorthorns,	370	3.73
Brown Swiss,	20	3.78
Devons,	50	4.57

(*b*) Foreign Data.

According to Hucho[2] and Koenig,[2] German authorities, the average composition of the milk of different breeds is as follows: —

Breed.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Holsteins,[3]	12.00	3.25	8.75
Ayrshires,	12.50	3.70	8.80
Shorthorns,	12.90	3.80	9.10
Devons,[3]	13.40	4.40	9.00
Jerseys,	14.70	5.00	9.70
Guernseys,	14.70	5.00	9.70

The average breed tests, conducted at the annual dairy shows of the British Dairy Farmers Associations, 1879–98 inclusive, have given the following results: [4] —

Breed.	Number of Cows	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys,	272	14.46	4.98	9.48
Guernseys,	98	13.50	4.61	8.89
Holsteins,	10	12.25	3.41	8.84
Ayrshires,	42	13.29	4.19	9.10
Shorthorns,	236	12.72	3.75	8.97
Devons,	2	14.34	4.90	9.44

[1] Twentieth report, p. 158.

[2] Hatch Experiment Station, Bulletin No. 110, pp. 6 and 7. See also Woll's Handbook, first edition, p. 213.

[3] Koenig, Die Menschlichen Nährungs- und Genussmittel.

[4] Woll's Handbook, fourth edition, 1907, p. 241.

Composition of Mixed Milk (largely Grade Cows, All Breeds).

American and Foreign.

Number Analyses.	Authority.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
793[1]	Koenig,[2]	12.88	3.69	9.19
200,000	Aylesbury Dairy Company, London,[3] .	12.90	3.90	9.00
4,103	Hatch Experiment Station,[4] . . .	13.63	4.43	9.20
110	Hatch Experiment Station,[5] . . .	13.23	4.49	8.74
5,552	Van Slyke,[6]	12.70	3.90	8.80

Naturally, the larger the proportion of cows in a given area producing thin milk, the nearer will the mixed milk in that area approach 12 per cent. solids; and the larger the proportion of cows in a given area producing thick or rich milk, the nearer will the average of the mixed milk be to 13 per cent. or more of solids.

[1] Number of cows.
[2] Koenig, Die Menschlichen Nährungs- und Genussmittel.
[3] Dairy Chemistry, Richmond, p. 120.
[4] Eighteenth report, p. 223.
[5] Bulletin No. 110 (Amherst and Northampton Milk Supply).
[6] Modern Methods of Testing Milk, p. 15.

2. The Effect of Food upon the Composition of Milk and Butter Fat, and upon the Consistency or Body of Butter.

J. B. LINDSEY.

The writer, together with a number of co-workers, from time to time has conducted a number of long-continued experiments relative to the effect of food and food constituents upon milk, butter fat and butter. Work of this sort is still in progress. The most important results thus far secured may be briefly enumerated below. The full data of the soy bean experiment have not been published.

(a) *Effect on the Milk.*

1. Different amounts of *protein* in the daily ration derived from linseed, cotton-seed, soy bean and corn gluten meals, do not seem to have any pronounced effect in changing the relative proportions of the several milk ingredients.

2. *Linseed oil* in flaxseed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage from 5 to 5.56, and slightly decreased the nitrogenous matter of the milk. This fat increase was only temporary, the milk gradually returning (in four or five weeks) to its normal fat content. The nitrogenous matter also gradually returned to normal, but more slowly than did the fat.

3. Three pounds of *cotton-seed meal* with minimum oil (8 per cent.), when fed daily to each animal, had no noticeable influence on the composition of the milk.

4. The addition of ½ to ¾ of a pound of *cotton-seed oil* to the cotton-seed meal ration appeared to increase the fat percentage of the milk about .4 of 1 per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

5. The substitution of *linseed meal* with a minimum percentage of oil (3 per cent.) in place of the cotton-seed meal and cotton-seed oil resulted in a decline of the fat in the milk to its normal percentage. This change probably was due to the removal of the cotton-seed oil from the ration, and not to the influence of the linseed meal.

6. The addition of .6 of a pound of *corn oil* to a ration made up of a mixture of grains low in fat increased the fat percentage of the milk .23 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.

7. The sudden removal of the *corn oil* from the daily ration caused a 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.

8. *Corn oil* appeared to have depressed the nitrogen percentage of 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.

9. *Corn meal* (a carbohydrate feed) was without effect on the composition of the milk.

10. Two to 3 pounds of *soy bean meal* with a minimum oil percentage (8 per cent.), fed daily to each animal, did not appear to in any way modify the proportions of the several milk constituents.

11. The addition of ½ to 1 pound daily of *soy bean oil* to a basal ration of grain and hay very slightly increased the fat percentage in the milk during the first two or three weeks (.10 per cent.). No other variation was noted.

12. The sudden removal of the *soy bean oil* from the ration caused a drop of .25 per cent. of the fat percentage of the milk. At the end of three weeks the milk had not regained its normal fat percentage.

(*b*) *Effect on Butter Fat.*

13. *Corn gluten* and *linseed meals* with a minimum percentage of oil (3 per cent.) produced a normal butter fat. *Cotton-seed and soy bean meals* with a minimum oil percentage (8 per cent.) likewise effected little change in the composition of the butter fat. *Corn meal* was without noticeable influence on the composition of the butter fat.

14. *Linseed oil* (1.4 pounds digestible oil per head daily)

produced a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and olein percentage (soft fat).

15. *Cotton-seed oil* (.5 pound daily per head) increased the melting point and the olein percentage of the butter fat.

16. *Corn oil* (.6 pound per head daily) decreased the volatile fats and increased the percentage of olein; the melting point of the fat remained unchanged.

17. *Soy bean oil* (.50 to 1 pound daily per head) caused a drop in the saponification number of some 10 points, a decrease in the soluble fatty acids and in the volatile fatty acids (Reichart-Meissl number), an increase in the iodine number (percentage of olein) from 32 to 40, while little or no change was noted in the melting point of the butter fat.

18. A rise in the iodine number (increase of olein) is a reasonably sure indication of a soft-bodied butter which will lack in firmness at a temperature of 70° F. An increase in the melting point of the butter fat is not a sure indication of a harder, firmer butter. It seems evident that the proportions of the several fats is more or less changed by an excess of oil in the feed and that this change of proportions varies the melting point in the fat in some such way as the melting point of a mixture of metals is changed by the resulting amalgamation.

(c) *Effect on Butter.*

19. The effect of *linseed meal* with a minimum percentage of oil (3 per cent.) on the general character of the butter was not positively identified.

20. *Cotton-seed meal* with a relatively high oil percentage (12.6 per cent.) produced butter that was rather crumbly when hard, and slightly salvy to the taste. Cotton-seed meal with a minimum percentage of oil (8 per cent.) likewise produced a hard, firm butter.

21. *Corn gluten meal* with a minimum percentage of oil (2 to 3 per cent.) produced a rather soft, yielding butter.

22. *Soy bean meal* with minimum oil (8 per cent.) produced butter that was rather softer and more yielding to the touch than that derived from a grain ration composed entirely of bran, ground corn and oats, gluten feed and cotton-seed meal.

23. An excess of *linseed oil* (1.4 pounds digestible oil per head daily) produced a very soft, salvy butter, with an inferior flavor.

24. The addition of *cotton-seed oil* (.5 pound per head daily) to a normal ration, or to one containing 3 pounds of cotton-seed meal low in oil, produced a softer, more yielding butter than that produced by the ration with the oil omitted.

25. The addition of *corn oil* (.6 pound daily per head) to a normal ration containing 2 pounds of corn gluten meal low in oil produced a noticeably softer butter than when the oil was omitted.

26. *Corn meal* tended to produce a reasonably hard, firm butter, of an agreeable flavor.

27. *Soy bean oil* (.5 to 1 pound daily per head) added to a grain ration produced a butter that was noticeably soft and yielding to the touch, and that would not stand up well at 70° F. and above.

The experiments thus far completed enable one to draw the following general conclusions: —

1. Neither the *proteid* nor the *carbohydrate groups*, when fed in normal amount, have any noticeable influence in changing the proportions of the several milk ingredients, nor in modifying to any marked degree the character of the butter fat as revealed by the ordinary chemical tests; such changes, so far as they are the result of food, are due to the presence of oil in the feed stuff.

2. Some proteids produce a harder, firmer butter than others, while the tendency of starchy foods is to produce a firm-bodied butter. *Vegetable oils* in excess of the normal amount produce a noticeably soft-bodied butter.

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

4. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, skill and care of the butter maker, and especially upon the character of the starter employed. Normal feed stuffs must be considered of secondary importance in establishing butter flavor.

3. Standard for Babcock Glassware.

E. B. HOLLAND, M.S.

The Massachusetts Legislature, in the spring of 1901, enacted a measure entitled "An Act to provide for the protection of dairymen,"[1] which took effect the first of July of that year. This dairy law, so called, required, among other things, that Babcock glassware should be tested for accuracy, and made it the duty of the director of the experiment station or his agent.[2] The statute designated no standards whatsoever, leaving the matter entirely to the discretion of the experiment station. After visiting several stations and consulting the official having charge of such work, a standard, methods of testing and an allowable limit of error, conforming in general to the requirements of other New England States, were adopted provisionally and published in the fourteenth and fifteenth annual reports of this station.[3]

Up to the end of the last fiscal year (Dec. 1, 1907), 18,855 pieces of glassware had been tested, of which 1,770 pieces, or 9.39 per cent., were condemned. The yearly totals recorded below show marked variations, but with a high average percentage of inaccuracy.

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[1] Acts and Resolves of Massachusetts for 1901, chapter 202, sections 1-7, Revised Laws of Massachusetts for 1902, chapter 56, sections 65-69.

[2] Sections 1, 2.

[3] Hatch Experiment Station, annual reports for 1901 and 1902.

Amount of Glassware tested.

Year.	Total Number of Pieces.	Number Inaccurate.	Per Cent. Inaccurate.
1901,	5,041	291	5.77
1902,	2,344	56	2.39
1903,	2,240	59	2.63
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
Totals,	18,855	1,770	9.39[1]

The grand totals may be further subdivided into the several classes of glassware of which they were composed : —

Character of Glassware tested.

Kind.	Total Number.	Number Inaccurate.	Per Cent. Inaccurate.
Cream bottles,	7,714	710	9.20
Milk bottles,	6,826	784	11.49
Skim milk bottles,	675	106	15.70
Pipettes,	2,834	69	2.43
Acid measures,	806	101	12.53
Totals,	18,855	1,770	9.39[1]

The manufacturers repeatedly protested against the refusal of their glassware, and asserted that similar shipments were passed in other States. Such might easily have been the case, where the error was small, due to differences in method of testing or in allowable limit of error, possibly both. In some instances the condemned pieces were forwarded to another station and retested, but even this apparently failed to satisfy the manufacturers. It became evident that further investigation was necessary in order to bring the matter to an unquestionable basis and to remove all reasonable grounds for complaint.

[1] Average.

Original Standard.

Dr. Babcock,[1] originator of the method, laid down the following requirements relative to the graduation of bottles: —

The 10 per cent. of fat represented upon the necks of the bottles correspond to a volume of 2 cubic centimeters.

In addition, this is stated to be equivalent by weight to 2 grams of water or 27.18 grams of mercury (specific gravity 13.59). No mention of temperature being made, presumably 60° F. was intended. This would indicate the Mohr cubic centimeter, and is supported by a statement of the Emil Greiner Company, under date of Dec. 3, 1906: —

When we made the first bottles for Dr. Babcock, nearly twenty years ago, we were simply told to graduate the space of 2 cubic centimeters into 50 parts, and each five parts representing 1 per cent. butter fat. Therefore, 1 per cent. is .2 of a cubic centimeter, and at that time the Mohr cubic centimeter was considered the standard.

Concerning the graduation of pipettes, Dr. Babcock stated: —

It should contain, when filled to the mark, 17.6 cubic centimeters . . . (and) . . . will deliver a little less than 17.5 cubic centimeters of milk.

Capacity in Mohr cubic centimeters was evidently the intent of the graduation.

Manufacturers' Basis of Graduation.

The eastern trade in Babcock glassware is largely supplied by three manufacturers, the Emil Greiner Company of New York, Kimball Glass Company of Chicago and Wagner Glass Works of New York. Upon request, the above firms furnished the following data relative to their standards of graduation. The Emil Greiner Company employed the Mohr cubic centimeter (1 gram of water at 15° C.), and calibrated with either water or mercury (specific gravity 13.6 at ordinary room temperature). The Kimball Glass Company used the true cubic centimeter, and calibrated with mercury (specific gravity

[1] Wisconsin Agricultural Experiment Station, seventh (1890), ninth (1892) and tenth (1893) annual reports.

13.5463 at 20° C.). The Wagner Glass Works reported 1 cubic centimeter as equal to 13.59 grams of mercury at 60° F., which was probably the Mohr cubic centimeter.

The differences were not large or the errors especially serious, but the need of a scientific standard was unmistakable, if uniformity was to be secured with a safe interchange of apparatus. Only the *limit* of error has permitted the interchange of apparatus in the past, which is a point to be noted.

Reasons for a New Standard.

With these facts at hand, it was necessary to submit the case to some recognized authority for a decision, or at least advice as to what action ought to be taken. This plan also seemed the most promising for the reason that the two parties interested, the manufacturers[1] and the State officials,[2] neither agreed with each other nor among themselves as to a standard or methods of testing. The matter was finally referred to the National Bureau of Standards at Washington, as the body best fitted to deal with the case. Director Stratton[3] wrote as follows: —

> We are decidedly of the opinion that there would be less likelihood of errors in milk-testing work if all volumes were expressed in true cubic centimeters. It of course does not make any difference what unit is used, provided the same one is used to measure the milk sample and the fat; but if — as might easily happen — the pipettes used to measure the milk are graduated on one basis and the neck of the flask on another basis, serious errors might be introduced in the result.
>
> Referring again to the question of graduating Babcock ware for testing milk, which we have given some attention, we hope that you will see your way clear to adopt as the unit in this work the true cubic centimeter at 20° C. This, we feel confident, will prevent confusion in the end, by bringing the apparatus used in testing milk and other dairy products in agreement with the volumetric apparatus used by chemists in general. While the practice of using the gram of water at a certain temperature may have possessed some advantages in Mohr's days, we doubt very much whether it would be any convenience to use such units as the gram of water at 15°, 17.5° or 20° at the present time.
>
> The use of the true cubic centimeter is necessary in all absolute work, and it cannot under any circumstances be dispensed with.

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[1] *Loco citato.* [2] Station reports and correspondence. [3] Correspondence.

New Standard.

The recommendation by the Bureau of the true cubic centimeter as the basis of graduation, because it is a well-defined unit, universally recognized, and for uniformity in volumetric apparatus, appeared worthy of acceptance. The standard or basis of graduation was eventually drafted as follows: —

SECTION 1. The unit of graduation for all Babcock glassware shall be the true cubic centimeter (0.998877 grams of water at 4° C.).

(*a*) With bottles, the capacity of each per cent. on the scale shall be two tenths (0.20) cubic centimeter.

(*b*) With pipettes and acid measures, the delivery shall be the intent of the graduation and the graduation shall be read with the bottom of the meniscus in line with the mark.

As the necessary change in graduation is slight and the manufacturers few in number, there appear no serious obstacles in the way of the adoption of the new standard, though one firm opposed it as impracticable.

Methods of Testing.

(*a*) *Babcock Bottles.* — Of the several methods[1] in vogue for testing Babcock bottles, calibration with a weighed amount of mercury was the most sensitive, because of the high specific gravity of the metal. The process had also the advantage of being generally understood and extremely simple. The figures assumed for the specific gravity of mercury, however, have usually been too high. According to the Bureau of Standards,[2] 1 cubic centimeter at 20° C. should weigh in air against brass weights 13.5471 grams. The official method was readily deduced from the above.

SECTION 2. The official method for testing Babcock bottles shall be calibration with mercury (13.5471 grams of clean, dry mercury at 20° C., carefully weighed on analytical balances, to be equal to 5 per cent. on the scale), the bottle being previously filled to zero with mercury.

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[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, pp. 280, 281; Vermont Agricultural Experiment Station, fourteenth (1901) annual report, pp. 222, 223; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 221, 222; tenth (1893) annual report, p. 125; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 47–53; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, pp. 45–49.

[2] Correspondence.

The provision as to clean, dry mercury weighed on analytical balances should be carefully observed. The scale equivalent in mercury of the ordinary bottles is stated below, and that of any other percentage can be readily calculated: —

KIND.	Capacity, in Per Cent.	Grams of Mercury at 20° C.
Cream bottles,	50.00	135.4710
Cream bottles,	30.00	81.2826
Milk bottles,	10.00	27.0942
Skim milk bottles,	.50	1.3547

A number of quick methods, that are reasonably sensitive, are employed to cull out the questionable bottles. For such a purpose they are extremely valuable, but they should never be considered official. This idea was incorporated into a section.

SECTION 3. Optional methods. The mercury and cork, alcohol and burette, and alcohol and brass plunger methods may be employed for the rapid testing of Babcock bottles, but the accuracy of all questionable bottles shall be determined by the official method.

(*b*) *Pipettes and Acid Measures.* — With Babcock pipettes and acid measures, as with other volumetric apparatus of similar character, the *delivery* is, or should be, the intent of the graduation. There has been considerable discussion on this point, but the recognized practice should not be set aside and an exception made in this case. Relative to pipettes, Director Stratton[1] wrote as follows: —

The basis of test is the actual volume of water *delivered* by the pipette when used in the manner specified under Regulations for Testing.[2]

He also went on to say that, while he could not state in absolute terms the accuracy of such pipettes when used for milk, in his opinion the error would not exceed .1 cubic centimeter. In other words, a 17.6 cubic centimeter pipette would deliver in milk approximately 17.5 cubic centimeters, — what has usually been assumed. Probably this difference with milk is largely due to viscosity, though other factors enter in. Calibra-

[1] Correspondence. [2] Circular No. 9, third edition.

tion with mercury is not permissible, as it involves many points of uncertain value, and all tests[1] based on *capacity* should be excluded.

SECTION 4. The official method for testing pipettes and acid measures shall be calibration by measuring in a burette the quantity of water (at 20° C.) delivered.

Limit of Error.

The demand of State officials as to accuracy and the claims of manufactures as to their ability to graduate within definite limits agreed very closely, consequently there was little difficulty in presenting figures acceptable to both parties.

SECTION 5. The limit of error.

(*a*) For Babcock bottles, it shall be the smallest graduation on the scale, but in no case shall it exceed five tenths (0.5) per cent., or for skim milk bottles one hundredth (0.01) per cent.

(*b*) For full quantity pipettes, it shall not exceed one tenth (0.1) cubic centimeter, and for fractional pipettes five hundredths (0.05) cubic centimeter.

(*c*) For acid measures, it shall not exceed two tenths (0.2) cubic centimeter.

The new standard was submitted to Dr. Babcock, and passed without criticism. It was also sent to Professor Woll, referee on dairy products for the association of official agricultural chemists, to be presented at the 1907 meeting, but by some oversight was not forwarded to the secretary. It will be offered at the next annual meeting.

It is desired to acknowledge the valuable assistance of the manufacturers, Director Stratton and station officials, for without their co-operation the proposed standard would not have been deduced.

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[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, p. 281; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 222, 223, tenth (1893) annual report, p. 126; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 53, 54; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, p. 49.

REPORT OF THE BOTANISTS.

G. E. STONE, BOTANIST; G. H. CHAPMAN, ASSISTANT.

1. Outline of the year's work.
2. Seed work.
3. Seasonal peculiarities.
4. Premature defoliation of trees.
5. Asparagus rust.
6. Asparagus fusarium.
7. Peony troubles.
8. Potato diseases.
9. Experiments with fungicides.
10. Influence of potash salts on potato scab.
11. Investigations relating to mosaic disease.
12. Some factors which underlie susceptibility and immunity to disease.

1. Outline of the Year's Work.

G. E. STONE.

During the past year attention has been given to the following lines of work: correspondence; observations on and investigations of various diseases; seed separation; seed germination and seed purity testing; mechanical analyses of soils; the study of mosaic troubles of tobacco and other crops; the testing of banding substances for trees; investigations of tomato rot; experiments with the spraying of potatoes; the study of the effects of temperatures, moisture, light, etc., on greenhouse crops; and a study of the meteorological conditions affecting plant diseases and the development of crops.

Mr. N. F. Monahan, who has been connected with the department since his graduation in 1903, resigned to take up practical greenhouse and market-garden work, and his place has since been filled by Mr. G. H. Chapman of the class of 1907.

From the pathologist's standpoint every season possesses distinct individuality, and the past season has been no exception in this respect. Since the meteorological conditions are never identical in any two seasons, plant diseases show considerable variation; and, while an exceptionally dry summer like the past may be conducive to the favorable development of some crops, it is also the means of checking that of others by favoring certain plant diseases. The long period of drought was especially severe for lawns, trees and shrubs, the effect being much more pronounced in the eastern than in the western part of the State.

During the year the department has changed its headquarters from the east experiment station to Clark Hall, a new building located on the college grounds, and its equipment has been enlarged to meet the increased demand of certain lines of work.

We have been obliged to sacrifice much valuable time from experiment work, owing to the difficulty experienced in moving and setting up equipment, and it has been necessary to omit certain lines of investigation from this report.

2. Seed Work.

Work has increased in this line to some extent during the past year, 359 samples of seeds having been tested and separated in 1907, as compared with 231 in 1906. During the year many improvements have been made in the appliances used for separating seed. A Bishop & Babcock blower has been installed for the separation of tobacco seed, and altogether much attention has been given to the development of improved apparatus for this work, which has resulted in the production of an exceptionally efficient method. Arrangements have also been made for separating onion seed by electric power. Constantly increasing interest is being shown in seed testing and seed separation, and in this State as well as others considerable interest has been aroused in making people realize the necessity for pure seed.

The following tables give in brief the seed work done in 1907: —

Table I. — *Records of Seed Germination, 1907.*

Kind of Seed.	Number of Samples.	Germination.		
		Average Per Cent.	Highest Per Cent.	Lowest Per Cent.
Onion,	40	86	98.5	57
Tobacco,	2	91	92	90
Corn,	9	63	100	–
Timothy,	4	98	100	96
Celery,	3	83	91	70
Miscellaneous,	189	44	100	–
Total,	247	–	–	–

Table II. — *Records of Seed Separation, 1907.*

Kind of Seed.	Number of Samples.	Weight in Pounds.	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	27	425	87.4	12.6
Tobacco,	85	47	84.5	15.5
Total,	112	–	–	–

The average germination of onion seed for 1907 was 86 per cent., and that of the preceding year 79 per cent., showing a better grade of seed for 1907 than 1906, so far as its germinating capacity is concerned. Some of the corn sent in did not germinate with repeated tests, which was apparently due to the immaturity of the seed.

The miscellaneous seeds in this list consist largely of flower and vegetable seeds. Some white pine seeds were tested, the per cent. of germination being 59, while frequently white pine seeds do not give more than 33 per cent. of germination.

Only 4 per cent. was discarded from the best tobacco seed by the process of air separation, while from the poorest sample 33 per cent. was discarded. At the present time most tobacco men grow their own seed, selecting carefully those plants representing the best types of tobacco; consequently, the seeds which are sent to us contain considerable chaff, which is blown out and included in the percentage of discarded seed. By this process of selection a more uniform type of tobacco is obtained and improvements in the crop rendered possible.

In the case of the best onion seed 1.6 per cent. was discarded by the use of the winnowing machine and 43.3 per cent. from the poorest sample.

The separation of tobacco and onion seed is quite generally acknowledged to be a wise course, and it is being practised extensively among growers in the Connecticut valley. In our opinion, this discarding of the inferior seed should be given more attention.

Seed to be tested or separated should be sent by either mail or express to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass. The work is done gratuitously by the station for people living in the State, but the postage or express charges should be paid by the person sending the samples.

3. Seasonal Peculiarities.

The extreme conditions which have prevailed during the past four years have been the cause of much injury to vegetation. In previous reports attention has been called to some of these troubles, more particularly to the extensive winter-killing which caused so much injury during the winter of 1903–04, at which time thousands of trees and shrubs were severely affected, many having been dying slowly ever since. Besides the trees which are dying, there are many others which are in a very weakened condition. Numerous oaks which were injured four years ago have died during the past two years, and some of those not yet dead are gradually becoming weaker. These trees are more noticeable in the eastern part of the State, and our attention has repeatedly been called to the serious condition of the elms, due to the same cause. Some very large specimens of this tree have died, and others are in poor condition.

Mention has previously been made in our reports of the condition of the red maples, many of which are now gradually dying, and the white and rock maples are suffering to a limited extent from the same cause. During the past spring some damage was done to the foliage of these trees by the late frosts.

The condition of the white pine roots has already been referred to a number of times in previous reports. Examinations of these have for the past four years been repeatedly made in various parts of the State, and it has been found that the injury to the fibrous roots is largely responsible for the poor condition of the foliage; but the present condition of the pine roots is much more alarming, since during the past year in a very large number of cases the small feeding roots have collapsed. This is true not only of those trees which show injury from sun scorch, but of those which appear to be perfectly healthy.

Our extensive observations connected with the effects of meteorological conditions on plants have led us to examine hundreds of roots in different localities, and we have found this poor condition of the roots to be widespread and serious. The injury involving the larger fibrous roots was observed extensively four years ago, but that affecting the smaller fibrous roots was not noted in connection with the pine until last summer.

Sun Scald.

The trunks of many apple trees which were affected by sun scald four years ago may be noticed at the present time. Two years ago a great many apple trees again showed the effects of sun scald, which was in many cases followed by canker, and this is very noticeable throughout the State on those trees which have not been pruned. It affected only the lower, shaded limbs, however, and is of little importance, being scarcely perceptible in properly pruned and well-cared-for orchards. The sun scald of two years ago affected many of our wild plants, causing much injury to the wild cornels, particularly to *Cornus stolonifera*, Michx., and *C. circinata*, L'Her.

During the past spring practically every sycamore lost its leaves when they were half grown, from the same cause, and an examination of the young wood of the sycamores showed that all last year's growth was injured; but as the sycamore is a difficult tree to kill by defoliation, from whatever cause, buds were thrown out from the old twigs, and the trees subsequently bore a good crop of foliage. The sycamore often becomes defoliated in early summer from the effects of the fungus *Glœosporium nervisequum* (Fckl.) Sacc., but always succeeds in providing itself with new foliage in a short period of time. Sun scald is a common trouble, and can be easily produced in the laboratory. Our attention has often been called to the sun scald of apple trees, caused by banding with tarred paper, showing that tarred paper should not be used around apple trees without taking precautions.

Sun Scorch.

The past season has been very favorable for sun scorch, this trouble having been much more severe in the eastern part of the State, where the effects of the drought were more marked. Sun scorch is prevalent every summer on certain trees, especially those located in dry soil, and rock maples are peculiarly susceptible in this respect. This season the white pine also sun scorched badly, the injury appearing to be much more general than that which occurred three years ago, but less severe on the foliage, since in practically all cases the burning was confined to the apical portion of the needle, and seldom extended to the base. If the needles are not wholly destroyed, no great injury results, and a large number of the trees which were burned three years ago have entirely recovered. Should nothing further affect the pines, and the condition of the roots improves, the present burning will be scarcely perceptible one year from now, as it is a matter of general observation that many of the trees which burned this season commenced to recover a few weeks after being affected.

Strong, dry winds are important factors in producing sun scorch, and an excellent illustration of this may be found in the ninth annual report of the Hatch Experiment Station (pp. 81, 82); but, technically speaking, the cause of sun scorch is the exhalation of watery vapor from the foliage in excess of the amount of water supplied by the roots. Sun scorch is a common phenomenon, peculiar to many plants, and, while its occurrence on the pine appears to be new to most people, we have observed it for twenty-five years to a very limited extent. The cause of the recent sun scorch of the maple and white pine is to be found in certain meteorological conditions, but the immediate cause may be traced to the peculiarly dry winds of July, together with the inability of the roots to supply sufficient water. The effect of sun scorch is more marked on the western side of a tree or forest, — a fact which has been noted by various observers besides ourselves.

4. Premature Defoliation of Trees.

The premature defoliation of trees, which has been very common this season and which occasioned considerable correspondence, as usual, gives rise to much unnecessary anxiety. Among the many well-known causes of defoliation may be mentioned severe drought, and even excess of water may cause it. Elm trees, however, are likely to lose their leaves both in early summer and fall, and this is also common to other trees; but the loss of foliage in the case of the elm is seldom serious enough to cause alarm; and even the shedding of the twigs of the elm, which occurs to considerable extent, often periodically, generally causes little damage.

5. Asparagus Rust.

This disease has been more prevalent than usual the past summer in certain localities, but less so in others. It has in some places affected those beds which in ordinary seasons seldom show outbreaks except in the late fall. The rust occurred in a rather unusual form for this section, since as a rule the summer stage (uredospore), which causes practically all the injury, was checked, and as a result the fall stage (teleutospore) developed early in the summer. This often occurs on beds which never suffer materially from the rust, but it is the first instance noticed in this section of the uredospore stage being supplanted by the teleutospore stage in midsummer on beds which are usually infected with the uredospore stage, and which suffer more or less loss from such infection. This supplanting of the summer stage by the fall is an advantage to the crop, as the fall stage causes little damage, and there is not the slightest opportunity for infection during the summer, as the teleutospores do not germinate until they are given a resting period. Prof. R. E. Smith[1] has shown that this often occurs in California, attributing it to a lack of atmospheric moisture.

6. Asparagus Fusarium.

During the past few years our attention has been called to an apparently new fungous trouble affecting asparagus, which has appeared in some instances in the spring, attacking the fresh, marketable shoots. On one bed it occurred two years ago, but the owner has not been troubled with it since. In this case the young, tender shoots rotted off near the surface of the ground, and an examination of the soft rot in the tissue revealed that the asparagus shoots were infected with a species of fungus known as fusarium. Many instances of fusarium infection have also been observed by us later in the season on the mature stalks, the infected stalks being contorted in their growth and often split open, and an examination of these stalks always reveals a dense growth of this fungus.

7. Peony Troubles.

For two years we have had complaints in regard to a serious trouble of the peony, concerning which much has been written in the florists' journals. The disease is characterized by the dying of the plant to the ground, and an examination of the portion under ground usually reveals a decidedly bad state of affairs. In most of the specimens examined, the crown of the

[1] The Water Relation of *Puccinia Asparagi*. R. E. Smith, Bot. Gaz., Vol. 38, July, 1904, pp. 19–43.

plant, which is located just below the surface, is more or less blackened and decayed, and often dead, the black areas and decayed spots frequently extending below the crown of the plant for some distance. Microscopic examinations of the rather limited material which we have had at hand have revealed no specific organisms associated with this trouble, although fungi, bacteria and eel worms are usually found in the decayed tissue, apparently as secondary factors or accompaniments of decay. In one instance plants were observed which had perfectly clean cavities in the crown, as though eaten out by some small animal; and in other instances the so-called club-foot or gall formation, containing eel worms, was noticeable on the roots, but these did not seem to be responsible for the trouble. Further investigations of this disease are at present under way.

8. Potato Diseases.

Potato foliage went through the season with comparatively little disease. There was no blight of any importance. Some potato crops always die down or mature earlier than others, which is due in part to the conditions under which they are grown, though it is often believed that this early maturity is caused by some blight. The abundance of rain in the fall, which followed the long drought, caused potatoes to rot badly in some cases, especially when located on low and not easily drained soil, but on the whole the season was favorable for potatoes, the dry summer holding in check certain fungi which are likely to be troublesome, especially during a wet summer. On some fields, late in the season, following the period of rain, a rather unusual outbreak of *Cladosporium fulvum*, Cke., occurred, although this fungus is usually confined to tomatoes in this section.

9. Experiments with Fungicides.

Some potato-spraying experiments were made on the station plots, for the purpose of testing and comparing certain spraying mixtures to discover their adhesive properties, as well as their value as fungicides. As there was little fungous infection on the potato during the summer, the deductions which were drawn from the various applications of fungicides are not of great value.

The plots selected were those which were being used in the agricultural department for testing the relative value of potash compounds,[1] and for our purposes five of these were used. With the exception of two plots, the standard Bordeaux mixture formed the basis of the fungicides, the regular 4 — 4 — 50 formula being used. The plots were tested as follows: —

Plot 1 was treated with Bordeaux and Paris green, 1 pound of Paris green being added to 50 gallons of the Bordeaux.

Plot 2 was treated with Bordeaux and "Disparene," or arsenate of lead, 5 pounds of "Disparene" being added to 50 gallons of the Bordeaux.

Plot 3 was treated with Bordeaux and sodium benzoate, 4 to 6 ounces of the sodium benzoate being added to 50 gallons of the Bordeaux mixture.

Plot 4 was treated with soda Bordeaux and Paris green, 1 pound of Paris green being added to the soda Bordeaux mixture.

The soda Bordeaux is made as follows: —

Soda (commercial lye),	2 lbs.
Copper sulfate,	6 lbs.
Lime,	½ to ¾ lbs.
Water,	60 gals.

The mixture was tested to insure its alkalinity, and the amount of lime was modified according to the strength of the lye.

Plot 6 was treated with copper phosphate and "Disparene." Copper phosphate is a compound prepared by the Bowker Chemical Company, and is being tested as a fungicide. Our formula is as follows: —

Copper phosphate,	5 lbs.
"Disparene,"	5 lbs.
Water,	50 gals.

The plots were sprayed July 6, when the sun was shining, in the order given in the outline, the ordinary barrel spray pump being used. No rain fell before the first observations were made on July 11. The potato bug and flea beetle were present

[1] See report of the agricultural department, p. 39.

in abundance before the plants were sprayed. The results of the observations of July 11 are given below: —

Plot 1. Bordeaux and Paris Green mixed: —
No live potato bugs found.
The flea beetles scarce.
The mixture colored the leaves well.

Plot 2. Bordeaux and "Disparene" mixed: —
No live potato bugs found.
Flea beetles scarce.
The mixture seemed to adhere rather better than the Paris green, and covered the plants more evenly.

Plot 3. Bordeaux and Sodium Benzoate: —
A few potato bugs found on this plot.
Flea beetles scarce.
Color not very strong.
The mixture adhered well.

Plot 4. Soda Bordeaux and Paris Green: —
No potato bugs found.
No flea beetles found.
No strong color shown on plants.

Plot 5. Copper Phosphate and "Disparene": —
No potato bugs found.
Flea beetles very scarce.
Mixture does not color plants to any appreciable extent.

Although careful observations were made from day to day on the general appearance of the field, and the presence and absence of bugs noticed, by the time set for a second spraying no material difference in appearance was noticeable. Without exception the plants maintained the same condition, *i.e.*, they were free from potato bugs and flea beetles. One plot, that on which sodium benzoate was used, did seem toward the last to have rather more flea beetles and potato bugs than the others, although these were not in sufficient numbers to do any but local damage. There was absolutely no sign of burning of the leaves or stems on any of the plots.

The field was sprayed as before for the second time on July 22. The night after the spray was applied it rained heavily, and most of the spray was apparently washed off; but when the field was examined on July 29 no potato bugs were found, and there was no sign of blight. There was no appreciable leaf burning except in a few isolated cases, and in all these the plants affected were small and weak, and had not made the growth of the others.

One week later the field was sprayed for the last time, as after this the plants became too large to be sprayed again. During the month of August the plants were inspected from time to time, but no late blight (*Phytophthora infestans*, (DBy)) occurred. In the first week in September, however, a disease appeared which seemed to make headway on some parts of the field, although of no general occurrence on potatoes. This was *Cladosporium fulvum*, Cke. A period of wet weather lasting about a week and a half occurred just after the Cladosporium was noticed, and under these favorable conditions the disease spread rapidly in some sections of the field.

No more observations were taken of the plots until September 16, when the field was again examined carefully, both with reference to the diseases present, the general appearance of the plots and the maturity of the plants. These results were the last taken before the potatoes were dug, and are given below.

Regarding the diseases present on the different plots treated with the spraying mixtures, it was found that plot 1 sprayed with Bordeaux and Paris green, showed the presence of both Alternaria and Cladosporium, although these diseases were found only in localized areas, and could not be considered as especially destructive to the plants. The Bordeaux and Paris green is productive of fairly good results, but does not prove to be so efficacious as some of the mixtures used on the other plots.

Plot 2, treated with Bordeaux and "Disparene," presented a better appearance than did plot 1, and showed very little Cladosporium or Alternaria. This was due to the fact that the mixture adhered to the leaves for a longer time, and was not so easily washed off as the Paris green-Bordeaux mixture.

Plot 3 was sprayed with Bordeaux and sodium benzoate, and the plants proved to be in exceptionally fine condition, practically no Alternaria or Cladosporium being found even on dead plants. This mixture, although not coloring the leaves to any appreciable extent, seemed to adhere better than any of the others, with the exception of that used on plot 4.

Plot 4 was sprayed with soda Bordeaux and Paris green, and when the observations were taken showed no Alternaria or Cladosporium, the whole plot presenting a good appearance. This mixture adhered to the leaves the best of any and possessed the advantage of not coloring the plants to any great extent.

Plot 5 was sprayed with copper phosphate and "Disparene," and was in very poor condition when examined. The whole plot was badly affected with both Alternaria and Cladosporium, and little good seemed to result from spraying with this mixture.

The following table shows the relative appearance of the sections of each plot: —

TABLE III. — *Showing the Relative Difference in the Condition of Each Plot, Sept. 16, 1907.*

Section.	TREATMENT.	PLOT 1. Bordeaux and Paris Green.	PLOT 2. Bordeaux and "Disparene."	PLOT 3. Bordeaux and Sodium Benzoate.	PLOT 4. Soda Bordeaux and Paris Green.	PLOT 5. Copper Phosphate and "Disparene."
Section 1,	No potash, . .	½ dead,	All dead,	All dead,	All dead,	All dead.
Section 2,	Kainit, . . .	¾ dead,	¾ dead,	¼ dead,	½ dead,	⅜ dead.
Section 3,	High-grade sulfate of potash.	¾ dead,	½ dead,	¼ dead,	¼ dead,	¾ dead.
Section 4,	Low-grade sulfate of potash.	½ dead,	½ dead,	¼ dead,	½ dead,	⅞ dead.
Section 5,	Muriate of potash, .	¾ dead,	¾ dead,	⅜ dead,	⅜ dead,	¾ dead.
Section 6,	Nitrate of potash, .	½ dead,	½ dead,	⅜ dead,	½ dead,	¾ dead.
Section 7,	Carbonate of potash,	¼ dead,	¾ dead,	½ dead,	½ dead,	¾ dead.
Section 8,	Silicate of potash, .	⅜ dead,	⅛ dead,	¼ dead,	¼ dead,	⅞ dead.

Of the different spraying treatments the copper phosphate shows the largest percentage of dying plants, and, as already stated, this plot was the most severely affected with fungi. The other plots which showed less infection were treated with Bordeaux mixture in some form of combination. The application of Bordeaux mixture is known to prolong the maturity of crops, and no doubt the difference in the maturity of the plots treated with the Bordeaux mixture and those treated with copper phosphate is due in part to the tonic effect of the Bordeaux. Too much reliance, however, cannot be placed upon these conclusions as they represent only one season's work, and the following summary must be interpreted with caution.

Summary.

I. Of the sprays used this year on the experimental plots, the soda Bordeaux and Paris green was the best. It adhered to the leaves the best of any used, it did not color the foliage greatly, and effectively prevented the plants from being injured by either fungi or insects. In mixing this spray, however, *great care should be taken to add sufficient lime to make the mixture slightly alkaline, otherwise serious leaf burn might result.*

II. Bordeaux and sodium benzoate ranked a close second in effectiveness, and hardly any discrimination can be made between the soda Bordeaux mixture and the benzoate mixture. This mixture colors the leaves scarcely at all, and adheres about as well as the soda Bordeaux. The sodium benzoate could be added in slightly larger amounts without injury to the plants.

III. Bordeaux and "Disparene" seemed to be productive of fairly good results, and held the blight and insects well in check. It did not, however, give such good results as the first two mentioned. It showed up well on the foliage, coloring it heavily, and it adhered well to the leaves.

IV. Bordeaux and Paris green did not seem to hold the diseases in check as well as some of the other sprays, and did not adhere as well to the leaves; nevertheless, it was productive of good results.

V. Copper phosphate and "Disparene" seemed to have no appreciable effect on checking the disease, and this year's results, at least, seem to indicate that it is not equal to other fungicides.

10. Influence of Various Potash Salts on Potato Scab (*Oospora scabies*, Thaxter).

In connection with the preceding spraying experiments on potatoes, observations were made on the occurrence of potato scab in the various plots treated with different combinations of potash.[1] As previously stated, there were five series, each containing eight plots, fertilized with seven different potash compounds, with normal or untreated rows between the ferti-

[1] See report of agriculturist, p. 39, for details as to fertilizer.

lized ones. Potato scab has been slowly working its way into these plots since the experiment was started a few years ago, although the seed potatoes were treated with the standard corrosive sublimate solution before being planted. Notwithstanding this, potato scab developed quite severely on some plots, and the following table shows to what extent. No stable manure has been applied to these plots, hence that source of contamination has been eliminated.

TABLE IV. — *Showing the Development of Scab on Plots treated with Different Potash Compounds.*

Fertilizer used.	Amount of Scab (Per Cent.).
No potash,	5.0
Kainit,	2.0
High-grade sulfate of potash,	1.0
Low-grade sulfate of potash,	1.2
Muriate of potash,	–
Nitrate of potash,	–
Carbonate of potash,	95.0
Silicate of potash,	3.0

The above estimates of proportion of tubers affected by scab is based upon observations upon the fourth and fifth series of plots. The relative abundance of the disease in other plots was similar, but the proportion of scabby potatoes was larger.

The results given in this table show that there is a marked difference in one instance of the development of potato scab which can be traced directly to the fertilizer employed. It should be noted in this connection that the results in the different plots are very uniform, practically all the potatoes in the carbonate of potash plots showing much scab, and it is quite evident that this fertilizer is favorable for the development of scab. It is also clear that the corrosive sublimate method of treating the seed potatoes, as well as any other similar method of treatment, is of little value when the soil conditions are especially favorable for the scab fungus. The muriate and nitrate of potash plots did not seem to have developed the scab, and undoubtedly much can be accomplished in holding the disease in check by applying fertilizers which are unfavorable to the growth of the fungus. Wheeler, Hartwell, Sargent and Towar,[1] who have investigated this subject, have shown that acid soils restrict, while lime, ashes, etc., increase, the amount of scab. Dr. Wheeler points out that sulfate of potash, kainit and muriate of potash, in connection with dissolved phosphates, etc., will benefit the soil and render infection less prevalent.

[1] *Cf.* various articles by H. J. Wheeler, J. D. Towar, B. L. Hartwell and C. L. Sargent, in Bulletin No. 26, 1893, No. 33, 1895, and No. 40, 1896, Rhode Island Experiment Station.

11. Investigations relating to Mosaic Disease.

G. H. CHAPMAN.

The Mosaic Disease of Tomato and Tobacco.

Work on this disease was taken up for the first time at the station in July, 1907; too late in the season to observe the seed beds and the transplanting of field-grown tobacco in its natural state. However, the work of the past year has been more in the nature of verifying the results obtained by other investigators than in research purely, so only a preliminary report can be made at the present time.

The disease occurs on several plants, but seems to be most injurious to tobacco, although it has been found that in the case of greenhouse-grown tomatoes a heavy pruning back will bring on the disease, and, as observed at this station, lessens production.

All investigators agree that the mosaic disease is a purely physiological one, but there seems to be much doubt as to whether it is infectious or contagious in character, or both. There also seems to be some difference in opinion as to the direct cause of the disease. In tomatoes it is always produced when the vines are heavily pruned, and in the work here it has been shown that it is connected in no way with methods of transplanting the young plants, and only results from subsequent pruning.

It has been found that tobacco is much more susceptible under conditions which tend to produce the disease than is the tomato. In the case of tobacco, A. F. Woods[1] found that when a plant was grown in soil containing small roots of diseased plants the disease always occurred sooner or later. In our

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry.

observations on the tomato we have been unable to verify this statement, as in no case has the disease appeared when normal plants were grown in soil which contained roots of plants which had been badly diseased, and in the growing of tomatoes year after year in the station greenhouses there has never been the slightest evidence of infection arising from the soil.

In the case of tomatoes grown under glass the disease did not make its appearance when the plants were left normal, but occurred when the plants were pruned. These conditions held true for soils in which there were diseased roots, as well as for those in which tomatoes had not previously been grown.

In the coming year the work will be renewed, and the disease studied under field conditions in the case of tobacco, and experiments carried on to determine the possibility of its occurrence in the seed bed and also after being transplanted from the seed bed to the field. It is thought that the conditions under which the transplanting takes place may account for the presence of this disease in some cases. One case, at least, has come to our notice which seems to indicate that the disease may result from improper handling. In the particular case referred to, two lots of plants were taken from the same seed bed. One lot was well moistened before being removed, and the second lot was removed in a dry condition. The same machine planted both lots, and it was reported that at least 70 per cent. of the plants removed from the seed bed in the drier state became more or less diseased, while of those properly removed and carefully handled only two or three plants became affected. It has also been frequently observed, in connection with the transplanting of aster seedlings from the same bed under identical conditions, that one lot will show the "yellows" badly, and another lot scarcely at all when transplanted into different localities.

In connection with the field work, experiments of a more technical character will be carried on in the laboratory, with a view to ascertaining the effects which different enzymes (oxidase, peroxidase, catalase, etc.) found in growing plants have upon the production of the disease. Woods[1] infers that oxidase and

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

peroxidase play an important rôle in the development of this disease; but in the work so far carried on in the laboratory at this station it seems more probable that catalase has more to do with the production of a diseased condition. This bears out Loew's[1] hypothesis to a great extent, as in the preliminary work here it has been found that catalase is present in far greater quantity in healthy plants than in diseased plants. However, this point cannot be considered proved, as enough work has not yet been done to warrant such a statement. The results so far obtained will be found in this report.

Description of Mosaic Disease on Tomato.

The appearance of this disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some difference is found in its appearance in extreme cases on the tomato, as will be noted from the following description: —

In the first stages of the disease the leaf presents a mottled appearance, being divided into larger or smaller areas of light and dark-green patches. At this point, however, no swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly, while the light-green areas do not grow so rapidly, and leaf distortion is brought about. In the tomato the light-green areas become yellowish as the disease progresses, and in badly affected plants become finally a purplish-red color. This purplish coloration is found principally on plants which are exposed to strong light, but does not always occur, as it has been found that sometimes, even in badly infested plants, the disease may reach its maximum without showing any reddish coloration whatsoever. The reddish appearance is noticeable only on the upper surface of the leaf, and appears to extend only through the palisade cells. As yet no investigation has been made with reference to its character, but from its appearance under the microscope it is thought that it may be due to the breaking down of the chlorophyll granules, as a result of the diseased condition of the leaf.

[1] Catalase, Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology, United States Department of Agriculture.

Under all conditions of disease, however, the leaves are much distorted and *stiff*, and often very badly curled, never possessing the flexibility of healthy, normal leaves.

The Growing of Plants used in Experiments.

As the mosaic disease seldom if ever occurs on field-grown tomatoes, and as these experiments were carried on in the greenhouse, a standard greenhouse variety of tomato, the Lorillard, was used in the work. This variety is of medium size, and possesses strong growing qualities.

The seed used was carefully selected and of uniform size, all being over 2.5 millimeters in diameter. The seed was first planted in drills in a seed plot in which no tomatoes had previously been grown, and which could in no way contain any roots, decayed or otherwise, of diseased plants. After the seedlings had reached a height of 4-6 centimeters they were transplanted to 4-inch pots, and then once more transplanted, when they had reached a height of 15-18 centimeters, to the boxes containing the coal ashes, mention of which will be made later, and to the benches into soil which had not previously produced tomatoes.

The plants transplanted to the boxes were used to ascertain the action of excess of various plant fertilizers on the production or intensifying of the disease after it had once been contracted. The plants transplanted to the benches were used for inoculation and various other minor experiments.

Action of Excess of Fertilizers on the Production or Intensifying of Mosaic Disease.

To test the action of excesses of various fertilizers on the pruned and unpruned tomato plants, a fertilizer containing all the necessary plant food for tomatoes was used. The fertilizing constituents in tomatoes, given in parts per thousand, are as follows:[1] —

	Parts.
Moisture,	940.0
Nitrogen,	1.7
Ash,	–
Potassium oxide,	3.6
Sodium oxide,	–
Calcium oxide,	.3
Magnesium oxide,	.2
Phosphoric acid,	.4

[1] Hatch Experiment Station report, 1902.

A fertilizer of the following composition was used, applied in the indicated amounts per acre : —

	Pounds.
Nitrate of soda, ...	400
Superphosphate of lime, ...	1,320
Muriate of potash, ...	280
Lime, ...	1,000

In order to be certain that the production or reduction of the mosaic disease was due to the excess of fertilizer which was added in each case, a growing medium was taken which contained little or no plant food. In this case pure anthracite or hard coal ashes, which had been sifted through a one-fourth-inch sand sieve, were used.

Five wooden boxes of the same dimensions (45 by 45 by 30 centimeters) were filled to a depth of 25 centimeters with the ashes; to this was added in each case the requisite amount of the complete fertilizer calculated from the above formula. Box 1 contained the complete fertilizer, and nothing else; to box 2 was added an excess of nitrates equal to that already in the fertilizer; to box 3 was added an excess of potash equal to that already in the fertilizer; to box 4 was added an excess of phosphate equal to that already used; and to box 5 was added an excess of lime equal to that already used, — so that the boxes contained : —

Table showing Contents of Each Box.

Here n represents the normal amount of fertilizer.
N represents the nitrates.
K_2O represents the potash.
P_2O_5 represents the phosphoric acid.
CaO represents the lime.

Number of Box.	Coal Ashes.	N.	K_2O	P_2O_5	CaO
Box 1, ...	n	n	n	n	n
Box 2, ...	n	n + N	n	n	n
Box 3, ...	n	n	n + K	n	n
Box 4, ...	n	n	n	n + P_2O_5	n
Box 5, ...	n	n	n	n	n + CaO

Two tomatoes were planted in each box, one being pruned and the other not. They were allowed to grow for one week, however, before the first pruning, then one plant in each box was cut back to a point about 2 centimeters above the first leaves. In from one to two weeks all the pruned plants showed symptoms of the disease on the new growth, and continued to show it throughout the growing season. None of the unpruned plants showed the slightest indication of the mosaic trouble at any period of growth.

There appeared to be no difference in the intensity of the disease in any of the boxes, and when the diseased plants in the boxes were compared with plants of the same age grown in soil and pruned back at the same time, no difference in intensity of the disease could be noticed, so it would appear from this experiment that *excess of plant food* will not produce or intensify the mosaic disease of the tomato, although it has been observed that an excess of nitrogenous fertilizers does intensify the disease in tobacco, as well as that an excess of lime tends to lessen it,[1] and there are characteristics displayed by plants resulting from overfeeding which resemble the mosaic trouble. In our experiments with the disease on tobacco these views have been borne out, and it has also been noted that the tobacco is far more susceptible to those changes which bring about the disease than is the tomato.

Catalase in Tomato Leaves.

Some leaves of a perfectly normal tomato plant were treated to ascertain the presence or absence of the enzyme catalase, which has been so well described by Loew,[2] as it occurs in tobacco. As only green tomato leaves were available, they were taken and ground up in a mortar with fine quartz sand and a little water. After the leaves were in this manner thoroughly disintegrated the mass was covered with a .2 per cent. solution of ammonium carbonate $(NH_4)_2CO_3$, and set aside for three hours in a room the temperature of which was 25° C. After standing for this length of time the mixture was filtered through a coarse filter, and the resultant mixture filtered again through a finer filter paper.

The residue, consisting of pulp and quartz sand, was allowed

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[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

[2] Catalase. Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology.

to stand for a short time to thoroughly drain, and the filtrate was treated with dilute acetic acid 1 : 4. The filtrate was greenish in color, and when acted upon by the acetic acid a flocculent precipitate was obtained which was also greenish in color, — whether due to impurities or pulp is a question.

A portion of unfiltered juice was also saved for treatment. A diluted solution of commercial hydrogen peroxide (H_2O_2, containing 3 per cent. of pure H_2O_2) was treated with a small amount of the residue obtained from the first filtration. An abundant evolution of oxygen gas resulted, showing that catalase was present, in insoluble form, at least. The insoluble catalase has been called by Loew α catalase. As no other known enzyme will break down hydrogen peroxide (H_2O_2) in this manner, it is safe to say that catalase was present.

The first filtrate was added to a diluted solution of hydrogen peroxide, and a somewhat smaller amount of oxygen relatively was evolved. To the precipitate obtained by the acidification and precipitation brought about by the action of the acetic acid on the second filtrate was also added a diluted solution of hydrogen peroxide, and the amount of oxygen evolved was very small, only traces of the gas being found. As this precipitate contained presumably all the soluble catalase found in the leaf, it was shown that the tomato leaf contained very little soluble catalase. The explanation for the greater amount liberated from the first filtrate is that the filter was so coarse that some of the pulp containing the insoluble form passed through into the filtrate, producing an energetic evolution of oxygen. The soluble form of catalase is known and is described by Loew as β catalase.

In the normal condition the tomato leaf contains a large amount of the insoluble form and only traces of the soluble form.

After finding that catalase was present in the normal tomato leaf, a number of leaves of plants affected with the mosaic disease were treated in a similar manner, to determine whether the presence or absence of this enzyme had anything to do with this disease. The leaves of the diseased plants were treated in exactly the same manner as the leaves of the normal plants, so that there might be no chance for error due to treatment of the leaves.

Some leaves of a plant badly affected with the mosaic disease were treated in the manner previously described. In appearance the pulp and the filtrate were lighter in color than in the case of the normal plants, due probably to the fact that there was less chlorophyll in them than in the normal specimens.

When allowed to react with hydrogen peroxide (H_2O_2) it was found that both forms of catalase α and β were present, as oxygen was evolved from the solutions in sufficient amounts to be measured.

Since it was obvious that both α and β catalase were present in healthy and diseased plants, it was decided to take a weighed amount of healthy and diseased leaves and measure the oxygen evolved in a given time from a solution containing a known percentage of hydrogen peroxide. For this purpose 5 grams of healthy leaves were treated in the manner previously described, and the oxygen given off was carefully measured by an ordinary water displacement method. The soluble catalase was not precipitated, however, but the filtered juice was added in each case directly to the solution of hydrogen peroxide. The strength of solution used was as follows: —

To 120 cubic centimeters of pure distilled water was added 20 cubic centimeters of commercial hydrogen peroxide, making a solution in the proportion of 1 : 6. The pulp containing the insoluble catalase was added to this solution, and the amount of oxygen given off carefully measured. This was done both for healthy and diseased plants. The results obtained for the insoluble or α catalase are given below: —

Table showing Oxygen developed by Catalase in Healthy and Diseased Leaves.

	Time (Minutes).	1.	2.	3.	4.	Average.
		c.c.	c.c.	c.c.	c.c.	c.c.
Healthy leaves, ...	5	90.00	165.70	147.30	87.00	122.50
Diseased leaves, . . .	5	34.75	80.50	65.48	21.60	50.58

From these results it may be safely stated that there is certainly a lack of insoluble catalase in leaves of the tomato which are affected with the mosaic disease.

To a watery solution of hydrogen peroxide of the same proportion as used above, *i.e.*, 1 : 6, was now added the soluble or β catalase extracted from normal and diseased plants. The results in this case indicated also that the leaves affected with mosaic disease were deficient in soluble catalase. The results obtained are tabulated below: —

Table showing Oxygen developed by β Catalase in Healthy and Diseased Plants.

	Time (Minutes).	1.	2.	3.	Average.
		c.c.	c.c.	c.c.	c.c.
Healthy leaves, ...	50	26.00	48.30	33.10	35.80
Diseased leaves, ...	50	14.40	23.70	27.40	21.80

The foregoing results show plainly that catalase is greatly deficient in both α and β form in leaves affected with the mosaic disease.

As catalase is possessed of the property of decomposing hydrogen peroxide, and as it is a well-established fact that hydrogen peroxide is highly injurious to plant life, and also that it may possibly be formed[1] as an intermediary step in the various metabolic changes in plant growth, it is an interesting problem to discover whether the lack of catalase is a prime factor in the production of the mosaic disease. Work along these lines will be continued, and the results announced in a future report.

12. Some Factors which underlie Susceptibility and Immunity to Disease.

The permanent existence of any species depends upon its capacity for adapting itself to its surroundings. Health and disease in organisms are intimately associated with environment; and heat, light, moisture, plant foods, etc., are important factors. An understanding of the optimum conditions necessary for the growth of a plant is of the greatest importance as regards its normal condition of health. The close student of physiology and pathology must always have in mind the perfect type of plant, that is, one possessing perfect health, otherwise his diagnosis may be of little value, and the cause of

[1] Erlenmeyer, Berichte der deutschen Chemischen Gesellschaft, 1877. (Notes by Loew.)

certain unfavorable symptoms may escape his notice. In the same way that a physician can diagnose a patient's condition by an examination of certain organs, or gain an idea of the state of his general health by considering various symptoms, can one familiar with the normal functions of a plant ascertain its condition by observing certain features which it may display, and then discover the cause of the trouble.

The highest conception of health and vigor in plants is brought to a realization through the remarkable skill of expert gardeners, and it is no exaggeration to say that this class of men possess the most profound knowledge of a plant's requirements and limitations. Those trained men who have made a specialty of greenhouse crops for years are unexcelled in their skill and knowledge of the plant's needs, and this is also true of many intensive agriculturists. Some of these specialists have gained remarkable insight into the nature of plant reactions, the slightest change which takes place in the plant organism being noticeable to them ; but such a large percentage of this knowledge is intuitive or instinctive, as it were, that it cannot be conveyed to others. The best gardeners are in sympathy with all that pertains to the well-being of their plants, and they are continually observing each minute change which the plant may undergo, thus gaining a knowledge of the influence of the external factors which in any way affect the organism. A slight modification in the light intensity or in the temperature for even a brief period is sufficient to cause variations in the plant development which are discernible to the expert gardener. The conditions which both directly and indirectly affect a plant in respect to susceptibility to disease are various. A plant, both in its chemical and physical characteristics, is affected by light, heat, electricity, gravity and soil, moisture, air, biological relationships, etc., and in greenhouses by such factors as ventilation, air space, quality of glass, and in fact the simplest features connected with greenhouse construction. It is in a greenhouse that we gain the most insight into the relationship existing between the condition surrounding plants and their susceptibility to disease, for here the gardener has the environment largely under his control, and can therefore regulate the conditions to meet the requirements of his plants. The relation of external factors to plant diseases can be most satisfactorily studied in the greenhouse, because it is possible to modify and eliminate those which have a direct bearing upon disease, and in this way their true significance may be determined. When the conditions surrounding the plant are far from the optimum, injury and even death may follow. A stimulus which may prove beneficial under certain conditions may injure or cause the death of the organism under others; and it is only by possessing a knowledge of the optimum conditions for stimulation and by meeting the normal requirements of the plant that we can expect to obtain a perfect organism. Everything which has a bearing upon the development of the plant must be carefully considered if the perfect type is to be realized. These factors not only affect development, but have a fundamental bearing upon immunity; and if the environment can be controlled, disease can be controlled to a large extent. Even when it is not possible to modify the heat, light and moisture, as is the case out of doors, infection can be largely eliminated by making use of certain cultural practices; in fact, cultivation constitutes one of the most important factors in the control of disease.

Light affords a good illustration of the rôle a single factor may play in the configuration of plants. The physiological effect of light is to inhibit growth and to induce the formation of a firm texture of the tissue, On the other hand, lack of light stimulates growth, but plants grown in darkness are etiolated and lack firmness of tissue. There are many instances of the absence of light being responsible for serious troubles, and in others light undoubtedly exerts a detrimental influence. The tonic influence of the Bordeaux mixture in favoring the formation of chlorophyll and carbon assimilation in many plants would appear to be due to the screening or lessening of the light intensity. Sun scald, which occurs on various trees, is brought about by excessive light, as in the case with apple trees, which, when defoliated by the gypsy moth, usually die from the effects of sun scald. On the other hand, shading often causes sun scald by preventing the ripening of the wood.

There are apparently some cases, at least in greenhouses, of too intense light, or the conditions resulting from it, causing trouble to crops. In the northern latitudes many greenhouse crops do not obtain sufficient light during the winter months, and when cloudiness prevails it is with some difficulty that crops are matured without becoming diseased. All expert greenhouse men mature their crops when the weather conditions will permit, and not according to the calendar; in other words, it requires a certain definite amount of light, or so many light units, as it were, to mature a crop. The light in May, for example, is equal in intensity and amount to about twice that of corresponding periods of a day in November; consequently, it requires about twice as much time to bring a crop to the same degree of maturity in November as it would in May.

Lack of light is responsible for various mildews and leaf spots, top-burn or tip-burn, wilts, etc. Many of these leaf spots are seldom if ever found on plants to which sunlight has access. The Sclerotinia diseases of lettuce, water cress and parsley are likewise induced by crowding and shading, and light in such cases will prevent infection by the formation of resistant tissues. It is well known that absence of light causes the so-called "layering" of wheat and "damping off" of cuttings, and the mildews of various plants grown in the shade are too well known to need consideration,

The improper regulation of atmospheric moisture and ventilation is responsible for many fungous diseases, and the control of these factors is important in preventing the troubles. Among the mildews, Cladosporium can be entirely controlled by holding the moisture in the greenhouse in check, and by paying strict attention to proper ventilation and to normal light conditions. Many gardeners have succeeded in controlling the chrysanthemum rust by using proper precautions in regard to moisture.

A series of the most troublesome diseases common to cucumbers and melons out of doors — Plasmopara, Alternaria and Anthracnose — can be absolutely controlled in the greenhouse by paying attention to moisture, light and ventilation. The circulation of air, as well as light, has a marked effect upon the development of resistant tissues in greenhouse crops, and the control of moisture is necessary to prevent the germination of various spores which are likely to infect crops. It is well known that the tops of trees are less likely to become infected by fungi, owing to the smaller amount of moisture there than about the branches nearer the ground ; and asparagus plants when grown under trees or covers which protect them from the dew seldom show any indications of rust.

Too great a degree of heat and moisture in the soil gives rise to serious troubles, as may be seen in the case of Œdema of tomatoes ; and when seedlings are grown in soil that is kept too moist and at too high a temperature, they are likely to "damp off." The presence of water in a plant in excess of certain amounts is favorable to disease, as is shown in the carnation's susceptibility to rust; for example, those carnation plants possessing the greatest amount of water in their tissues appear to be the most susceptible to rust. The stimulating effects of electricity, fertilizer and sterilized soil often prove injurious by developing too high a water content in the tissues, thus rendering them more susceptible to disease. Tillage, manuring, irrigation, mulching, etc., are important factors in securing vigorous plants, and go a long way towards rendering them immune to certain diseases. An excessive amount of moisture in the soil stimulates growth and often renders plants more susceptible to fungous diseases, and a lack of water has the same effect; in fact, stimulation of various sorts may result in weakening a plant and rendering it less immune to disease.

The life history of an organism presents different stages of susceptibility or immunity to disease, corresponding to different stages of development ; for example, young plants may be more susceptible to certain diseases than older ones. Very young seedlings often fall a prey to the "damping off" fungus, but when they have reached a certain stage of development they become immune to fungi, and the younger and less-developed parts of mature plants are more susceptible than the older parts. Vegetative rest and overmaturity are also favorable to disease, while the conditions associated with isolation are unfavorable for infection. Weakened plants are more susceptible to disease than strong ones, and in most cases, if not all, vital depressions are the real causes of disease. Vital depressions are brought about by the abnormal conditions which modify and reduce the power of resistance, consequently the organism falls a prey to the ever-present germ.

The causes underlying susceptibility are much better understood than those of immunity. Why it is that the moment a plant becomes weakened various organisms attack it, is not fully understood. We have observed many instances of certain treatments weakening plants, and as a result it is surprising to note the number of organisms which always attack the plant a very short time afterwards. The changes which actually take place in an organism in a depressed condition are not known, but many of these may be of an abnormal chemical nature. It is possible that these abnormal chemical changes stimulate organisms to attack weakened plants; that is, the loss of immunity increases the susceptibility of the organism to disease, due to vital depressions in the plant, which may result in the giving off of substances that act as a stimulus and attraction to invading organisms. Briefly stated, susceptibility to disease may be associated with chemotactic irritability.

Some crops are probably rendered more susceptible to fungous diseases by cultivation. The limitations of forcing have undoubtedly been overstepped in some cases, and this is especially true of the carnation, which has been much troubled with the wet and dry stem rots since the modern methods of forcing have come into vogue.

In the case of outdoor crops, great differences exist in the environment, due to climatic influences. The conditions may be such that a disease constantly causes loss in one locality and scarcely any in another; and, while it may be necessary to spray for a trouble in one State, in others no attention need be given it. No doubt in some instances it would be wiser to devote one's energies to cultivation, as a means of preventing plant diseases, than to resort to the use of fungicides. Our most skilled agriculturists, such as florists and market gardeners, seldom if ever resort to spraying, and in greenhouse culture the use of fungicides is practically unknown. Certain crops are greatly benefited by being sprayed with fungicides; but, on the other hand, there are crops which have been sprayed for many years with little or no benefit as far as the control of pathogenic fungi is concerned, and the money spent for spraying would in such instances be more wisely used in methods of cultivation. Some of our best landscape gardeners have advocated that, if $25 were to be used in planting a tree, about $23.50 of it should be used for preparation; and such advice is based upon the best agricultural practices. If intensive agricultural methods were applied more often to the growing of plants, pathologists would have much less diagnosing of diseases to do.

Every influence which may in any way affect plants should be carefully studied. We should understand what influence the chemical, physical and biological properties of soil, manures, fertilizers, air drainage, etc., have upon susceptibility to disease. The plant organism is an extremely complex mechanism, very plastic and responsive, and is continually being acted upon by a number of forces or stimuli which in turn produce a series of self-regulatory and correlative reactions. Undoubtedly in the future the control of plant diseases will depend more upon breeding and cultural conditions than now; but for the present, spraying must be employed when practicable for the control of diseases until something better shall have been discovered.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

Outline of Work.

The four divisions into which the entomological work of the experiment station is naturally divided — correspondence, experimental investigations, special research and publication — have each received their share of attention during the past year.

The correspondence has been as large in amount as heretofore. Many inquiries about many kinds of insects have been received and answered as fully as possible: and in this connection the printing of a number of circulars, treating of the insects most frequently asked about, has greatly facilitated the work, as a circular can be sent in a small fraction of the time necessary to write out the same information, besides giving an opportunity to send illustrations of the insects and of their work.

Experimental investigations during the year have been along numerous lines. Determinations of the resistance of different crops to fumigation with hydrocyanic acid gas have been continued, and are now complete for the cucumber, and similar tests for muskmelons are under way.

An extensive series of tests of different methods for the control of cabbage, turnip and onion maggots was also begun. The cabbages, being the first crop on which treatment was possible, were experimented with in nine different ways. Unfortunately, it soon became evident that no treatment of any kind would be needed, almost no maggots being present either in the check rows or in the field anywhere, so that the only data of any value which could be obtained were those relative to the cost of different materials and the ease with which they were applied, leaving the question of their relative efficiency for subsequent determination in other seasons.

Observations on the dates of appearance of the oyster-shell, scurfy and white pine scales have been made as usual, and should be continued for a number of years, to obtain reliable averages for use in spraying. Observations on the number of broods of the codling moth have also been continued, and a more extensive series of experiments with this pest is now being planned for next season.

In 1906 the "blight" caused a large monetary loss in the Connecticut River valley on the onion crop, and as this is caused by a thrips, studies of the best methods of controlling this pest were undertaken in co-operation with several large onion growers. The main difficulty in this work seems to be to devise a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. This problem is now being worked upon, and with good prospects of success.

The number of new mixtures produced for use against the San José scale has necessitated many tests of these materials, some of which seem quite effective, though expensive, while others apparently are of no value. Thus far nothing tested at this station which is reasonable in cost has excelled the lime and sulfur wash, though a few trials of one substance are quite promising, and these will be continued during the spring of 1908.

Investigations on the work of cranberry insects and the best methods for controlling them have been continued in charge of a special investigator located at Wareham, and it is hoped to publish the results of this work soon as a bulletin. At the request of the Cranberry Growers' Association, sets of cranberry insects and samples of their work are being prepared, to be placed in different parts of the cranberry-growing region, where they will be most easily accessible for examination by growers.

During the summer the life history of the oriental moth was carefully studied, and all stages of its existence were described and photographed. In addition, a study was made of the local conditions where it occurs, and it was found that the limits of its distribution, as already published, though approximately correct, are not entirely so, the insect having been found in one or two directions beyond those limits. In most of the infested territory the brown-tail moth is abundant, and spraying with arsenate of lead was very general in that region last summer. The result was also to destroy large numbers of the larvæ of the oriental moth, the treatment being so effective that in August it was hard to find any of the caterpillars without making a prolonged search.

These facts indicate that this insect is not likely to become a serious pest. If it should become well established, however, in some locality where no attention is paid to insect pests, it is possible that it might cause considerable injury; but in such a case it is probable that a single thorough treatment there would be effective for several years. The Japanese name "ira-mushi," for this insect means "the nettle insect," and during the summer several reports of the nettling caused by the spines of the caterpillars were received, indicating that, if this insect should at any time become very abundant in an inhabited locality, the residents there might suffer some inconvenience from its presence.

Massachusetts is close to the northern limit of the distribution of some insect pests and near the southern limit of others. It seems probable that for some of these there are portions of the State where these pests may be of importance, while in others they will require no attention. It is important that the exact facts in this regard should be determined, and researches have been begun to ascertain the localities in which comparative immunity from certain pests may be expected. To obtain definite results on this subject will be the work of several years and much correspondence, but it is hoped that when they are obtained, directions can be prepared which will guide towns in different localities in making their annual appropriations for the protection of their trees, which will save many thousands of dollars.

Three bulletins on insects (Nos. 114, 115 and 116) have been published during the year, besides numerous circulars already referred to, these last being used only in answering correspondence. In addition, a number of other articles too brief for bulletin material or not adapted for a publication of this nature have appeared elsewhere, and several more are nearly ready for the printer.

Insects of the Year.

The year 1907 has brought many inquiries about different insects. As heretofore, however, the San José scale has been most prominent in the correspondence, followed closely by the oyster-shell scale, plant lice, — particularly the woolly apple louse, — the codling moth, the plum curculio as an apple pest, the elm-leaf beetle and the apple maggot or railroad worm.

The elm-leaf beetle, after several years of comparative unimportance, is again becoming a serious pest. In 1900 and 1901 it caused much injury in the Connecticut valley and in eastern Massachusetts, and in 1902 its work was also very noticeable. In the spring of 1903 the beetles were abundant, large numbers of egg clusters were found, and there was every promise of another year of serious injury. During May and June, however, there was a drought so marked that grass dried in the fields and the leaves of the elms became hard and tough and many fell off. It was noticed that many of the egg clusters of the elm-leaf beetle failed to hatch under these conditions, and that the young larvæ in many other cases seemed unable to bite into the tough, dry leaves, so that the work of this insect in 1903 was unimportant. The following winter was unusually severe, but whether this was also a factor in the result cannot be stated. Whatever the cause, however, few elm-leaf beetles were present in 1904, 1905 and 1906, though in the year last named they were increasing in abundance; but last summer (1907) they had become quite plentiful, at least in certain localities, and it is probable that they will be as injurious as formerly in a year or two, unless climatic factors again cause their destruction.

Just how far the drought of 1903 was responsible for the destruction of these insects it is of course impossible to say; but the abundance of unhatched egg clusters and the evident struggles of the tiny grubs to break through the unusually toughened epidermis of the leaves during that period are very suggestive.

The appearance of the leopard moth (*Zeuzera pyrina*) in and around Boston during the past year adds another important insect to the list of pests with which Massachusetts must deal. This insect has been quite abundant around New York City for some years, but has not been reported from this State. As a borer in shade trees it is a serious pest, and its presence must hereafter be taken into consideration by our city foresters and tree wardens.

The brown-tail moth has continued to spread over the State, but in those localities where it has been longest present it seems to be becoming less serious and more generally attacked by disease. Whether this condition will be permanent or is only temporary cannot be determined now, but its permanency is greatly to be desired.

The presence of the San José scale in the Housatonic valley has been suspected for several years, simply because there seemed to be no reason why it should not be present there. Specimens of this scale from several localities in this region, received during the past season, demonstrate its presence there, leaving only the higher parts of the Berkshire hills and the northwestern corner of the State as localities from which it has not as yet been reported, and time will probably add these portions of the State to the list of infested regions.

The marked decrease in abundance of root maggots and cut worms this year should be noted, while the spruce gall louse, squash bug and several kinds of caterpillars, all common pests, appear to have been unusually abundant; but on the whole the year has been without a serious insect outbreak of any kind.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

Outline of Work.

The work in the veterinary department of the station naturally falls under one of the following divisions: correspondence, examination of specimens, and original investigations. These merge so much one with the other that they are by no means as distinct as the divisions would seem to indicate. It not infrequently happens that through correspondence attention is called to the existence of a peculiar disease among farm animals. Specimens are asked for, and forwarded for examination, which sometimes afford material for original investigations.

Correspondence.

During the past year letters have come to hand from people in every part of the State, asking for information regarding the sickness of individual animals, or perhaps regarding a disease that has appeared in a herd or flock, affecting many animals. Of necessity it is impossible to make a correct diagnosis in every such instance, from the description of the case as detailed by the correspondent. In other instances the symptoms are so accurately given and of such a character as to enable one to diagnose the case with certainty, and advise a specific course of treatment. The correspondence work carried on with those living in rural sections, where no qualified veterinarian is accessible, has proven of such benefit to the farmers as to warrant its continuance, notwithstanding the difficulties that are encountered in arriving at definite conclusions as to diagnosis and treatment. When it is impossible to give definite directions for the treatment of an individual animal, it is possible from the symptoms enumerated to recommend a line of treatment, or general directions can be given which when carried out make it possible for the stock owner to pursue such a course as to prevent the spread of the disease to other animals exposed, or to prevent its recurrence.

Examination of Specimens and Original Investigations.

For many years it has been the practice of the veterinarian of the college to examine material from sick or dead animals, and to report the findings to the one sending the specimen, and advise a line of treatment for the individual animal or protection of the remaining animals of the flock or herd.

From an examination of such specimens as have been sent in during the past year, a diagnosis has been made of nodular disease of sheep, caused by the parasite œsophagostoma Columbianum, enterohepatitis of turkeys, verminous bronchitis of sheep, fowl cholera, swine plague and other more common diseases of a less serious nature. Through correspondence and the sending of specimens a very interesting and quite uncommon disease of poultry in this country was brought to the attention of the department.

In January of the present year there arrived at the department by express a dead fowl, which upon post-mortem examination exhibited some of the lesions of European fowl cholera. Microscopic examination gave support to that diagnosis. To confirm the same, a pigeon was inoculated with a small quantity of blood from the heart of the dead fowl. After the lapse of about twelve hours the inoculated pigeon was found dead. A microscopic examination, together with culture tests, demonstrated the presence of the fowl cholera organism in the blood. Subsequent inoculations and examinations gave similar results.

Considering the seriousness of the disease, its rare occurrence in this State, together with the possibilities of its rapid distribution among flocks of poultry, through sale of birds and otherwise, a visit was made to the farm from which the specimen had come.

It was found that about two hundred birds were kept by the poultryman, in two different flocks situated some fifty feet apart. About one-half of the fowls had been raised upon the farm the previous summer. The remainder of the flock, consisting of fowls and chicks, had been purchased of a dealer in live poultry the previous November. At this time all the birds raised and purchased seemed to be in perfect health. The history of the outbreak is briefly as follows: —

About Jan. 1, 1907, one morning the poultryman found, upon going into the house containing the purchased stock, a dead bird upon the dropping board. No sick fowls had been noticed the day previous. During the next two weeks several dead birds were found under conditions similar to the first. Few or no fowls of the flock exhibited symptoms of sickness at any time during the existence of the trouble. The loss continued, however, up to the middle of January, when the specimen was sent to the station. The total loss amounted to about twenty per cent. of the entire flock. One morning three dead birds were found under the roosts. At no time did the disease appear among the fowls raised upon the farm. This is probably to be accounted for by the fact that the infectious material was brought on to the place by the purchased stock, and that the two flocks were kept entirely separate. As soon as a diagnosis of the disease had been made, the poultryman was advised of the contagiousness and seriousness of it, and the possibilities of its spreading to other flocks in the neighborhood. He showed a willingness to do all in his power to eradicate the disease as soon as possible. At an early date all the remaining birds in the infected house were destroyed, the house thoroughly cleaned, fumigated and sprayed with a disinfectant solution. The treatment was so heroic and so faithfully carried out that there has been, so far as known, no recurrence of the trouble.

On April 18, 1907, a dead fowl from a farm on the opposite side of the street to the one where fowl cholera had existed was sent to the station.

An autopsy, supplemented by inoculation experiments and microscopic examinations, resulted in a diagnosis of fowl cholera, identical in every respect with that found to exist in the fowls kept on the adjoining farm. There were from four to five hundred birds on the place. A part had been raised on the farm, a part purchased of itinerant dealers in live poultry. The fowls were divided into two lots. About one hundred had the run of a large, dry, open barn cellar; the remainder were kept in a single long poultry house, divided into sections with partitions of wire netting. Both lots were allowed free range, all mingling together in one flock during the day.

It was learned from the owner on April 27 that the two weeks preceding the date of sending the dead fowls to the station (April 18), between fifty and sixty fowls, a part from each flock, had died very suddenly. It was also learned that during the winter of 1906 about one hundred and twenty-five birds had died from flocks kept in the poultry house and barn cellar during that winter. No cause was found to account for this large mortality. Taking into account the history of the case and the symptoms exhibited by the birds as given by the owner, it seems probable that the loss in 1906 was also due to fowl cholera. There is no positive proof that this was the case.

It was reported by the owner of the flock in question that his birds frequently came in contact with fowls kept on the opposite side of the street, and that individuals from both flocks ranged over the same ground.

In dealing with the last and larger flock, circumstances did not seem to warrant the application of the line of drastic treatment that had been carried out with the flock dealt with earlier in the year. Deaths had occurred among fowls kept in the poultry house and in the barn cellar; all had run together, when the weather permitted their being outside the buildings, and it seemed certain that the infection had become widely spread about all parts of the farm in the immediate vicinity of the buildings.

To arrest the spread of the disease, the owner was advised to thoroughly clean all parts of the buildings with which the fowls had come in contact, including a removal of the surface soil from the barn cellar and pens in the poultry house. He was further advised to follow this cleaning with a liberal application of a coal tar disinfectant and a fresh lime whitewash. As a further precaution against the spread of the infection through the medium of food and water contaminated with infectious fecal matter, specially constructed automatic feed boxes and drinking fountains were recommended. In addition, it was suggested that from five to ten grains of permanganate of potash be added to each gallon of drinking water, the water to be supplied fresh twice daily, and kept as free as possible from organic matter, which destroys the antiseptic properties of the potash salt. These measures, supplemented by frequent cleaning of houses, disinfection of fæces, etc., seem to have completely stamped out the disease, as nothing has been learned of its recurrence.

Judging from the reports that have been made of the few previous outbreaks of fowl cholera that have occurred in this country, it would seem that the two in question have been of a mild type, for in each outbreak previously reported the spread of the disease has been much more rapid and the mortality greater, amounting in some instances to one hundred per cent., as is frequently the case with the outbreaks in Europe. The successful treatment adopted in dealing with the second case, which consisted of mild measures, also tend to show that the disease was not of that virulent nature frequently met with.

Considering the few outbreaks of fowl cholera that have occurred in this country, and the benefit to be gained from knowing the source of the infection in combating this disease, it is to be regretted that the source of the contagion in the cases under consideration could not have been determined. It seems fair to conclude that it must have been introduced on one of the farms through some of the fowls purchased of the traveling dealers in live poultry.

Another interesting and, so far as can be determined, new disease for poultry was brought to the attention of the department through a communication from a poultryman on the Cape in the summer of 1906. An investigation of the disease was begun on June 27 of that year and concluded in October of the present year. During this time a series of experiments have been carried on at the college in conjunction with those conducted at the farm.

The part of the farm given up to poultry culture consisted in the main of a sand plain. A portion on which the chicks were kept consisted of pure white quartz sand, and was devoid of vegetation except for an occasional weed growing upon it. This locality had many years previously been the site of salt works.

The present owner had built upon this location a poultry plant with a capacity sufficient to handle from fifteen hundred to two thousand birds. This plant consisted of poultry houses, incubator cellar, brooder houses, coops, etc. Everything about the place, including equipment, was of the latest pattern and of modern construction. The practice was to hatch chickens in incubators and brood them under hens and in brooders. The hens with chicks were kept in coops placed some distance apart in yards. Several small yards were fenced off with wire netting, each of which contained a brooder of sufficient size to accommodate from fifty to seventy-five chicks. The disease never made its appearance among any of the adult fowls or any of the young chicks except those brooded in brooders. Those kept with hens in individual coops never contracted the trouble. The mortality among the brooder chicks usually ranged from ninety to one hundred per cent. The loss of from three to five hundred in a season was not an uncommon occurrence. It was extremely rare that a chick once attacked ever recovered. In some lots a few escaped contracting the disease, while others of the same lot succumbed to it. It usually attacked chicks at the age of three weeks, although those older or younger than this were not exempt.

The first appearance of the trouble was characterized by the development of large serous or water blisters on the front and upper parts of the featherless portions of the legs and feet. After a period of twenty-four to forty-eight hours the blisters would rupture and the serum escape. Frequently the affected parts would be rubbed with the head, and as a result the featherless parts of the head would become affected in a similar manner to the feet and legs. An extension of the disease about the head invariably led to an affection of the eyelids, which would become fastened together by the sticky exudate. The ball of the eye was not involved. In some instances the head would first become affected, later the feet and legs. Occasionally it was found that the head or the feet alone would be the only part involved. So far as known, the posterior part of the leg or parts of the body covered with feathers never became affected. After rupture of the blisters and escape of their contents the surface skin became dry and shriveled, after a time becoming detached, leaving behind the moist underlying vascular tissues. These soon become covered with soil and encrustations of tissue and serum. Forced removal of these crusts was followed by capillary hemorrhage and the formation of new crusts. A shedding of the crusts frequently occurred as the disease advanced. As a final result, all parts of the soft tissue of the feet were destroyed or modified to such an extent that the toes became bent upward, and the foot deformed so that only the ball of the foot would come in contact with the ground when walking was attempted. In addition to the local lesions, there were symptons indicating a considerable degree of constitutional disturbance. Nutrition seemed at a standstill. Growth was arrested, although there was a disposition to eat and drink. The closing of the eyelids often made it impossible for the chicks to take food or water, even though they were disposed to do so. When the lids were separated the birds usually ate and drank ravenously until they became filled.

Numerous remedies had been employed for the treatment and prevention of the trouble, but to no avail. The disease made its appearance in each lot of chicks shortly after they were placed in the brooders.

It was the opinion of the poultryman that the soil contained some poisonous irritating substance that was accountable for the trouble. Why it should appear in brooder chicks and not among those brooded under hens he was not able to explain. To settle this matter a sample of soil was submitted to chemical analysis, but nothing of an irritating or poisonous nature was found.

The general course and character of the disease seemed to indicate that it was the result of the local action of something. It was suspected that it might be due to the heat from exposure to direct sunlight. Experiments were made upon chicks by the use of a lens to concentrate the sun's rays upon the legs and feet, and it was found possible to produce upon experimental chicks lesions identical with those found upon chicks brought from the yards, even to the extent of producing a slight deformity of the toes, due to the contraction of the tendons and the cicatricial tissue. An attempt was made to rear feathered-legged varieties of chicks upon the same ground where there had been the greatest mortality, but owing to some mishap in connection with the incubation of the eggs, the work along this line was not completed. It is hoped to carry out this detail at a later date.

As a practical remedy for the trouble this poultryman has had to contend with, it was suggested that all chicks be removed to and raised upon an adjoining piece of ground sufficiently fertile to support vegetation, that would protect the featherless and tender portions of the body from the heat of the sun.

During the past summer this suggestion has been complied with, with the result, to quote the owner's own words, under date of Oct. 4, 1907 : "That so far this season I have not had a single case of sore head or feet, such as you know of, among my chicks."

At present a series of experiments is being carried on to determine the effect of poisons, used in tree-spraying work, upon animals consuming forage grown beneath the trees.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

In meteorology, where the work is in a large degree essentially that of observation and tabulation, the records must be continued from year to year without material change, if the results are to be of value for the purposes of comparison. As the length of time covered by the records increases, the data become more valuable, and the mean climatological conditions can be determined with constantly increasing accuracy.

During the past year the work of this division has been a continuation of that of previous years, and no material modification has been made. Although efforts are constantly made to increase the precision of the records, the general form and range remain unchanged.

The semi-daily observations, at 8 A.M. and 8 P.M., have been taken regularly, and the results transcribed in the permanent record book. Many records from the self-registering instruments have also been entered, to keep them compact and accessible. The usual monthly bulletins, giving much of these data, have been printed on the first of each month. These are now mailed from the director's office instead of from the printing office as heretofore, which involves a little loss in promptness of distribution. The December bulletin will contain a summary for the year, instead of the usual remarks.

The local forecasts have been received by telegraph from the section director of the United States Weather Bureau, at Boston, and the signals displayed from the flagstaff on the tower. This division has co-operated with the section director in furnishing the usual voluntary observer's reports for each month, and the snow reports during the winter season. The horticultural division has consented to keep a phenological record during the growing season for the use of this division, and a copy is furnished the section director at Boston.

The old thermometer shelter on the campus has been replaced by a larger and more convenient one, and an underground lead-covered cable placed for the purpose of providing an electric light in the shelter. A second underground cable is in place for connecting the tipping-bucket rain gauge with the recording instrument in the tower. A specially designed cover for the man-hole of the heating system, which is near the rain gauge, has been secured. It is proposed to place the rain gauge on this cover in such a manner that the heat from the man-hole will melt the snow which falls in the gauge, and thus furnish a precise record of the time of the beginning and ending of snowstorms.

A maximum thermometer of standard pattern is the only addition to the instruments made during the year.

No change in the personnel of the observers has been made during the year.

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Public Document No. 31

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PART I.,

BEING PART III. OF THE FORTY-SIXTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

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INTRODUCTION.

In accordance with the provisions of the act relative to the publication of the reports of the Massachusetts Agricultural College, passed by the Legislature of 1908, the report of the experiment station, which is a department of the college, is presented this year in two parts. Part I. will contain papers of a popular character and will be given wide circulation. Part II. will contain the formal reports of the director, treasurer and the heads of departments, and papers of a technical character, giving the results of investigations carried on in the station. This will be sent to agricultural colleges and experiment stations, and to workers in these institutions, as well as to libraries. Part II. will be published also in connection with the report of the secretary of the State Board of Agriculture, and will reach the general public through that channel.

WM. P. BROOKS,
Director.

TWENTY-FIRST ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

GENERAL REPORT OF THE EXPERIMENT STATION.

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PART I.

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

TWENTY-FIRST ANNUAL REPORT.
PART I.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

The papers published in this part of the annual report are designed to present the results of observations and experiments in brief popular form and without unnecessary use of technical terms. The articles included treat a wide range of subjects, and each aims to make the practical conclusions prominent.

The full list of subjects will be found in the table of contents, and those interested in any subject treated should read the entire article on that subject, but for the possible convenience of those who " read while they run " the more important of the conclusions presented may be summarized as follows: —

1. Corn can be raised on fertilizers in Massachusetts at a cost considerably below the usual market price.
2. Wheat bran is a cheaper feed for milk production than alfalfa meal at prevailing prices.
3. Alfalfa as a forage crop appears to be worth trial.

4. Tankage may, with advantage, be used in rations for pigs, and the better grades of dried blood, in small quantities, in rations for horses, calves and cows.

5. Molasses may, with advantage, be used, in moderate amounts, as food for cows, fattening cattle, horses and pigs.

6. Varieties of corn which mature in this climate are to be preferred either for fodder or for ensilage to the very late varieties.

7. Wet brewers' grains, when they can be fed fresh, may be used with advantage, in moderate quantities, under some conditions.

8. It is often possible to obtain a given amount of plant food in desirable forms at lower cost by the purchase and home mixture of materials than by the purchase of ready-mixed fertilizers.

9. Gluten feeds sometimes contain free acid and aniline coloring matter, but probably not in such quantities as to be directly injurious, although manufacturers are urged to take steps to remove acidity and to give up the practice of artificially coloring such feeds.

10. Farmers should be on their guard against feeds which contain weed seeds, whether ground or unground, although they are especially undesirable if unground. Farmers should also use great care in the purchase of grass seeds, which not infrequently are imperfectly cleaned.

11. Subjecting commercial samples or even home-grown lots of seeds to a thorough process of separation, for the rejection of impurities and light, imperfect seeds, insures more perfect germination and stronger and better seedlings.

12. Onion smut may be largely if not wholly prevented by the formalin treatment. A machine with attachment for carrying out this treatment is described and illustrated.

13. A fungous disease of greenhouse radishes has become common. This can be prevented by sterilizing the soil.

14. It is probable that the injuries to greenhouse crops due to eel worms can be prevented by abundant sub-irrigation.

15. Neither lime nor formalin applied to the soil have prevented damage to greenhouse crops from eel worms, but sterili-

zation and freezing, if thorough, are effective. The introduction of trap crops, such as mustard or rape, is useful.

16. Weeds in walks, roadways, tennis courts, and poison ivy about trees or near houses or walls, can be destroyed by the use of arsenic compounds, among the most effective being arsenate and arsenite of soda.

17. Many weeds can be destroyed by spraying the foliage with a solution of sulfate of iron, while some of the commercial preparations are effective weed killers.

18. Some of the insects most destructive to greenhouse crops can be destroyed by fumigation with hydrocyanic acid gas, and such fumigation should be carried on on clear nights without a moon, or on cloudy nights at a house temperature of 55° to 65°, followed by complete ventilation and a rather low temperature in the house the next day.

The Cost of a Bushel of Corn.

WM. P. BROOKS, DIRECTOR.

The question is very frequently asked in this State whether the farmer can afford to cultivate corn. The belief appears to have been quite general for many years that corn can be purchased more cheaply than grown. It is generally admitted that our soils and climate are as a rule well suited to the crop, but all over the State will be found landowners who are purchasing corn to feed either to horses, cattle, hogs or poultry.

The results obtained in one of the fields of the experiment station clearly demonstrate that corn can be produced at a cost per acre considerably below the average purchase price. The following brief account of the experiments will make this clear.

The field in question contains 1 acre. This is divided into four equal plots. One of these plots has produced twelve corn crops during the last eighteen years. It has been seeded to mixed timothy, redtop and clovers three times, the seed being sown in the corn. In the years following seeding the plot has been cut twice. The average yield for the six years, two crops per year, has amounted to 4,886 pounds. For a number of years at the outset corn was grown continuously, but the policy followed during the past fourteen years has been to put the land alternately into hay and corn, two years each.

Nature of the Soil. — The soil of this field is a medium loam, consisting largely of very fine sand and silt. Soil of this character extends to a depth of about 2 to 3 feet below the surface, below which depth the subsoil is gravelly in character. The gravel of the subsoil is of a type containing rather too small a proportion of clay for road building. The subsoil, therefore, permits perfect drainage. The surface soil, on the other hand, is so fine in texture that it has good capacity to retain moisture, and crops seldom suffer in dry weather. Previous to 1889 the field had been in grass for a number of years, and had been used as a pasture. It would at that time produce about 30 to 40 bushels of shelled corn per acre, without manure or fertilizer.

Fertilizers used. — There has been a little variation in the fertilizers applied to the plot in different years, but throughout the greater portion of the time the actual application per acre has been as follows: —

	Pounds.
Nitrate of soda,	200
Dry ground fish,	200
Acid phosphate,	200
Muriate of potash,	250

The market price of these fertilizers has varied somewhat from year to year, but in the amounts used they have usually cost from $15 to $18 per acre.

The Corn Crops produced. — The yields of corn on this plot, under the above system of management and fertilization, have varied from 29.15 bushels of sound shelled grain per acre in 1893 to 90.23 bushels per acre in 1908. The yield in 1893 was much below the yield in any other year. This was due in a large measure to the ravages of wire worms. The average yield for the twelve years has amounted to 55.8 bushels of shelled grain and 5,189 pounds of well-dried stover per acre. The first two corn crops, 1891 and 1892, averaged at the rate of 56.3 bushels of shelled grain and 4,013 pounds of stover per acre. The last two corn crops, 1907 and 1908, have averaged 72 bushels of sound shelled grain and 8,057 pounds of stover per acre. The crop of last year was the heaviest that the field has ever produced. This was no doubt due to the fact that the season was exceptionally favorable for the crop. The fact that the average crop of the past two years is considerably greater than the average for the first two years makes it apparent that the fertility of the field is not declining.

Elements of Plant Food applied and removed. — A comparison of the total amounts of the leading plant food elements applied to the soil and removed is of interest in connection with the question as to what is the present condition of the soil, as regards fertility, as compared with its condition at the time the experiments began. Supposing the substances applied and the crops removed to have been of average composition, the income and outgo of plant food elements per acre has been as shown in the following table: —

Plant Food Elements applied and removed, per Acre.

Nitrogen (Pounds).		Phosphoric Acid (Pounds).		Potash (Pounds).	
Applied.	Removed.	Applied.	Removed.	Applied.	Removed.
611	1,509	1,295	534	2,255	1,058

This comparison, which must represent the facts with substantial accuracy, shows that the soil has received rather more than double the application of phosphoric acid and potash removed, and since scientific investigations have shown that under ordinary conditions there is but little waste of these elements from soils by leaching, the condition of the soil of this field in so far as regards these elements, must evidently be much better now than when the experiments began.

On the other hand, it will be noted that the crops have carried away substantially two and one-half times as much nitrogen as has been applied to the field. It might be supposed, therefore, that this soil must now be highly exhausted of this element, but, in view of the large crops which it is now producing, it does not seem probable that this is the case; and in considering this matter it must be remembered that during the past twelve years a mixed hay crop, which has always contained a large proportion of clover, has alternated with corn in periods of two years for each. It is a well-known fact that when soils are highly enriched in phosphates and potash in available forms, and at the same time prevented from becoming acid by suitable applications of lime, the conditions are peculiarly favorable for the assimilation of atmospheric nitrogen by clovers and other legumes. The clover in this field has, without doubt, assimilated large quantities of atmospheric nitrogen. It is indeed true that the clover crops have not been plowed under; they have been harvested and made into hay; but a large amount of nitrogen originally taken from the air must have remained in the roots and stubble, and we must conclude that the corn crops have drawn upon the nitrogen compounds formed when the clover roots and stubble decayed for a large proportion of the needed supply of this element.

The Labor Cost. — The acre of corn referred to in this discussion is laid out in plots, and is not managed under conditions which have made it possible to determine with any accuracy what would be the actual cost of labor under the usual farm conditions. The following estimate is based upon the labor cost of producing a corn crop in fields of considerable size, sufficiently free from obstructions to allow the free use of machinery: —

Labor Cost of the Corn Crop per Acre.

Plowing,	$2 00
Harrowing, three times,	2 00
Planting by machine,	1 00
Cultivating once with the harrow and twice with the weeder,	2 00
Cultivating with horse cultivator, three times,	2 50
Cutting out weeds with hoes, once,	3 00
Cutting with harvester, and shocking,	2 00
Husking at 10 cents per bushel of shelled grain,	5 58
Total,	$20 08

Additional Costs. — In addition to the fertilizer and labor costs, we must include the following items: —

For seed,	$0 50
Annual tax on the value of the land,	1 50
Interest on the value of the land,	5 00
Total,	$7 00

Total Cost of Crop. — Adding together the three items, fertilizers, labor and miscellaneous, we obtain the grand total cost of $45.08. The average yield of stover has been a little more than 2½ tons. This must be worth at least $8 per ton for feeding out upon the farm. If, then, we deduct the value of the 2½ tons, $20, from the $45.08, we have the net cost of the grain, $25.08. The average product has been about 56 bushels. The average cost per bushel on the basis of the above calculations must therefore have amounted to about 45 cents.

It is believed that all allowances in estimating the cost of corn as grown in this field have been liberal. In many cases the fertilizer has been purchased for considerably less than $18, and can be so purchased for cash by the ordinary farmer. The labor items are estimated at about what the farmer would be obliged to pay for labor should he hire. The actual cost to the farmer of team labor is undoubtedly less where he owns his own team. Forty-five cents per bushel is much below the average price per bushel at which corn is sold in our markets. It would seem, therefore, to be perfectly clear that the farmer having land suited to the crop can in many cases much better afford to raise corn than to purchase it. It is of course possible that in some cases a man's land, capital and labor may be even more profitably used in the production of other crops.

Conclusions. — These experiments clearly indicate: —

1. That corn can be produced at a profit in Massachusetts.

2. That by the use of properly selected fertilizers and adoption of a short rotation, making corn follow mixed grass and clover, it appears to be unnecessary to use nitrogen fertilizers in large amounts, at least on the better soils.

3. That the soil used in these experiments is not declining in fertility, but, on the other hand, appears to be gradually improving.

4. That both corn and hay can be profitably raised, at least on soils of good physical characteristics, by the use of fertilizers only.

5. The writer would not have the reader conclude that the particular selection of fertilizers used throughout the greater portion of the time during which this experiment has continued will necessarily be the best under all conditions. Indeed, in the light of all his previous experience in the selection of fertilizers he would now be inclined to recommend the following selection of materials as well suited for average conditions: —

	Pounds per Acre.
Nitrate of soda,	150
Dry ground fish, or high-grade tankage,	200
Acid phosphate,	200
Basic slag meal,	400
High-grade sulfate of potash,	200

The sulfate of potash and basic slag meal might with advantage be mixed, and applied in the autumn or very early spring. The other materials should be mixed, applied after the preparation of the soil is nearly finished and lightly harrowed in just before planting the crop.

Work in Animal Feeding.

BY J. B. LINDSEY.

Alfalfa Meal v. Wheat Bran.

The merits of alfalfa hay when early cut and well cured are fully recognized by feeders of farm stock. Considerable alfalfa hay is being ground, and offered both as a food for poultry and as a substitute for wheat bran for dairy animals. The station has made a study of the comparative merits of ground alfalfa and bran for milk production, and briefly presents the results.

Composition of Alfalfa.

	Alfalfa Meal used in Experiment.	Alfalfa Hay for Comparison.	Wheat Bran for Comparison.
Water (per cent.),	10.06	9.56	10.00
Protein (per cent.),	13.01	13.24	16.30
Fat (per cent.),	1.28	3.36	4.40
Fiber (per cent.),	32.32	31.07	10.00
Extract matter (per cent.),	35.39	34.13	53.10
Ash (per cent.),	7.94	8.64	6.20

Alfalfa differs chemically from bran in containing rather less protein, decidedly less extract matter and correspondingly more fiber. Both have a high ash percentage, which renders them well suited as food for young stock.

Organic Matter digestible in 2,000 Pounds.

	Protein (Pounds).	Fiber (Pounds).	Extract Matter (Pounds).	Fat (Pounds).	Total (Pounds).
Alfalfa,	190.6	292.0	491.4	28.9	1,002.9
Bran,	251.0	78.0	754.0	55.4	1,138.4

It will be seen that bran furnishes noticeably more digestible protein, extract matter and fat than alfalfa; the latter has a much larger percentage of digestible fiber. Fiber is the least desirable food nutrient to purchase, as it requires noticeably more energy for its digestion than any of the other groups of nutrients. Bran contains over 100 pounds more total digestible nutrients to the ton, and, other things being equal, should be regarded as a more economical food for milk production.

Alfalfa Meal for Milk Production.

The station conducted an experiment with 6 milch cows, and, from the results secured, concluded that pound for pound wheat bran proved slightly superior to the alfalfa meal. Both feeds act as slight laxatives and are well suited to dilute or distribute the heavy concentrates.

The Pennsylvania station made a similar experiment, and stated: (*a*) "The results do not warrant the recommendation of alfalfa meal as a substitute for wheat bran as a feed for dairy cows at present market prices (bran, $20, alfalfa meal, $23, per ton);" (*b*) "the alfalfa meal was less palatable, and resulted in a decreased milk production in every case."

The writer can see no advantage in replacing bran by alfalfa meal, for the reason that the quality of the latter, as measured by the grade of the hay employed, is likely to vary considerably. Late cut alfalfa has a low digestibility, and will prove decidedly inferior to a good quality of bran.

Alfalfa as a Forage Crop.

For a number of years this department has had under observation a small lot of alfalfa (⅓ acre), growing upon a well-drained, rather light loam. It has yielded from 3½ to 4½ tons of dry hay to the acre (15 per cent. water basis).

During the season of 1907 it was cut for the last time about the middle of September. It did not grow as freely as usual thereafter, and went into the winter without as much of a growth as usual with which to protect it. The early winter being devoid of snow, the alfalfa was exposed most of the time until well into January. A careful study of the field in the spring of 1908 made clear that from one-third to one-half of the plants had died or had been seriously weakened. During the season (1908) the growth was cut three times; orchard grass and couch or quick grass took the place of a large proportion of the alfalfa, and comprised approximately one-half of the yield, which was not weighed. Winterkilling of alfalfa was also experienced on other plats on the college farm. In spite of the apparent tendency of alfalfa to kill out at intervals, it is believed to be worthy of careful trial on well-drained farms in Massachusetts, because of its heavy yields and value both as a green fodder and as hay. (For method of seeding, fertilizing and harvesting, see Bulletin No. 120, p. 37, and Circular No. 18, published by this station.)

Dried Blood and Tankage for Dairy Stock.

Tankage for animal feeding is prepared "from scraps of meat of cattle and hogs (lungs, tendons, bones, etc.), cooked for four hours in large steel tanks under 25 to 40 pounds' pressure. . . . The tankage is then pressed, to remove the excess of water and fat, after which the feed is dried and ground." The highest grade contains from 50 to 60 per cent. protein, 10 to 15 per cent. fat and 6 to 10 per cent. bone ash, and has a noticeable odor. It is recommended chiefly as a supplement to corn for feeding pigs, in the proportion, by weight, of 1 part tankage to 5 to 10 parts corn, and has been shown to be productive of very satisfactory results. It seems probable that 1 part tankage to 5 parts corn could be fed to young pigs, and the proportion of corn increased as the process of fattening took place. This station fed Swift's digester tankage to cows in place of twice the amount of high-grade distillers' grains, the ration consisting of 4 pounds wheat middlings, 1 pound distillers' grains and 1½ pounds tankage. The animals made no objection to eating the tankage, in spite of its noticeable odor. Frequent samples of milk were examined, both cold and at a lukewarm temperature, but it was not possible to detect any flavor or odor that could be attributed to the meat product. It is not considered advisable, however, to feed such material to dairy stock.

Dried blood for feeding purposes is prepared by heating the fresh blood of cattle and swine in large tanks at 212° F. The excess of water is removed from the coagulated mass by means of heavy pressure, and it is then passed through steam driers and eventually ground and bagged. As thus treated it appears as a friable powder of dark color and with only a slight odor.

For horses that are hard worked ½ to 1 pound daily of dried blood, mixed with the corn, bran and oat ration, will prove very satisfactory.

For calves, as a remedy against scours, the Kansas experiment station recommends a teaspoonful of especially prepared blood (soluble blood flour) added to each feeding of milk.

For dairy stock the Massachusetts station has found dried blood quite a satisfactory protein concentrate as compared with cotton-seed meal.

The conclusions in this experiment were as follows: —

1. Dried blood contained about 85 per cent. protein, and for cows in milk may be fed in amounts varying from 1 to 2 pounds daily, mixed with concentrates of vegetable origin. A satisfactory combination for a day's ration for cows producing 10 quarts of milk may consist of 2 to 3 pounds wheat bran, 2 to 3 pounds corn or hominy meal and 1.5 pounds dried blood. Other mixtures can be made containing blood as a substitute.

2. It is believed to be the part of economy to first utilize as much as possible of the cattle blood product of the country as an animal food, rather than to apply it directly as a fertilizer.

3. The present price of prepared blood, its lack of distribution in local markets and the ignorance of the consumer concerning its merits as a food have thus far prevented its general use for feeding purposes.

Molasses for Farm Stock.

In 1907 this station published Bulletin No. 118, bearing the above title. Inasmuch as the edition is entirely exhausted, and constant inquiries continue to be received concerning the use of molasses as a food for farm animals, a very brief résumé of the bulletin may not be out of place.

Composition of Molasses.

The molasses offered for cattle feeding in New England is the residue resulting from the extraction of sugar from the juice of the sugar cane, and is imported from Porto Rico. It is composed of about 25 per cent. water, 6 to 7 per cent. ash, 2 to 3 per cent. crude protein, and the balance — 65 to 67 per cent. — sugars and allied substances. The chief constituent of the ash is potash (3 to 5 per cent.). The crude protein consists largely of amid bodies, which do not serve the same purpose as true protein. Fiber and fat are naturally not present.

Molasses has the same type of composition as corn meal, both being low in protein and very high in carbohydrates. The dry matter of molasses differs chemically from corn meal in containing less protein with an inferior nutritive value, more ash, and in having its extract matter in the form of sugars rather than starch.

Relative Value of Molasses and Corn Meal.

Allowing a ton of Porto Rico feed molasses to contain 1,100 pounds and a ton of corn meal to contain 1,470 pounds of digestible organic matter, if the latter retailed at $30 a ton the molasses would be worth $22.50 a ton, or molasses would have 75 per cent. of the value of corn meal as a source of digestible carbohydrates.[1]

The Use of Molasses.

For Dairy Stock. — The station has conducted experiments with molasses for dairy stock. The animals were in good health at the beginning of the experiments and no particularly favorable effect of the molasses was noted. A ration composed of 3 pounds wheat bran, 1 pound cotton-seed meal and 3 pounds molasses proved a desirable one. The molasses can be diluted somewhat with water and mixed with the bran and cotton-seed meal, or considerably diluted and sprinkled over the roughage, or given in water as a drink. Being very deficient in protein it must be fed with feeds rich in that ingredient, such as bran, malt sprouts, brewers' dried grains, cotton-seed meal and gluten feed. The writer would make the following general statement: *There is no particular advantage to be gained by northern farmers from the use of molasses as a food for dairy stock in the place of corn meal and similar carbohydrates. As an appetizer*

[1] The particularly favorable effect which molasses is supposed to have upon the general health of the animal is not included in the above calculations; neither does the lack of protein as compared with corn meal nor the extra cost and bother of handling molasses enter into the calculations.

for cows out of condition, and for facilitating the disposal of unpalatable and inferior roughage and grain, 2 to 3 pounds of molasses daily would undoubtedly prove helpful and economical.

For fattening Cattle. — Some 3 pounds daily of molasses may be fed advantageously, especially during the finishing process, when the appetite is likely to prove fickle. The object at such time should be to make the food especially palatable and thus induce a maximum consumption, and also to secure a bright, sleek appearance.

For Horses. — Molasses is fed to a considerable extent both in Germany and France, and most feeders consider it a valuable addition to the daily ration. As a result of experience and a review of the work of others the following opinion is expressed relative to the place of molasses in the nutrition of horses: *In spite of the many reports favorable to the use of molasses for horses, the writer is not inclined to recommend to northern farmers its indiscriminate use in place of the cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive and for improving the palatability of rations, 2 to 3 pounds daily of molasses would undoubtedly prove productive of satisfactory results.*

Rations containing Molasses.

1. — Nicolas (French Origin).[1]		*2. — Nicolas (French Origin).*[1]	
Grain hulls,	13 pounds.	Grain hulls,	13 pounds.
Bran and shorts,	13 pounds.	Bran and shorts,	4.5 pounds.
Molasses,	3 pounds.[2]	Crushed oats,	6.5 pounds.
Water,	6 quarts.	Molasses,	3 pounds.[2]
		Water,	6 quarts.
3.[3]		*4.*[3]	
Dried brewers' grains,	5 pounds.	Crushed oats,	5 pounds.
Hominy feed,	5 pounds.	Cracked corn,	5 pounds.
Molasses,	2 pounds.[2]	Molasses,	2 pounds.[2]
Hay,	15 to 18 pounds.	Hay,	15 to 18 pounds.
5.[3]		*6.*[3]	
Cracked corn,	6 pounds.	Hominy feed,	7 pounds.
Wheat bran,	4 pounds.	Gluten feed,	3 pounds.
Molasses,	2 pounds.[2]	Molasses,	2 pounds.[2]
Hay,	15 to 18 pounds.	Hay,	15 to 18 pounds.

[1] The grain hulls are spread upon the floor, sprinkled and mixed with one-half of the molasses (each pound of molasses is diluted with 2 quarts of water). The bran and shorts are mixed in, after which the balance of the molasses, dissolved in water is sprinkled over the mass, which is once more mixed and is then ready for use.

[2] A quart of molasses weighs about 3 pounds

[3] Suggested by Lindsey for horses weighing 1,200 pounds and doing moderate farm work. Grain can be increased if work is strenuous, and hay somewhat reduced.

For Pigs. — If molasses is used for the nutrition of pigs it must be mixed with foods reasonably rich in protein. If skim milk is not available, a combination by weight of 2 parts bran, 1 part gluten feed, 1 part corn meal and 1 part molasses, or 1 part tankage, 4 parts corn meal and 1 part molasses ought to prove satisfactory. It is not believed there is any particular advantage under ordinary conditions for the northern farmer to employ molasses for pig feeding other than as an appetizer. About 1 pound daily of cane molasses per 100 pounds live weight is the usual amount. A few ounces daily should be fed at first and the amount gradually increased.

Eureka Silage Corn.

Eureka silage corn, a large southern dent, is considerably used by farmers in Massachusetts for silage purposes and is especially recommended by a large agricultural warehouse. During the season of 1903 and 1904 the station studied the value of this corn on its own grounds, and in its report[1] of the two years' trials drew the following general conclusions: —

1. The corn grew to a height of 13 or more feet, and when cut (September 15) the ears were just forming. It contained some 6 per cent. more water than Pride of the North (a medium dent that will mature its ears in our latitude), noticeably more ash and fiber, and much less starchy matter. The analysis indicated a very immature condition. The field-cured fodder contained some 69 per cent. of water, against 38 per cent. found in Pride of the North under similar conditions.

2. The Eureka did not yield any larger proportion of leaves than did the other variety. Of the entire plant, 67 per cent. were stalk, as compared with 47 per cent. from the Pride of the North.

3. While the Eureka produced one-third more weight of green material to the acre than did the other variety, the latter contained nearly as much actual food material. The excess of yield of Eureka green corn, therefore, consisted of water. As a result of the inquiry the northern farmer was advised not to grow such late sorts as the Eureka, but to hold fast to those

[1] Eighteenth report of the Hatch Experiment Station, pp. 86-93.

varieties that would reach maturity not later than September 10 to 15.

The writer was criticised at the time, it being claimed because of the lack of height of the corn (13 feet) that the land on which the corn was grown was not sufficiently supplied with plant food, and that the Eureka did mature its ears in central and southern Massachusetts. In order partly to answer these criticisms the station has grown the Eureka during the years 1907 and 1908. The land, in a fair state of fertility, was dressed with manure at the rate of 6 cords to the acre, and in addition a very liberal application of commercial fertilizer was made. In neither season was it possible to mature the corn on the station grounds. The corn reached about the usual height, silked, and the ears were forming and showed kernels about September 15. The ears form very near the top of the stalk, which is not a desirable feature. The writer does not question the veracity of parties who state that in central and southern Massachusetts fields of this corn have produced more or less matured ears. It is his belief, however, in view of the coarseness and general immaturity of the plant under average conditions, that it is not a desirable corn for Massachusetts dairymen to grow. The farmer will do far better to plant Leaming, Rustler's Minnesota dent, Pride of the North, Longfellow and Sanford White. Such varieties will undergo less fermentation and decomposition in the silo and will yield a less sour and more nutritive silage.

Wet Brewers' Grains.

Wet brewers' grains contain 75 to 77 pounds of water in 100, and are practically all sold to farmers living in the immediate vicinity of the brewery, at prices ranging from 10 to 12 cents a bushel. Assuming that 33 bushels weigh a ton, the cost would be from \$3.30 to \$4 at the brewery, to which the cost of cartage should be added. Four tons wet grains contain nutritive material equivalent to that found in 1 ton dry grains, or in 1.1 tons wheat bran, or in ¾ ton gluten feed. With this data at hand, the purchaser of this material can calculate at what price he can secure an equal amount of nutrients in the various dry feed stuffs. The writer has not had any experience in feeding wet grains, but believes that 25 pounds is a fair allowance daily for average-sized cows.[1] In addition, 2 to 4 pounds dry grain may be fed daily, such as a mixture of equal parts by weight of (1) mixed wheat feed and gluten feed, (2) wheat bran and fine middlings, or (3) wheat bran and corn meal.

The succulency of the wet grains is a factor not to be overlooked in estimating the value of the feed. It is not believed that the wet brewers' grains are an objectionable feed stuff when fed in a fresh condition and in moderate quantities. It must be remembered, however, that they are likely to spoil easily, excepting when the temperature is low, and the partly decomposed grains would not be considered suitable for producing first-class milk. When milk is intended for the use of infants, young children or invalids, it is better not to use the wet grains.

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[1] It is understood that 50 or more pounds are frequently fed daily. It is believed, however, that the smaller quantity is preferable when the grains are fed continuously and it is desired to retain the same animals in the herd from year to year.

Sour and Colored Gluten Feeds.

BY P. H. SMITH.

Gluten feed is, excepting the germ, the residual product in the manufacture of starch and glucose from corn. It is used extensively in dairy rations, its sales being probably second only to those of the wheat by-products. During the past season considerable agitation has been caused by the condition of certain shipments of gluten feed, which had not only a decidedly acid taste but were found upon examination to have been colored with an aniline dye. The experiment station has, through Mr. P. V. Goldsmith, made a somewhat extended investigation of the gluten feed found on the Massachusetts market, both as to acidity and coloring.[1] Some lots of feed were, if at all, only slightly sour; others were so sharply acid to the taste as to be considered unpalatable. As a very dilute solution of sulfurous acid is used to soften the corn before separating the starch, it seemed probable that the sour taste was largely due to this acid. On examination, however, it was found that neither sulfurous nor sulfuric acid was present in sufficient quantities to account for all the acid found. In the light of the evidence now at hand it is believed that the acidity is due principally to the salts of phosphorus, and that sulfurous acid and the sulfites are present in such minute traces as not to be considered harmful. It is not thought that the amount of acid present is in any way injurious to animals. It is believed, however, that a more satisfactory product would result if, before placing on the market, the feed were treated in such a way as to leave only a minimum amount of acid evident to the taste.

Coloring Matter. — Some 80 per cent. of the gluten feeds on the market were found to be artificially colored with an aniline

[1] See Part II. of the report of this station, published under separate cover.

dye. The manufacturers claim that coloring matter is added for two reasons: (1) to make the feed more attractive, and (2), as both white and yellow corn are used, it is necessary to resort to coloring in order to obtain a uniform product. The color in gluten feed is present in only minute traces, and, while it may not be injurious, the practice of coloring is believed to be unnecessary. Buyers are urged to be governed largely by the guarantee and taste and less by the color in purchasing gluten feeds.

Weed Seeds in Feed Stuffs.

BY P. H. SMITH.

Screenings are composed of the light, immature grain separated from the good grain in the process of winnowing, together with such dirt, chaff, straw and weed seeds as may be present in the grain as it comes from the field. It is quite obvious that screenings may be of a very uncertain character, depending upon the kind of seed making up the mixture, and also upon the amount of other foreign matter in the grain as received. Screenings are used with some success as a food for sheep. An increasing amount of screenings is being used, especially as a component of molasses feeds, and occasionally with wheat middlings and other prepared cattle feeds. Flax screenings have been ground and put on the market as flax feed. While screenings are a legitimate by-product and of some feeding value, they are inferior to the grains from which they are derived, and much inferior to the high-grade protein concentrates. Their addition to any prepared feed can only tend to cheapen it, and any feed on the market which contains any considerable proportion of screenings should sell for a considerably lower figure than the ruling price for standard goods. Their use is objectionable for the following reasons: —

1. They are unpalatable, many of the weed seeds found in screenings being decidedly bitter.

2. They are likely to carry considerable fiber, due to the presence of straw, chaff and to the tough hulls of the weed seeds. This fiber tends to decrease their digestibility.

3. They are a prolific source of weeds on the farm.

4. They are not usually sold on their merits, but are offered in disguise by being mixed with feeds of better quality.

5. The price asked for such feeds at retail is quite out of proportion to the original cost. Manufacturers of molasses feeds are attempting, in some instances, to destroy the germinating power of the seeds by grinding. Farmers, is it good business policy to buy weed seeds? Why carry coals to Newcastle!

Common Weed Seeds in Grass Seed and Cattle Foods.

BY G. H. CHAPMAN.

During the past two years the writer has had occasion to examine numerous samples of commercial feed stuffs and grass seed for the purpose of identifying the various weed seeds contained in them. The cattle feeds were examined for the Department of Plant and Animal Chemistry, which is charged with the execution of the feed law. The grass seeds tested were mostly from samples sent by farmers and others. In the case of the cattle feeds the seeds partly ground and partly whole were added usually in the form of grain screenings, while those contained in commercial grass seed are accounted for by improper cleaning. Samples of wool waste used for fertilizer purposes have been found to contain a considerable variety of weed seeds, such as clotbur, bur clover, species of medicago, alfalfa, ragweed, plantain, red clover, wild turnip, corn-cockle, etc. A person buying such a product should be very careful to treat it with something which will destroy the germinating power of the seeds before using it on the land. Treatment with dilute sulfuric acid or some such reagent might be recommended, but it is an open question as to the economy of such a proceeding.

Some of the weed seeds found in foods and seeds are harmless, but by far the greater number are noxious, and not only likely to choke out useful plants and grasses, but in themselves are injurious to cattle when eaten in any large quantity. These, however, are easily distinguished, and a description of them will be given later. A great many of the weed seeds found in cattle foods are undoubtedly digested and their germinative power destroyed, but some of the varieties with thick, hard cell walls will pass through the digestive tract uninjured and later germinate.

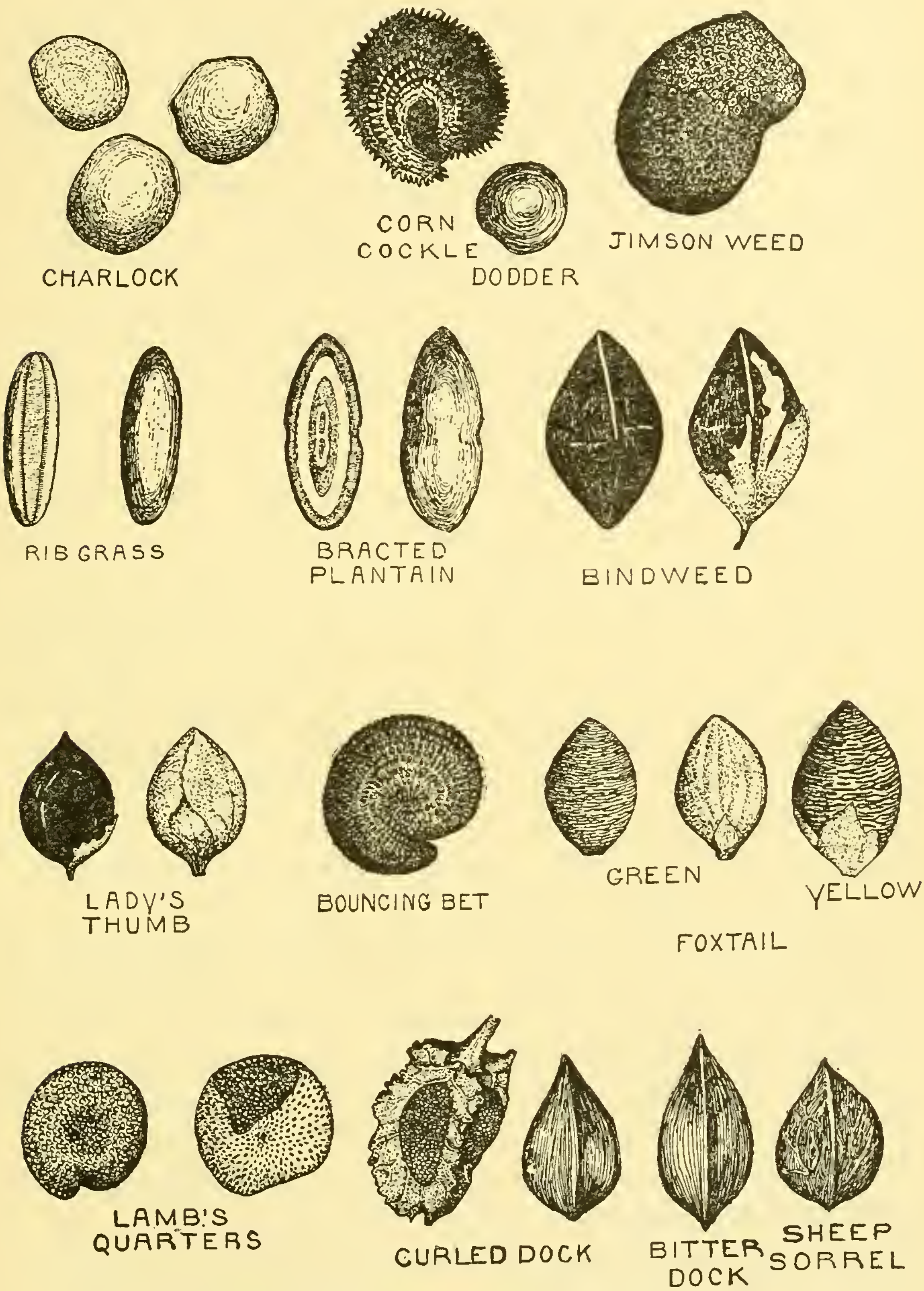
The principal weed seeds found were as follows: corn-cockle, charlock, Jimson weed, wild turnip, rib grass, broad-leaved plantain, bindweed, lady's thumb, bouncing Bet, ragweed, medicago, lamb's-quarters, green and yellow foxtail, curled dock, bitter dock, crab grass, pigweed, darnel, clotbur, bur clover, dodder, and occasionally others. Nearly all of the weeds mentioned above may be classed as noxious, and are a menace to any farm. Three of them — corn-cockle, darnel and Jimson weed — are harmful to cattle on account of the alkaloidal principles they contain, and are poisonous to animals when eaten by them in large quantities.

A detailed description of several of the more commonly occurring weed seeds is given below, by use of which it is hoped the reader may identify them when present in a feed or in grass seed.

Charlock or Wild Mustard (*Sinapis arvensis,* L.). — Wild mustard is very often found in feeds and occasionally in grass seeds. In appearance it is similar to rape seed, but much smaller. It is a deep brown to dull black in color, and nearly spherical in shape, and under a reading glass or hand lens the surface of the seed appears smooth. In size the seed is about $\frac{1}{16}$ of an inch or less in diameter. When growing in the field it is easily recognized by its bright yellow flowers.

Corn-cockle, Cockle (*Agrostemma githago,* L.). — This seed is very often found in feed stuffs, and when present in any great number is injurious to cattle on account of the poisonous alkaloid, sapotoxin, which it contains. The seed is roughly kidney shaped, resembling "a rolled up caterpillar." In size the seed is from $\frac{1}{16}$ to $\frac{3}{16}$ of an inch in diameter, and in color varies from brownish black to dead black. The surface is rough, and to the naked eye there seem to be parallel rows of minute projections over the whole seed. When cut open the seed is found to be filled with a mealy white substance, forming a strong contrast to the black outside covering.

Jimson Weed, Jamestown Weed (*Datura stramonium,* L.). — This weed is occasionally found as an impurity in commercial products, and is very harmful to animal life on account of the poisonous principle it contains. It is, however, a very easy matter to identify this seed when found, as its markings are



Common Weed Seeds, magnified about Ten Diameters.

characteristic. It is from ⅛ to $\frac{3}{16}$ of an inch long and about three-fourths as broad; shaped very much like a small lima bean. Its color varies from brown to black, and to the eye the surface appears to be covered with small depressions of a roughly pentagonal form, which give a wrinkled appearance to the seed. This troublesome weed seed is, however, very seldom found.

Rib Grass (*Plantago lanceolata*, L.). — The seeds of this as well as of other varieties of plantain are very often found in grass seeds as well as in commercial feed stuffs, but each is so different in appearance that it is easy to recognize them, either with the naked eye or by the help of a hand lens. The seed of *Plantago lanceolata* is shaped very much like a blunt, double-ended canoe, the convex side being shiny brown to black in color, and the concave side a little lighter as a rule. The seeds are about 1/16 of an inch in length. There is in this variety no transverse line crossing the back of the seed.

Bracted Plantain (*Plantago aristata*, L.). — The seeds of this variety of plantain are somewhat larger than those of the rib grass but are of much the same shape, *i.e.*, canoe shaped, but are flatter. They vary in length from 3/32 to 1/8 of an inch, and on the concave side are distinctly marked with a concentric ring of light color enclosing an inner portion of a grayish white color. They are brown on the convex side, and this side is marked with a slight transverse depression, which is usually visible to the naked eye and which is easily distinguished under the hand lens.

Bindweed, Wild Buckwheat (*Polygonum convolvulus*, L.). — This weed seed is probably the one that occurs most frequently as an adulterant and impurity in feeds and grass seeds. It is shaped like the seed of buckwheat, but is smaller, never being over 1/8 of an inch long. In color the seed is jet black or sometimes brownish black. Under the lens the seed appears to be covered with very minute projections, giving it a roughened appearance.

Lady's Thumb, Smartweed (*Polygonum persicaria*, L.). — This seed belongs to the same family as the one just described, and is often found as an impurity in grass seeds, etc. In shape it is much like a flattened buckwheat seed, having two distinct sides instead of three. In color it varies from dark, glossy brown to black, and the surface is very smooth. The seed is about $\frac{1}{16}$ of an inch in length and has a width of about three-fourths its length.

Bouncing Bet (*Saponaria officinalis,* L.). — This seed is flattened, somewhat disk shaped, resembling a lima bean, and of a dull black color. In size it varies from $\frac{1}{16}$ to $\frac{3}{32}$ of an inch in length. Under the hand lens the surface can be seen to be covered with minute projections arranged in more or less parallel rows along the long axis of the seed.

Green and Yellow Foxtail (*Chætochloa viridis and C. glauca,* L.). — The seeds of the two varieties are different in size, although both have the same general appearance. The seeds of both are flat on one side and very convex on the other. In shape they resemble a double-ended canoe. They are usually a little less than $\frac{1}{8}$ of an inch long. The seeds of the yellow fox-tail are usually somewhat larger and less convex than those of the green, and the color of the seed is somewhat different. The seeds of *glauca* are greenish yellow in color, while those of *viridis* are from pale green to light brown in color. Under the hand lens the convex side of the seeds is seen to be covered with transverse wrinkles, which are much more prominent in *glauca* than in the other.

Lamb's-quarters, Pigweed, Goosefoot (*Chenopodium album,* L.). — This seed is usually found whole, and on account of its very similar appearance is likely to be confounded with the true pigweeds. It is double convex in shape, and its diameter is usually a little less than $\frac{1}{16}$ of an inch. In color it is a glossy black. Very often it is found incased in the hull or cover in which it grows; it is then gray in color, but has the same general shape as the seed itself. By rubbing between the fingers the covering may be removed and the shiny black seed exposed.

Curled Dock (*Rumex crispus,* L.). — The seeds of the docks and sorrels are often found in grass seeds but are so well known to most people that only a brief description of them will be given here. The seed of the curled dock is a little larger than that of the sorrel, being about $\frac{3}{32}$ of an inch long, and is shaped very much like buckwheat, but is relatively rather broader at the base. In color the seed is a beautiful, glossy, reddish brown.

Bitter Dock (*Rumex obtusifolium*, L.). — The seeds of the bitter dock are very similar to those of curled dock, but are a little narrower at the base. In color they are lighter, more of a grayish brown, and are not so glossy as those of the curled dock.

Sheep Sorrel (*Rumex acetosella*, L.). — This seed is shaped like that of buckwheat, but is not nearly so large, measuring only about $\frac{1}{16}$ of an inch in length. In color the seed is dull reddish brown. Under the hand lens the surface shows rough, being covered with numerous small ridges and projections.

Dodder (*Cuscuta sp.*). — The last seed which we shall take up in this article is that most noxious of all weeds, namely dodder. This is a parasite form and chokes out all other growth when well established. The seeds are very small, more or less globular and of a light yellow or buff color. No other seed is likely to be confounded with it, as it is smaller than any of the clovers, and no other resembles it closely.

It is realized that the foregoing descriptions are meager, but they are as simple and as full as possible without going into the microscopical characteristics of each seed. Only a few of the more commonly occurring weed seeds have been described as lack of space prevents a description of the numerous others found in commercial products.

Brief Notes on the Weeds of Massachusetts.

BY G. E. STONE.

There is considerable historical data concerning the introduction of weeds and foreign plants in Massachusetts. Josselyn in 1672 mentions as many as forty species of European weeds which had become more or less well established in New England at that time. Some of the plants which he described were so thoroughly naturalized that it was doubtful in some cases whether they were indigenous or not, and this was particularly true of plantain and white clover, which followed the footsteps of the new colonists so closely.

In 1783 Dr. Cutler enumerated over sixty introduced plants to be found in New England, and Dr. Bigelow in 1814, in his "Florula Bostoniensis," mentioned over eighty, while in 1840 the number had nearly doubled, and at the present time there are about six hundred foreign plants which have been recorded as found growing here and there in Massachusetts. From this it appears that the number of introduced plants has increased quite rapidly, and while a number of them are confined to dumps, and have shown little tendency as yet to become established, they deserve to be watched, as the history of some introduced plants teaches us that they are capable of remaining dormant for long periods and then suddenly becoming pests. The golden hawkweed or paint-brush is an excellent illustration of a plant of this description, since this species has existed in New England for many years, and only comparatively recently has spread to any extent, but is now becoming a nuisance. On the other hand, the Russian thistle, which became disseminated over a large territory a few years ago, and which caused much concern among farmers, is seldom referred to at the present day.

The introduction of foreign plants is constantly increasing, and will continue to increase, owing to our more extended commercial relations with foreign countries. The only possible way to check it is to restrict commercial enterprise, which it is needless to say is an absurd proposition. At the present day we import one thousand plants from foreign countries where years ago only one was imported, and there is scarcely any section of the globe with which we have not commercial relations.

The wool imported into our State comes from many sources, and the wool waste, containing many foreign seeds, when thrown out on dumps is responsible for many of our foreign plants. A large number of manufacturers import their raw material, and railroads are common carriers of weed seeds. Plants of this description are sent to the station every year for identification, and it is our purpose to have these preserved in the State herbarium, located at the college. Records are also kept of these foreign plants for future reference.

Our weeds may be conveniently divided into the following classes: first, those which are common to lawns, such as dandelions, plantain, moneywort, etc. Second, those which are common to grass lands, such as the white daisy, dock, sorrel, wild carrot, witch grass, golden hawkweed, etc. Third, those which are found in cultivated fields and gardens, like chickweed, pursley, shepherd's purse, etc. Fourth, those found on roadsides and dumps, like burdock, ragweed and various others, many of which are recent introductions. Fifth, those which are common to pastures, often native plants, like sweet fern, etc. Finally, the so-called native weeds, which under modern conditions find favorable opportunities for growth. There is a considerable number of the latter class which adapt themselves to open places, roadsides, etc., and which are often troublesome in fields. Many of these plants are undesirable, that is, they are often found growing where they are not wanted, and in this sense are weeds. As an illustration of this type of plant may be mentioned *Potentilla fruticosa*, L., a native plant which often becomes very troublesome in pastures in western Massachusetts. Dr. R. M. Harper[1] has recently given a tentative list of the so-called native weeds which he has observed growing in southern New England. The large open spaces which now prevail

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[1] Torrey Bulletin, 1908.

are undoubtedly the principal factors responsible for this class becoming more common than formerly, and the changed conditions of the soil, brought about by the constant deforestation and cultivation, which have been the means of changing the humus and water-retaining capacity of the soil, are also responsible for the present distribution of many of our plants.

Results of Seed Separation.

BY G. E. STONE.

The following tables show the results of some seed separation tests made the past year. In the case of the parsnip seed, in Table I., the seeds were cleaned, just as they came from the field, with a winnowing machine, and were separated into four different grades. The chaff and very small, imperfect seeds were discarded and the three remaining grades tested. Two hundred seeds of each grade were planted, with the following results: —

Table I. — *Experiment with Separated Parsnip Seed.*

	Large Heavy.	Small Heavy.	Small Light.
Number of seedlings, . . .	129	79	27
Weight of seedlings (grams), .	4.5	1.9	.7

The results given in this table show conclusively the advantage of seed separation. The number of seedlings, which in this case represents the percentage of germination, and the weight show important differences. The " small heavy seeds " resemble the larger ones in being fairly well filled out, but the wings were either broken or not developed characteristically. For the purpose of obtaining large plants of a uniform size all but the large parsnip seed should be discarded before planting.

TABLE II. — *Showing Results of Seed Separation.*

Kind of Seed.	Per Cent. of —		Per Cent. Germination of —		
	Heavy.	Light.	Normal.	Heavy.	Light.
Lettuce,	91.6	8.4	77.5	100.0	60.0
Lettuce,	89.8	10.2	86.0	95.0	85.0
Average,	90.7	9.3	81.7	93.0	72.5
Celery,	89.0	11.0	85.0	98.0	52.0
Celery,	88.1	11.9	84.0	98.0	69.0
Celery,	85.7	14.3	90.0	95.0	69.0
Celery,	86.6	13.4	90.0	97.0	49.0
Celery,	90.7	9.3	83.0	92.0	65.0
Celery,	88.1	11.9	80.0	96.0	35.0
Celery,	86.2	13.8	87.0	91.0	54.0
Celery,	86.6	13.4	89.0	98.0	78.0
Average,	87.6	12.4	86.0	95.5	59.0
Onion,	80.0	20.0	-	70.0	10.0
Onion,	87.5	12.5	74.5	90.5	41.0
Onion,	83.4	16.6	80.0	90.0	75.0
Onion,	90.0	10.0	39.0	90.0	69.0
Onion,	86.6	13.4	-	85.0	73.0
Onion,	85.0	15.0	91.0	96.0	83.0
Onion,	88.4	11.6	-	38.5	16.0
Average,	85.9	14.1	71.1	80.0	52.0

The preceding table gives the results of seed separation and the percentage of germination of the normal, heavy and light seed of lettuce, celery and onion. The "normal" column represents seeds taken from the sample as sent in, and the "heavy" and "light" grades those obtained by separation. By the process of separation the average germination of lettuce was increased from 81 to 93 per cent., that of celery from 86 to 95 per cent. and that of onion from 71 to 80 per cent. The average percentage of the seed discarded was 9 for lettuce, 12 for celery and 14 for onion.

Seed separation may be used to advantage to increase the percentage of germination of seeds left over from one year to another. In many cases the seeds which show too low a percentage of germination may be rendered available for planting if a sufficient number is taken out.

Examination of Onion Seeds for Fungous Spores.

BY G. E. STONE.

In connection with our work in separating onion seed occasional microscopical examinations were made of the filtered residue from the seeds washed with hot water. Onions are affected with various fungous diseases, and this examination was therefore made for the purpose of determining what likelihood there is of onion seed contaminating the soil with smut spores; or, in other words, acting as agents of infection.

The few examinations of seeds made show that there is much foreign material adhering to them, and we found in all instances numerous spores of onion smut and rust.

We hope to make a more extensive examination of onion seeds in the coming spring, and if necessary shall give some attention to methods of ridding seeds of infectious material before they are planted.

Bacterial Rot of Cabbage and Cauliflower.

BY G. E. STONE.

Severe outbreaks of this disease occur more often than formerly in Massachusetts, and are often responsible for much loss. The disease is characterized by a rotting of the head, which eventually becomes a slimy mass.

Little or no attempt has been made to prevent this disease, and the writer recommends that more attention be given to the rotation of crops. Another remedy consists in treating the seed with formalin for fifteen minutes, at the rate of 1 pound (1 pint) to 20 gallons of water.

Crown Gall.

BY G. E. STONE.

The crown gall, which occurs on fruit trees and some other plants, and which has been more common in other sections than here, has been noted from time to time in this State. The last two or three years much of the young stock in the college nursery has been infected, necessitating the destruction of quite a large number of nursery trees. These trees were growing on Doucin and Paradise stock and in some cases native stock has shown infection. Much of the stock imported from other States seemed to be infected with crown gall, and it is also known that much of the European stock is in a similar if not worse condition.

When peach stones have been planted directly in the soil, and the stock budded upon the seedlings, infection has followed, and this is also true of seedling apple stock, apparently indicating that some of our soils harbor the germs of this disease.

Very little is known concerning remedies for this trouble; neither is the full life history of the organism well understood, but investigations of both are being made.

The Preservation of Maple Syrup.

BY G. E. STONE.

Those who delight in the fresh and delicious flavor of new maple syrup, and who care little for the fermented product, will be interested in the fact that by the simple process of sterilization much of the flavor is retained indefinitely.

The writer often receives complaints in regard to the fermentation and loss of flavor of maple syrup, and for some years has sterilized it, with good results. There is much difference in the specific gravity of the syrup sold, some grades spoiling more quickly than others.

The fermentation of maple syrup is evidently due to the fact that it becomes contaminated with organisms, and by sterilization its freshness is retained. The ordinary blue molds — *Penicillium glaucum*, Link, and *Aspergillus glaucus*, de Bary, — are occasionally found growing in maple syrup, and one year we found a number of flasks contaminated with *Penicillium brevicaule*, Sacc.

There is almost no limit to the amount of sugar which some organisms will tolerate. Heald[1] and Poole[1] have recently discovered a species of Torula in maple syrup, and their experiments have shown that this species is capable of growing in a 75 per cent. solution of sugar.

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[1] Twenty first report of the Nebraska Agricultural Experiment Station.

Onion Rot.

BY G. E. STONE.

In some sections much damage is occasionally done to onions by the disease known as onion rot. Sometimes one-third or more of the crop is destroyed, occasionally the whole, but in most instances a much smaller percentage would represent the loss. The diseased onions examined by us are generally affected with either *Botrytis* or a species of bacteria and sometimes with both. The symptoms caused by both these organisms are characteristic, and easily recognized by careful observers. The rot may be distinguished in the field, but develops further in storage, so that care should be taken to destroy the infected onions before storing, if possible.

Some varieties of onions are said to be more susceptible to the rot than others, and according to our observations unfavorable seasonal conditions induce the rot. The location of the field is also an important feature, as well as the nature of the soil on which the onions are grown.

Onion rot appears to be less prevalent in dry than in moist soil, and we have observed some features which would indicate that it is not so severe on soil to which commercial fertilizers are applied, and which are, in consequence, deficient in organic matter, as on soil fertilized with stable manure, and containing more organic matter.

Onion rot was severe in some fields in 1907, resulting in considerable loss. The summer of 1907 was very dry, but from the latter part of August on an unusual amount of rain fell, which undoubtedly increased the susceptibility of the crop to this disease. On the other hand, the unusually severe drought of the past summer and fall has no doubt been responsible for the decrease in the amount of the rot.

There appears to be at present no outdoor treatment for this trouble other than by obviating the conditions which favor the rot. Some growers may associate this rot with that caused by smut, but the rot caused by bacteria and *Botrytis* is quite distinct, and should not be confounded with the smut.

Onion Smut.

BY G. E. STONE.

Onion smut is known to be a very formidable disease in certain sections of the United States, in some localities onion growing having been abandoned on account of its prevalence. It has not occurred so seriously in the Connecticut valley in this State, where a large proportion of our onions are grown.

Onion smut has been known in Massachusetts for many years, Mr. Benjamin P. Ware having referred to the injury caused by it in the Massachusetts State Board of Agriculture report for 1869 and 1870. The disease appears to be on the increase now in the Connecticut valley and onion growers are making efforts to combat it. It is known that the critical period for infection occurs in the early or seedling stage of the plants, and for this reason onion "sets" are immune to the disease. The smut on the young plants forms dark-colored or sooty masses, and on the older, mature specimens it is very conspicuous. Since infection takes place in the early stages of the seedlings, any method which will kill the smut spores which happen to be attached to the seed or are dormant in the soil will prove beneficial. The formalin treatment is cheap and efficient, and when smut is troublesome this remedy should be applied.

The past year we have devised a simple and inexpensive formalin drip which can easily be attached to any onion sower, treating the seed in the drills. The tank which carries the formalin is made of copper, although other metal will answer as well, and the one we have constructed for our purpose is 12 inches long and 7 inches high and holds 1 gallon. It can be made larger if necessary, and it is so simple that any tinsmith can construct it. It has an opening at the top, with a cover, and a flexible block tin tube provided with a wheel valve is attached to the bottom and regulates the flow of the formalin (see

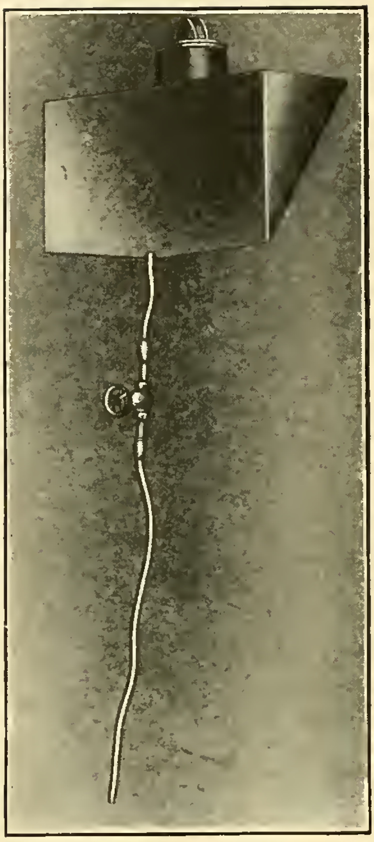

Fig. 2.—Showing Copper Tank with Flexible Block Tin Tube and Valve.

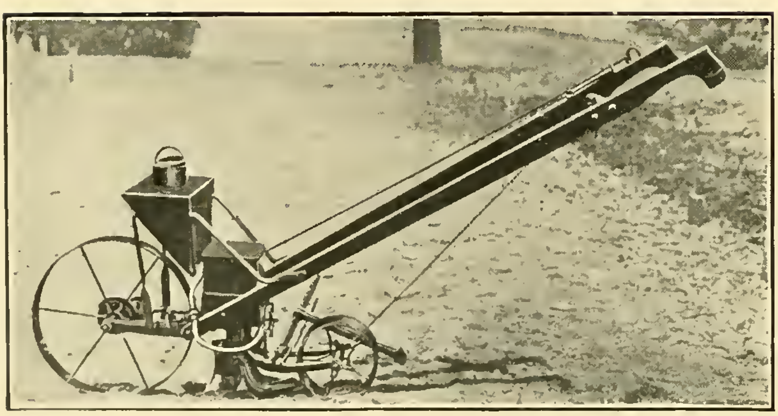

Fig. 1.—Showing a Formalin Drip attached to a Planet Junior Seed Sower.

Figs. 1 and 2). The flexible tube allows an easy adjustment, by which means the formalin drip can be directed wherever needed. The shape of the tank is triangular in cross-section and it is constructed so as to be about half an inch lower in the center of the bottom, where the drainage tube is attached, than elsewhere, so that it is easily emptied.

From repeated trials of this machine it is found that the flow of the tank is uniform, and when the valve is properly adjusted no further adjustment is necessary. The tank is held in place by iron bands fastened to the woodwork. A number of onion growers who have been troubled with smut have treated their seeds with formalin the past year or two, and our seed sower, with the formalin drip attachment, was loaned to those who wished to try it, with very favorable results.

It is necessary to use only a small quantity of formalin, — just enough to wet the seeds and a portion of the soil one inch or so either side of the line formed by the seeds. We found by actual experiments that 1 gallon would cover about 1,000 feet in length of drill. The strength of formalin employed for this purpose is 1 pound (pint) of commercial formalin to 30 gallons of water (1 part to 240), or 1 ounce of formalin to 1 gallon of water (1 part to 128). Some have used 2½ quarts of formalin to 50 gallons of water (1 part to 80).

A Disease of the Radish.

BY G. E. STONE.

A greenhouse disease of the radish, caused by a fungus (*Ascochyta sp.*), has been brought to our attention a few times. In one instance a large number of plants were affected. The fungus attacks the young plants, in some instances quite severely, and the same fungus is known to cause injury to seedlings.

We are unable to find any reference to this fungus occurring on the radish, neither does Saccardo give the radish as a host for any of this genus. It may, therefore, be an undescribed one, although we have not attempted to compare it with species affecting other plants.

For the purpose of determining whether this infection came through the soil, or whether the seeds were responsible for it, experiments were made at our station by Mr. A. V. Osmun and Mr. Ralph Watts, who were working in the station laboratory at that time, with the following results: —

One box of soil was taken from the infected house and planted with seeds from the same lot as those used for the infected house. Result, all plants diseased.

One box of soil from the infected house, sterilized, was planted with seeds taken from the same lot as those used for the infected house. Result, only one plant infected.

The same experiment repeated. Result, no diseased plants.

One box of soil taken from the infected house and planted with experiment station seeds. Result, plants infected.

One box of experiment station soil planted with seeds taken from the same lot as those used in the infected house. Result, no infection.

From these experiments it is evident that the disease germs were in the soil and not associated with the seed, and that sterilization of the soil would prove an efficient remedy for this disease.

Rhizoctonia, a sterile soil fungus which is more or less troublesome to lettuce, occasionally injured radishes, causing a rot below the surface of the ground. Sterilizing the soil is also effective for this trouble.

Celery Crown Rot.

BY G. E. STONE.

During the summer of 1907 our attention was called to a disease which we found to be doing much damage to celery. The affected crop was in a small field near the proprietor's house. As a result of this disease the income from the crop fell from $400 to $25.

Recent investigations of the crop in the field showed that the disease had spread to other parts of the farm and had become quite a serious trouble the past summer (1908). The disease appears to be confined to this one farm, as far as we know at the present time. It is not particularly noticeable when the plants are young, except to one familiar with this crop, but as the plants grow older, and later stages of the disease appear, they assume a sickly, yellowish appearance, and become stunted in their growth. A few plants slightly affected may grow long enough to be marketable, but the majority never exceed 3 or 4 inches in height.

If the crown is split open longitudinally a dead area will be noticed, extending to the tap root. In the more advanced stages a cavity is formed, containing a brownish, gummy substance which is usually moist and slimy within. The early stages show simply a brown or blackish area extending to the tap root. The disease apparently extends to the smaller roots, as is evident from the discolored veins traceable through various parts of the root system. In severe cases the rot may destroy the whole crown, and infection will follow up the celery stalks, causing the whole plant eventually to collapse.

On this farm 3 acres of celery were planted this year, and all but ½ acre was affected more or less severely. The small plot which showed the disease severely last year was not planted this year, with the exception of three rows for experimental purposes. Examinations of these three rows after they had been planted a few months showed practically every plant affected and about 85 per cent. already dead. Those still alive were not over 2 or 3 inches in height.

To the west of this plot ½ acre was planted to Golden Self-blanching, and although the plants had been set out for only three weeks the disease was quite prevalent among them. The plants adjoining the plots affected in 1907 were very much more severely affected than those further away. On a slope some distance from this plot about 2 acres were planted to Golden Self-blanching, Albany Market and Boston Market, and this field contained numerous affected plants, although the disease here was not so marked. Golden Self-blanching seemed to be affected most severely, while Boston Market was troubled the least. On a plot further removed from the original source of infection ½ acre of Golden Self-blanching was planted. This appeared to be entirely free from the disease. The seed used was obtained from two Boston firms, but no difference in susceptibility was shown.

The early plants, which were most seriously affected, were raised in sterilized soil in hotbeds, and no disease made its appearance among the few plants which were left in this sterilized soil, which would seem to indicate that infection did not come from that source. The plants taken from seed beds in the open ground, in which unsterilized soil was used, showed a little of the disease, and the plants left in these seed beds subsequently became infected.

The soil in which this celery grew had up to this time produced good crops. It had received heavy dressings of horse manure, and commercial fertilizers had been applied freely.

Observations made of the affected plants in both seasons show that the trouble is caused by bacteria, and little difficulty is experienced in isolating them. The symptoms of this disease do not coincide with those of any previously described. It seems to have originated on one piece of land on this farm and spread from this to the different fields, and from the fact that no disease occurred on the plants left in sterilized soil it would seem that the germs must be in the field.

A study is now being made of this trouble, both in the laboratory and in the field.

Eel Worms on Lettuce (*Heterodera radicicola* (Greef.), Müll.).

BY G. E. STONE.

There was recently sent into the station a number of small, greenhouse-grown lettuce plants which were badly infected with eel worms. Apparently the whole crop in a large house was similarly affected. It is quite unusual, so far as our observations go, for eel worms to attack lettuce, the only other instance being about ten years ago, in a greenhouse which had been used for growing lettuce and cucumbers in the usual rotation for some time; that is, two or three crops of lettuce were grown in the fall and winter, followed by a crop of cucumbers in the spring and early summer. We have frequently grown lettuce in soil which was badly infested by eel worms without the slightest indication of root infection. This has been the experience of many growers, inasmuch as eel worms occur in numerous houses devoted to lettuce growing.

In the house previously referred to as being contaminated with nematodes[1] ten years ago, the lettuce plants were infected only once, notwithstanding the fact that eel worms were in the soil for quite a time both before and after this infection.

The nematode[1] (*Heterodera radicicola* (Greef.), Müll.) is known to affect a very large number of plants, and it evidently has decided preferences as to its host. Such plants as cucumbers, melons, tomatoes, roses, violets, mustard, rape, etc., are always susceptible, but why eel worms should attack lettuce only at certain periods, and then severely, is a mystery.

A recent correspondent writes us from the south that his carnations have been badly affected by eel worms, but we have

[1] Nematodes are also known as eel worms.

never heard of any similar affection occurring in our northern greenhouses. Our extended observations on these worms confirm us in the opinion that there are many peculiarities associated with their habits which are not well known at the present time.

Influence of Water on Eel Worms (*Heterodera radicicola* (Greef.), Müll.).

BY G. E. STONE.

In some subirrigation experiments with tomatoes, which have been carried on here for some years in connection with the blossom end rot of the fruit, observations of the roots have shown that the presence of considerable water in the soil for any length of time has an injurious effect on eel worms. Our observations on the plots which were subirrigated, and which contained more soil moisture below the surface than the top-watered plants, showed that the eel worms were always rare, in most cases entirely absent, whereas the roots of the top-watered plants, growing in soil of a like character, showed numerous galls. These observations were made on several crops of tomatoes.

Further experiments were made under our direction in the winter of 1906–07, in 8-inch boxes, by Mr. David Larsen, at that time a student assistant, to demonstrate the injurious effects of water on eel worms. These experiments were conducted as follows: —

Two boxes were filled with soil contaminated with eel worms and were planted with cucumber seed, one box being arranged in such a way as to allow a free passage of water through the bottom, and set in a galvanized iron tray filled with water to the depth of 1½ inches. By this means the bottom soil was kept quite moist, while the surface remained comparatively dry. The other box was surface watered, and the soil contained less water. A number of cucumber seeds were planted in each box, and every few days some of the plants were removed from the boxes and the roots examined. This experiment was continued for ten weeks, and in every case upon examination the plants in the box immersed in water showed roots free from eel worm galls, while the top-watered plants, which were growing in more or less dry soil, were in all cases severely infected with eel worms. This experiment was repeated, with similar results.

In some correspondence relating to eel worms Dr. Ernest Bessey of the United States Department of Agriculture recently informed us that the same effects had been observed by him in the south, along river banks where the soil is inundated for a brief period of time each year. This application of excessive amounts of water to the soil for brief periods may prove to be a practical method of ridding the soil of this pest, and it may follow that liquid manure containing refuse contaminated with nematodes may be safely employed on roses and other crops if the manure is left in water for a sufficient period of time.

Influence of Lime on Eel Worms (*Heterodera radicicola* (Greef.), Müll.).

BY G. E. STONE.

Various writers in florists' and gardeners' journals have for years advocated the use of lime for destroying eel worms in the soil. In one of our earlier publications[1] we have given the results of tests made of a large number of substances, among others lime. Our former as well as our more recent experiments have shown that lime has little or no effect upon eel worms, as was evident from the fact that we were able to keep them alive in a saturated solution of lime water for some days. When sugar was added to the lime, making saccharate of lime, the results were quite different, the latter solution killing them. Undoubtedly the application of lime to greenhouse soil improves it by modifying its acidity, but eel worms will thrive in soils which are not acid.

For many years we have been experimenting with boxes of soil contaminated with eel worms, and have treated them in different ways. In one experiment, started Oct. 8, 1901, and continued to 1907, two boxes were used, having the dimensions of 5 by 5½ by 14 inches. Both boxes were filled with soil contaminated with eel worms. The soil in one box was treated with about 200 grams of lime, thoroughly incorporated. The other box was treated with 2,000 cubic centimeters of water containing 100 grams of sugar and 100 grams of slaked lime. The results of these experiments, which extended to 1907, are as follows: —

The first three crops showed abundant eel worm galls on the roots. Then 60 grams of lime were added to the box containing lime, and incorporated with the soil. Seven subsequent

[1] Bulletin No. 55, Hatch Experiment Station, 1898.

crops showed galls on the roots in both boxes, the limed boxes sometimes showing a less and sometimes a greater number of galls on the roots than the box treated with saccharate of lime.

In another experiment, started July, 1904, made with contaminated soil in three boxes 8 by 8 by 8 inches, we obtained the following results: —

Box No. 1, contaminated with eel worms, did not receive any treatment.

Box No. 2, similarly contaminated with eel worms, was treated with 400 grams of lime thoroughly mixed with the soil.

Box No. 3, similarly contaminated, was treated with 15 cubic centimeters of formalin, which was poured into a hole in the soil 4 or 5 inches deep, the hole being covered over to allow the formalin vapor to permeate the soil. After treatment the boxes were planted with melon seeds, or those of some other very susceptible plant, and the roots examined for galls. Only three crops were grown in these boxes and the galls were present on the roots of the plants in each case. From these experiments it is evident to us that lime and formalin have little or no effect on eel worms in the soil; at least in the proportions which we used. The amount of lime used, however, was considerable in this last experiment, and when thoroughly incorporated with the soil was sufficient to give it quite a little color.

While there are many chemicals which will kill eel worms, it would not be advisable to use them, since they will cause injury to both plants and soil. In some of our former experiments with eel worms, described in Bulletin No. 55, the formalin method was tested on free-moving forms of the worms, with the result that they succumbed in a few minutes when subjected to the vapor, but we were not successful in applying formalin to soil containing growing plants without injuring them. Of late years formalin has been recommended as a remedy for eel worms on violets. This is used by applying it to holes made in the soil where the plants are growing. The formalin being volatile, the gas penetrates the soil and is said to kill the worms. Our experiments with it would not seem to warrant the use of this method of treatment, as formalin is injurious to plants, and there is reason to believe that it would not affect in the least the eggs of eel worms, which are fairly well protected by a resistant covering. If applied strong and in sufficient quantities it might destroy many of the free-moving forms. When the female has become encysted in the roots of the violet plants it is difficult to conceive how she can become affected without causing injury to the plant.

Formalin as a remedy for soil organisms has been recently recommended by Prof. A. D. Selby[1] of the Ohio Agricultural Experiment Station. The strength recommended is 1 to 200, or 2 pounds (2 pints) of formalin to 50 gallons of water. It is recommended that 1 gallon be applied to each square foot of soil surface. This may be applied by any sprinkling device. Repeated applications of the formalin are made when the crop is removed and at a time when the soil is more or less moist. It is necessary that the soil should not be used for at least two weeks after the application of the formalin. Professor Selby recommends applying the formalin at intervals of a few hours, and the soil should be stirred for a few days after the applications.

While this treatment is recommended by Professor Selby for such organisms as Rhizoctonia and Sclerotinia, which cause lettuce rots, it is believed not to be applicable for eel worms, since it apparently does not succeed in destroying the more resistant eggs.

The methods of destroying eel worms in greenhouse soil, with which the writer has experimented for many years, are as follows: —

Sterilization. — This is one of the cheapest and best methods of destroying eel worms in greenhouse soil. It is necessary that the soil be heated to at least 180° F. and a higher temperature is better. This is accomplished by driving steam through the soil by a system of perforated pipes.

Freezing. — If the soil is frozen for any length of time the eel worms are destroyed, and some use has been made of this method by practical growers. As a rule, the soil is removed from the house and frozen in bulk out of doors.

Desiccation. — Drying the soil is destructive to eel worms, but it is difficult to dry soils sufficiently in deep benches to make

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[1] Circular No. 57, Ohio Agricultural Experiment Station.

this method effectual. The application of unslaked lime, however, will materially aid in drying the soil, by virtue of the water-absorbing qualities of the lime.

Inundation. — The effects of water on eel worms have already been alluded to, and in some instances inundating or flooding the soil might be successful.

Trapping, or the Catch-crop Method. — It has been found in Germany that sowing very susceptible crops, like mustard or rape, on soil contaminated with eel worms, and, after the females have become encysted in the roots, pulling up the plants and exposing them to the drying rays of the sun, is capable of reducing the worms to some extent in contaminated soils. We have found, however, that two or three catch crops are much better than one.

Effects of Chemicals on Vegetation.

BY G. E. STONE.

A general interest is manifested by the public in weed exterminators, or substances which will destroy noxious growths in soils or water, and a number of different preparations have been recommended. Some of these have proprietary names, such as Herbicide, Weedicide, etc., and the proprietary preparations which we have tested have proved to be valuable.

There are numerous chemicals which will kill vegetation, and in exterminating noxious growths it becomes necessary to employ different substances and a variety of methods of applying them. The writer has carried on a series of experiments with various chemicals covering a period of years, and many of the proprietary weed killers and other substances have been tested, as well as various methods. The results of some of these experiments are given in the tables which follow.

In the experiments reported in Table I. the plots used were one-twentieth of a square rod in size, and were arranged on a small tract of land which had occasionally been mowed with a lawn mower, and which was well covered with various grasses and clover, intermixed with plantain and dandelion.

Different chemicals were employed, usually at the rate of 1 part to 20 parts of water. In the case of the gasoline we used a different ratio, and the water mixture was, of course, a mechanical one. The substances were applied at the rate of 10 gallons to the square rod, which, when put on in the proportion of 1 to 20, would be equivalent to applying 4 pounds to 10 gallons of water. These experiments were made in June, 1901, and the observations recorded were made at different periods for two months.

TABLE I. — *Showing the Effects of Chemicals upon Vegetation.*

No. of Plot.	Chemicals used.	Strength employed.	Results of Experiments covering a Period of Two Months.
1,	Carbolic acid,	1 to 20	Vegetation killed more quickly than by any other method, but recovered very shortly. Treatment not perceptible two months later.
2,[1]	Benzine,	50 per cent.	Similar in its effects to No. 1.
3,[1]	Gasoline,	50 per cent.	Similar in its effects to No. 1.
4,[1]	Kerosene,	50 per cent.	Little or no effect. Blistered a few plantain leaves. No effect on grass. Treatment not perceptible two months later.
5,	Sodium arsenite,	1 to 20	Killed everything. New grass came in two months later.
6,	Lead acetate, C.P.,	1 to 20	Little effect. Plantain and grass slightly burned. Treatment not perceptible two months later.
7,[2]	White arsenic, sal soda,	1 to 20	Most effective treatment. Killed all vegetation. Effect permanent.
8,[2]	White arsenic, sal soda,	1 to 66	Killed all vegetation. New grass came in freely at the end of two months.
9,	Salt,	1 to 5	Killed plantain and some of the grass. Effect not permanent.
10,	Paris green,	1 to 20	Plantain distroyed and some grass. Effect not permanent.
11,[3]	Salt, dry,	1 pound	Less effective than No. 9. Treatment hardly discernible two months later.
12,	Corrosive sublimate,	1 to 20	Very effective in destroying vegetation. Treatment not perceptible two months later.

A glance at the results given will show that all these substances, when applied at the stated strength, caused injury to vegetation, but the extent of the injury and the permanency of the effect differ. Plot No. 7, treated with 1 part of white arsenic to 20 parts of water, to which was added twice as much sal soda as arsenic, making arsenite of soda, gave by far the best results. An examination of this plot, made the following spring, showed not the slightest trace of living vegetation. This treatment proved so effectual that there was no living vegetation for nearly two years afterwards, while on all other plots, except Nos. 5 and 8, no effects were perceptible two months after the treatment was made. In some instances the effects

[1] Mixed with water and applied.
[2] Twice the amount of sal soda was added to dissolve the white arsenic.
[3] At the rate of 20 pounds to 1 square rod.

disappeared in a few weeks. No. 5 was treated with a commercial arsenite of soda, and No. 8 was only one-third as strong as No. 7. These tests show that the arsenic compounds are many times more effective than any of the other substances employed. The carbolic acid gave the quickest results, but this substance appears to affect merely the foliage of the plant. In some cases this treatment is all that is necessary to destroy weeds, while in others it is of little value.

Salt as a weed killer loses some of its reputed efficiency when compared with the arsenic compounds; nevertheless it is capable of injuring vegetation, as may be seen where large quantities are applied to electric railroad beds in the winter to clear the tracks, or to sidewalks to help in removing the ice. There are instances of valuable shade trees being injured by the application of salt, and even the salt-water drainage from dairies, when allowed to pass close to trees, has been known to destroy their roots. Salt is not, however, very toxic to most plants, and its principal action consists in plasmolysing the cell. If applied at all it should be put on in hot, dry weather.

The series of experiments shown in Table II. was conducted in the same general way, but different chemicals were employed. The observations recorded were made at different periods for two months.

TABLE II. — *Showing the Effects of Chemicals upon Vegetation.*

No. of Plot.	Chemicals used.	Strength employed.	Results of Experiments covering a Period of Two Months.
1,	Arsenate of soda, corrosive sublimate, equal amounts.	1 to 20	Killed all vegetation. Effect quite permanent.
2,	Nitrate of soda, . .	1 to 20	Injured vegetation, but grass revived quickly. No permanent effect.
3,	7 parts arsenate of soda, 1 part corrosive sublimate.	1 to 20	Effect same as No. 1.
4,	6.4 parts corrosive sublimate, 1.6 parts arsenate of soda.	1 to 20	Not quite so effective as No. 3.
5,	Arsenite of soda, . .	1 to 20	Similar to No. 1, but slightly less effective.
6,	Bowker's Weedicide, .	1 to 20	About the same as No. 5.
7,	Copper sulfate, . .	1 to 10	Killed vegetation. Not permanent. Less effective than Nos. 1, 3, 4, 5 and 6.
8,	Nitrate of soda, . .	1 to 10	Similar to No. 2, but stronger. Slightly more effective.
9,	Sodium sulfide, . .	1 to 10	Little or no effect at any time.
10,	Niter cake, . . .	1 to 10	Slight effect. Scarcely noticeable two months later.
11,	White arsenic, . .	1 to 20	Killed all vegetation. Effect quite permanent.
12,	Arsenic sulfide, . .	1 to 20	Killed all vegetation. Effect fairly permanent. Less effectual than No. 11.

Of the treatments shown in this table, Nos. 1, 3, 4 and 11 gave the quickest, most effectual and permanent results. Nos. 5, 6 and 12 proved about as effective, but in this experiment the effect was not so permanent. The arsenic sulfide in this case was dissolved in an alkaline solution of potassium sulfide. Observations made one year after treating the various plots showed that there was little or no permanent injury to vegetation in any case. The nitrate of soda, when applied at the strength given, was not permanently injurious, and what injury was caused to grass at first was quickly followed by a marked change in color and greatly stimulated growth. Neither were the effects produced by sodium sulfide, copper sulfate and niter cake of any value from the point of view of permanency.

It was not the purpose of this experiment to test the relative poisonous effects of these substances on vegetation; nor would this method be accurate enough for the purpose. It should also be borne in mind that one test can only be an indication of the relative merits of the chemicals used; moreover, there was considerable difference in the purity of the chemicals used. There are many different grades of crude chemicals on the market, and with the exception of corrosive sublimate everything which we used was a crude commercial chemical. These in some instances differ in their composition. It is, therefore, impossible for us to state whether Nos. 1, 3, 4 and 11 would always prove to be superior to Nos. 5, 6 and 12. It would require a series of experiments under similar conditions to establish reliable data, but in all probability there is very little important difference in the relative efficiency of these arsenic compounds as regards their toxic effect on vegetation. Some of the proprietary poisons on the market for killing weeds are arsenic compounds, probably in most cases arsenate of soda. Their purity may not in all cases be as high as some of the grades we used, but this is not an objection and may be an advantage, since the crude forms are cheaper, and are efficient enough for all practical purposes.

The writer has used many chemical substances for exterminating weeds in lawns, walks, on tennis courts, railroad tracks and other places, and is well aware that a variety of results is obtained from the use of the same substances under different conditions. We have employed extensively the Weedicide manufactured by the Bowker Fertilizer Company, with excellent results.

Some other experiments were made on some plots composed of sand and gravel containing growths of Panicum sanguinale, Panicum crus-galli, Poa annua, chickweed, dandelion, pepper grass, Roman wormwood, pursley, sorrel and pigeon grass. These plots were treated with formalin, salt, crude potash, benzine, gasoline, carbolic acid and arsenate and arsenite of soda, with similar results to those already mentioned. The arsenate and arsenite of soda destroyed all plants quickly and with quite permanent effect, while the other compounds were more or less effective for the foliage, but failed to be of value in preventing new growths. Carbolic acid, as before, gave the quickest results, and formalin in the proportion of 4 to 400 proved to be superior to salt.

The following results were obtained from several treatments of a driveway more or less troubled with a variety of weeds.

Parts of the driveway were treated respectively with white arsenic and sal soda, commercial sodium arsenate, carbolic acid and lead nitrate, in the proportion of 1 to 20 and at the rate of 10 gallons per square rod. The latter solution proved to be of little value, and while carbolic acid destroyed the weeds, a new crop appeared shortly afterward. The arsenate and arsenite of soda were both very effective.

Numerous comparisons of the arsenate of soda and arsenite of soda, made by dissolving white arsenic with equal parts or more of sal soda in water, seemed to favor the latter somewhat. The driveway referred to had been treated with arsenic compounds about four times in ten years, and the absence of weeds is quite noticeable. Where the wash in the highway accumulates on this drive a few weeds occasionally appear, and this is also true of ditches along highways which have been treated. It is noticeable in one case that a ditch put through a driveway which had been treated for weeds grew up luxuriantly to weeds, due to the fact that the bottom soil of the ditch was placed on top in filling it in. We have observed that when walks and driveways have received a few treatments with arsenic compounds, applied at the rate of 2 pounds to 10 gallons of water,

Showing Elm-tree Trunk profusely covered with Poison Ivy.

The Same after Two or Three Applications of Bowker's Weedicide.

and about 10 gallons applied to the square rod, weeds are not likely to come in again for a few years.

A few applications will kill poison ivy about trees, near houses, on walls, etc., but only large trees should be treated, otherwise injury to the tree might result. The treatment of a space 2 feet wide around a large tree will not injure the tree. This method of treating ivy in the open fields and mowings is not advisable, as it is too expensive, since the amount necessary to kill ivy in such locations would render the treated land useless for several years. The best way to exterminate ivy in mowings is by plowing up the land and planting it for a few years.

In one experiment where we made applications of arsenate of soda, carbolic acid, white arsenic and sal soda to a mowing filled with ivy, at the rate of 1 to 20 and 10 gallons to the square rod, we found that the ivy was not permanently exterminated, although both the ivy and grass were temporarily killed. The plots treated with white arsenic and sal soda showed the effect of the treatment six years afterward, but it did not kill out all the ivy or all the grass. Four other plots of poison ivy were treated with 10, 20, 30 and 40 per cent. solutions of crude nitrate of soda, at the rate of 10 gallons per square rod. This treatment destroyed the grass and the tops of the ivy plants soon after application, and the stronger the solution used the more marked was the effect. A month later, however, all the plants showed a deep green color, and the grass and ivy thrived more luxuriantly than before.

From these experiments it is evident that arsenic compounds are the most effective poisons for plants.[1] Solutions of such substances as arsenate and arsenite of soda, corrosive sublimate and arsenic sulfide are most effective; they penetrate the soil to some extent and kill the roots. It would appear, moreover, that these substances do not leach out of the soil like some others and are for this reason probably more permanent in their effect. There are other substances which are effective in destroying foliage, and for the complete elimination of certain weeds they do the work.

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[1] Prof. L. R. Jones, who has experimented with various weed killers, found certain arsenic compounds best adapted for killing weeds. Twelfth Annual Report, Vermont Agricultural Experiment Station, 1889.

We may therefore consider weed exterminators under two heads: those which particularly affect the root system and those which affect only the foliage. Some of the latter type will be dealt with subsequently. The use of chemicals for killing weeds is practical in many cases. They are useful, also for killing ivy about stone walls, around houses and trees, on tennis courts, driveways, etc. The writer has applied them on lawns close to buildings, to save the expense of hand trimming. About 3 or 4 inches of the grass adjacent to a building may be treated without any injury to the appearance of the lawn, and much saving of labor in hand trimming results. In treating walks care must be exercised in running the solution close to the edge of the lawn and not touching the grass. For this purpose the writer has used an ordinary sprinkling can with a special attachment on the spout to confine the flow to narrow limits. Tennis courts need, as a rule, to be treated only around their edges, where the weeds and grass are more likely to come in, and two or three treatments made on succeeding years should keep the courts practically free from weeds. This treatment is applicable to paved ditches, highways and drives, and the difficulties arising from the grass growing on electric railways, causing slippery rails, may be obviated by a treatment of a narrow limit near the rails. Care should be exercised, however, in using weed killers too extensively, especially near the feeding roots of valuable shade trees.

The writer has frequently treated walks near which shrubbery grew closely, as well as large trees, with arsenic compounds, but in such cases there is a likelihood of injuring only a small part of the root system, if any, and such injury would be merely local, of course, and of small consequence.

Substances and Methods used in Exterminating Weeds.

BY G. E. STONE.

"Weedicide", "Herbicide", "Weed Killer", etc. — The preparations bearing proprietary names, such as Weedicide, Herbicide, etc., are, so far as we have had occasion to examine them, thoroughly reliable products, and the manufacturers make no extravagant claims for them. Probably all of these contain arsenic compounds; at any rate, when applied to walks, tennis courts, etc., they destroy noxious weeds, and when applied in sufficient quantities new growth is checked.

Sulfate of Iron, Copper Sulfate, etc. — Sulfate of iron is extensively used in the west in exterminating weeds in grain fields. It is employed in the eradication of mustard, Canada thistle, ragweed, etc. Copper sulfate, common salt and sodium arsenite are also used for this same purpose. Prof. H. L. Bolley, who has experimented a great deal with these chemical weed killers, has used them in the following proportions for the extermination of weeds in grain fields: iron sulfate at the rate of 75 to 100 pounds to 52 gallons of water; copper sulfate at the rate of 12 or 15 pounds to 52 gallons of water; common salt at the rate of ⅓ to ½ barrel to 52 gallons of water; and sodium arsenite at the rate of 1½ pounds to 52 gallons of water. Since sodium arsenite is more poisonous than the other substances it is a question whether it should be used in the hay field and places where stock is likely to feed.[1]

Professor Bolley gives the following list of weeds which are amenable to treatment by means of chemical sprays: false phlox, wormseed mustard, tumbling mustard, common wild mustard, shepherd's purse, pepper grass, ball mustard, corn-cockle,

[1] Bulletin No. 80, North Dakota Experiment Station, 1908.

chickweed, dandelion, Canada thistle, bindweed, plantain, rough pigweed, kinghead, red river weed and ragweed cocklebur. For treating dandelions — and plantain is susceptible to some extent — he advises spraying a lawn with iron sulfate, at the rate of 1⅓ to 2 pounds of iron sulfate to each gallon of water.

J. L. Stone[1] found that wild mustard could be destroyed in grain fields when treated with a solution of copper sulfate, at the rate of about 10 pounds to 40 gallons of water, without injury to the crop.

Prof. L. R. Jones[2] found that salt at the rate of 3,000 pounds per acre would kill orange hawkweed in mowings, and it may be mentioned that this weed is becoming more common on highlands in this State. It is advisable that these spraying treatments be given in bright, sunshiny weather, when the temperature is relatively high.

Climax Lawnsand. — This is a weed killer put out by the Boundary Chemical Company, Ltd., of Liverpool, Eng., and has been sold the past year by some of the leading seedsmen. It is a finely powdered, dry chemical, and when applied in bright, dry weather is said to kill daisies, plantain, moss and other weeds having spreading surface roots and rough, hairy leaves, to which it can adhere. At the same time this lawn sand acts as a fertilizer, promoting a luxuriant growth of grass.

According to Mr. G. H. Chapman, who made an examination of its chemical constituents in the laboratory, it contained over 66 per cent. of sand, which acts as a carrier, together with iron sulfate and nitrate of soda. The effects of the nitrate of soda were plainly apparent on lawns after this had been used. They recommend the use of 28 pounds to 100 square yards to destroy weeds. For daisies and moss it is recommended that from 3 to 5 ounces be applied to the square yard, and for dandelions, plantain, thistle, rib grass, etc., they recommend the application of one heaping teaspoonful to the crown of each plant, the amount depending upon the size of the plant. Some tests of this substance made on various weeds showed, as might be expected, since it contains sulfate of iron, that it destroys certain weeds, while the grass in the treated plots was stimu-

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1 Bulletin No 216, New York (Cornell) Agricultural Experiment Station, 1904.

2 Bulletin No. 56, Vermont Agricultural Experiment Station, 1907.

lated to quite an extent. Not enough tests were made, however, to fully determine the value of this substance, but from the few which were made, and from a knowledge of its constituents, it is safe to say that it will no doubt be found useful in exterminating certain classes of weeds.

Special Device for killing Weeds. — A recent device for destroying weeds on walks and drives is known as the Buckeye Weed Burner. This consists of a boiler mounted on two wheels, weighing about 350 pounds, pushed about by hand. The burners are supplied with air under 30 pounds' pressure. It is claimed by the manufacturers of this contrivance that roots, seeds and foliage are destroyed more quickly and cheaply than can be done by hand. The machine is also used for melting snow and ice on drives and sidewalks in winter.

A few years ago an electric weed killer was devised for destroying weeds on electric railroad tracks. This consists of a powerful dynamo mounted on a railroad truck and propelled by steam. A series of small wires led from the dynamo to the ground, and when these wires came in contact with the plants they were electrocuted. This weed killer has apparently not been extensively used, and perhaps did not prove to be satisfactory. It is very evident that it would require a very powerful electric discharge to kill weeds in this way.

Various devices have been described for killing weeds by injecting chemicals into them, but it is a question whether spudding and hand pulling would not kill them as cheaply.

Other Methods of killing Weeds. — There are many reliable methods of destroying weeds other than by the use of chemicals. The oldest and most valuable method is by cultivation. Besides the use of the cultivator and hoe, which are of great value in destroying weeds and benefiting the soil, gang plows and different types of harrows may be used. For the permanent destruction of weeds, however, much depends upon the method used, the amount of cultivation and the time at which the cultivating is done. The practice of rotating crops and the plowing up of mowings and keeping them in a state of cultivation for a few years constitutes one of the most valuable methods of removing certain noxious weeds.

Pasturing land containing noxious growths with sheep or

Angora goats is beneficial, and the early mowing of grass lands contaminated with weeds is also effective in certain cases, as it destroys them before they go to seed. In other cases hand pulling or spudding must be resorted to.

Heavy mulches applied to cultivated soil are a most excellent means of exterminating weeds. This method can be used on beds of shrubbery and to some extent on garden crops, in orchards and in the case of young shade trees, although mulched plants, in our estimation, will not make the growth of those freely cultivated. Cultivation also conserves the soil moisture and is valuable in more ways than one. Mulching with tarred paper has also been recommended for the extermination of poison ivy and other plants. This method of exterminating plants is based on the principle of excluding the light, thereby preventing the formation of plastic materials and the storage of reserve substances, although the tar has toxic properties in itself.

The practice of composting manures and allowing them to heat is said to be quite beneficial in destroying weed seeds and the spores of certain pathogenic fungi which may be in the manure.

For holding weeds on lawns in check a very important feature is first to have a deep loamy soil to support a good growth of grass. Seeding heavily is excellent for crowding out weeds, and the application of fertilizers in midsummer and reseeding is also good. Many lawns are troubled with certain weeds because they become too dry, and applications of water are beneficial, although the water would be much more effectual if it could be applied below the surface. Finally, some weeds in lawns may be destroyed by allowing the grass to remain uncut for a short time, the high grass crowding out the weeds.

Undoubtedly one of the greatest sources of weeds in mowings and cultivated fields is the use of unclean seed, and too much emphasis cannot be laid on the necessity for using seed free from noxious weed seeds. It is difficult to separate some weed seeds from grass seed, and little or no attempt has been made to separate the noxious weed seeds from much of the seed put on the market.

Fumigation Dosage for Forcing Crops.

BY H. T. FERNALD.

For four years experiments have been continued on the resistance of different crops raised under glass to hydrocyanic acid gas. These experiments have been completed for the tomato and cucumber, and it seems desirable to summarize at this time the results obtained by W. V. Tower and C. W. Hooker, who conducted the experiments.

The insects most often present in greenhouses in Massachusetts are the white fly, thrips and plant lice. The latter may be neglected here, for any treatment effective for the first two named will also destroy the plant lice. Dr. Morrill has shown[1] that the white fly can be destroyed by fumigation with from .007 to .01 gram of potassium cyanide per cubic foot for three hours' time after sunset, and Dr. Hinds' experiments[2] indicate that this strength will, in all probability, destroy thrips also. How much the plants themselves can stand, however, has been unknown with any certainty, varying results having been attributed to differences in the conditions of the experiments.

What these differences are, how much influence they have, and what strength of fumigation the plants can withstand without injury under all these conditions were accordingly the questions to be determined. For this purpose tomatoes were selected for the first crop to be tested, the more common greenhouse varieties grown in Massachusetts being used.

The plants were raised in accordance with the methods of the most successful growers in the State, and experiments were made with them at ages of six, seven, eight, nine and eleven weeks, the last fumigations being given while the crop was ripening. No effect of the treatment upon the fruit could be

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[1] Technical Bulletin No. 1, Hatch Experiment Station, Massachusetts, p. 50, 1903.
[2] Bulletin No. 67, Hatch Experiment Station, Massachusetts, p. 11, 1900.

discovered, and tomatoes gathered the morning after fumigation were eaten with a relish by all who did not know to what the fruit had been subjected.

The conclusions reached from the experiments are as follows: —

1. Fumigation during sunlight cannot be practised without resulting in the serious injury or death of the plants.

2. Fumigation during cloudy days is very unsafe at best and is not advised.

3. Fumigation on moonlight nights is also unsafe, frequently resulting in considerable injury.

4. Good results are obtained by fumigation on clear nights, without a moon, or on cloudy nights.

5. The best results are obtained by fumigation on clear, dark nights, with a house temperature of from 55° to 65° F., followed by complete ventilation for from fifteen to thirty minutes and a rather low temperature in the house the next day.

6. Plants fumigated while drops of water remain on them are likely to be injured; fumigation should therefore be given only to plants not so recently watered as to have leaves or stems still wet.

7. The moisture in the house (humidity) should not be high, to obtain the best results.

8. Under the conditions named in Nos. 5 and 7, fumigation for tomatoes, using .01 gram of 98 per cent. potassium cyanide for each cubic foot of space for a period of forty minutes, should insure satisfactory results, and the time with cucumbers could safely be extended to an hour and a half with advantage.

In general, the experiments show that with tomatoes the period during which fumigation can safely be applied to the plants is hardly long enough to more than kill the adult white fly, but a repetition of the treatment three times at intervals of two weeks should be effective. With cucumbers, treatment can be prolonged with safety, but it is doubtful if the eggs can be destroyed, using a safe strength of the cyanide, and for this reason repetition of the treatment as with the tomato is desirable.

Insects of the Year.

BY H. T. FERNALD.

The year has been an interesting one, not because of any serious outbreaks giving an unusually good opportunity for a study of such pests, but because of the large number of species which have caused injury in different portions of the State.

The San José scale still holds the center of the stage, its spread being rapid through the orchards and among ornamental trees and shrubs of various kinds. The unusually dry summer and fall and the unusually late continuance of warm weather have been distinctly favorable for this insect, an extra brood having made its appearance in a number of places. As a consequence, many plants first infested late in the season have begun the winter with a large number of partly developed scales on them, and these promise to seriously affect such plants next year. The same influences seem to have also favored other scale insects, all of which have been much in evidence.

The weather conditions have also been advantageous for plant lice, which have been unusually abundant. Among these the spruce gall louse has perhaps attracted particular attention, judging from the correspondence, though the woolly apple louse has also been much in evidence both on the branches and on the roots of the trees.

The elm-leaf beetle has been extremely abundant and destructive in most parts of the State. Its work was very irregular, however, for while some places suffered severely, adjoining towns, in some cases, showed but little injury. In general, the more southerly towns of the State and others not lying more than three or four hundred feet above the sea level were most infested, while the hill towns suffered but little or not at all.

Cutworms, wire worms and root maggots appear to have been less abundant than for several years, while the squash bug, squash-vine borer, and pear-leaf blister mite have been unusually plenty, and the rose bug was present in considerable numbers.

In 1907 the green-striped maple worm was very abundant in portions of the wooded areas west of the Connecticut River. During the past summer it was several times reported, but apparently was of less importance.

Early in the fall complaints began to come in of the destruction caused in forest areas in western Massachusetts by a caterpillar, which upon examination proved to be *Heterocampa guttivitta,* Walk. This insect has been known for over fifty years, and is generally distributed through the Atlantic States. During this time, however, it has never caused any appreciable injury and has therefore never received any common name. Two years ago, in Maine, it became quite injurious, and this year was very abundant in New Hampshire and, as already stated, in western Massachusetts, and it is at least probable that more will be heard of it during 1909. What conditions have led to the sudden appearance of this insect as a pest after years of obscurity cannot be determined, but it is likely that these conditions will assume control again in two or three years and the insect in consequence become unimportant.

The oriental moth is now present over a larger territory than at the last report, but has not thus far shown any indication of becoming an important pest.

The discovery of gypsy moth egg clusters at two or three places in the Connecticut valley last spring indicates that sooner or later this insect may be found in all portions of the State. With complete extermination impossible this is only to be expected, and hope of controlling this pest by other than protective measures in the residential districts depends upon the success of the attempt now being made to establish effective parasitic and predaceous enemies of this pest in Massachusetts.

During 1907 the brown-tail moth seemed to be held in check by a fungous disease. The warm, dry weather this last summer was presumably unfavorable for the disease, as has been shown to be the case with similar diseases of other insects. Whatever may be the cause, the brown-tail moth was unusually abundant last fall, particularly to the north of Boston, and the leaves on many acres of woodland were turned brown by the ravages of this pest. Unless the summer of 1909 be wet, or some other adverse factor appears, next year is likely to witness a large increase in the abundance of this insect.

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MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

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REPORT OF THE DIRECTOR.

The general work of the Massachusetts Agricultural Experiment Station during the past year has followed the usual lines, but there has been a considerable increase in the amount of work in all the various departments of its activities. There has been no increase in the number on the station staff, but notwithstanding this fact there has been a considerable increase in the amount of purely experimental and research work as well as in the amount of work done in connection with the fertilizer, feed and dairy laws and in meeting the requests of our public for analytical work and for advice and information. This increase has been made possible chiefly through better organization in the chemical department.

Changes in Staff.

The station has been fortunate in retaining the services of all heads of departments. The official connection of Prof. E. A. White, B.Sc., with the station as floriculturist terminated September 1. At the same time Prof. F. C. Sears, M.Sc., became pomologist to the station. This change seemed desirable in view of the fact that while the floricultural interests of the State are important, those of fruit culture would seem to be yet more important. Professor White's connection with the college, however, remains unchanged, and he can accordingly still be consulted on such special problems connected with floriculture as are brought before us.

The following changes affecting subordinate positions have been made during the year: —

James C. Reed, B.Sc., and P. V. Goldsmith, B.Sc., have been engaged as assistants in the department of chemistry, in place of E. T. Ladd, M.Sc., and Walter E. Dickinson, B.Sc., resigned during the latter part of last year.

J. K. Shaw, B.Sc., has been engaged as assistant in the department of horticulture, in place of C. S. Pomeroy, B.Sc., who resigned to accept a more responsible and lucrative position.

F. A. Johnson, B.Sc., has been engaged as assistant in entomological work on cranberry insects, in place of H. J. Franklin, Ph.D., who resigned to accept a more important position in another institution.

Buildings.

During the past year the shed referred to in my last annual report for use in connection with the asparagus work at the substation in Concord has been completed, at a total cost of $298.

The hothouse designed for use in connection with the work of the department of vegetable physiology and pathology has been completed. This building is 70 by 28 feet in size. This was not put up under contract, but under college management by direct purchase of materials and employment of workmen. The building has been paid for by the use of funds appropriated by the Legislature for the erection and equipment of Clark Hall. The cost of the hothouse and of the passages connecting it with the main building has been about $3,000. This hothouse has been but recently completed. It will make it possible for the department of vegetable physiology and pathology once more to take up numerous lines of investigation which it has not been possible to prosecute during the past year, and which were necessarily discontinued at the time of the removal from the old quarters of the department to the new, a little more than a year ago.

Much-needed additional room in the chemical laboratory for control and research work has been obtained by removing from the feed and research laboratories the machinery and fixtures used in grinding and preparing substances for analysis, for testing Babcock glassware and for making the Babcock test. This machinery and apparatus have been set up in a basement room fitted for the purpose, and all these lines of work are now carried on under conditions far more satisfactory than formerly. The cost of the needed changes has been met from current station funds.

During the past year the building formerly used for office and laboratory purposes by the department of vegetable physiology and pathology has been put into thorough repair and refitted for use by the department of agriculture, for administrative headquarters and offices. The most important change consists in the provision of fireproof rooms for storage of records, papers and the more valuable files of station and government publications. One-quarter of the building has been rebuilt, with the exception of the exterior walls, which were originally of brick, on the lines of the usual vault construction. This part of the building contains three rooms, each about 11 by 12 feet in size, two of them provided with wire-glass windows and steel shelving, and all with heavy vault doors. In addition to this change the basement floor has been concreted and the ceiling plastered, new floors have been laid throughout the building; new windows have been provided in place of the old on the entire second floor, the walls throughout the building have been refinished, and a number of minor changes and improvements have been made. The cost of these improvements, as well as of some much-needed repairs and improvements in the chemical laboratory, has been met by the State appropriation of $4,000, made by the last Legislature.

Station Activities.

There will be general agreement that the objects primarily in view in the establishment of experiment stations were: (1) to provide for the carrying out of experiments whose results should make possible definite and decisive answers to as many as possible of the unsettled questions affecting agricultural practice; (2) to provide an agency which by true research should endeavor to broaden the bounds of human knowledge, especially in the field of the sciences, and particularly in their relations with and application to agriculture; (3) to disseminate useful information having a bearing upon agriculture and the welfare of the people, and especially the people of the rural districts; (4) in addition, this station has been charged with the execution of several control laws. Those at present in force relate to the trade in fertilizers, feed stuffs and the apparatus used in making the Babcock test; and provide, moreover, for the inspection of the machinery used in making this test in creameries and the examination of those desiring to qualify for carrying it out.

To discover and demonstrate the value of new and better methods in agriculture as an art; to test and introduce new and better varieties or species of plants and animals; to improve plants and animals by selection and breeding; to broaden our knowledge of the influences of air, water, electricity, light, heat and cold on plants and animals in health and disease; to add to our knowledge of the chemistry and physics of soils, manures and fertilizers; to increase our knowledge of foods and their functions in the animal and human economy; to make us better acquainted with the life histories of fungi and insects in their manifold relations to plants and animals and to man; these are a few among the many things coming under the first two classes which the agricultural experiment stations are striving to do. They are not, however, in most cases, the things which they are most frequently asked to do, although there can be no doubt that the interests of the great agricultural public are most advanced by new discoveries in these and similar fields.

There is no room to doubt the salutary effect of our control laws. They are recognized to be both important and useful by dealers as well as by consumers, and in carrying out the necessary inspection and looking after the strict execution of these laws the stations are rendering important service. The cost of the execution of the fertilizer law is covered by license fees paid by the manufacturers and dealers, while the execution of the feed and dairy laws is provided for by special State appropriation for that purpose. In a certain sense the execution of these laws may be regarded as outside of the special lines of work for which the experiment stations were founded. There is doubtless danger, moreover, that such work will be allowed to interfere with the more appropriate work of the station. In the early days of experiment stations it was undoubtedly an advantage that the stations should be charged with the execution of these laws. This arrangement served to bring the station and the farmers into closer touch, and, moreover, the station laboratories were equipped with the apparatus and the men necessary for carrying on the work, which at that time was not true of any other existing State institution. These reasons do not now have equal force, but as the station has been so developed both on the side of material and personal equipment as to provide for this work, it would seem best that these laws, at least for the present, be executed by the station. It would seem best, indeed, that the station be charged also with the execution of such additional control laws as shall in the future become desirable. Already we may anticipate the wisdom or necessity of laws to control the trade in seeds, in insecticides and fungicides, and perhaps in still other directions. Laws to control the trade in insecticides and fungicides are already much needed. National and State authorities and the manufacturers have for some time been studying this subject. It is hoped that in the near future a law which seems likely to prove mutually satisfactory will be agreed upon, and it seems wise, therefore, to defer State action until such a law can be framed, or until it becomes apparent that the necessary understanding cannot be reached. Uniformity in the laws affecting the trade in these materials throughout the Union is greatly to be desired, on account of the fact that it is not confined within State lines. Most of the manufacturers undoubtedly do an interstate business.

It is service coming under the third of the three classes which I have enumerated which appears at present to be most appreciated, and which is most in demand. Under this class must be placed such diverse activities as the publication of reports, bulletins and circulars, answering letters of inquiry, preparation of articles for the press, practical demonstrations and object lessons, exhibitions at fairs, and lectures by members of the station staff. Under this class must be placed, also, the various requests for information which can be given only after analyses or other special laboratory examinations or tests. The amount of time consumed in meeting the demands of the public for work of this description is very great, and so rapidly does the demand for service along these lines increase, that there is undoubtedly great danger that the time available for experiment and research may be seriously curtailed. The following summary will give a general idea of the amount of work involved in meeting this demand, and in the execution of the control laws which have been referred to: —

Summary of Station Work not Experimental.

Dissemination of information and work for individuals: —	
Publications of the year 1908: —	
Reports,	1
Bulletins,	8
Circulars,	8
Answers to letters of inquiry,	8,000
Lectures and demonstrations by members of the staff,	67
Exhibits at fairs,	2
Miscellaneous analyses: —	
Water,	143
Milk,	625
Cream,	2,899
Feed stuffs,	122
Fertilizers and fertilizer materials,	169
Soils,	33
Miscellaneous substances,	26
Tests of cows: —	
Yearly,	76
Seven day,	68
Fourteen day,	5
Thirty day,	10
Forty-four day,	6
Miscellaneous: —	
Tests of seeds for germination,	196
Tests of seeds for purity,	12
Separation of seed,	160
Control work: —	
Fertilizers, samples analyzed,	624
Feeds, samples analyzed,	895
Babcock apparatus, pieces tested,	2,713
Candidates examined,	23

This statement makes it apparent that these lines of work, many of which are undertaken on the request of individuals, and which are of such a nature that the results are of value chiefly or exclusively to the particular individual concerned and of little or no interest to the public, must make very heavy inroads both upon station funds and upon the time of members of the station staff. The members of our staff are unfailingly glad to help individuals to the utmost of their ability in so far as is consistent with their obligations to render service which is of wider interest and importance. Individuals should remember that the station is supported by public funds, in the interest of the public. The public funds are a public trust, and station men must first of all and chiefly work in the public interest.

That the bearing of this general principle may be made more apparent, and in the hope that individuals may be led thereby to exercise a wiser discretion in the demands they make upon the station, a brief consideration of the usefulness and limitations of some of these lines of work as well as of the extent to which they can be undertaken will be presented.

Publications.

Our publications are chiefly of three kinds, — annual reports, bulletins and circulars. These are designed primarily to present the results of investigations carried on in the various departments of the station, and to convey practical advice based upon these results or upon the results of others. The bulletins are sent without charge, so long as the supply lasts, to all citizens of the State whose names are on our mailing list, or who may apply for them. They are also sent to all libraries in the State which will care for them, to the newspapers, to members of agricultural college and station staffs, and to many persons all over the world who apply for them.

This year, for the first time, the annual report is to be published in two parts, — popular and general. This change has been made in order that those portions of the report which are believed to be of widest popular interest may be given a more general circulation. The number of annual reports heretofore available for distribution from the station has been 6,000, and it has not been possible to send it to all those on our mailing list. Hereafter we are to have 16,000 copies of the popular portion, and this will be sent to all on our general State list. We are to have 4,000 copies of the general report, and this will be sent to libraries, workers in other experiment stations and, so far as possible, to such as apply for it. Fifteen thousand copies of this part of our report will be bound with the report of the secretary of the State Board of Agriculture, and distributed in that form from the office of the Board.

The circulars, which briefly treat subjects of wide interest, as made evident by correspondence, are used chiefly in answers to letters of inquiry.

Publications during 1908.

Annual report: —

Contains report of the director, treasurer and heads of departments, with papers on a number of miscellaneous subjects. 172 pages.

Bulletins: —

No. 119. Inspection of Commercial Fertilizers, H. D. Haskins, E. T. Ladd and W. E. Dickinson. 64 pages.
No. 120. Inspection of Commercial Feed Stuffs, P. H. Smith and L. S. Walker. 48 pages.
No. 121. Seed Separation and Germination, G. E. Stone. 16 pages.
No. 122. Poultry Keeping for Egg Production, Wm. P. Brooks. 64 pages.
No. 123. Fungicides and Insecticides and Spraying Directions, G. E. Stone and H. T. Fernald. 32 pages.
No. 124. Bee Diseases in Massachusetts, Burton N. Gates. 12 pages.
No. 125. Shade Trees, E. A. Start, G. E. Stone and H. T. Fernald. 64 pages.
No. 126. How to fight Cranberry Insects, H. J. Franklin. 12 pages.
No. 127. Inspection of Commercial Fertilizers for Season of 1908, H. D. Haskins, L. S. Walker and J. C. Reed. 68 pages.

Circulars: —

No. 12. The Unprofitable Cow and how to detect Her. 4 pages.
No. 13. Laws regulating the Sale of Commercial Fertilizers in Massachusetts, J. B. Lindsey. 4 pages.
No. 14. Fertilizers for Potatoes, Wm. P. Brooks. 4 pages.
No. 15. The Cost of testing Pure-bred Cows, J. B. Lindsey. 2 pages.
No. 16. Seeding Mowings, Wm. P. Brooks. 8 pages.
No. 17. An Act to regulate the Sale of Concentrated Commercial Feed Stuffs, J. B. Lindsey. 4 pages.
No. 18. Alfalfa as a Crop in Massachusetts, Wm. P. Brooks. 4 pages.
No. 19. The White Fly, C. E. Hood. 2 pages.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

Bulletins: —

No. 33. Glossary of Fodder Terms.
No. 41. On the Use of Tuberculin (translated from Dr. Bang).
No. 64. Analyses of Concentrated Feed Stuffs.

No. 68. Fertilizer Analyses.
No. 76. The Elm-leaf Beetle.
No. 83. Fertilizer Analyses.
No. 84. Fertilizer Analyses.
No. 89. Fertilizer Analyses; Ash Analyses of Plants; Instructions regarding Sampling of Materials to be forwarded for Analysis.
No. 90. Fertilizer Analyses.
No. 92. Fertilizer Analyses.
No. 97. A Farm Wood-lot.
No. 103. Analyses of Manurial Substances; Instructions regarding Sampling of Materials to be forwarded for Analysis; Instructions to Manufacturers, Importers, Agents and Sellers of Commercial Fertilizers; Discussion of Trade Values of Fertilizing Ingredients.
No. 113. Fertilizer Analyses.
No. 115. Preliminary Report on Cranberry Insects.
No. 116. The San José Scale.
No. 117. Trade Values and Fertilizer and Soil Analyses.
No. 120. Inspection of Commercial Feed Stuffs.
No. 121. Seed Separation and Germination.
No. 122. Poultry Keeping for Egg Production.
No. 123. Fungicides and Insecticides and Spraying Directions.
No. 124. Bee Diseases in Massachusetts.
No. 125. Shade Trees.
No. 126. How to fight Cranberry Insects.
No. 127. Fertilizer Bulletin for Season of 1908.
Technical Bulletin No. 2. The Graft Union.
Technical Bulletin No. 3. The Blossom End Rot of Tomatoes.
Index to bulletins and annual reports of the Hatch Experiment Station published previous to June, 1895.
Index to bulletins and reports, 1888–1907.

Annual reports: —
Annual reports of the station are available for the years 1898 (9th) to 1908 (20th) with the exception of 1907 (19th).

Of some few other bulletins we have a very limited supply. These will be furnished only in order to complete sets for libraries. Circular No. 8, which gives a complete list of bulletins published by this station up to March, 1907, will be sent on application.

Extent and Nature of Demand for Publications.

The demand for station publications has greatly increased. Our editions of bulletins treating subjects of general interest now reach 25,000. Our annual expenditure for publications and distribution of bulletins and circulars now amounts to rather more than $3,000.

Almost every mail brings requests for bulletins of information. These requests cover the whole field of agriculture. Correspondents within the last few days, for example, have called for "your pamphlet," "manual," "work" or "bulletin" on asparagus, orchard management, potato growing, duck raising, strawberry culture, small fruit growing, management of hothouse crops, etc. Whatever the line of work, the public looks to the station for literature exhaustively treating the subject. It is manifestly impossible to meet any considerable proportion of such requests under present conditions. We have published no comprehensive manuals for the different farm and garden specialties. It may be questioned whether the publication of such manuals would be the wisest use either of station talent or funds. It is freely granted that such manuals, carefully prepared, would be useful, they would meet a want; but is it not reasonable to leave something for private enterprise? Should not the members of the farming public, as well as other citizens, satisfy their requirements in this direction by purchase? May we not safely depend upon the agricultural publishers to furnish works of this character? However these questions may be answered, it is certain that under existing conditions the station cannot engage in the preparation, publication and gratuitous distribution of any considerable number of manuals on our various specialties.

Letters of Inquiry.

Thousands of letters of inquiry are received at the station annually. Every head of department has repeatedly called attention to the increase in the numbers of such letters and the heavy demands upon the time and energy which answering such letters entails, involving as the preparation of answers in many cases does a considerable amount of investigation. The fact that our public more and more looks to the station to settle doubtful points and to give desired information and help is gratifying; and until satisfactory, special provision can be otherwise made for work of this kind, the members of the station staff will gladly meet the demand to the best of their ability. The circulars which have been elsewhere referred to are proving of great assistance in meeting requests for information and advice.

In conclusion on this topic I would like to emphasize these points: —

1. This work, from its very nature, is primarily for the benefit of individuals and often of no general interest. Individuals therefore should refrain from sending inquiries which can as well be answered by reference to standard works or to other channels of information.

2. It is impossible for station officials in most cases to give business advice. They cannot know, for instance, whether A can make the hen business profitable in the town of X; nor whether B will succeed in producing cranberries at a profit in the marshes of the county of W.

3. Letters of inquiry should refer to specific problems. It is clearly not within the bounds of possibility to discuss general problems with results satisfactory either to the writer or to the receiver within the limits of a letter. A common type of letter received runs somewhat as follows: —

DEAR SIR: — I have recently inherited [or purchased] a farm situated in the town of ——. This farm was formerly productive, but has been neglected and the soil is much exhausted. Will you not kindly tell me how it may be so handled as to restore it to fertility and at the same time return a profit to the owner?

The discussion of the problems thus presented would involve the whole field of agricultural science and practice. The problems are important and the need of the individual is great. It cannot, however, be met through the channels of ordinary correspondence. The most we can do is to refer to sources of information, or to advise either a short winter course or a correspondence course in agriculture.

Miscellaneous Analyses.

The summary presented shows that a large number of miscellaneous analyses have been made during the past year. Had the individuals and associations sending in these materials paid for the analyses at current commercial rates, the cost to them must have amounted to between $5,000 and $6,000. It is not the policy of the station to invite commercial work, and we do not accept it except in cases where it appears to be almost a necessity that the station make the desired analyses. Such analyses are made without charge for individuals in all cases where the results are likely to be of some public interest. Indeed, we do not limit our free work strictly in accordance with this rule, as we believe it to be good general policy to encourage the spirit of study and inquiry which the desire for such analyses usually indicates.

A few words in explanation as to the attitude of the station as regards the analysis of different classes of materials for the public seem called for.

Water Analyses. — The station makes a uniform charge of $3 for a sanitary analysis of drinking water. This is much below the usual charge for such work, which varies widely, but will probably average at least $10. The results of water analysis are of interest and value, as a rule, only to the individual sending in the sample. So long as these analyses were made without charge the number of samples sent in was so large that the work of making the analyses became a great burden and seriously interfered with other work. It is not believed that the charge now made is sufficiently high to deter parties from sending samples for analysis in cases of necessity. The charge does, however, act as a check upon the indiscriminate forwarding of samples, and this was the result aimed at.

Analyses of Milk and Cream. — Under existing laws in this State the station determines fat or fat and solids in samples of milk and cream at cost for creameries. Farmers' occasional samples are analyzed without charge.

Analyses of Feeds and Fertilizers. — The total number of samples of feeds, fertilizers and fertilizer materials analyzed during the year has been considerable, and this work is becoming something of a burden. Individuals should consult the station publications, in which analyses of identical materials will often be found, before sending in samples or writing for analyses. The inspection service of the station is now so thoroughly organized that there are relatively few materials coming under these classes which have any considerable importance that are not officially collected and analyzed. In all cases, however, where individuals desire to purchase either feeds or fertilizers on a guaranty of composition to be determined by station analysis, the station holds itself in readiness to make such analyses as are needed, and will undertake to do this work and to report results with all possible promptness in all cases where the quantity involved is large enough to make the work worth while. Such analyses will be made without charge, if parties desiring them conform with the instructions sent.

Analyses of Soils. — During the past year there has been a very great increase in the number of requests for chemical analyses of samples of soils. It is evident that there exists a widespread misapprehension as to the value of such analyses. It appears to be believed that it is necessary only to make a chemical analysis in order to determine what fertilizers will be required. The following letter, received within a few days, fairly represents the attitude of most correspondents relative to this work: —

Gentlemen: — I write for information for Mr. ——, the owner of a large farm in ——, Mass. He wishes to know if he can send you samples of soil for analysis; most likely would send 8 or 10 samples from different parts of his farm. In what form and in what quantity should he send, and what would be the expense for analysis of each package sent? He would also like to know what crop would produce the best results for each sample sent, and the best fertilizer for each sample and the quantity required, and would be pleased to pay for any catalogue or information in circular form you can furnish him on scientific farming. . . .

The views which we hold relative to the possible value of such work, and the attitude of the station in relation to it, will perhaps be made clear by the following quotation from a circular on the subject: —

The results of chemical analysis of soils do not, as a rule, afford a satisfactory basis for determining manurial requirements. The chemist, it is true, can determine what the soil contains, but no ordinary analysis determines with exactness what proportion of the several elements present is in available form for the crop. Indeed, there is no such thing as a constant ratio of availability. While one crop may find in a given soil all the plant food it requires, another may find a shortage of one or more elements. Further, on the very same field one crop will find an insufficient amount of potash, another may find enough potash for normal growth but insufficient phosphoric acid, and a third may suffer from an insufficient supply of nitrogen.

Most of our soils are of mixed rock origin, and as a rule possess similar general chemical characteristics, provided they have been farmed under usual conditions. The manurial and fertilizer requirements are determined more largely in most instances by the crop than by peculiarities in the chemical condition of the soil. The chemical analysis of soils, then, does not, as a rule, afford results which have a value commensurate with the cost, and as a rule this station will not make such analyses unless the soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of such a nature as to probably greatly influence its chemical condition.

In some cases the correspondent reports that his crop is diseased and that he desires a chemical analysis in order to ascertain what is the cause. The chemical composition of the soil may in some instances exercise a controlling influence in determining a condition of health or disease, and is never unimportant from the standpoint of vigorous, normal and healthy growth; but in the case of most diseases the immediately active cause is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the plant whatever may be the composition of the soil. A knowledge of the chemical composition of soils, therefore, will not make it possible to advise such manurial or fertilizer treatment as will insure immunity from disease.

It will be noted that the correspondent quoted evidently believes that the chemical composition of the soil will determine its suitability for different crops. The chemical composition may not be without importance in determining what the soil is fitted to produce, but the physical characteristics of the soil and subsoil, as affecting drainage, the capacity to hold water, the capacity to conduct water from below upwards, texture and aeration, are of much greater importance in determining what crops the soil is fitted to produce. It will be noted that the correspondent expresses a willingness to pay the cost of analysis. Very many express themselves to that effect. The fact that this is the case does not, however, and should not change our attitude relative to such work. We believe that the results would not have the value which correspondents suppose they would have, and it therefore seems best to decline to make such analyses except in cases where conditions widely different from those which usually prevail seem to render it probable that the results will possess unusual value.

Analyses of Miscellaneous Substances. — A wide variety of materials coming under this class is offered for analysis each year. Materials of such a character as render analysis likely to prove of especial interest or value in our agriculture will be analyzed without charge, but it should be here stated that the station cannot undertake the analysis of ores and minerals.

Testing Cows.

The conditions under which pure-bred cows are tested are set forth fully in the report of the head of the department of chemistry. The director desires to call attention here simply to the fact that since such tests involve a large amount of detail work, and since they appear to be conducted primarily for the private interest of the individuals owning the cows, it is regarded as only proper that the station should be fully reimbursed for the cost of doing the work. It has been found necessary during the past year to make a small increase in the amount charged.

Seed Work.

Tests of seeds for germination and for purity, when asked for by farmers or gardeners, are made without charge. The number of requests for seed testing is increasing quite rapidly. In a number of instances seedsmen call upon us for similar work, preferring to have it done by the station rather than to undertake it themselves. Since it is highly desirable that seedsmen should be encouraged by all possible means to offer only seeds whose quality is well known, the station will for the present undertake such work, which will be charged at cost. Samples of seeds from farmers or gardeners brought in for separation are subjected to treatment without charge. Should seedsmen call upon us for work of that character, our policy would be the same as in reference to tests for germination and purity.

Mailing Lists.

The persons on our general lists and receiving our publications regularly may be classified as follows: —

Residents of Massachusetts,	14,705
Residents of other States,	2,045
Residents of other countries,	174
	16,924

During the year we have made up as full a list of bee keepers in the State as possible. Most of the addresses had been collected by Burton N. Gates, apiculturist, United States Department of Agriculture, and this list was very kindly placed at our disposal. We have made several additions as a result of correspondence and the list is now probably fairly complete.

We have made a special effort during the past year to secure the co-operation of the libraries of the State in preserving files of our publications, in order that they may be accessible for consultation in all parts of the State. Circular letters were sent to all libraries, offering to make up as complete a set of station publications for each as could be got together, calling attention to the fact that such sets must in the future be valuable for consultation, and offering to place the libraries upon our mailing list. We received many favorable replies, but in a number of instances the libraries stated that they felt obliged to decline to undertake the completion and preservation of a file of station publications on account of lack of suitable accommodations for preserving them. As a result of our correspondence, however, we added 175 libraries to our mailing list, and we made up and sent out to libraries a large number of sets of publications which were made as nearly complete as our stock of the different issues would allow.

The following special mailing lists are now in use: —

Cranberry growers,	1,507
Bee keepers,	2,510
Meteorological,	263
Libraries,	333

The total net addition to all lists during the past year has been 3,175.

Asparagus Substation, Concord.

It will be remembered that the substation work with asparagus in Concord is located on land leased of Mr. Charles W. Prescott. This work was begun in the spring of 1906. The leading lines of investigation are two: (1) breeding experiments, with a view especially to the production of a desirable type of asparagus with greater capacity to resist rust; (2) fertilizer experiments.

During the past year a new line of work has been begun in a small way, *i.e.,* experiments to determine the effects of the cultivation of asparagus under tent shade, after the manner which has been successfully followed in the production of certain grades of tobacco. This station enjoys the co-operation of the Bureau of Plant Industry of the United States Department of Agriculture in the breeding and tent experiments.

Breeding Experiments. — During the past year the number of varieties and selections of varieties of asparagus brought together has been still further largely increased. The total number of such varieties and selections now growing in the experimental plots is 105. Most of these selections have made an excellent growth. They exhibit, as might be expected, wide differences in habit and vigor of growth as well as in capacity to resist the attacks of rust. Mr. J. B. Norton, an expert of the Bureau of Plant Industry, was stationed in Concord during the latter part of the summer. He was engaged in making close observations and study of the different types, and in selecting such as seemed to possess characteristics likely to render them valuable for the purposes in view. Mr. Norton will devote most if not all of his time to work in Concord next season, and the actual work of hybridizing will then begin.

Fertilizer Experiments. — The plants in the fertilizer plots have continued to make excellent growth. Those in the different plots now exhibit considerable variation, due, no doubt, to the varying fertilizer treatment. The past season is the second season since the plants were set, and so vigorous has been their growth that commercial cutting was begun in a small way last spring. It is not deemed best to present results at this time, for the amount cut was no doubt affected in considerable measure by the violent spring winds, which affected some plots much more seriously than others. In order to prevent injury from winds in the future a wind break, made by tacking cheese cloth to substantial posts standing about 8 feet above ground, has been put up. It is necessary, of course, to keep the cloth in position only during that period in the growth of the plants when they are peculiarly liable to injury (when the shoots are first starting).

Tent Shade Experiment. — This experiment was commenced after the cutting season was begun. The purposes in view are to note the effect of the tent upon

(*a*) The amount of rust.

(*b*) Time and rate of yield of commercial asparagus.

(*c*) The quality of the asparagus.

As the tent was in place only a portion of the cutting season the results will not be reported in detail. It may be remarked only in passing that tests of asparagus grown in the tent in comparison with the product of another portion of the same bed not shaded, which were carried out independently by a number of different parties, led to the conclusion that the tent asparagus was more tender and of better quality.

Cranberry Substations.

It will be remembered that the work with cranberries is along two lines and in two locations: (1) work with cranberry insects in Wareham; (2) fertilizer experiments in Waquoit. The work with insects has not made the progress hoped for during the past year. There are two principal causes: (1) it has been found impossible to acquire control of a cranberry bog suitable for the practical experiments in view on terms which the station can accept; (2) the resignation of Mr. Franklin, and the necessity of starting some one on the work in his place, has inevitably meant delay. There was practically no fruit on any of the fertilizer plots this year.

Substation for Orchard Experiments.

The work in the substation for orchard experiments, on the farm of Myron C. Graves in South Amherst, has been well begun. Six acres have been laid off in eight plots, containing substantially the same number of trees in each. Each plot has received different fertilizer treatment. The entire area is subdivided in the opposite direction into four sections for different cover-crop treatment. The orchard which had been in grass for a number of years was plowed in early spring and given sufficiently frequent tillage throughout the summer to keep down weeds. The trees have made excellent growth during the season, but a few of them have been recently somewhat damaged by the browsing of deer. It is not believed, however, that the damage from this cause is serious except to a limited number of young trees, which had been set to replace a few of those originally planted.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1908.

The United States Appropriations, 1907–08.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the treasurer of the United States as per appropriations for the fiscal year ended June 30, 1908, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$9,000 00
Cr.		
By salaries,	$6,359 88	$7,121 81
labor,	2,654 09	932 68
publications,	1,192 88	–
postage and stationery,	527 21	23 45
freight and express,	164 57	4 70
heat, light, water and power,	423 19	–
chemical supplies,	417 48	11 48
seeds, plants and sundry supplies,	531 33	17 50
fertilizers,	383 72	357 51
feeding stuffs,	732 97	–
library,	249 38	–
tools, implements and machinery,	155 42	16 35
furniture and fixtures,	70 27	30 00
scientific apparatus,	299 41	333 54
live stock,	324 20	–
traveling expenses,	160 28	133 95
contingent expenses,	15 00	–
buildings and land,	338 72	17 03
Total,	$15,000 00	$9,000 00

State Appropriation, 1907–08.

Cash balance brought forward from last fiscal year,	$11,533 31	
Cash received from State Treasurer,	13,500 00	
from fertilizer fees,	5,165 00	
from farm products,	2,732 07	
from miscellaneous sources,	5,762 26	
		$38,692 64
Cash paid for salaries,	$13,713 92	
for labor,	6,832 41	
for publications,	2,185 80	
for postage and stationery,	648 46	
for freight and express,	294 15	
for heat, light, water and power,	639 03	
for chemical supplies,	416 65	
for seeds, plants and sundry supplies,	751 01	
for fertilizers,	1,859 18	
for feeding stuffs,	956 12	
for library,	234 62	
for tools, implements and machinery,	134 99	
for furniture and fixtures,	85 82	
for scientific apparatus,	373 21	
for live stock,	49 51	
for traveling expenses,	1,348 05	
for contingent expenses,	12 87	
for buildings and land,	627 32	
Balance,	7,529 52	
		$38,692 64

REPORT OF THE AGRICULTURIST.

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work of the department of agriculture during the past year has followed the usual lines. These it will be remembered have for their principal object throwing light upon what appear to be some of the more important problems connected with the selection and method of use and application of manures and fertilizers. Much attention has been paid also to experiments designed to show the relative efficiency as sources of nitrogen and phosphoric acid of different materials which may be purchased by the farmer as sources of these elements.

The number of plots used in connection with our field work during the past year was 313. The work in the vegetation house involved the use of 384 pots. The crops used in the crop experiments in the vegetation house were Japanese millet, dwarf Essex rape, the soy bean, tobacco and tomato. The experiments with the two latter crops were carried out in the hope of throwing light on the causes of diseases or physiological troubles affecting these crops. The results are not yet conclusive. In addition to the work in the field plots and in the vegetation house we have carried on experiments in 136 closed plots. These have been for the most part used in fertilizer experiments. The results serve as a valuable check on field work.

The number of letters of inquiry answered in the department during the past year has been greater than ever before. The total is rather over 1,200, as against 824 for the year 1907.

The pressure for space from the other departments in the experiment station is so great that no attempt will be made to present detailed reports of the different experiments in the department of agriculture. As soon as opportunity and means permit, the different lines of investigation will be taken up one by one and reported in full. Some of the more important results of the experiments which have been carried on during the past year may be briefly stated as follows: —

I. The experiment on Field A, which has for its object to determine the relative value, as sources of nitrogen, of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood, has been continued. This experiment was begun in 1890. The crop of this year was alsike clover, which, however, was considerably mixed with grass that came into the different plots. The nitrogen fertilizer giving the highest yield this year was dried blood, closely followed by nitrate of soda. Representing the yield of the latter by 100, the relative standing of the different materials used as sources of nitrogen, as compared with the plots receiving no nitrogen, as indicated by the total yields, were as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	71.67
Sulfate of ammonia,	59.86
Dried blood,	102.08
No nitrogen,	70.45

The relative increase produced by the different nitrogen fertilizers, as compared with the no-nitrogen plots for the nineteen years during which the experiment has continued, is represented by the following figures: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	81.57
Dried blood,	68.40
Sulfate of ammonia,	60.18

These figures make it apparent that the nitrate of soda has on the average given a much greater increase in crop than either of the other materials used as a source of nitrogen. Since a pound of nitrogen usually sells at a lower price in nitrate of soda than in either of the others, the wisdom of making a large use of this material as a source of nitrogen is apparent.

II. On the field where different potash salts have been under comparison for so many years the crops this year have been sweet corn and early cabbages. The former on two series of plots, the latter on three. Last year the entire field was in potatoes, and the results showed a marked dependence of the potato crop on this soil on a liberal supply of potash, the average yield of the plots to which potash was applied exceeding that on the no-potash plots by 36.96 per cent. During the past year the fields both of sweet corn and cabbages have been remarkably even, and the most striking result of the experiment is that the yield both in the case of sweet corn and cabbages is about the same on the plots to which no potash has been applied for eleven years as on any of the potash plots. The difference in favor of the potash plots has been for the corn 2.7 per cent; for the cabbages the no-potash plots average 6.33 per cent better than those receiving potash. The yield of the corn on the no-potash plots was at the rate of 48.57 bushels per acre. The yield of the early cabbages on the no-potash plots was 48,213 pounds per acre.

III. The corn crop on the field where special corn fertilizer is under comparison with a mixture richer in potash was unusually good on both fertilizer combinations. On the special corn fertilizer it was at the rate of 94 bushels of sound corn and 7,760 pounds of stover per acre. On the fertilizer richer in potash it was at the rate of 90.23 bushels of sound corn and 9,224 pounds of stover per acre. This experiment has now been continued for eighteen years. Incidentally it furnishes a very conclusive answer to the question as to whether corn can be profitably raised on fertilizers. The cost of fertilizers applied to this field, where corn and mixed grass and clover hay have alternated, each being grown for two successive years, has varied in different years from about $12 to $16 per acre. There has not been a single unprofitable crop, and the crop of the last season is the heaviest so far secured.

IV. The crop of corn produced on the south corn acre, where manure alone is under comparison with a small quantity of manure and a potash salt, was also exceptionally heavy. On the manure alone (6 cords) the rate per acre amounted to 90.43 bushels of hard grain and 8,800 pounds of stover per acre. On the manure and potash (4 cords of the former and 160 pounds per acre of high-grade sulfate of potash) it was at the rate of 86.72 bushels of hard corn and 8,280 pounds of stover per acre. This experiment has now continued for nineteen years, corn and grass alternating during most of the time in periods of two successive years each. The manure alone gives slightly larger crops, but at a cost disproportionally greater than that of the product on the combination of manure and potash.

V. The field used in experiments comparing different phosphates was planted to late cabbages during the past season. The crop was a poor one on account of the prolonged drought. The experimental result, however, was satisfactory, as it illustrated as strikingly as in any previous year the marked dependence of the cabbage upon a liberal supply of highly available phosphoric acid. The average product of the three no-potash plots was at the rate of only 2,573 pounds per acre, all heads, both hard and soft, being included. The best results were obtained on plots to which raw bone, dissolved bone black and basic slag meal were applied, these being respectively at the following rates per acre: —

	Pounds.
Raw bone,	20,240
Dissolved bone black,	20,018
Basic slag meal,	19,120

During the past year, therefore, we have on the best plots a yield of cabbages eight times greater than was produced on the no-phosphate plots. In 1908 these same no-phosphate plots gave a yield of hay at the rate of about 4 tons to the acre, as compared with a yield only 1,200 to 1,300 pounds per acre greater on the plots to which the most soluble phosphates were applied. These facts illustrate in a striking manner the remarkable difference in the degree of dependence of the two crops (mixed grass and clover hay, and cabbages) upon the phosphoric acid content of the soil.

VI. The experiment on the nine-acre field in top-dressing grass land with manure, fine ground bone and muriate of potash, and wood ashes has been continued. The product this year of the different materials was at the following rates per acre: —

	Pounds.
Manure,	5,005
Bone and potash,	5,345
Wood ashes,	4,624

The average yield for the entire area during the past season was at the rate of 4,977 pounds per acre. The average for the entire period, 1893 to 1908 inclusive, has been 6,220 pounds. The yields this year were considerably lower than usual, especially those of rowen, and undoubtedly on account of the marked deficiency in rainfall.

VII. In the experiment comparing winter with spring application of manure the crop this year has been mixed grass and clover hay. The field was cut twice, and the averages for the plots representing the two systems of application have been as follows per acre: —

Winter Application.

	Pounds.
Hay,	6,209
Rowen,	1,227

Spring Application.

	Pounds
Hay,	6,804
Rowen,	1,409

Spring application has given substantially 10 per cent. more hay and about 14½ per cent. more rowen than winter application.

VIII. Our work with poultry has been directed principally to a comparison of the so-called dry mash with the moist mash system of feeding laying fowls. The results have not indicated any marked superiority for either. The number of eggs from the fowls receiving the moist mash has been somewhat greater than the number produced by the fowls receiving the dry mash. Whether the difference is sufficiently great to offset the greater labor cost of the moist mash system of feeding we are not yet prepared to say.

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

Research division: Edward B. Holland, Robert D. MacLaurin.
Fertilizer division: Henri D. Haskins.
Feed and dairy division: Philip H. Smith.
Assistant chemists: Lewell S. Walker, James C. Reed, Philip V. Goldsmith.
Assistant in animal nutrition: Roy F. Gaskill.
Inspector: William K. Hepburn.
Clerks and stenographers: Harriet M. Cobb, Alice M. Howard.

This department of the experiment station conducts experiments in animal nutrition and applies the science of chemistry in studying dairy problems, the composition of soils and the composition and food requirements of plants and animals. It inspects the fertilizers and cattle feeds sold in the State, as well as Babcock machines and the accessory apparatus employed in determining the commercial value of milk and cream; tests water used for drinking, at a cost of $3 per sample; analyzes farmers' samples of fertilizer, milk and cream free of cost, and conducts tests of pure-bred cows under the rules and regulations of the several cattle clubs. Its work for the year ending Dec. 1, 1908, is outlined below.

1. Correspondence.

The department conducts correspondence with interested parties on all of the subjects mentioned above, endeavoring so far as possible to answer all questions promptly and completely. The number of letters of all kinds sent out during the year has approximated 4,800.

2. Numerical Summary of Laboratory Work.

From Dec. 1, 1907, to Dec. 1, 1908, there have been received and examined 143 samples of water, 625 of milk, 2,899 of cream, 122 of feed stuffs, 169 of fertilizers and fertilizer materials, 33 soils and 26 miscellaneous. In connection with experiments made by this and other departments of the station there have been examined 256 samples of milk, 194 samples of skim milk and buttermilk, 54 samples of butter, 151 samples of cattle feeds and 476 samples of agricultural plants. There have also been collected and examined 895 samples of cattle feeds in accordance with the requirements of the feed law, and 624 samples of fertilizer in accordance with the fertilizer law. The total for the year has been 6,667.

In addition to the above, 23 candidates have been examined and given certificates to operate Babcock machines, and 2,713 pieces of Babcock glassware have been tested for accuracy of graduation, of which 33, or 1.22 per cent., were inaccurate.

3. Report of the Fertilizer Division.

Mr. Henri D. Haskins makes the following report, including topics (*a*) through (*j*): —

The principal work of the fertilizer division has been in connection with the official inspection of commercial fertilizers and the analyses of materials forwarded by farmers and farmer organizations.

The new law, obliging the station to publish commercial valuations and the percentage of differences, has added materially to the detail of the inspection work, more particularly with reference to the necessary correspondence and clerical work. The results of the year's work indicate a more complete collection and analyses of the licensed brands than ever before, and show, on the whole, an improvement over the preceding year in the quality of the goods that have been sold in Massachusetts markets.

(*a*) *Fertilizers licensed.*

During the year 76 manufacturers, importers and dealers have secured licenses for the sale of 409 distinct brands of fertilizers and agricultural chemicals in Massachusetts; this is

23 more than were licensed in 1907. They may be grouped as follows: —

Complete fertilizers,	306
Fertilizers furnishing potash and phosphoric acid,	8
Ground bone, tankage and dry ground fish,	40
Agricultural chemicals,	55

(*b*) *Fertilizers collected.*

The samples which furnished the material for this year's inspection were taken by Mr. W. K. Hepburn, the authorized sampling agent of the experiment station. During the months of April, May and June, 624 samples, representing 400 distinct brands, were taken from dealers' stock in various parts of the State. Ninety towns were visited and samples were taken from about 180 different agents. Duplicate samples of the same brand have been taken from various parts of the State whenever possible, as in previous years, and an analysis has been made of a composite sample composed of equal weights of the various samples.

(*c*) *Fertilizers analyzed.*

Ninety-two more analyses have been made than during the previous year. One hundred and eleven more samples, representing 44 more brands, have been collected and analyzed than during 1907. In the inspection of the licensed fertilizers the following analyses have been made: —

Complete fertilizers,	322
Ground bone, tankage and fish,	39
Acid phosphate, dissolved bone black and slag,	14
Cotton-seed meal, linseed meal, castor pomace, blood and nitrate of soda,	26
Muriate, sulfate and carbonate of potash and kainit,	24
Materials furnishing potash, phosphoric acid and lime, such as ashes,	8

Aside from this, 21 samples of fertilizer have been analyzed that were sampled officially by the collecting agent and which represent goods manufactured for private use, making in all 454 analyses.

(*d*) *Trade Values of Fertilizing Ingredients.*

	Cents per Pound.
Nitrogen: —	
In ammonia salts,	17½
In nitrates,	18½
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	20½
Organic nitrogen in fine[1] bone and tankage,	20½
Organic nitrogen in coarse[1] bone and tankage,	15
Phosphoric acid: —	
Soluble in water,	5
Soluble in ammonium citrate (reverted phosphoric acid),	4½
Soluble in fine[1] ground bone and tankage,	4
Soluble in coarse[1] bone and tankage,	3
Soluble in cotton-seed meal, linseed meal, castor pomace and ashes,	4
Insoluble (in neutral citrate of ammonia solution) in mixed fertilizers,	2
Potash: —	
As sulfate, free from chlorides,	5
As muriate (chloride),	4¼
As carbonate,	8

The above trade values of fertilizing ingredients in raw materials and chemicals are the same as for the previous year, and represent the values agreed upon by representatives of the experiment stations in New England and the Middle States, after a careful study of prevailing prices in the large cities in these localities.

The average comparative commercial value of the complete fertilizers analyzed during the season of 1908 is $25.81, the retail cash price per ton $36.20, and the percentage of difference 40.25.

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[1] Fine and medium bone are separated by a sieve having circular openings one fiftieth of an inch in diameter, the valuation being based upon the degree of fineness.

(*e*) *Guarantees and Analyses compared.*

Manufacturer.	Number Brands analyzed.	Number with Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	2	1	2	1	-	-
American Agricultural Chemical Company,	76	51	75	22	2	1
Armour Fertilizer Works,	10	7	10	3	-	-
Beach Soap Company,	3	3	3	-	-	-
Berkshire Fertilizer Company,	5	3	5	2	-	-
Bonora Chemical Company,	1	1	1	-	-	-
Bowker Fertilizer Company,	29	17	27	10	2	-
Joseph Breck & Sons,	3	2	2	1	-	-
Buffalo Fertilizer Company,	7	3	6	4	-	-
Coe-Mortimer Company,	8	5	8	2	1	-
Eastern Chemical Company,	1	1	1	-	-	-
Essex Fertilizer Company,	8	3	8	5	-	-
R. & J. Farquhar & Co.,	5	2	5	3	-	-
Fertilizer Products Company,[1]	1	1	1	-	-	-
C. W. Hastings,	1	-	1	1	-	-
Lister's Agricultural Chemical Works,	7	4	6	2	1	-
J. E. McGovern,	1	1	1	-	-	-
Mapes Formula and Peruvian Guano Company.	17	10	14	7	-	-
National Fertilizer Company,	13	11	13	2	-	-
National Guano Company,	1	-	-	1	-	-
New England Fertilizer Company,	6	5	5	1	-	-
Northwestern Fertilizer Company,	1	-	1	1	-	-
Olds & Whipple,	6	3	6	2	1	-
Parmenter & Polsey,	4	2	2	1	1	-
R. T. Prentiss,	3	1	3	2	-	-
Pulverized Manure Company,	1	1	1	-	-	-
W. W. Rawson & Co.,	3	1	3	2	-	-
Rogers Manufacturing Company,	8	2	8	6	-	-
Rogers & Hubbard Company,	7	6	7	1	-	-
Ross Brothers Company,	1	-	-	1	-	-
N. Roy & Son,	1	-	-	-	1	-
Sanderson Fertilizer and Chemical Company.	8	5	6	1	1	1
M. L. Shoemaker & Co., Limited,	2	2	2	-	-	-
Smith Agricultural Chemical Company,	7	5	7	2	-	-
Swift's Lowell Fertilizer Company,	12	5	12	7	-	-
Whitman & Pratt Rendering Company,	4	3	4	1	-	-
Wilcox Fertilizer Works,	5	4	5	1	-	-
A. H. Wood & Co.,	1	1	1	-	-	-
Wunsch Manufacturing Company,	3	2	3	1	-	-

A study of the preceding table, showing a summary of the results of the inspection of complete fertilizers, reveals the fact that out of the 282 distinct brands analyzed, 110, or about 39 per cent, of the whole number, fell below the manufacturers' guarantee in one or more elements. Ninety-eight were deficient in one, 10 in two and 2 in all three elements. Twenty-nine brands were deficient in nitrogen, 57 in potash and 38 in phosphoric acid. The deficiencies in many of these brands were made up by an excess of some of the other elements, so that only 17 out of the 282 brands analyzed showed a commercial shortage.

[1] Ellis Chalmers Company (successors).

This shortage ranged from a few cents to $3.36 per ton; only 8 brands showed a commercial shortage of over $1 per ton.

The following table shows a comparison between the commercial shortages found during 1908 and 1907: —

Commercial Shortage.	Number of Brands.	
	1908.	1907.
Between $1 and $2, ...	7	11
Between $2 and $3, ...	1	6
Between $3 and $4, ...	3	–
Between $4 and $8, ...	–	6

The above certainly shows an improvement this year over conditions which existed during 1907.

(f) *High-grade v. Low-grade Fertilizers.*

It is gratifying to note the large proportion of high-grade as compared with the medium and low-grade fertilizers that are being sold in Massachusetts. One hundred and fifty-one out of a total of 282, or 53.55 per cent, of the complete fertilizers sold, have a value of over $24 per ton. Some interesting information is brought out by comparing the quantity and value of plant food furnished by three grades of mixed fertilizer. The 282 brands analyzed may be grouped as follows: —

Brands valuing $18 per ton or less (low grade), ...	26
Brands valuing between $18 and $24 per ton (medium grade), .	105
Brands valuing over $24 per ton (high grade), ...	151
Total, ...	282

Grade.	Number of Brands.	Per Cent. of Whole.	Average Composition.				Average Valuation.	Average Cost.	Excess of Selling Price over Valuation.	Percentage Difference.
			Per Cent. Nitrogen.	Per Cent. Available Phosphoric Acid.	Per Cent. Potash.	Pounds Available Plant Food in 100 pounds Fertilizer.				
Low grade, . .	26	9.22	1.74	6.90	2.22	10.86	16.06	28.48	12.42	77.33
Medium grade, .	105	37.23	2.42	8.02	3.73	14.17	20.93	31.13	10.20	49.16
High grade, . .	151	53.55	4.06	7.65	7.44	19.15	30.51	40.96	10.45	34.25

It is apparent from the above table that with less than a 44 per cent advance in price over the low-grade fertilizer, the high grade furnishes more than 75 per cent increase in available plant food and nearly 90 per cent increase in commercial value. A ton of the high-grade fertilizer furnishes about 46 pounds more of nitrogen, 15 pounds more of available phosphoric acid and 104 pounds more of potash than do the low-grade goods. The high-grade fertilizers, with a 31.6 per cent advance in price over the medium grade, furnish 35 per cent more plant food with about 46 per cent increase in commercial value. The medium-grade goods also furnish much better value for the money invested than do the low-grade fertilizers. The medium grade, costing 9 per cent more than the low-grade fertilizers, furnish 30.5 per cent more plant food and have about 30.5 per cent greater commercial value. The consumer purchasing the low-grade fertilizers has paid, on the average, 8.83 cents per pound more for nitrogen, over 2 cents per pound more for available phosphoric acid and 2.15 cents per pound more for potash than has the user of the high-grade fertilizers. The purchaser of the medium-grade goods has paid, on the average, 3 cents more per pound for his nitrogen and three-fourths of a cent per pound more for his available phosphoric acid and potash than has the purchaser of the high grade goods. These figures speak for themselves.

(*g*) *Quality and Commercial Cost of Bone, Tankage and Fish.*

Out of the 34 samples of ground bone, tankage and dry ground fish, 5 showed a deficiency in nitrogen and 6 in phosphoric acid; only 1 of these brands, however, showed a commercial shortage.

The average retail cash prices, valuations and percentages of difference of the ground bone, dissolved bone, tankage and dry ground fish are as follows: —

	Average Retail Cash Price.	Commercial Valuation.	Percentage Difference.
Ground bone,	$30.08	$29.09	3.40
Dissolved bone,	29.33	27.08	8.31
Tankage,	27.50	31.66	13.14[1]
Dry ground fish,	39.00	40.63	4.01[1]

[1] In excess of selling price.

(*h*) *Quality of Other Raw Materials.*

In the chemicals and raw materials furnishing nitrogen, only 1 sample of cotton-seed meal failed to meet the guarantee in this element. Three samples of dissolved bone black and 2 samples of acid phosphate failed to meet the guarantee in available phosphoric acid. Among the potash compounds 1 sample of high-grade sulfate, 5 of muriate and 1 of carbonate failed to meet the potash guarantee.

(*i*) *Cost of Plant Food in Raw Materials.*

The various agricultural chemicals and raw materials, as *sold at retail in our local markets,* have furnished nitrogen, phosphoric acid and potash to the consumer at the following prices: —

	Cents per Pound.
Nitrogen: —	
From nitrate of soda,	18.40
From blood,	20.50
From cotton-seed meal,	22.05
From linseed meal,	26.70
From castor pomace,	22.40
Available phosphoric acid: —	
From dissolved bone black,	7.80
From acid phosphate (superphosphate),	5.90
Potash: —	
From carbonate of potash,	8.00
From high-grade sulfate of potash,	5.00
From potash-magnesia sulfate,	5.70
From muriate of potash,	4.50
From kainit,	5.11

(*j*) *Miscellaneous Fertilizers, Soils and By-products for Free Analysis.*

During the past year 169 samples of fertilizer and by-products used for fertilizer, 33 samples of soil and 11 samples of miscellaneous materials have been analyzed for farmers and others interested in agriculture. Comparative valuations, with advice as to the best method of using these materials, have been furnished the applicant at the time the results of analyses were reported. We have every reason to believe that the samples forwarded have been representative in each instance, as they were invariably taken according to instructions forwarded from this office. The above analyses have not been published in our fertilizer bulletin.

Aside from the above, an active part has been taken in the work of the Association of Official Agricultural Chemists. The writer has acted in the capacity of referee on inorganic plant constituents, planning and compiling the work for this section of the association as well as executing the detailed work as a co-operator.

Eighteen complete soil analyses have also been made in connection with field experiments conducted by the agricultural department of the station.

4. Report of the Feed and Dairy Division.

Mr. P. H. Smith, in charge of the division, reports as follows, including topics (*a*) through (*h*): —

(*a*) *Execution of the Feed Law.* (*Acts of 1903, Chapter 122.*)

The feed law now in force in this State went into effect July 1, 1903. Its purpose is to so regulate the sale of commercial concentrated feed stuffs as to enable the consumer to purchase with a full understanding of what he is buying. Briefly stated, the law requires that every lot or parcel of concentrated feed offered or exposed for sale shall bear a statement giving the name and address of manufacturer, net weight and guarantee of protein and fat. The wheat by-products and the cereal grains, ground or unground, are exempt from the provisions of this act. Any adulterated feed must bear a statement of its true composition. An inspector is kept on the road during a considerable part of the year, who collects samples of the feeds offered for sale and reports any violations of the law. The director of the experiment station or his deputy is authorized to carry out the provisions of the act and to publish such results as are of value.

There have been collected by the inspector during the past year 895 samples of feed stuffs which were found offered for sale in the Massachusetts markets. As it is only possible for the experiment station to issue one feed bulletin yearly, the results of the examination of those feeds collected during the winter and early spring were not published in bulletin form. In every case, however, the analyses were sent to the manufacturers, and in case of misrepresentation or failure to meet the guarantee, attention was especially called to these points. All of these feeds were practically as represented. When results are of sufficient importance, it is the intent of the experiment station to keep the public fully informed by means of circulars, newspaper articles and correspondence, as well as by the regular annual feed bulletin.

During the season of 1906–07, the cotton-seed meal found on the northern market varied greatly in composition and much of the meal offered fell decidedly below its guarantee. This situation has been greatly improved, and for the season just past practically all of the cotton-seed meal found has been of good quality.

In general it may be said that there have been few violations of the feed law. Occasionally dealers neglect to mark material of good quality with guarantee tags, as required by statute. No new types of feed have been found during the last twelve months, although many new brands of existing types are freely offered. For a full description of the results of the feed inspection the interested reader is referred to the special feed bulletins.

(*b*) *Execution of the Dairy Law.* (*Acts of 1901, Chapter 202.*)

The purpose of the dairy law is to insure accuracy in the manipulation of the Babcock test where used in fixing the value of milk or cream, either in buying or selling. The work required by this act is subdivided into three natural divisions: (1) the examination of candidates, (2) the testing of glassware and (3) the inspection of machines.

Examination of Candidates. — During the past year 23 examinations have been given and certificates issued for proficiency in Babcock testing. Several candidates have been refused certificates, chiefly on account of not being sufficiently familiar with all phases of the work. If it happens that an operator is proficient in testing whole milk, it does not necessarily follow that the experiment station is justified in giving him a certificate until he has shown the requisite skill in the whole field. It is obvious that a tester may pass a perfectly satisfactory examination and yet employ careless and slovenly methods in practice. The writer wishes to re-emphasize the point made by the head of the department in the last annual report, "that the present law should be so amended as to give the experiment station the privilege of revoking the license of all operators who employ dirty glassware and who are not conscientiously performing their duties."

Testing Glassware. — All Babcock glassware intended for use where the Babcock test is a basis for fixing the value of milk and cream must be tested for accuracy and marked "Mass. Ex. Sta.," to signify that it has been so tested and found correct. During the past year 2,713 pieces of glassware were examined, and only 1.22 per cent were found incorrect, an improvement of 5.4 per cent over the previous year.

Annual Inspection of Babcock Machines. — This inspection was made in November, 1908. Of the 31 places visited, 19 were creameries, 10 milk depots, 1 city milk inspector and one a chemical laboratory. Thirteen of the creameries were cooperative and 6 were proprietary. The 10 milk depots were, in every case, proprietary. Thirty-one machines were inspected, of which 2 were condemned. As a whole, the machines were in good condition. Those in use are 13 Facile, 5 Argos, 6 Wizard, 3 electrical and 4 Stoddard. The glassware, as a whole, was clean, but a few still use very dirty bottles. In one case the pipettes were not tested. The creameries and milk depots in operation that pay by the Babcock test are as follows: —

1. *Creameries.*

Location.	Name.	President or Manager.
1. Ashfield, ...	Ashfield Co-operative, .	Wm. Hunter, manager.
2. Belchertown, . . .	Belchertown Co-operative, .	M. G. Ward, president.
3. Brimfield, ...	F. N. Lawrence, . . .	F. N. Lawrence, proprietor.
4. Cheshire, ...	Greylock Co-operative, .	C. J. Fales, president.
5. Cummington, . . .	Cummington Co operative, .	W. E. Partridge, manager.
6. Egremont, . . .	Co operative, . . .	E. A. Tyrrell, manager.
7. Easthampton, . . .	Hampton Co-operative, .	W. H. Wright, superintendent.
8. Heath, ...	Cold Spring, . . .	F. E. Stetson, manager.
9. Hinsdale, ...	Hinsdale Creamery Company.	W. C. Solomon, propriètor.
10. Monterey, ...	Berkshire Co-operative, .	F. A. Campbell, manager.
11. New Salem, . . .	New Salem Co-operative, .	W. A. Moore, president.
12. North Brookfield, . .	North Brookfield, . .	H. A. Richardson, proprietor.
13. Northfield, . . .	Northfield Co-operative, .	L. R. Smith, superintendent.
14. Shelburne, . . .	Shelburne Co-operative, .	Ira Barnard, manager.
15. Shelburne Falls, . .	Shelburne Falls, . . .	T. M. Totman, proprietor.
16. Springfield, . . .	Tait Brothers, . . .	Tait Brothers, proprietors.
17. Westfield, P. O. Wyben Springs.	Wyben Springs Co-operative.	C. H. Wolcott, manager.
18. Williamsburg, . . .	Williamsburg, . . .	D. T. Clark, manager.
19. Worthington, P. O. Ringville.	Worthington Co-operative, .	M. R. Bates, superintendent.

2. *Milk Depots.*

Location.	Name.	President or Manager.
1. Boston, P. O. Charlestown.	D. W. Whiting & Sons, .	George Whiting, manager.
2. Boston, P. O. Charlestown.	H. P. Hood & Sons, . .	Wm. Brown, manager.
3. Boston, ...	Boston Dairy Company, .	W. A. Graustein, president.
4. Boston, ...	Walker-Gordon Laboratory,	Merrill B. Small, manager.
5. Boston, P. O. Roxbury, .	Alden Brothers, . . .	Alden Brothers, proprietors.
6. Cambridge, . . .	C. Brigham Company, .	J. R. Blair, manager.
7. Cheshire, ...	Ormsby Farms, . . .	E. B. Penniman, proprietor.
8. Dorchester, . . .	Elm Farm Milk Company, .	J. H. Knapp, manager.
9. Sheffield, ...	Willow Brook Dairy, . .	G. W. Patterson, manager.
10. Southborough, . . .	Deerfoot Farm, . . .	S. H. Howes, manager.
11. Springfield, . . .	Emerson Laboratory, . .	H. C. Emerson, proprietor.
12. Springfield, . . .	Milk inspector, . . .	Stephen C. Downs.

(c) *Milk, Cream and Feeds sent for Free Examination.*

The experiment station has in the past analyzed and will continue in the future to analyze samples of milk, cream and feeds sent for examination, in so far as the time and resources at its command will allow. Only in exceptional cases should material intended for free chemical examination be sent to the experiment station, except by previous arrangement. Upon application full instructions for sampling and directions for shipping will be furnished.

(d) *Sanitary Analysis of Drinking Water.*

During the year ending Dec. 1, 1908, there have been examined 143 samples of water. The cost of an analysis is $3, which must be forwarded in advance and the express charges on the sample prepaid. In order to secure an analysis, application must be made, whereupon a suitably encased glass jar, together with full instructions for gathering and shipping, are forwarded by express. An analysis of water sent in shipper's jar will not be made, neither will a bacteriological nor mineral analysis be undertaken. The station does not examine water to determine its fitness for manufacturing purposes, it being held that this is the legitimate work of the commercial chemist. The object of the station in making an examination of water is to enable citizens of the State depending upon wells and springs to ascertain, at a minimum expense, whether their supply is free from objectionable matter, which is likely to gain access to it from sink, privy or barn drainage. Such an examination is referred to as a sanitary analysis. Those who are dependent upon local wells and springs are frequently very careless in the care of the same. As a result the water becomes polluted, and serious sickness is likely to follow. After the soil has once become contaminated it requires considerable time to purify itself, and the water is often rendered unfit for use for a number of years. Farmers and others are strongly urged to guard the well and spring from all possible bad drainage. Sink drainage should be conducted at least 100 feet or more away from the well and properly cared for, privy vaults should be located a similar distance and be frequently cleaned and made water tight. Barns should not be located near wells or springs when the water is to be used for either human or animal consumption.

Lead pipe should never be employed for conducting drinking water; in case it is in use its removal is urged and iron pipe coated with asphaltum or galvanized iron pipe substituted. *Lead is a poison,* and if it once gains access to the system it is difficult to eliminate. The station frequently finds lead in drinking water when lead pipe is used, and cases of lead poisoning are of common occurrence. Beware of lead pipe!

(e) *Miscellaneous.*

This division has co-operated with the Association of Official Agricultural Chemists in a study of methods for the determination of the various ingredients in condensed milk. The results have been reported to the association.

(f) *Testing of Pure-bred Cows.*

The experiment station continues its work of testing pure-bred cows for the various pure-bred cattle associations. This work is often confused with the work of cow-testing associations. The work is entirely different, in that pure-bred cows are tested under the rules of their respective associations, while the cow-testing association is purely local, and may include any or all breeds. One man is employed practically all of the time in connection with the Guernsey, Jersey and Ayrshire tests, which usually run for one year, it being necessary for the supervisor to visit the farms where the animals are on test once each month. The Holstein tests are of much shorter duration, usually from seven to thirty consecutive days, and require the presence of the supervisor during the entire test. For this work it is necessary to depend on men who cannot be regularly employed. Such men are difficult to obtain, and there is at times considerable trouble in obtaining men to fill all applications.

During the past year 20 yearly Guernsey, 5 seven-day and 56 yearly Jersey tests have been completed. For the Holstein-Friesian Association 63 seven-day, 5 fourteen-day, 10 thirty-day and 1 forty-four day tests have been completed. There are now on test for yearly records 54 Jerseys, 21 Guernseys and 6 Ayrshires. It is believed that the semi-official yearly tests would give a much better indication of the true productive capacity of an animal than tests of shorter duration.

5. Special Chemical Work.

Work in the laboratory has also been carried out on the chemical composition of soils, butter fat and insecticides, and is being continued at the present time. This work forms a part of various investigations which are in progress, and it is not considered necessary to more than mention it in this connection.

REPORT OF THE BOTANIST.

G. E. STONE.

The work of this department during the past year has consisted in the usual routine work, correspondence, seed testing and research work dependent upon some phase of pathology and physiology. The laboratory work has been carried on by Mr. George H. Chapman, with occasional aid from students and recent graduates, and Miss J. V. Crocker, besides attending to other duties, has had practically entire charge of the seed testing.

During the past year a conservatory, 28 by 70 feet, divided into compartments, with a lean-to and a propagating pit, has been added to Clark Hall. A part of this will be used for various experiments with market-garden and florist's crops during the coming year.

The past summer and fall have been unusually dry and have proved to be very severe for vegetation. Many public reservoirs have been unusually low, and wells which have never been known to fail in their supply of water have been completely dry this fall; in fact, the drought has been the worst known for many years. The season preceding this was also exceptionally dry, although followed by much rain in the fall; and the winter following was responsible for some winter-killing of peach tree roots.

This year's drought affected potatoes severely, causing much sun scald of the foliage, and was responsible for a small yield. The results of good feeding, tillage and spraying, however, were noticeable on the yield. There was very little blight of potatoes due to fungi, although here and there might be found evidence of the early blight and *Cladosporium,* which is seldom troublesome to potatoes. The potato mildew (late blight) and rot were not common.

Some trouble was experienced with tulip bulbs, but there seemed to be no infection, and the trouble was apparently associated with a poor grade of bulbs on the market this season. The peach leaf curl was more or less abundant in the spring, and much complaint was also received in regard to sweet peas. The diseases affecting sweet peas are obscure and need investigation. There was considerable mildew on phlox, which was in some cases associated with other difficulties, the cause of which is not as yet clearly established. A few cases of strawberry winter-killing were observed; these may have been associated in some cases with a bacterial trouble. Specimens of blackberries and raspberries were sent in which showed cane blight. Crown gall was reported on the peach and Carolina poplar, and we received specimens of the latter affected with *Didymosphœria populina*, Vuill. Some diseased specimens of *Shortia galacifolia* were sent in affected with a fungus, probably a *Glœosporium*. The Baldwin fruit spot was quite common in the fall; this seems to be more abundant in dry seasons. A serious *Macrosporium* disease of the spinach was also found to be doing severe damage to the crop of one of our large market gardeners.

Our attention was called at different times to the bacterial blight and the downy mildew of cucumbers under glass. These occur when the plants are set in August, but not if set later. Among amateur growers of greenhouse products the misuse of fertilizers is on the increase, and many troubles result from applying fertilizers to soil already well provided with plant foods. Many onion fields suffered severely from sun scald, which in some cases was associated with thrips and in others not. Corn smut, which is generally of minor importance with us, was unusually abundant this year, the dry weather apparently favoring it, and the apple rust, which is seldom seen in Massachusetts, was common, although it caused little damage.

The burning of the white pine was much less severe than during the preceding summer. Most of the burning which did occur took place on the young buds in the spring, and as they developed these brown areas might be noticed on the tips. The usual fungi frequently found on the leaves were present, but no instances of infection were observed. Frequent examination of the pine roots showed the results of the former winter-killing, but a decided improvement of the new feeding roots was noticed. The severe burning of the pitch pine, noticeable in some localities, is associated largely, if not wholly, with insect work.

Shade and forest trees have had much to contend with in recent years owing to severe drought and other factors, and some of our finest specimens of maples, elms, ash and other specimens have been slowly dying for some years. A peculiar trouble of the elm and sycamore has been brought to our attention many times the past few years; that is, the loss of the outer bark. This trouble has been noted in other States, and in one city which was visited by us a large number of trees in this condition was found. In some instances the injury had extended to the wood, large areas of the bark having died back to the wood, but in most cases the trouble is confined to the outer bark. In such instances no permanent damage will result. This injury dates back to the cold winter of four or five years ago. Some large sycamore trees shed their outer bark to the ground, causing much concern to those who prize them highly as shade trees.

Much premature defoliation and sun scald have occurred during the past two summers, but this sun scald has not been confined to city and village trees. It is often seen on trees growing in their native habitat.

Seed Work.

There has been an increase in the seed work of the past year, samples for germination tests having been received from many more growers than ever before. Eight hundred ninety-eight pounds more seed were separated than in the year 1907. By the aid of the new methods and improved apparatus which have been adopted the work was done with greater facility than has before been possible.

During the past year attention has been given to the further development of apparatus for the separation of seed. One of the worst contaminated seeds which the farmer has to contend with is grass seed, and at the present time we have no suitable methods for separating certain weed seeds from the grass seed.

In the coming year we expect to give this problem further consideration.

Onion and tobacco seed constitute the bulk of the seed received for separation. Both of these crops are grown extensively in the Connecticut valley. The object of separation is, of course, to discard the small seed and chaff, leaving only the large and heavy seed for planting. The percentage of the seed discarded varies somewhat. This would naturally be expected, as the seed comes from different dealers and varies in size and quality, although much of the tobacco seed is home grown.

In some of our seed separation work the amount discarded depends upon the percentage of germination of the sample. Certain growers make a practice, before purchasing in bulk, of obtaining samples, which are sent to the experiment station for testing. A certain percentage of the small seed is blown out, and the original sample, as well as the large and small seed are tested for germination. The results are then sent to the grower, and if satisfactory he purchases in bulk and requests that a certain percentage be blown out.

Small seeds, like tobacco, which are received in small quantities, are separated in glass tubes with bulbs of a special form, and in this form of separation, which is fully described in Bulletin No. 121 of this station, we make use of fifteen pounds' air pressure. The larger seeds, like onion, are separated by a special winnowing machine, given a constant speed by an electric motor. The machine is so arranged that a bushel or more may be separated at one time.

Careful germination tests were made again this year to prove the value of seed separation, and experiments in planting the different grades of separated seed were also made in co-operation with growers in different parts of the State.

The following tables give an outline of the seed work which has been done the past year: —

Table 1. — *Records of Seed Germination, 1908.*

Kind of Seed.	Number of Samples.	Germination.		
		Average Per Cent.	Highest Per Cent.	Lowest Per Cent.
Onion,	65	74.2	98.5	-
Tobacco,	10	78.2	97.0	20
Celery,	24	79.0	98.0	35
Corn,	5	87.9	100.0	60
Lettuce,	7	99.0	100.0	95
Pansy,	50	86.9	100.0	59
Miscellaneous,	35	82.7	100.0	7
	196	-	-	-

Table 2. — *Records of Seed Separation, 1908.*

Kind of Seed.	Number of Samples.	Weight in Pounds.	Per Cent of Good Seed.	Per Cent of Discarded Seed.
Onion,	57	722.65	86.2	13.8
Tobacco,	84	56.43	86.0	14.0
Celery,	16	551.45	93.7	6.3
Lettuce and parsnip,	3	40.00	90.0	10.0
	160	1370.53	-	-

The average germination of the onion seed for 1908 is not as high as for either of the two preceding years, some very poor seed having been received. Onion seed was occasionally brought in for testing which had been left over from previous years and was too old for use. The corn and lettuce seeds received were remarkably good samples, six lots of the lettuce seed giving 100 per cent. of germination, — a very unusual percentage.

Only 2.5 per cent. was discarded from the best sample of onion seed, 4.6 from the best tobacco seed and 9.3 per cent. from the best celery seed. From the poorest onion seed 29.7 per cent. was discarded, 26.9 per cent. from the poorest tobacco and 33⅓ per cent. from some of the celery seed. The large percentage discarded, however, does not in all cases imply that the seeds were poor; on the other hand, as much as 33⅓ per cent. was frequently discarded purposely, especially when the seed was to be used for experimental purposes, which was the case with the celery. The average percentage of germination shown is good when one considers the large amount of poor seed which is yearly placed on the market.

Farmers who use large quantities of seed are naturally more particular about its quality than those who purchase small quantities. Tobacco and onion growers and market gardeners may be considered specialists, and the quality and source of the seed which they purchase are important items with them, making it a matter of good business to obtain the best seed from the most reliable firms. Since practically all tobacco men grow their own seed they have an opportunity to exercise great care in the selection of their seed plants, and onion growers purchase from reliable dealers; but the general farmer and the individual who plants only his vegetable and flower garden need only small quantities of seed, and often purchase the so-called "packets" (commission seed) from the local dealer. These seeds are often not true to name and are too frequently worthless as regards quality.

Mr. Edgar Brown[1] in charge of the United States Department of Agriculture Seed Laboratory, found that the average germination of 2,778 packets, including 26 kinds from 27 seed-packeting houses, was only 62.2 per cent.

> The average germination of seeds from one firm was only 37.3 per cent., and from another 44.3 per cent.
>
> The variation in germination of different packets of the same kind of seed from the same firm was in several cases more than 90 per cent.
>
> By 21 of the 27 seedsmen whose seed was tested, 200 lots of seed were put up which germinated 10 per cent. or less.
>
> By 13 packeting houses 62 lots of seed were put up which entirely failed to germinate.
>
> The average germination of the "commission" seeds tested was 25.7 per cent. lower than that of those sent out in the congressional seed distribution during the past six years.

It is quite evident from the results of Mr. Brown's investigations on seeds — and there is no reason to believe that the results are different than would be obtained from any testing — that we are sadly in need of seed legislation. However, the large dealers in seeds who sell direct to the consumer are not,

[1] Bulletin No. 131, Bureau Plant Industry, United States Department Agriculture, 1908.

as a rule, unscrupulous, most of them testing their own seed, as they do not care to injure their business by unloading on the public seeds which are worthless. They do not, however, as a rule, guarantee purity or the percentage of germination.

Twelve purity tests of clover, alfalfa and mixed grass seed were made, the highest percentage being 99.4, the lowest 85.3. The impurities found in our seeds are largely weed seeds of a noxious nature. One farmer informed us that after seeding down his large piece of land it required considerable time and expense to pull up the dock which had established itself in his field as a result of using seed which contained seeds of this noxious weed. There is constant complaint in regard to the impurity of seeds, and a considerable burden is imposed on the farmer by his being obliged to waste time and money in exterminating the noxious weeds introduced in his grass seed. It should be stated, however, that all weeds found in newly seeded land do not necessarily come in the grass seed. The past summer many lawns planted with the best seed obtainable produced nothing but pigweed, crab grass, etc., for the soil moisture, on account of the drought, has been insufficient to start grass and clover, while it is one of the characteristics of many weeds that they possess a wide range of adaptability, and will survive under conditions which would be disastrous to grass and clover.

Seed to be tested or separated should be sent by mail or express to G. E. Stone, Massachusetts Agricultural Experiment Station. The work is done gratuitously by the station for people living in the State, but the postage or express charges should be paid by the person sending the samples.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

During 1908 the entomological work of the experiment station has progressed along the usual lines. The correspondence has been extensive, requiring much time and often a considerable amount of study before all the inquiries received could be satisfactorily answered. The year has been a favorable one for the increase to destructive numbers of many different kinds of pests, and this condition has been reflected in the letters received.

The experimental work of the division has been the continuation of investigations previously begun, these requiring so much time as to practically prevent taking up additional lines of research. Tests of the resistance of muskmelons under glass to the effects of hydrocyanic acid gas have been continued, but have not as yet been completed. A determination of the best methods for the control of the cabbage maggot was started in the spring, but, as was the case the preceding year, almost no maggots appeared either in the experimental portion or elsewhere in the field, so that no results of any great value could be obtained. This, though disappointing, only signifies that the experiments must be continued until the maggots become sufficiently abundant to give real tests as to the value of the different treatments; and as these must be begun before the maggots appear, it is very possible that the work may require repetition for several years before any data can be obtained.

Observations on the dates of the appearance of the young of the more common and injurious scales have also been continued, adding to our knowledge of this subject and making it possible to more nearly set the date limits within which spraying for these insects must be done in order to be effective; but these observations have not thus far covered a sufficiently long term of years to provide complete data, and they will therefore be continued.

The importance of the second brood of the codling moth in Massachusetts is also still unsettled, though the facts for another year can now be added to those previously collected. This question is an important one, as the answer to it may determine the value of a late treatment for this insect.

The onion thrips was a less serious pest in 1908 than in the preceding year, if conditions in all parts of the onion-growing region be considered, though it was very injurious in some places. This insect, which is widely distributed both in Europe and the United States, is known to feed on about fifty different plants, and was reported by Packard in 1872 as seriously injuring onions in Essex County, Mass., causing a probable loss there that year of $10,000, and as having been known as an onion pest in that region for about fifteen years.

Various methods for the control of this insect in the onion fields have been tested during the past two years, with more or less success, but without entire satisfaction, and it is now the intention to try other measures for its destruction, and extended experiments along these lines will be undertaken during the coming season.

The results of tests of a new material for the San José scale, referred to in the last report, were encouraging and were therefore repeated last spring, but with less success, the material seeming to be different from that previously used. It is probable that farther experiments with this substance will be necessary before its real value can be determined.

The cranberry insect investigations, conducted at Wareham during the summers of 1906 and 1907 by Dr. H. J. Franklin, have resulted in many additions to our knowledge of these pests, and have led to the formulation of numerous recommendations as to methods of treatment. Practical tests of these, repeated for several years, would now be in order, but to make them, entire control of a bog is necessary, and it has thus far proved impossible to obtain a bog for experimental purposes of this kind except on terms which could not be accepted. Under such circumstances it has been impossible to accomplish much during the past summer, and it would seem doubtful if very much more can be done as long as present conditions remain unchanged. Bulletin No. 126 contains the conclusions drawn from this work thus far.

Studies on the distribution of insect pests in Massachusetts, and of the factors determining this, have been continued since the last report, but the pressure of other work has prevented much progress in this line. It has become evident, however, that in southeastern Massachusetts the climatic conditions are such that many animals and plants can survive the winters there when this would not be possible in most, probably any, other parts of the State. Study of the lines of dispersal of insect pests shows many southern forms spreading to the north and east from their earlier homes, together with a probably gradually increasing power of resistance to low temperatures. This indicates that some, at least, of these insects may be able to live in the southeastern portion of this State if they once reach so far. The reverse condition also holds for northern forms, some of which can undoubtedly live and become injurious in the colder parts of the State. To determine the limits of the possible distribution of these pests is important, as this knowledge will be of much practical utility. It is hoped that more time can be devoted to this subject in the future.

Spraying has been from its very beginning an empirical subject. Many thousands of experiments have been made and the results compared, to learn the causes of success and failure. In spite of this little real progress has resulted in the determination of the fundamental principles, or what might perhaps be termed the science of spraying. Thus far the work has been done wholly with commercial materials varying in composition, both qualitatively and quantitatively, and in most cases with no knowledge of the nature of the variations. The only new line of research taken up by this division during the past year has been on this subject. The plan is to obtain the various stomach poisons in as nearly an absolutely pure condition as possible; to determine their exact composition, qualitatively and quantitatively, and then to test them on foliage of different kinds, under varying conditions of heat, light, temperature, humidity and wind, and to study the results in the hope that by working with materials of unusual purity and known composition certainty in results may be obtained; and with these as a basis for comparison, to extend the investigation to the ordinary commercial materials, and ultimately to find an explanation for the diverse and often contradictory results so frequently met with in commercial spraying. In this work the services of the chemical division are necessary in making chemical studies of the different materials; of the entomological division in the preparation and application of these materials, and in the study of the results; and very possibly the botanical division may be called on for assistance in an examination of the effects of these treatments on the plant tissues. The field for experiment in this subject is very large, and at present we have very little accurate, positive knowledge of it. Thus far the work has not progressed sufficiently to give any results, and ten years promises to be too short for its entire completion, but already some significant points have developed which indicate that this investigation will be well worth all the time which it will require.

REPORT OF THE HORTICULTURIST.

DEPARTMENT OF HORTICULTURE.

F. A. WAUGH, HORTICULTURIST; F. C. SEARS, POMOLOGIST; J. K. SHAW, ASSISTANT.

The work of the department of horticulture during the year 1908 has followed the lines already adopted and set forth in former reports. The most important piece of new work undertaken is a series of orchard experiments in South Amherst, in which the pomologist, Professor Sears, co-operates with the director, Professor Brooks.

During the year some changes have been made on the staff. Prof. F. C. Sears has been added as pomologist, and Prof. E. A. White has been temporarily detached from service as florist. Mr. C. S. Pomeroy resigned September 1 to take up work with the United States Department of Agriculture, and his place was filled by the appointment of Mr. J. K. Shaw, a graduate of University of Vermont and of Massachusetts Agricultural College.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

At the close of the year the division will have the meteorological records for this station for a period of twenty years. The temperature records for the first year of the period (1889) are not complete, otherwise the records are unbroken.

The policy of the division in general has been to make as few changes as possible in methods of observation or in character of instruments, in order that the comparisons for the different years may be as reliable as is desired.

Five years ago a change was made from tridaily to semidaily observations, so as to conform with the practice of the United States Weather Bureau, — this station having become a voluntary observer of that bureau at about that time. It is not thought that the change has sensibly affected any of the records, so that they may not safely be compared with the records existing before the change was made.

An electric sunshine recorder was installed about two years later, which increased the precision of the sunshine records without materially affecting the mean values.

During the past year the work has continued along the same lines as heretofore, — instrument readings taken at 8 A.M. and 8 P.M., self-recording instruments kept in working order, and the records transcribed weekly in a permanent record book.

The usual monthly bulletins, containing the more important daily records and remarks on the general character of the weather during the month, have been regularly issued, and the annual summary will form a part of the December bulletin.

The New England section of the United States Weather Bureau has furnished us daily, except Sunday, with the forecasts for this section of the State, and the flags indicating the probable weather for the following day have been regularly displayed from the flagstaff over the tower. The flags are five in number, namely, a white flag, indicating fair weather; blue and white, indicating local showers; blue, indicating rain or snow; white with black center, indicating a cold wave or a drop of more than 20° in temperature for the next day, or the first frost of the season. The first three read downward on the staff. When any of them are displayed together, as white above blue, it means fair followed by rain or snow. A triangular black flag is the temperature flag, which displayed above the others indicates rising temperature or warmer, and displayed below the others falling temperature or colder. The cold-wave flag is never displayed with any of the other flags.

The usual weekly snow reports are being sent to the Boston office this season as heretofore and the voluntary observer's reports are sent there monthly.

A summary of the twenty years' records is nearly complete and will be ready for publication soon after the close of the year. I would recommend that it be published as a part of this report.

EFFECT OF SOY BEAN MEAL AND SOY BEAN OIL UPON THE COMPOSITION OF MILK AND BUTTER FAT, AND UPON THE CONSISTENCY OR BODY OF BUTTER.

BY J. B. LINDSEY, E. B. HOLLAND AND P. H. SMITH.

EXPERIMENT IX.

This experiment is the continuation of a series designed to study the effect of different foods and food groups upon the character and composition of the product of the dairy cow.

Object of the Experiment.

The object of the experiment about to be described was to determine the effect of soy bean meal with a minimum percentage of oil and of the soy bean oil (*a*) upon the proportions of the several milk ingredients; (*b*) upon the chemical character of the milk fat; and (*c*) upon the consistency or body of the butter. It was desired, further, to observe the effect of both the beans minus the oil and of the oil itself upon the separation of the fat from the milk serum, time of ripening of the cream and the thoroughness of the churning process. The present investigation, then, may be spoken of as a study in milk secretion to note the effect specific foods and food groups have in modifying the character of the milk product. Studies of the effect of different food groups upon the percentage composition of the milk, and upon the chemical character of the butter fat, have been made by other investigators. It is not intended, at this time, to review the work of others. References, however, will be made to it whenever the circumstances seem to require.

Plan of the Experiment.

Twelve cows were divided into two lots of 6 each, to be known as herds I. and II. During the first period of four weeks (the first two preliminary) both herds received the same ration, which is spoken of as the normal ration. During the next period Herd I. continued to receive the normal ration, and Herd II. received an addition of soy beans minus oil, which replaced a like amount of the normal grain ration. During the third period Herd I. continued to receive the same ration as in the two preceding periods, and to the ration of Herd II., after it had been brought back to the normal grain ration, was added a definite amount of soy bean oil. This method was followed instead of adding the oil direct to the soy bean meal ration because of the shortage of soy bean meal, and since it was feared that the bean and excess of oil would have too great a laxative effect upon the animals. The method of feeding enabled one to note the direct effect of soy bean meal and the soy bean oil upon the chemical character of the milk and butter fat.

TABLE I. — *Duration of Experiment, 1907.*

Periods.	Character of Rations.	Dates.	Length of Period (Days).
1,	Herd I., normal grain ration,	Jan. 12 through Jan. 25,	14
	Herd II., normal grain ration,	Jan. 12 through Jan. 25,	14
2,	Herd I., normal grain ration,	Feb. 8 through Mar. 8,	28
	Herd II., soy bean (extracted) ration,	Feb. 8 through Mar. 8,	28
3,	Herd I., normal grain ration,	Mar. 30 through Apr. 19,	21
	Herd II., normal ration plus soy bean oil,	Mar. 30 through Apr. 19,	21

TABLE II. — *Data concerning Cows.*

Herd.	Name.	Breed.	Age (Years).	Last Calf dropped.	Approximate Milk Yield, Beginning of Experiment (Pounds).	Cows served.
I.,	Daisy,	Grade Jersey,	8	Aug., 1906,	16–17	Nov. 10, 1906
	May Rio,	Pure Jersey,	4	Aug., 1906,	16–17	Nov. 20, 1906
	May,	Grade Jersey,	10	Sept., 1906,	22–23	– –
	Cecile,	Pure Jersey,	2	Dec., 1906,	22–23	Feb. 11, 1907
	Gladys,	Pure Jersey,	4	Nov., 1906,	21–22	Dec. 31, 1906
	Betty,	Grade Jersey,	3	Dec., 1906,	22–23	Jan. 21, 1907
II.,	Blanche,	Grade Jersey,	11	Sept., 1906,	21–22	– –
	Fancy,	Grade Jersey,	7	Aug., 1906,	18–19	Nov. 20, 1906
	Susie,	Grade Jersey,	2	Mar., 1906,	10–11	Dec. 9, 1906
	Samantha,	Holstein-Jersey,	4	Sept., 1906,	21–22	Nov. 27, 1906
	Maude,	Guernsey-Jersey,	4	Oct., 1906,	11–12	Nov. 28, 1906
	Red II.,	Shorthorn-Jersey,	10	Oct., 1906,	32–33	Jan. 24, 1907

Feeding and Care of the Animals.

The cows were housed in the station barn, especially set apart for feeding experiments. Each animal was kept in a roomy stall, well carded and turned daily into a yard for several hours when the weather conditions permitted. The barn was heated to a temperature of about 50° F., and particular attention was paid to ventilation and the admission of sunlight. The feed was given in two portions daily, and water was kept continually before each animal by means of the Buckley self-watering device.

Weighing.

Each cow was weighed for three consecutive days at the beginning and end of each period, the weighing being done in the afternoon, before feeding.

Character of the Feeds.

The hay was composed largely of Kentucky blue grass with an admixture of some clover, sweet vernal and a little orchard grass. It was cut when in bloom, well cured, and was considered a first-class hay for milk production. Washburn-Crosby's spring bran was used; the oats were bought in one lot and were of extra quality; the corn meal, gluten feed and cotton-seed meal were satisfactory both in appearance and composition. The so-called normal grain ration was composed of the above feed stuffs mixed in the following proportions: 2 pounds bran, 3 pounds ground oats, 1¼ pounds corn meal, 1¼ pounds gluten feed and ½ pound cotton-seed meal. It is not claimed that this ration had any superior advantages over others; it had been found by experience, however, that such a mixture could be fed with comparative safety, and would produce a firm butter, free from any objectionable flavor; it was used, therefore, as a standard for the comparison of other feed stuffs. The soy bean meal was derived from a number of varieties, the medium green and southern yellow predominating. They were shipped to the V. D. Anderson Company of Cleveland, O., and the oil extracted by pressure. The green variety, according to information from the above firm, furnished 8 per cent. of filtered oil, while the southern variety yielded 11 per cent. The pressed cake from the several varieties was mixed and ground before being fed; the oil from the several containers, which was of a dark brown color, was mixed previous to feeding. According to Lewkowitsch the bulk of the solid fatty acids in the oil consists of palmitic acid and the liquid fatty acids of oleic and linolic acids.[1] Our tests showed it to have a saponification value of 191.95, a Hehner number of 95.31 and an iodine value of 130.77. Its chemical character will be more fully discussed in a separate article.

Sampling the Feeds.

The hay was sampled at the beginning of each period and every two weeks thereafter. This was considered sufficient to furnish reasonably satisfactory information concerning its chemical character. Forkfuls were taken from different parts of the pile, run through a cutter, subsampled, and the reduced sample placed in a large glass-stoppered bottle and taken to the laboratory. A dry matter determination was made immediately and a definite weight of each individual sample composited. The normal grain ration and the soy bean meal were sampled daily into glass-stoppered bottles and dry matter determinations made at the end of the periods. In case of the normal ration, one analysis was made from a mixture of the three different samples.

Sampling the Milk.

The milk of each cow was sampled twice daily for five consecutive days of each week of the trial, and preserved with formalin in tightly corked bottles. The method of sampling consisted in mixing the freshly drawn milk with a perforated tin disk, 8 inches in diameter, fastened to the end of a rod. This disk was drawn slowly up and down through the quantity of milk a number of times, and then a small dipperful was immediately removed.

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[1] Technology of Fats, Oils and Waxes, third edition, Vol. II., p. 506.

Disturbances during the Experiment.

The first period passed with each animal in excellent condition. Ten days previous to the end of the second period, Blanche, of Herd II., produced very soft fæces, although her general health appeared to have been in no way seriously affected. For the remainder of the period her hay was reduced 4 pounds daily and only one-half her usual allowance of grain given. We also endeavored, by the use of tannin and gentian, to correct the trouble, but it manifested itself more or less during the remainder of the experiment. This necessitated a reduced daily hay and grain ration, and the feeding of not over one-third the amount of oil supplied to the other cows. Towards the close of the third period Red II. began to show signs of a disturbed digestion, although she took her regular ration until the end of the period, after which it was necessary to reduce her food supply. It is believed that the oil was responsible for the condition of the latter cow.

Table III. — *Total Feed consumed by Each Cow (Pounds).*

First Period: normal grain ration.

Herd I.

Name.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Daisy,	98	-	-	280
May Rio,	98	-	-	238
May,	112	-	-	280
Cecile,	98	-	-	210
Gladys,	112	-	-	252
Betty,	112	-	-	238

Herd II.

Name.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Blanche,	112	-	-	322
Fancy,	112	-	-	247
Susie,	70	-	-	196
Samantha,	112	-	-	308
Maude,	84	-	-	252
Red II.,	140	-	-	322

TABLE III. — *Total Feed consumed by Each Cow (Pounds)* — Con.

Second Period: Herd I., normal grain ration; Herd II., soy bean meal ration.

Herd I.

NAME.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Daisy,	196	-	-	560
May Rio,	196	-	-	476
May,	224	-	-	560
Cecile,	196	-	-	420
Gladys,	224	-	-	512
Betty,	224	-	-	476

Herd II.

NAME.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Blanche,	110.5	55	-	626
Fancy,	154.0	70	-	504
Susie,	98.0	42	-	340
Samantha,	140.0	84	-	616
Maude,	112.0	56	-	504
Red II.,	168.0	84	-	644

Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.

Herd I.

NAME.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Daisy,	150	-	-	420
May Rio,	147	-	-	357
May,	168	-	-	420
Cecile,	147	-	-	315
Gladys,	168	-	-	378
Betty,	168	-	-	357

Herd II.

NAME.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
Blanche,	126.0	-	7.00	420
Fancy,	168.0	-	17.50	378
Susie,	105.0	-	10.50	252
Samantha,	168.0	-	17.50	462
Maude,	126.0	-	12.25	378
Red II.,	175.5	-	16.00	459

Table IV. — *Average Daily Rations for Each Cow (Pounds).*

Herds.	Normal Grain Ration.	Soy Bean Meal.	Soy Bean Oil.	First Cut Hay.
First period: both herds, normal grain ration.				
Herd I.,	7.5	-	-	17.8
Herd II.,	7.5	-	-	19.6
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.				
Herd I.,	7.5	-	-	17.9
Herd II.,	4.7	2.3	-	19.3
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.				
Herd I.,	7.5	-	-	17.8
Herd II.,	6.9	-	.6	18.6

Table III. shows the total feed consumption of each animal in the two herds. Table IV. shows the average daily consumption of each cow in both herds. In the first period the cows in Herd I. consumed daily from 6 to 8 pounds of grain and those in Herd II. from 5 to 10 pounds, the average being the same in both herds. The cows in Herd II. consumed rather more hay than those in Herd I. In the second period Herd I. continued to consume the same amount of grain as in the first period and substantially the same amount of hay. In the case of Herd II. it became necessary to cut down the amount of grain for two of the cows, so that the daily total average was ½ pound less than in the first period. The soy bean meal replaced the normal ration in amounts varying from 1½ to 3 pounds per diem, with a daily average of 2.3 pounds. The amount of hay was about the same as that consumed in the first period. In the third period Herd I. continued to consume the same kinds and amounts of food as in the previous two periods. With Herd II. the soy bean meal was replaced by an equal amount of the normal grain ration, and to this was added for each cow from .25 to .83 of a pound of soy bean oil, with an average daily consumption of .6 of a pound. This amount of oil did not seem to in any way interfere with the normal condition of the herd, except in the instance previously noted. The average daily consumption of hay decreased .7 of a pound during this period. It may be stated that the amount of hay and grain fed daily depended partly upon the calculated nutrients needed by the animal and partly upon the animal's individuality. This latter condition can only be ascertained by being in close touch with each cow and by careful observation. If an animal appeared to be having more than she could consume to advantage, or did not eat clean her daily allowance, the ration was reduced in amount.

TABLE V. — *Average Dry Matter and Digestible Nutrients in Ration of Each Cow (Pounds).*

Herds.	Average Weight of Cows (Pounds).	Total Dry Matter.	Digestible Organic Nutrients. Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
First period: both herds, normal grain ration.						
Herd I.,	809	22.70	1.91	11.00	.52	1:6.4
Herd II.,	933	24.31	2.01	11.77	.54	1:6.5
Second period: Herd I., normal grain ration: Herd II., soy bean meal ration.						
Herd I.,	828	22.86	1.92	11.01	.52	1:6.3
Herd II.,	948	23.67	2.50	11.15	.60	1:5.0
Third period: Herd I., normal grain ration: Herd II., soy bean oil ration.						
Herd I.,	832	22.63	1.90	10.97	.52	1:6.4
Herd II.,	967	23.41	1.87	11.05	1.11	1:7.2

In the above table is given an estimate of the amount of digestible nutrients contained in the average daily rations. The average weight of the cows in Herd I. varied from 809 to 832 pounds in the several periods, and in Herd II. from 933 to 967 pounds. The method of calculating the digestible nutrients consisted in applying average digestion coefficients to the actual analysis of the hay and soy beans, and to multiplying the product by the average number of pounds fed daily. In case of the normal ration, coefficients were employed that were obtained from the normal or standard grain ration, so-called, fed in previous experiments of a similar nature.[1] The present normal ration differed, however, somewhat from the former, as will be seen from the following statement: —

Present Normal Ration.	*Earlier Normal Ration.*
2 pounds wheat bran,	3 pounds wheat bran,
3 pounds ground oats,	5 pounds ground oats,
1¼ pounds gluten feed,	½ pound gluten meal,
1¼ pounds corn meal,	½ pound cotton-seed meal.
½ pound cotton-seed meal.	

The digestion coefficients evidently would be somewhat higher for the present normal ration, and hence the total digestible nutrients contained in the present average daily ration would be rather in excess of those given. The data presented, however, are at least comparative; in fact, the exact amount of digestible nutrients contained in the rations has no direct bearing on the objects sought; they simply indicate that the two herds were sufficiently and normally nourished.[2]

In the second period Herd II. consumed about ½ pound more digestible protein than Herd I., due to the presence of the soy bean meal. In the third period Herd II. ate some .6 of a pound more fat (derived from soy bean oil) than did Herd I.

TABLE VI. — *Average Weight of Each Cow at Beginning and End of Each Period (Pounds).*

First period, Herd I.

	Daisy.	May Rio.	May.	Cecile.	Gladys.	Betty.
Beginning, . .	863	782	993	693	788	758
End, . . .	875	793	940	673	798	760
Gain or loss, .	12+	11+	—53	—20	10+	2+

[1] Sixteenth report of the Hatch Experiment Station, p. 47.

[2] It was not considered of sufficient importance to make an actual digestion trial with the normal ration; neither were all the feed stuffs entering into its composition completely analyzed, hence average coefficients of the individual concentrates could not be employed.

TABLE VI. — *Average Weight of Each Cow at Beginning and End of Each Period (Pounds)* — Con.

First period, Herd II.

	Blanche.	Fancy.	Susie.	Samantha.	Maude.	Red II.
Beginning,	1,202	885	650	957	868	1,013
End,	1,198	892	653	965	893	1,020
Gain or loss,	—4	7+	3+	8+	25+	7+

Second period, Herd I.

	Daisy.	May Rio.	May.	Cecile.	Gladys.	Betty.
Beginning,	893	812	1,005	693	818	767
End,	883	812	995	677	800	777
Gain or loss,	—10	-	—10	—16	—18	10+

Second period, Herd II.

	Blanche.	Fancy.	Susie.	Samantha.	Maude.	Red II.
Beginning,	1,210	908	652	1,002	915	1,040
End,	1,153	907	657	972	927	1,042
Gain or loss,	—57	—1	5+	—30	12+	2+

Third period, Herd I.

	Daisy.	May Rio.	May.	Cecile.	Gladys.	Betty.
Beginning,	893	810	1,002	677	798	775
End,	915	838	1,002	672	817	785
Gain or loss,	22+	28+	-	—5	19+	10+

Third period, Herd II.

	Blanche.	Fancy.	Susie.	Samantha.	Maude.	Red II.
Beginning,	1,140	935	670	980	942	1,053
End,	1,145	977	702	1,035	977	1,050
Gain or loss,	5+	42+	32+	55+	35+	—3

In the first period the first weights were made at the beginning of the preliminary period; in the other two periods at the beginning of the periods proper. In the first period Herd I. showed only slight variations, excepting May, which lost some 53 pounds, and evidently was not receiving quite sufficient nutriment. In the same period Maude was evidently eating a little more than was required.

In the second period proper of 28 days, 4 of the cows in Herd I. showed a little loss in live weight; the animals in Herd II. manifested only slight variations, excepting Samantha and particularly Blanche. Samantha during most of her milking period did not appear to be in first-class condition, although she ate her food clean and gave no evidence of pronounced indisposition. The loss in live weight in case of Blanche was due to the intestinal disturbance already referred to. In the third period both herds made a noticeable increase of weight, due to the advance in lactation and the consequent milk shrinkage.

TABLE VII. — *Average Gain or Loss of Each Herd (Pounds).*

Herds.	Number of Cows.	First Period.	Second Period.	Third Period.
Herd I.,	6	-38	-44	+ 74
Herd II.,	6	+46	-69	+166

The average gain or loss in weight makes clear that each herd was well nourished, and that during the several periods, extending over four months, the variations in weight were not more than would have been expected.

TABLE VIII. — *Total Amount of Milk produced by Each Cow in Each Herd (Pounds).*

Herd I.

Cows.	First Period, Fourteen Days.	Second Period, Twenty-eight Days.	Third Period, Twenty-one Days.
Daisy,	261.96	498.29	370.69
May Rio,	248.45	491.25	357.41
May,	334.25	659.03	479.53
Cecile,	333.83	643.64	460.05
Gladys,	314.81	609.91	436.06
Betty,	325.84	583.39	409.79
Average,	303.19	580.92	418.92

Table VIII. — *Total Amount of Milk produced by Each Cow in Each Herd (Pounds)* — Con.

Herd II.

Cows.	First Period, Fourteen Days.	Second Period, Twenty-eight Days.	Third Period, Twenty-one Days.
Blanche,	336.47	649.28	466.58
Fancy,	270.94	545.88	439.55
Susie,	144.33	312.03	248.68
Samantha,	328.70	731.02	562.82
Maude,	158.96	293.66	201.40
Red II.,	384.56	811.15	444.28
Average,	270.66	557.17	393.89

Table IX. — *Average Amount of Milk produced daily by Each Cow (Pounds).*

Herds.	Number of Cows.	First Period.	Second Period.	Third Period.
Herd I.,	6	21.66	20.75	19.95
Herd II.,	6	19.33	19.90	18.76

In the first period Herd I. was producing nearly 12 per cent. more milk than Herd II., in the second period over 4 per cent. more, and in the third period about 6 per cent. more.

Table IX., giving the average daily amount yielded by each cow, shows that a fair flow was maintained by both herds during the entire experiment.

Effect of Food upon the Composition and Quality of the Products.

Table X. — *Composition of the Milk (Per Cent.).*

First period: both herds, normal grain ration.

Samples.	Total Solids.		Fat, Herd I.		Fat, Herd II.		Solids not Fat.		Ash.		Nitrogen.		Protein.		Lactose.	
	Herd I.	Herd II.	Gravimetric Method.	Babcock Method.	Gravimetric Method.	Babcock Method.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Jan. 12-17,	14.88	14.83	5.32	5.48	5.18	5.25	9.56	9.65	.771	.796	.605	.609	3.78	3.81	4.83	4.87
Jan. 19-24,	14.87	14.68	5.44	5.53	5.10	5.25	9.43	9.58	.755	.775	.591	.606	3.70	3.79	4.92	4.96
Average,	14.88	14.76	5.38	5.51	5.14	5.25	9.50	9.62	.763	.786	.598	.608	3.74	3.80	4.88	4.92
Second period: Herd I., normal grain ration: Herd II., soy bean meal ration.																
Jan. 26-31,[1]	14.66	14.72	5.14	5.20	5.10	5.15	9.52	9.52	-	-	-	-	-	-	-	-
Feb. 2-7,[1]	14.82	14.83	5.36	5.40	5.21	5.20	9.46	9.43	-	-	-	-	-	-	-	-
Feb. 9-14,	14.86	14.71	5.31	5.40	5.04	5.25	9.55	9.67	.779	.783	.604	.648	3.84	4.05	4.87	4.92
Feb. 16-21,	14.94	14.75	5.40	5.17	5.55	5.33	9.54	9.20	.784	.778	.611	.614	3.82	3.84	4.96	4.98
Feb. 23-28,	14.94	14.64	5.29	5.45	5.05	5.25	9.65	9.59	.772	.758	.610	.609	3.81	3.80	4.91	4.91
Mar. 2-7,	14.86	14.67	5.24	5.43	5.02	5.25	9.62	9.65	.734	.752	.599	.615	3.74	3.85	4.97	4.94
Average,	14.90	14.69	5.31	5.36	5.17	5.27	9.59	9.53	.767	.768	.606	.622	3.80	3.89	4.93	4.94

Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.

Mar. 12-15,[1] . .	14.84	14.70	-	5.53	-	5.25	-	-	-	-	-	-	-	-	-	-
Mar. 15-19,[1] . .	14.65	14.65	-	5.25	-	5.10	-	-	-	-	-	-	-	-	-	-
Mar. 20-21,[1] . .	14.87	14.96	-	5.35	-	5.35	-	-	-	-	-	-	-	-	-	-
Mar. 22-23,[1] . .	14.87	14.70	-	5.35	-	5.30	-	-	-	-	-	-	-	-	-	-
Mar. 24-26,[1] . .	15.05	15.15	-	5.40	-	5.55	-	-	-	-	-	-	-	-	-	-
Mar. 27-29,[1] . .	14.98	14.71	-	5.55	-	5.35	-	-	-	-	-	-	-	-	-	-
Mar. 30-Apr. 4, .	14.96	14.87	5.32	5.40	5.29	5.38	9.64	9.47	.752	.759	.604	.590	3.78	3.68	4.90	4.90
Apr. 6-11, . .	15.27	14.81	5.45	5.70	5.10	5.30	9.82	9.71	.756	.759	.614	.610	3.84	3.81	4.99	4.99
Apr. 13-18, . .	15.12	14.73	5.39	5.45	5.08	5.23	9.73	9.65	.748	.758	.608	.606	3.80	3.79	4.98	4.97
Average, . .	15.12	14.80	5.39	5.52	5.16	5.30	9.73	9.61	.752	.759	.609	.602	3.81	3.76	4.96	4.95

After removal of oil.

Apr. 20-25, . .	15.11	14.52	5.33	5.50	4.74	5.00	9.78	9.78	.767	.772	.624	.612	3.90	3.83	4.93	4.97
Apr. 27-30, . .	15.11	14.31	5.40	5.50	4.76	4.90	9.71	9.55	-	-	-	-	-	-	-	-
May 6, . . .	15.11	14.65	5.37	5.40	4.85	5.00	9.74	9.80	-	-	-	-	-	-	-	-

[1] Preliminary.

Each analytical determination in the above table was from a five-day composite, taken as previously described. The total solids were determined by drying on sand; the fat by extracting the sand residue with water-free ether, and also by the Babcock method; the ash by evaporating the milk in a platinum dish with nitric acid and burning the residue at a low red heat; the nitrogen by the Kjeldahl-Gunning method; the lactose with the aid of Fehling's solution and the Low "zinc-acetate" method.

In the second and third periods the partial composition of the milk was ascertained during the preliminary period in order to note any immediate change resulting from the feeding of soy bean meal or soy bean oil.

In the first period Herd I. produced milk with a slightly higher percentage of total solid matter than did Herd II.; this evidently was due to the higher fat percentage in the former milk (5.38 against 5.14). The percentage of ash, nitrogen and lactose were nearly the same in each case. It may be said that the chemical composition of the milk from each of the two herds of 6 cows each, when fed the same ration, was substantially alike.

The addition of the soy bean meal (average of 2.3 pounds per cow daily in place of a like amount of normal grain ration) did not appear to have any noticeable effect upon the total solids or fat percentages of the milk produced by Herd II. during the preliminary period of two weeks. During the period proper, lasting four weeks, the average percentages of fat and solids not fat in case of both herds showed only slight differences from those in the first period,[1] and the same may be said of the lactose percentages. The ash and nitrogen percentages of the milk yielded by Herd I. were quite similar to those in the first period, while with Herd II. the ash showed a slight decrease and the nitrogen a very slight increase. One, however, would not consider it wise to attribute these variations directly to the modification of the grain ration.

[1] During the week of February 16 to 21 the fat percentages as determined by the gravimetric method increased perceptibly, a change which cannot be accounted for. In most cases the gravimetric method gave lower results than the Babcock, while in this instance the reverse was the case.

In the third preliminary period, lasting from March 9 to 30, during which time the soy bean meal was removed and the oil added to the ration of Herd II., total solids and fat determinations were made in order to note any changes which might result during the process. No change could be observed, however, that might be attributed to the oil. In the three weeks of the period proper it is to be noted that the total solid matter in the milk produced by Herd I. had increased a little (from 14.88 in the first period to 15.12), due to the advance in lactation. The milk produced by Herd II. in the third period proper remained remarkably even in composition, and one could not say that the addition of the oil to the ration produced any noticeable effect in varying the proportions of its several constituents.

The above results are somewhat different from those secured with linseed,[1] cotton-seed,[2] and corn oils,[3] where there appeared to be an increase in the fat content of the milk (.15 to .50 per cent.) which lasted, however, in two out of three cases only for a week or two; the nitrogen was, on the contrary, slightly depressed.

After the completion of the third period the soy bean oil was suddenly removed and the composition of the milk analyzed and recorded. It will be seen that the percentage of fat in the milk of Herd II. suddenly dropped several tenths of a per cent., and after an interval of ten days began to come back to normal. Similar results were secured in previous experiments. This, it would seem, indicated that the fat in the food helped in the formation of the milk fat, and its sudden removal caused a temporary milk fat decrease. The animal, however, soon corrected the condition by making the fat from other sources.

Flavor of the Milk. — A sample of each cow's milk was taken several times during the second and third periods, and tested for odor and flavor, by two different parties, both when cold and warm. The milk was taken by one of the chemists immediately after it had been drawn, and was placed in thoroughly cleaned and well-dried glass-stoppered bottles. Each cow was given a number, so that the parties making the ob-

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[1] Hatch Experiment Station, 13th report, p. 19.
[2] Hatch Experiment Station, 14th report, p. 164.
[3] Hatch Experiment Station, 16th report, p. 50.

servations would not know whether the samples came from one herd or the other. In the second period no differences or peculiarities were noted. In the third period the milk from each cow likewise appeared quite normal, except that produced by Red II., which had a strong odor and taste, which became especially pronounced towards the close of the period. This was due directly to the condition of the cow already referred to. In neither the second nor third period did it seem possible to detect any objectionable condition due to the soy bean meal or oil.

Chemical Composition of the Butter Fat. — In describing this experiment it is not intended to discuss the constitution of the butter fat molecule. It is believed that butter fat consists primarily of the triglycerides olein, palmitin, myristin and butyrin, united in simple molecules. Investigations by J. Bell,[1] Blythe[2] and others have indicated, however, that a portion of the different fatty acids may be bound together in a complex molecule ($C_3H_5\lessgtr$). In the tables of analyses which follow, all of the important constants are given as well as considerable other data of interest, a portion of which was obtained by actual analysis and a portion by mathematical calculation. The results are indicative of the changes which took place when an excess of soy bean oil was fed, but the methods thus far available are not adequate to give a complete understanding of the changes brought about as a result of the addition of oil to the ration. Such knowledge can be secured only by a more exhaustive investigation of the chemistry of the entire subject. Work along this line is already planned.[3]

The analyses in connection with the present experiment were made by Mr. E. B. Holland, assisted by P. H. Smith and L. S. Walker. The methods followed were substantially those of the Association of Official Agricultural Chemists, with such modifications as circumstances seemed to warrant. It is not considered necessary to describe the several methods in detail.

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[1] Chemistry of Foods, second edition, p. 44.

[2] Proceedings of Chemical Society, 1889, p. 5; from Lewkowitsch, third edition, Vol II., p. 839.

[3] For lack of space it has been necessary to hold a number of valuable papers for later publication. It is hoped to include these, and a report upon an original investigation now in progress by Dr. R. D. MacLaurin on "The Constitution of Fats and the Chemistry of Fat Formation," in our next annual report.

Sufficient information will be given in the proper place to enable the reader to have a clear understanding of the processes employed.

The butter from which the samples for analyses were prepared was taken shortly after churning, melted, filtered through a jacketed funnel into clean bottles, stoppered, and set away at an approximate temperature of 40° to 45° F. until used. The samples of fat were examined as soon as possible after the close of the period; it is evident, however, that some four to six weeks elapsed between the preparation and examination of the first samples. This, in some respects was unfortunate, inasmuch as slight changes would occur. Because of the large number of samples to be examined the condition could not well have been avoided. It is believed that the low temperature and the exclusion of air prevented any serious changes. Each analysis represents a composite of two weekly samples.

TABLE XI. — *Butter Fat Constants.*

Sample Number.	Saponification Number.		Reichert-Meissl Value.		Iodine Number.		Oleic Acid Equivalent.		Melting Point.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds, normal grain ration.										
17261-2	236.40	232.26	31.00	27.14	25.85	29.08	28.70	32.28	34.00	33.58
17263-4	235.37	232.22	30.38	28.12	26.05	29.00	28.92	32.20	33.75	33.60
17265-6	236.12	231.76	30.34	27.05	26.46	29.25	29.38	32.47	33.90	33.58
17267-8	234.74	232.30	29.10	26.77	27.18	29.91	30.18	33.21	34.20	33.68
Average	235.66	232.13	30.21	27.27	26.39	29.31	29.30	32.54	33.96	33.61
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.										
17269-70	234.32	232.28	29.78	26.73	27.47	31.46	30.50	34.93	34.25	33.05
17271-2	234.34	232.81	28.81	27.15	27.12	30.65	30.11	34.03	33.80	33.08
17273-4	234.58	232.01	29.21	27.12	27.30	31.43	30.31	34.89	33.98	33.50
17275-6	236.06	232.20	28.83	27.90	27.25	31.69	30.25	35.18	34.03	33.58
17277-8	236.51	232.45	29.78	27.61	26.81	31.13	29.77	34.56	33.75	33.53
17279-80	235.04	231.59	29.67	27.00	28.00	32.00	31.09	35.53	33.70	33.30
17521-2	233.55	230.61	29.19	26.75	28.23	33.08	31.34	36.73	33.75	33.05
17523-4	232.24	228.80	28.55	26.15	28.38	33.77	31.51	37.49	33.95	33.63
Average	234.58	231.59	29.23	27.05	27.57	31.90	30.61	35.42	33.90	33.34
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.										
17525-6	230.92	222.42	29.00	24.29	27.82	38.49	30.89	42.73	33.75	32.95
17527-8	231.68	222.44	28.00	24.20	27.26	38.60	30.27	42.86	33.65	32.90
17529-30	232.14	222.68	28.24	23.52	27.71	39.12	30.76	43.43	33.65	32.70
17531-2	231.59	221.65	28.43	22.94	27.95	40.61	31.03	45.09	33.78	32.93
17533-4	232.02	221.07	29.49	23.12	28.32	41.46	31.44	46.03	33.65	32.60
17535-6	232.56	221.16	29.99	22.79	27.54	41.63	30.58	46.22	33.85	32.75
17537-8	232.76	220.83	29.84	23.09	27.71	41.22	30.76	45.76	33.95	33.03
17539-40	232.07	220.97	29.17	22.21	27.18	40.84	30.17	45.34	33.95	33.43
Average	231.97	221.65	29.02	23.27	27.69	40.25	30.74	44.68	33.78	32.91

The saponification or Köttstorfer value represents the number of milligrams of potassium hydrate necessary to completely saponify one gram of fat. In case of butter fat, Brown[1] states that the probable mean[2] is 228.5, with extremes of 224 and 234.9; Thorpe[3] shows variations of from 219.7 to 232.6.

In butter fat a high saponification value is accompanied by a relatively high Reichert-Meissl value and a relatively low iodine value. This is natural, for a high percentage of oleic acid having a low combining power would increase the amount of iodine absorbed; and, *vice versa,* an increase in the percentage of soluble fatty acids of high combining power (Reichert-Meissl value) would increase the saponification and depress the iodine value.

In the first period it is shown, in the above table, that both herds produced butter fat with relatively high saponification values; such a condition may be considered characteristic of the animals, all of which were grade or pure-bred Jerseys and none in an advanced stage of lactation. Herd I. yielded a fat with a little higher saponification value than Herd II. The former herd likewise showed a higher Reichert-Meissl[4] and a lower iodine value.[5] The melting point[6] of the fat produced by Herd I. was also a trifle higher than from Herd II., although this test is not sufficiently delicate to enable one to place much value upon it.

The results of the various determinations all point to the fact that in the first period, with both herds receiving the same ration, Herd I. yielded butter fat with slightly less insoluble fats (especially olein) and slightly more soluble fats than Herd II.

In the second period, in case of Herd II. 2.3 pounds per day of soy bean meal replaced a like amount of normal ration. It may be recalled that the partially extracted soy bean meal as fed contained some 45 per cent. of protein and 9 per cent. of fat, while a normal soy bean meal averages about 35 per cent. protein and 18 per cent. fat. The influence of the bean on the

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1 Pennsylvania Experiment Station, report, 1899-1900, pp. 226 to 245.

2 Average of 40 samples.

3 Lewkowitsch, third edition, Vol. II., p. 834, calculated from 357 English analyses.

4 Leffmann-Beam modification.

5 Wijs' modification.

6 Wiley method.

butter fat might be attributed in part to the bean protein and in part to the bean oil. A careful study of the analytical data fails to reveal any marked differences that could be attributed to the change in the ration. In the butter fat from Herd II. the higher iodine number might indicate a small increase in the amount of unsaturated acids beyond that resulting from the advance in the period of lactation. If such were the case the increase in all probability would be attributed to the influence of the oil rather than to the bean protein.

In the third period, when the bean meal was replaced by the normal ration (Herd II.) and an average per day and head of .6 of a pound of soy bean oil was added, striking differences are noted. In case of Herd I. (normal ration) the Köttsdorfer number dropped from an average of 234.58 to 231.97, — some 3½ points, — while with Herd II. it fell from 231.59 to 221.65, — a difference of 10 points. The former decline was due largely to the advance in the milking period, and perhaps to a slight decomposition in the fat, while the latter decline must have resulted, to a considerable extent, from the feeding of the bean oil. The Reichert-Meissl number in the fat of Herd I. fell slightly from that in the second period (29.23 to 29.02); in the fat from Herd II. it dropped from 27.05 to 23.27, showing a marked decrease in the amount of soluble fats. The iodine value of the fat produced by Herd I. was similar to that in the second period, while with Herd II. it increased from 31.90 to 40.25, giving additional evidence of the increase of oleic and possibly of linolic acids. In terms of oleic acid, by calculation,[1] this increase amounts to 9.26 points, it being 35.42 in the second period and 44.68 in the third period.

The determination of the important constants, therefore, makes clear that the addition of the bean meal, with a high percentage of bean protein, had little if any effect upon the chemical composition of the butter fats. The feeding of the bean oil, on the other hand, depressed the volatile fats and noticeably increased the percentage of unsaturated acid. Whether the bean oil entered directly into the butter fat molecule without change resulting from its passage through the digestive and

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[1] Oleic acid $= \frac{\text{iodine number}}{.9007}$ (based on a combining weight of 127 for iodine).

circulatory systems has not been fully demonstrated. Results similar to the above have been secured at this station by feeding corn, cotton-seed and linseed oils.[1]

In addition to a determination of the several constants reported in Table XI., numerous other determinations were made which are given in the following table: —

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[1] Hatch Experiment Station, *loco citato*.

TABLE XII. — *Chemical and Physical Data of the Butter Fat.*

First period: both herds, normal grain ration.

Sample Number.	Acid Number (Mgs. KoH).		Ether Number (Mgs. KoH).		Free Fatty Acids (Per Cent.).		Glycerol.		Total Fatty Acids.		Valenta Test.		Refractive Index.		Mean Dispersion.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
17261-2,	.40	.32	236.00	231.94	.18	.14	12.90	12.68	94.67	94.77	40.00	42.50	1.4528	1.4530	.00842	.00869
17263-4,	.43	.43	234.94	231.79	.19	.19	12.84	12.67	94.70	94.77	39.50	42.00	1.4525	1.4532	.00827	.00870
17265-6,	.29	.33	235.83	231.43	.13	.15	12.89	12.65	94.68	94.78	40.00	43.00	1.4525	1.4531	.00827	.00881
17267-8,	.31	.33	234.43	231.97	.14	.15	12.81	12.68	94.71	94.76	41.00	43.50	1.4527	1.4535	.00868	.00856
Average,	.36	.35	235.30	231.78	.16	.16	12.86	12.67	94.69	94.77	41.13	42.75	1.4526	1.4532	.00841	.00869
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.																
17269-70,	.40	.35	233.92	231.93	.18	.16	12.78	12.68	94.72	94.77	41.50	43.50	1.4528	1.4525	.00828	.00897
17271-2,	.37	.34	233.97	232.47	.17	.15	12.79	12.70	94.72	94.75	41.00	43.50	1.4525	1.4535	.00815	.00911
17273-4,	.39	.30	234.19	231.71	.18	.13	12.80	12.66	94.71	94.77	40.50	44.50	1.4529	1.4535	.00843	.00844
17275-6,	.35	.30	235.71	231.90	.16	.13	12.88	12.67	94.68	94.77	40.50	44.50	1.4526	1.4531	.00868	.00910
17277-8,	.34	.26	236.17	232.19	.15	.12	12.91	12.69	94.67	94.76	39.00	43.50	1.4525	1.4530	.00827	.00843
17279-80,	.36	.30	234.68	231.29	.16	.13	12.83	12.64	94.70	94.78	40.50	45.00	1.4529	1.4532	.00817	.00963
17521-2,	.45	.34	233.10	230.27	.20	.15	12.74	12.58	94.74	94.80	41.50	44.50	1.4528	1.4535	.00895	.00911
17523-4,	.40	.36	231.84	228.44	.18	.16	12.67	12.48	94.77	94.84	43.75	48.25	1.4530	1.4537	.00895	.00938
Average,	.38	.32	234.20	231.27	.17	.14	12.80	12.64	94.71	94.78	41.03	44.66	1.4528	1.4534	.00849	.00902
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.																
17525-6,	.42	1.62	230.50	220.80	.19	.73	12.60	12.07	94.80	95.02	41.50	51.50	1.4530	1.4550	.00802	.00940
17527-8,	.53	1.23	231.15	221.21	.24	.55	12.63	12.09	94.78	95.01	40.50	52.00	1.4528	1.4549	.00790	.00873
17529-30,	.57	1.17	231.57	221.51	.26	.53	12.65	12.11	94.77	95.00	41.00	52.25	1.4528	1.4549	.00816	.00890
17531-2,	.54	1.37	231.05	220.28	.24	.62	12.63	12.04	94.79	95.03	42.50	53.50	1.4530	1.4550	.00828	.00885
17533-4,	.65	2.43	231.37	218.64	.29	1.09	12.64	11.95	94.78	95.07	41.50	52.50	1.4529	1.4550	.00828	.00859
17535-6,	.36	.83	232.20	220.33	.16	.37	12.69	12.04	94.76	95.03	41.50	54.00	1.4529	1.4551	.00802	.00859
17537-8,	.31	.91	232.45	219.92	.14	.41	12.70	12.02	94.75	95.04	41.50	54.00	1.4529	1.4551	.00828	.00885
17539-40,	.43	1.55	231.64	219.42	.19	.70	12.66	11.99	94.77	95.05	41.00	54.00	1.4529	1.4550	.00802	.00873
Average,	.48	1.39	231.49	220.26	.21	.62	12.65	12.04	94.78	95.03	41.38	52.97	1.4529	1.4550	.00812	.00874

The acid number, obtained by heating a definite quantity of the fat in alcohol, allowing it to cool and titrating the solution with tenth normal alkali, represents the number of milligrams of potassium hydrate necessary to neutralize the free acid in one gram of fat. The column headed free fatty acids was calculated by the use of a mean molecular weight of 252.

Inasmuch as the butter fat was prepared directly after the butter was made, the small amount of acidity could not be due to the action of bacteria, since butter fat offers no suitable medium for bacterial development. It is not believed that the acidity was due to a decomposition of the glycerides, as the low temperature and exclusion of air would not be favorable to such a transformation. Brown[1] has shown that fresh butter fat has an acid number of .50; Lewkowitsch[2] likewise calls attention to a similar condition.

In the above table it will be seen that in the first two periods both herds showed quite similar acid numbers, varying from .32 to .38, equivalent to from .14 to .17 per cent. of acidity. In the third period, in case of Herd I. the acid number increased slightly to .48, and noticeably in case of Herd II. from an average of .32 in the second period to 1.39. This change could not have been due to the effect of long standing, otherwise the butter fat from Herd I. would have shown a similar condition. It may have been due partly to the direct entrance of the soy bean oil[3] into the butter fat and partly to the disturbance as the result of feeding the oil.

The ether number, or difference between the saponification and the acid numbers, represents the milligrams of potassium hydrate required to neutralize the acids of the neutral fat. Naturally it varied with the saponification and acid numbers, being lowest in the butter fat produced by Herd II. in the third period.

The percentage of glycerol in fat may be determined directly according to the method worked out by Benedict and Zsigmondy[4] and modified by Allen,[5] or in case of triglycerides it

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[1] Pennsylvania State College, report *loco citato*.

[2] Lewkowitsch, *loco citato*.

[3] The soy bean oil had an acid number of 1.27.

[4] Journal Society Chemical Industry, 1885, p. 610; abs. Lewkowitsch, third edition, Vol. I., p. 283.

[5] Commercial Organic Analyses, second edition, II., p. 290.

may be calculated from the ether number.[1] The above results were secured by the latter method on the understanding that 3 molecules of potassium hydrate replace 1 molecule of glycerol: —

$$168.474 : 92.064 :: 1 : G.$$

in which case G = .5465.

Multiplying the ether number, therefore, by .05465 gives the percentage of glycerol. Direct determinations of glycerol in neutral fats by quantitative methods, and by the above method of calculation, have given substantially identical results. Thus, Brown found in beef tallow 10.61 per cent. by determination and 10.68 by calculation, and in butter fat 12.70 and 12.69 per cent. respectively.[2] Bell has found 12.54 per cent. of glycerol in genuine butter fat.[3] Our own results compared very closely to the above figures, excepting in the case of Herd II. in the third period, when the average falls to 12.04 per cent. This is in harmony with results already presented, and indicates a decrease in the amount of the soluble acids of high combining power and low molecular weight and a corresponding increase in the insoluble fats.

The percentage of total fatty acids was calculated in accordance with the formula presented by Zulkowsky.[4] This method, in common with that for the determination of the glycerol, depends upon the determination of the ether number. The formula is as follows: —

$$C_3H_5(RO_2)_3 + 3\ H_2O = C_3H_5(OH)_3 + 3\ RO_2H$$

Fat + water (54.048) = glycerol (92.064) + fatty acids.

$$\text{Fatty acids} = 100 + \frac{54.048}{92.064}\ G - G;\ \text{or}\ 100 - \frac{38.016}{92.064}\ G.$$

Substituting the value of glycerol in terms of ether number: —

$$F = 100 - \frac{38.016}{92.064} \times .05465\ E\ \text{or}\ 100 - .02257\ E.$$

The total fatty acids as presented in the tables are all quite uniform, excepting for Herd II. in the last period, when they increased slightly, for the reason already mentioned.

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[1] Lewkowitsch, third edition, Vol. I., p. 281; original by Zulkowsky, Berichte, 16, p. 1140.

[2] *Loco citato*, p. 216.

[3] Lewkowitsch, p. 833.

[4] Berichte, 16, p. 1315.

The Valenta test, as modified by Allen,[1] was employed in securing the reported results, and consisted in warming 3 cubic centimeters of melted butter fat with an equal quantity of glacial acetic acid in a test tube with agitation until complete solution took place. The solution was allowed to cool while being stirred with a thermometer and the temperature noted at which the solution became turbid. Allen gives temperatures of from 56° C. to 61.5° C. for pure butters. Our own temperatures, for some unexplained reason, were noticeably lower; they are at least comparable. It will be noted that in the first period Herd I. had a slightly lower turbidity point than Herd II., showing, as have other tests, a slight difference in the composition of the butter fat. In the second period this difference was more noticeable, and was very marked in the third or soy bean oil period, amounting to nearly 12°. It would appear that the higher the percentage of olein in the butter the higher was the point of turbidity. Whether the excess of free fatty acids had anything to do with the higher point of turbidity is uncertain.[2]

The refractive index on the various samples was made with a water jacketed Abbé refractometer at 40° C., according to the instructions given. Only in the third period in case of Herd II. does one note a slight variation and increase over the fat produced in the other two periods.

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[1] Lewkowitsch, p. 862. [2] Lewkowitsch, p. 218.

TABLE XIII. — *Data of the Fatty Acids.*

First period: both herds, normal grain ration.

Sample Number.	Insoluble Acids (Hehner Number).						Soluble Fatty Acids.						Volatile Fatty Acids.			
	Percentage.		Saponification Number.		Mean Molecular Weight.		Percentage.		Saponification Number.		Mean Molecular Weight.		Saponification Number.		Mean Molecular Weight.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
17261-2, . .	86.56	87.24	215.19	214.54	260.96	261.76	8.11	7.53	618.13	598.94	90.85	93.76	553.94	554.87	101.38	101.21
17263-4, . .	86.72	87.24	213.35	213.01	263.22	263.64	7.98	7.53	630.95	616.07	89.01	91.16	555.41	559.29	101.11	100.41
17265-6, . .	86.63	87.28	212.33	213.29	264.48	263.29	8.05	7.50	648.20	608.00	86.64	92.37	548.26	548.63	102.43	102.36
17267-8, . .	86.74	87.68	214.69	214.04	261.58	262.37	7.97	7.08	608.78	630.37	92.25	89.09	555.85	556.57	101.03	100.90
Average, .	86.66	87.36	213.89	213.72	262.56	262.76	8.03	7.41	626.72	613.35	89.69	91.60	553.37	554.84	101.49	101.22

Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.

Sample Number.	Insoluble Acids (Hehner Number).						Soluble Fatty Acids.						Volatile Fatty Acids.			
	Percentage.		Saponification Number.		Mean Molecular Weight.		Percentage.		Saponification Number.		Mean Molecular Weight.		Saponification Number.		Mean Molecular Weight.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
17269-70, .	86.54	87.02	213.82	215.05	262.64	261.14	8.18	7.75	602.44	582.45	93.22	96.42	556.74	553.94	100.87	101.38
17271-2, . .	86.82	86.60	214.68	214.88	261.59	261.35	7.90	8.15	606.96	573.25	92.52	97.96	552.46	560.96	101.65	100.11
17273-4, . .	86.74	87.52	212.95	211.68	263.71	265.30	7.97	7.25	625.72	644.83	89.75	87.09	558.95	557.62	100.47	100.71
17275-6, . .	86.22	86.65	210.01	210.26	267.41	267.09	8.46	8.12	650.00	615.89	86.40	91.18	549.22	564.29	102.25	99.52
17277-8, . .	86.40	86.99	211.93	207.92	264.98	270.09	8.27	7.77	645.71	663.84	86.97	84.60	553.88	553.28	101.39	101.50
17279-80, .	86.39	87.33	212.05	210.07	264.83	267.33	8.31	7.45	623.95	646.17	90.00	86.91	555.85	557.23	101.03	100.78
17521-2, . .	86.75	86.96	211.95	210.11	264.96	267.28	7.99	7.84	621.78	610.97	90.32	91.92	551.00	547.03	101.02	102.66
17523-4, . .	86.83	87.17	211.38	207.56	265.67	270.56	7.94	7.67	613.35	624.12	91.56	89.98	544.59	552.41	103.12	101.66
Average, .	86.59	87.03	212.35	210.94	264.47	266.27	8.13	7.75	623.24	620.19	90.09	90.76	552.84	555.85	101.59	101.04

Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.

17525–6, . .	86.59	88.53	213.20	207.87	263.41	270.16	8.21	6.49	564.07	591.53	99.56	94.94	547.03	554.21	102.66	101.33
17527–8, . .	87.23	88.43	215.00	208.16	261.20	269.78	7.55	6.58	584.64	582.98	96.06	96.33	539.88	556.19	104.02	100.97
17529–30, .	87.04	88.77	213.78	208.83	262.69	268.92	7.73	6.23	595.99	598.72	94.23	93.80	543.27	551.76	103.37	101.78
17531–2, . .	87.23	89.01	214.20	205.41	262.18	273.39	7.56	6.02	591.80	644.68	94.89	87.11	543.90	556.68	103.25	100.88
17533–4, . .	87.25	89.17	213.05	205.59	263.59	273.16	7.53	5.90	612.62	639.83	91.67	87.77	554.54	562.93	101.27	99.76
17535–6, . .	87.91	88.99	213.92	205.48	262.52	273.30	6.85	6.04	649.63	634.11	86.45	88.56	562.59	556.57	99.82	100.90
17537–8, . .	87.08	88.80	212.20	205.65	264.65	273.08	7.67	6.24	625.55	612.34	89.77	91.71	554.65	561.47	101.25	100.02
17539–40, .	87.74	89.51	212.71	205.64	264.01	273.09	7.03	5.54	646.37	666.06	86.88	84.31	558.12	557.17	100.62	100.79
Average, .	87.26	88.90	213.51	206.58	263.03	271.86	7.52	6.13	608.83	621.28	92.44	90.57	550.50	557.12	102.03	100.80

The insoluble fatty acids, or Hehner number, were determined by saponifying in a flask a definite amount of fat with a glycerol-soda solution, destroying the resulting soap with dilute hydrochloric acid, solidifying the insoluble fatty acids in ice water, and filtering; the acids, after repeated washing, solidifying and filtering, were eventually weighed in the flask. It is, of course, understood that all details and precautions were fully observed.

In the first period Herd II. showed a slightly higher percentage than did Herd I.; the same condition was observed in the second period. In the third period this difference was increased, due in a measure to the effect of the soy bean oil in increasing the unsaturated acids.

The saponification number of the insoluble acids was obtained by titrating the weighed acids, dissolved in alcohol with N/2 alkali solution; the number of milligrams of potassium hydrate required to neutralize 1 gram of fatty acids is the saponification number. But very little difference was noted until the third period, when in case of Herd II. a noticeable depression was observed.

The mean molecular weight (M) of the insoluble acids was calculated from the saponification number (S) by the formula

$$M = \frac{56158}{S.}$$

The soluble fatty acids represent the difference between the total and insoluble acids. The fat produced by Herd I. (first period) had rather more than did that yielded by Herd II. (also indicated by the Reichert-Meissl number). In the second period the fat from Herd I. contained about the same percentage, the amount being reduced in the third period by one-half per cent., due, probably, to the advance in the lactation period. Herd II. in the second period showed a slight decrease, from 8.13 per cent. in the first period to 7.75 per cent., and in the third period the percentage had fallen to 6.13.

The saponification of the soluble acids was calculated as follows: knowing the saponification number of the fat, the percentage and saponification number of the insoluble acids, and the percentage of soluble acids: —

235.66 mgs. KoH required to saponify 1 gram fat.
213.89 mgs. KoH equals saponification number of insoluble fats.
86.66 equals per cent. of insoluble acids.
$.8666 \times 213.89 = 185.35$ mgs. KoH to saponify insoluble acids in 1 gram fat.
$235.66 - 185.35 = 50.30$ mgs. KoH required to saponify soluble acids in 1 gram fat.
$50.30 \div .0803 = 626.46$ theoretical saponification number of soluble acids.

The mean molecular weight of the soluble acids was calculated by the same formula as in case of the insoluble acids.

The mean molecular weight of the volatile acids was determined by evaporating to dryness the titrated portion resulting from the Reichert-Meissl number. From the weight of the salts and of the alkali present in them the mean molecular weight can be readily calculated by the following formula: —

$$M = \frac{40.058\ [\text{salts} - (\text{c.c. } N/10\ \text{NaOH} \times .0040058)]}{\text{c.c. } N/10\ \text{NaOH} \times .0040058} + 18.016$$

$$= \frac{10000\ [\text{salts} - (\text{c.c. } N/10\ \text{NaOH} \times .0040058)]}{\text{c.c. } N/10\ \text{NaOH.}} + 18.016$$

Every precaution was taken and blank determinations were made on all of the reagents and deducted.

The saponification number (S) of the volatile fatty acids was obtained from the mean molecular weight (M), as follows: —

$$S = \frac{56158}{M}$$

The figures which follow represent the averages of analyses made in the experiment described. Number I. includes an average of all the data excepting those from Herd II. in the third or soy bean oil period. Because the soy bean oil so distinctly modified the composition of the fat the average for this period is presented by itself under Number II. Number III. represents the analysis of a sample of superior butter sent by Gude Brothers of New York. Number IV. represents the maximum and minimum tests usually recognized, with the approximate averages.

Table XIV. — *Complete Analytical Data of Butter Fat.*[1]

	Number I.	Number II.	Number III.	Number IV.
Number of cows,	12	6	–	–
Length of period (days),	109	35	–	–
Number of samples composited,	80	16	1	–
Number of determinations,	40	8	1	–
Neutral fat (per cent.),	99.83	99.38	99.74	–
Saponification number,	233.01	221.65	224.04	227[2] 219.7–233.4
Acid number,	.38	1.39	.57	.50[3] .20–.66
Ether number,	232.06	220.26	223.47	228[3] 223.5–234.4
Free fat acids (per cent.),	.17	.62	.26	–
Reichert-Meissl number,	28.51	23.27	26.10	24[4] 26–38
Iodine number (Wijs),	28.75	40.25	37.52	33[3] 25.7–37.9
Oleic acid (per cent.) (calculated),	31.92	44.68	41.66	–
Melting point,	33.70	32.91	32.35	32[3] 31–34.7
Valenta test,	42.25	52.97	51.50	–
Refractive index (40° C., N_D),	1.4530	1.4550	1.4547	–
Mean dispersion ($N_F - N_C$),	.00855	.00884	.00966	–
Total fatty acids (per cent.),	94.75	95.03	94.96	94.85[3] 94.72–94.94
Glycerol (per cent.),	12.71	12.04	12.21	12.46[3] 12.24–12.79
Insoluble fatty acids (per cent.) (Hehner number),	86.97	88.90	88.54	87.5[3] 85.5–90.1
Saponification number,	212.65	206.58	205.74	214.5[3] 212.5–217.0
Mean molecular weight,	264.11	271.86	272.96	261[3] 258.1–263.5
Soluble fatty acids (per cent.),	7.78	6.16	6.42	7.20[3] 6.52–8.96
Saponification number,	618.05	621.28	652.34	571.7[3] 563.7–577.3
Mean molecular weight,	90.98	90.57	86.09	98.12[3] 97.17–99.52
Saponification number of volatile fatty acids.	553.32	557.12	549.98	–
Mean molecular wt. of volatile fatty acids.	101.50	100.80	102.11	–

Manufacture of the Butter. — The butter was made twice weekly during the first two periods by Instructor Brintnall of the college dairy school, and during the last period by N. J. Hunting, also an instructor in the school. The cows were well groomed and all ordinary precautions taken to insure cleanly conditions. The cream was separated by a United States separator, and the entire process of manufacture was carried out in the experiment station creamery especially set aside for such work and fitted with all modern conveniences. The complete data of the process will be found tabulated further on.

[1] In column Number IV., the number above represents the mean, and the numbers below with the dash between represent the extremes.

[2] Lewkowitsch. [3] Brown. [4] Minimum generally recognized.

TABLE XV. — *Chemical Composition of the Butter.*

First period: both herds, normal grain ration.

Samples.	Water. Herd I.	Water. Herd II.	Fat. Herd I.	Fat. Herd II.	Salt. Herd I.	Salt. Herd II.	Curd.[1] Herd I.	Curd.[1] Herd II.
January 16,	14.19	14.82	81.86	82.26	2.83	2.11	1.12	.81
January 19,	15.94	14.46	79.83	81.37	2.81	3.03	1.42	1.14
January 23,	14.33	14.64	80.75	80.64	3.23	3.38	1.69	1.34
January 25,	15.20	14.84	80.09	80.77	3.02	2.88	1.69	1.51
Average,	14.92	14.69	80.63	81.26	2.97	2.85	1.48	1.20
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.								
February 13,	13.92	14.35	82.04	80.71	3.17	3.94	.87	1.00
February 15,	14.68	14.97	81.32	80.40	3.23	3.75	.77	.88
February 20,	13.78	12.79	82.17	83.75	2.73	2.37	1.32	1.09
February 22,	13.49	12.87	83.75	81.67	3.49	3.63	1.35	1.04
February 27,	12.69	12.77	82.92	81.66	3.13	4.43	1.26	1.14
March 1,	12.30	12.82	82.66	81.91	3.94	4.09	1.10	1.18
March 6,	13.17	14.72	83.73	81.67	2.30	2.75	.80	.86
March 8,	12.25	13.28	84.38	82.49	2.62	3.46	.75	.77
Average,	13.29	13.57	82.87	81.78	3.08	3.55	1.03	1.00
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.								
April 10,	13.37	15.09	81.92	80.01	3.67	3.86	1.04	1.04
April 11,	12.69	16.08	83.33	79.42	3.01	3.36	.97	1.14
April 12,	14.46	15.05	80.36	79.55	4.14	4.44	1.04	.96
April 16,	13.51	16.75	82.02	77.90	3.42	4.34	1.05	1.05
April 17,	13.68	17.02	81.90	77.40	3.39	4.66	1.03	.92
April 18,	13.27	16.82	82.72	78.11	4.66	2.83	1.18	1.26
April 19,	12.91	15.21	82.23	79.30	3.58	4.27	1.28	1.22
April 20,	13.48	17.85	82.04	76.28	3.39	4.67	1.09	1.20
Average,	13.42	16.23	82.07	78.50	3.78	4.05	1.09	1.10
Average of three periods,	13.67	14.86	82.10	80.36	3.34	3.61	1.14	1.08
Average of 40 samples,	14.26		81.23		3.47		1.11	

The following method was employed in analyzing the butter: approximately 5 grams were brought on to quartz sand in a flat-bottomed dish and heated at a low temperature until the

[1] Including natural ash.

bulk of the moisture was expelled, then dried at 100° C. for two to three hours. The residue was transferred to an S. & S. capsule and extracted with anhydrous ether in a continuous extractor and the fat weighed. The sand containing the salt was agitated with a definite quantity of water and the chlorine titrated in an aliquot with standard silver nitrate. Curd, including natural ash, was calculated by difference.

The butter was sampled immediately after it was worked and ready for packing. In the first two periods the analyses from each of the two herds were much the same, with only such minor variations as one would naturally expect. In the third period the butter from Herd II. contained noticeably more water than that from Herd I. This is explained on the ground that it was more difficult to work than that from Herd I., being of a soft, salvy nature. The butter maker found that by working it more this condition would become too pronounced.

Flavor and Body of the Butter. — The writer[1] made frequent observations upon pound prints made from each of the two herds. The butter was allowed to stand until it had reached a uniform temperature of 70° F., and then it was tested by pressing it with the finger, and by pushing a glass rod into it and noting the resistance. The butter was then gradually heated to 80° or thereabouts and further observations noted.

In the first period the several lots produced by both herds were fairly firm at 70° F., but at 80° a soft condition was noted, although the prints held their form fairly well. It was repeatedly noticed that the butter produced by Herd II. appeared to be slightly softer than that yielded by Herd I., and this result must be regarded as characteristic of the herd.

In the second or soy bean meal period the samples from both herds were quite firm at 62°, but even at that comparatively low temperature the butter produced by Herd II. appeared to be of a softer and more yielding character when pressed with the finger. At 70° this difference was still more marked, and at 80° the prints from Herd II. frequently went into a shapeless, slushy condition.

In the third period the above conditions were still more pro-

[1] J. B. Lindsey.

nounced. The butter from Herd I. was quite hard and firm at 70° F., and maintained its form fairly well at 80° to 85°, while that from Herd II. was noticeably soft at 70° and collapsed into a slushy mass at the higher temperature. The writer did not attempt to pronounce on the flavor.

Penetration Tests. — In order to still further establish the effect of the two rations on the body of the butter, penetration tests were made by Mr. Smith. By degrees of penetration is meant the number of millimeters a small glass plunger, weighing 10 grams when loaded with mercury, will penetrate the butter when dropped from a height of about 1 meter. The prints were removed from the refrigerator and allowed to stand for some time (over night) at ordinary room temperature. In the morning they were generally within a few degrees of the temperature of the surrounding atmosphere. Each print was tested in a number of places. The detailed results follow, and likewise a summary of the average results: —

TABLE XVI. — *Penetration Tests (Millimeters).*

Laboratory Number.	Herd.	Butter made.	Penetration Test made.	Temperature of Room (Degrees F.).	Temperature of Butter (Degrees F.).	Single Trials.	Average.
First Period.							
17261,	I.,	Jan. 15,	Jan. 27,	68	63	11, 11, 11.25, 10, 10, 10,	10.5
17262,	II.,	Jan. 15,	Jan. 27,	68	64	12.5, 12.5, 12, 15, 14, 15,	13.5
17263,	I.,	Jan. 17,	Jan. 27,	68	64	10.25, 11, 10, 10, 10.5, 10,	10.3
17264,	II.,	Jan. 17,	Jan. 27,	68	64	10.5, 10, 11, 10, 10, 10,	10.3
17265,	I.,	Jan. 22,	Jan. 27,	68	63	10.5, 10, 12, 12.5, 10, 10.3,	10.9
17266,	II.,	Jan. 22,	Jan. 27,	68	64	13, 13, 13.5, 12, 12.5, 12,	12.7
17267,	I.,	Jan. 24,	Jan. 27,	68	64.5	17, 17, 18, 15.5, 17, 15,	16.6
17268,	II.,	Jan. 24,	Jan. 27,	68	64	18.5, 19, 18.5, 24, 21, 21,	20.3
Second Period.							
17269,	I.,	Feb. 13,	Feb. 15,	64	64	11, 11, 11, 10, 10, 10.5,	10.6
17270,	II.,	Feb. 13,	Feb. 15,	64	64	16, 17, 18.5, 15, 17, 17,	16.8
17271,	I.,	Feb. 15,	Feb. 18,	68	64	10.5, 14, 13, 14, 12, 13,	12.8
17272,	II.,	Feb. 15,	Feb. 18,	68	64	22, 19, 19, 18, 19.5, 19,	19.4
17273,	I.,	Feb. 20,	Feb. 22,	62	63	9.5, 9, 9.5, 9.5, 10, 10,	9.6
17274,	II.,	Feb. 20,	Feb. 22,	62	63	13, 13.5, 14, 14.5, 14, 13,	13.7
17275,	I.,	Feb. 22,	Feb. 25,	64	65	14.5, 15.5, 14, 14, 15, 15,	14.7
17276,	II.,	Feb. 22,	Feb. 25,	64	65	19, 19.5, 21, 22, 21.5, 21.5,	20.8
17277,	I.,	Feb. 27,	Mar. 1,	71	64	13, 13, 12, 12, 13, 14,	12.8
17278,	II.,	Feb. 27,	Mar. 1,	71	64	15.5, 16, 17, 16, 17.5, 17,	16.5

17279,	I.,	Mar. 1,	Mar. 4,	76	70	28, 29.5, 33, 32, 28, 27,	29.6
17280,	II.,	Mar. 1,	Mar. 4,	76	71	57, 58, 62, 58, 68, 50,	58.8
17281,	I.,	Mar. 6,	Mar. 8,	64	66	21, 18, 17, 17.5, 18.5, 22,	19.0
17282,	II.,	Mar. 6,	Mar. 8,	64	66	31, 33.5, 38, 28, 32, 35,	32.9
17283,	I.,	Mar. 8,	Mar. 11,	69	62	11.5, 12.0, 17.0, 12, 12, 13,	12.9
17284,	II.,	Mar. 8,	Mar. 11,	69	62	21, 17, 17, 17, 18, 21,	18.5
Third Period.							
17525,	I.,	April 10,	April 15,	62	61	8, 8, 7.5, 8, 8, 8,	7.9
17526,	II.,	April 10,	April 15,	62	61	23, 23.5, 22, 21.5, 22.5, 22,	22.4
17527,	I.,	April 11,	April 15,	62	61	7, 7, 7, 7, 7, 7,	7.0
17528,	II.,	April 11,	April 15,	62	61	19, 19.5, 19.5, 19, 18, 18,	18.8
17529,	I.,	April 12,	April 15,	62	62	9.5, 9, 8, 8, 9, 8,	8.6
17530,	II.,	April 12,	April 15,	62	62	23.5, 24, 26, 23.5, 24.5, 23.5,	24.2
17531,	I.,	April 16,	April 22,	61	61	9, 9, 9, 8.5, 9, 10,	9.1
17532,	II.,	April 16,	April 22,	61	61	25, 28, 28, 29.5, 28, 27,	27.6
17533,	I.,	April 17,	April 22,	61	61	8.5, 8.5, 8.5, 9, 8, 9,	8.6
17534,	II.,	April 17,	April 22,	61	61	26, 30.5, 28, 26, 25.5, 27.5,	27.3
17535,	I.,	April 18,	April 22,	61	61	7.5, 8, 8, 8.5, 8, 8.5,	8.1
17536,	II.,	April 18,	April 22,	61	61	22, 23, 24.5, 25, 25, 26,	24.3
17537,	I.,	April 19,	April 22,	61	61	8, 8, 9, 9, 10, 10,	9.0
17538,	II.,	April 19,	April 22,	61	62	25, 25.5, 26, 27, 29, 26,	26.4
17539,	I.,	April 20,	April 22,	61	61	8.5, 9, 8.5, 9.5, 9, 10,	9.1
17540,	II.,	April 20,	April 22,	61	61	25, 27, 25, 28, 29, 27,	27.0

Table XVII. — *Average Degrees of Penetration (Millimeters).*

First Period (63° to 64.5° F.).		Second Period (64° to 66° F.).		Third Period (61° to 62° F.).	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
10.5	13.5	10.6	16.8	7.9	22.4
10.3	10.3	12.8	19.4	7.0	18.8
10.9	12.7	9.6	13.7	8.6	24.2
16.6	20.3	14.7	20.8	9.1	27.6
-	-	12.8	16.5	8.6	27.3
-	-	29.6[1]	58.8[1]	8.1	24.3
-	-	19.0	32.9	9.0	26.4
-	-	12.9	18.5	9.1	27.0
Averages 12.1	14.2	15.3	24.7	8.4	24.8

Table XVII. shows that the butter from Herd II. was a trifle softer in the first period than that produced by Herd I., and this condition, as has been stated, may be considered characteristic of the herd. In the second period the butter from Herd II. was noticeably softer than that from Herd I. (15.3° and 24.7°), a result due presumably to the oil in the soy bean meal, and perhaps partly to the soy bean protein. In the soy bean oil period the butter was tested at some 3° to 4° lower temperature than in the second period, hence the results from the two periods are not directly comparable. The data showed, however, that the butter produced by Herd II. in the last period was very much softer than from Herd I., due without doubt to the presence of so much soy bean oil in the ration. The penetration tests fully confirm the writer's personal observations, previously described.

[1] Temperature of butter, 70° to 71° F.

TABLE XVIII. — *Butter Scores and Observations* (*Gude Brothers*).

First period: both herds, normal grain 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	35	25	25	15	15	10	10	5	5	90	90
38	34	25	25	15	15	10	10	5	5	93	89
34	34	25	25	15	15	10	10	5	5	89	89
36	36	25	25	15	15	10	10	5	5	91	91
Average,										91	90
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.											
35	38	24.5	25	15	15	10	10	5	5	89.5	93.0
35	35.5	24.5	24	15	15	10	10	5	5	89.5	89.5
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
Average,										89.5	91.0
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.											
33	33	25	24	15	15	10	10	5	5	88	87.0
33	33	25	24	15	15	10	10	5	5	88	87.0
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
35	35	24	25	15	15	10	10	5	5	89	90.0
36	38	25	25	15	15	10	10	5	5	91	93.0
36	37.5	25	25	15	15	10	10	5	5	91	92.5
36	37.5	25	25	15	15	10	10	5	5	91	92.5
Average,										90	90.0

The butter submitted to Gude Brothers of New York was scored by Mr. P. H. Kieffer. That produced in the first period he considered of reasonably good quality, noting no particular difference in the product of the two herds. He criticised it frequently as being greasy and having a tallowy odor.

The first two lots made in the second period he referred to as being of about the same quality as those produced in the first period. Samples sent from February 19 through March 7, completing the second period, all appeared to him to be of the same general character, and he did not give them any definite score, referring to them as "off in flavor," "having a pronounced tallowy and oily flavor," and not being of good grain. It did not seem possible for him to detect any differences that could be attributed to the influence of the food.

In the third period he noted the first few lots as having an oily and tallowy flavor, but seemed to think that the condition was not as pronounced towards the close of the period. Twice he criticised the body of the butter produced by Herd II. as being a trifle sticky or greasy.

The principal criticism of Mr. Kieffer consisted in his objection to the so-called lardy or tallowy flavor in place of the butter flavor in most of the samples. It was not possible for us to explain the cause of this condition, neither were we able to detect it in as pronounced a way as he. In the third period Mr. Kieffer did seem occasionally to note the softer body of the butter produced by Herd II., although apparently he did not consider it decidedly objectionable. Judging from his scores and from his general criticisms he noted no pronounced difference in the butter produced by the two herds, although he considered most of the lots sent him to be of second quality, particularly in flavor.

TABLE XIX. — *Butter Scores and Observations* (*Orrin Bent*).

First period: both herds, normal grain 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.
44	43.0	25	25	10	10	10	10	5	5	94	93.0
42	45.0	25	25	10	10	10	10	5	5	92	95.0
41	41.0	25	25	10	10	10	10	5	5	91	91.0
42	41.5	25	25	10	10	10	10	5	5	92	91.5
Average,										92	93.0

TABLE XIX. — *Butter Scores and Observations* (*Orrin Bent*) — Con.

Second period: Herd I., normal grain ration; Herd II., soy bean meal 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.
44	43	25	25	10	10	10	10	5	5	94	93
42	42	25	25	10	10	10	10	5	5	92	92
–	–	–	–	–	–	–	–	–	–	96	93
–	–	–	–	–	–	–	–	–	–	94	95
–	–	–	–	–	–	–	–	–	–	96	94
–	–	–	–	–	–	–	–	–	–	95	94
–	–	–	–	–	–	–	–	–	–	94	96
–	–	–	–	–	–	–	–	–	–	94	95
Average,										94	94

Third period · Herd I., normal grain ration; Herd II., soy bean oil 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.
44.0	43.0	25	23	10	10	10	10	5	5	94.0	91.0
44.0	42.0	25	23	10	10	10	10	5	5	94.0	90.0
45.0	43.0	25	25	10	10	10	10	5	5	95.0	93.0
45.0	42.0	25	25	10	10	10	10	5	5	95.0	92.0
45.0	43.0	25	23	10	10	10	10	5	5	95.0	91.0
44.0	43.0	25	23	10	10	10	10	5	5	94.0	91.0
46.5	47.5	25	25	10	10	10	10	5	5	96.5	97.5
46.5	47.5	25	25	10	10	10	10	5	5	96.5	97.5
Average,										95.0	92.9

Samples of butter were likewise submitted to Mr. Orrin Bent of Boston, who gave them very careful consideration, observing them on arrival and likewise after they had stood for a week. He scored noticeably higher than the New York party, and appeared, on the whole, to think more favorably of the butter. He occasionally noted the so-called oily condition in samples, but in no way made it as emphatic as did Mr. Kieffer. In the first two periods the product from each of the two herds was scored quite uniformly. In the third period Mr. Bent appeared to notice more than did Mr. Kieffer the soft body of the butter produced by Herd II., referred to it in his letters and marked it off frequently in body as well as in flavor.

TABLE XX. — *Churning Data A.*

First period: both herds, normal grain ration.

Date.	Milk (Pounds).		Cream (Pounds).		Fat in Cream (Per Cent.).		Fat in Cream (Pounds).		Fat in Skim Milk (Per Cent.).		Buttermilk (Pounds).		Fat in Buttermilk (Per Cent.).		Fat in Buttermilk (Pounds).	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
1907.																
Jan. 15,	126.50	111.50	22.60	19.50	26.38	25.88	5.96	5.05	.020	.150	17.50	18.50	-	-	-	-
Jan. 17,	128.00	114.00	24.00	23.00	26.63	25.00	6.39	5.75	.030	.040	16.00	17.00	.37	.31	.06	.05
Jan. 22,	125.00	104.00	23.50	22.00	26.25	22.28	6.17	4.90	.030	.070	17.00	18.00	.23	.21	.04	.04
Jan. 24,	122.50	119.00	23.00	22.00	26.88	23.75	6.18	5.23	.020	.040	16.00	18.50	.23	.25	.04	.05
Averages,	125.50	112.13	23.28	21.63	26.54	24.23	6.18	5.23	.025	.075	16.63	18.00	.28	.26	.05	.05

Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.

Date.	Milk (Pounds).		Cream (Pounds).		Fat in Cream (Per Cent.).		Fat in Cream (Pounds).		Fat in Skim Milk (Per Cent.).		Buttermilk (Pounds).		Fat in Buttermilk (Per Cent.).		Fat in Buttermilk (Pounds).	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
1908.																
Feb. 12,	115.000	115.00	22.50	25.00	25.38	22.25	5.71	5.560	.01	.02	19.50	20.50	.23	.320	.040	.070
Feb. 14,	119.000	116.25	24.00	22.75	24.25	23.00	5.82	5.230	.03	.31	19.00	19.00	.13	.050	.020	.010
Feb. 19,	124.000	118.00	25.00	27.00	24.00	23.00	6.00	6.210	.04	.08	18.50	21.00	.14	.070	.030	.010
Feb. 21,	117.000	121.00	25.00	25.50	25.38	23.13	6.35	5.900	.02	.04	19.50	17.50	.10	.090	.020	.020
Feb. 26,	123.000	117.00	24.50	25.00	25.38	20.63	6.22	5.160	.07	.07	19.50	21.50	.13	.180	.030	.040
Feb. 28,	120.500	116.00	25.50	25.75	23.50	21.50	5.99	5.540	.03	.03	21.75	22.25	.12	.100	.030	.020
Mar. 5,	116.500	113.25	25.00	25.00	22.75	21.00	5.69	5.250	.03	.03	19.75	19.25	.06	.190	.010	.040
Mar. 7,	118.000	113.50	24.00	23.50	21.88	19.00	5.25	4.470	.04	.07	18.75	18.75	.14	1.200	.030	.230
Averages,	119.125	116.25	24.44	24.94	24.07	21.69	5.88	5.415	.03	.08	19.53	19.97	.13	.275	.026	.055

Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.

1908. Apr. 9-10, .	106.00	108.50	23.50	25.25	21.75	20.50	5.11	5.18	.07	.080	20.00	22.00	.13	.13	.03	.03
Apr. 10-11, .	117.00	100.75	25.00	22.25	23.88	21.38	5.97	4.76	.03	.030	19.00	19.50	.14	.26	.03	.05
Apr. 11-12, .	119.00	99.00	25.75	23.00	23.88	20.63	6.15	4.74	.08	.130	21.25	19.50	.90	1.10	.19	.21
Apr. 15-16, .	102.50	100.75	22.00	23.00	21.88	21.25	4.81	4.89	.05	.080	19.50	19.00	.07	.09	.01	.02
Apr. 16-17, .	102.25	105.50	21.75	23.75	22.63	21.38	4.92	5.08	.08	.043	19.00	20.50	.08	.12	.02	.02
Apr. 17-18, .	115.00	95.25	25.50	22.25	22.50	19.50	5.74	4.34	.07	.050	21.25	20.00	.10	.28	.02	.06
Apr. 18-19, .	110.50	88.50	24.00	20.50	23.75	20.75	5.70	4.25	.06	.160	20.00	18.50	.08	.16	.02	.03
Apr. 19-20, .	115.50	90.00	23.75	20.00	24.13	20.50	5.73	4.10	.07	.090	19.25	18.00	.09	.22	.02	.04
Averages,	110.97	98.53	23.91	22.50	23.05	20.74	5.52	4.67	.06	.083	19.91	19.63	.20	.30	.04	.06

TABLE XXI. — *Churning Data B.*

First period: both herds; normal grain ration.

Date.	Kind of Starter.		Per Cent. Starter.		Temperature Ripening (Degrees F.).		Time Ripening (Hours).		Acidity of Cream (Mann).		Time Churning (Minutes).		Temperature Churning (Degrees F.).		Temperature Buttermilk (Degrees F.).		Temperature Wash Water (Degrees F.).	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Jan. 15, .	Douglas, .	Douglas, .	10	10	70–72	70–71	22	22	26⅕	21⅕	67	72	57	57	60	60	58	58
Jan. 17, .	Natural, .	Natural, .	–	–	70–75	70–75	46	46	28¾	35	43	40	57	56	64	64	60	60
Jan. 22, .	Douglas, .	Douglas, .	15	15	70–72	70–72	23	23	32½	33¾	55	56	55	55	58	58	57	57
Jan. 24, .	Douglas, .	Douglas, .	12	12	70–72	70–72	23	23	32	35	55	53	56	56	62	62	57	57
Second period: Herd I., normal grain ration; Herd II., soy bean meal ration.																		
Feb. 12, .	Douglas, .	Douglas, .	15	15	70–75	70–77	–	–	37½	38¾	30	38	59	58	63	62	58	58
Feb. 14, .	Douglas, .	Douglas, .	15	15	72	72	–	–	32½	35	25	17	58	58	62	60	58	58
Feb. 19, .	Douglas, .	Douglas, .	15	15	65	65	22	22	33¾	36¼	90	90	56	56	56	56	56	56
Feb. 21, .	Douglas, .	Douglas, .	15	15	63	63	22	22	33¾	38¾	31	31	58	58	58	58	58	58
Feb. 26, .	Douglas, .	Douglas, .	15	15	64	63	22	22	33¾	40	24	30	62	62	62	62	60	60
Feb. 28, .	Douglas, .	Douglas, .	15	15	64	63	22	22	36¼	36¼	28	25	61	61	61	61	60	60
Mar. 5, .	Douglas, .	Douglas, .	15	15	64	64	22	22	36¾	38¼	20	20	62	60	62	60	60	60
Mar. 7, .	Douglas, .	Douglas, .	15	15	64	64	22	22	35	37½	20	18	62	63	62	63	60	60
Third period: Herd I., normal grain ration; Herd II., soy bean oil ration.																		
Apr. 9, .	Buttermilk,	Buttermilk,	10	10	61–64	61–64	33½	37½	33½	37½	54	49	59	59	62	62	60	60
Apr. 10, .	Buttermilk,	Buttermilk,	10	10	61–63	61–63	34	35½	33¾	35½	29	34	62	62	64	64	60	60
Apr. 11, .	Buttermilk,	Buttermilk,	10	10	62–64	62–64	32½	31½	32½	31½	66	40	63	63	66	65	62	62
Apr. 15, .	Douglas, .	Douglas, .	15	15	62–64	62–64	38	40½	38	40½	36	32	60	60	64	64	61	61
Apr. 16, .	Douglas, .	Douglas, .	15	15	62–70	61–68	35	38½	35	38½	40	77	58	57	62	64	59	59
Apr. 17, .	Douglas, .	Douglas, .	15	15	61–64	61–64	35	36	35	36¼	33	38	62	62	65	66	62	62
Apr. 18, .	Douglas, .	Douglas, .	15	15	62–64	62–64	19	19	36½	39¼	50	49	61	61	61	61	62	62
Apr. 19, .	Douglas, .	Douglas, .	15	15	63–65	63–65	16½	16½	35½	38	21	35	62	63	64	64	62	62

Table XXII. — *Analyses of Feed Stuffs.*

Dry Matter Determinations (Per Cent.).

	Hay.	Normal Grain Ration.	Soy Bean Meal.
First period,	89.7	89.7	-
Second period,	89.7	90.3	92
Third period,	89.7	88.8	-

Composition of Feed Stuffs (Dry Matter).

	Hay (Per Cent.).	Normal Grain Ration (Per Cent.).	Soy Bean Meal [1] (Per Cent.).
Protein,	10.46	18.24	45.22
Fat,	2.69	5.28	9.34
Extract matter,	48.42	63.55	34.38
Fiber,	31.58	9.26	5.15
Ash,	6.85	4.17	5.91

Coefficients of Digestibility.

	Hay.	Normal Grain Ration.	Soy Bean Meal.
Protein,	57	78	91
Fat,	50	85	93
Extract matter,	61	72	81
Fiber,	60	32	-

Conclusions.

1. Soy bean meal partially extracted (2.3 pounds per day and head) seemed to be without influence in changing the proportions of the several milk constituents or in imparting any flavor to the milk.

2. Soy bean oil (.6 of a pound per day and head) was likewise without influence on the composition and flavor of the milk.

3. Soy bean meal did not modify the chemical character of the butter fat, neither did it have any effect upon the separation of the fat from the milk serum, the time of ripening of the cream nor on the thoroughness of the churning. Expert butter

[1] Partially extracted.

scorers could not detect any particular flavor in the butter as a result of feeding the meal. The meal imparted a noticeable softness to the body of the butter, but not sufficiently so as to injure its commercial value excepting during the warm months. The softness of the body of the butter was due probably to the oil contained in the bean meal and not to the bean protein.

4. Soy bean oil depressed the volatile fatty acids (Reichert-Meissl number) and thus lowered the saponification number of the butter fat; it increased the percentage of unsaturated acids (iodine number) and the total insoluble acids. The acid number and Valenta test were also increased. The oil did not noticeably change the melting point of the fat as measured by the Wiley test; it increased somewhat the refractive index.

5. The oil caused a marked softness of the butter; the latter also contained some 2 per cent. more moisture than did the butter produced by the normal ration. No other changes were observed.

SOY BEANS AND SOY BEAN OIL.

BY E. B. HOLLAND, M.SC.

1. Economic Uses.

The soy bean,[1] *Glycine hispida,* Moench, is a native of the Orient, where it is grown chiefly for its seed, which constitutes one of the staple products. J. J. Rein[2] states that in China and Japan the soy bean ranks first of leguminous crops in extent, variety of use and value, excelling all other vegetables in nutritive qualities, and when properly prepared second to none in flavor. While soy beans are eaten plain cooked, special foods prepared from them seem to be more generally used, prominent among which are several fermented products known as *shoyu,* an aromatic table sauce; *miso,* a thicker relish; and *natto,* a mush; also a bean curd or cheese called *tofu.* These preparations and others are described more fully by Rein,[2] C. F. Langworthy,[3] S. H. Angell,[4] Kellner,[5] M. Inoyue,[6] H. C. P. Geerligs[7] and Bloch.[8] Such products, rich in protein, prove a valuable adjunct to rice. Of the land under cultivation in Manchuria, from one-eighth to one-sixth, according to N. Ssemenow,[9] is devoted to the soy bean, and the production of an edible oil from the seeds forms one of the principal industries. Soy beans are considered too valuable in the east to be fed to horses or cattle, though the straw and sometimes the green fodder are used for that purpose.

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1 Japanese, Daidzu and O-mane.

2 The Industries of Japan, pp. 56–60, 62, 105–108.

3 U. S. Dept. Agr., Farmers' Bul. 58 (1897), pp. 20–23.

4 U. S. Cons. Rpts., Dec., 1897, pp. 551, 552.

5 Bul. Col. Agr., Tokyo Imp. Univ., 1, No. 6; Chem. Ztg. 19 (1895), pp. 97, 120, 265; Abs by H. Trimble, Amer. Jour. Pharm. 68 (1896), No. 6, pp. 311, 312.

6 Bul. Col. Agr., Tokyo Imp. Univ., 2, No. 4; Abs. Amer. Jour. Pharm.

7 Chem. Ztg. 20 (1896), No. 9, pp. 67–69; Abs. Exp. Sta. Rec., 8, p. 72.

8 Bul. Sci. Pharmacol., 13 (1906), pp. 138–143; Abs. Exp. Sta. Rec., 18, p. 857.

9 Abs. Exp. Sta. Rec., 15, pp. 669, 670.

It is rather uncertain when the soy bean was first introduced into the United States. The earliest references in experiment station literature would indicate between twenty and twenty-five years ago. C. A. Goessmann[1] reports growing two varieties on the station grounds in 1888. Of recent years the soy bean has been quite extensively cultivated for soiling (or pasturage) and silage purposes, and to a less extent for the production of commercial seed, for hay and as a green manure or cover crop. In Europe and America soy beans have been very little used as a human food. As they contain only a small amount of starch, sugar and dextrin, flour from the beans has been recommended by A. L. Winton[2] and Angell[3] for making bread and biscuits for people suffering from diabetes. Soy beans, dried and roasted, have been mentioned as a possible coffee substitute.[4]

2. The Chemistry of Soy Bean Meal.

The Massachusetts experiment station has given considerable attention to the soy bean as a forage crop, with particular reference to varieties, yield, composition, digestibility and general adaptability for dairy purposes. In addition to work of that character the station inaugurated, in the summer of 1898, a series of feeding experiments,[5] to note the effect of the different nutrient groups[6] — protein, fat and carbohydrates — in the various feeds on the composition of the milk and of the butter fat, and on the character of the butter. Fodder groups suitable for such work are usually obtained to the best advantage from the seeds or their manufactured products. The action of soy bean protein and of soy bean oil was under investigation during the winter of 1906–07.

The soy beans employed in the test were a mixture of several varieties, with medium green and southern yellow predominating. The analysis of the medium green will undoubtedly approximate that of the mixture.

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[1] Mass. State Exp. Sta. Rpt., 7 (1889), pp. 140, 141.

[2] Conn. State Exp. Sta. Rpt., 30 (1906), pp. 153–165.

[3] *Loco citato.*

[4] Agr. News (Barbados), 2 (1903), No. 36, p. 281; Abs. Exp. Sta. Rec., 15, p. 285; Langworthy in Farmers' Bul.

[5] Hatch Exp. Sta. Rpts., 13 (1901), pp. 14–33; 14 (1902), pp. 162–168; 16 (1904), pp. 45–62; Mass. Exp. Sta. Rpt., 21 (1909), pp. 66–110.

[6] It was thought this method would yield more definite information than could be learned from the influence of the combined groups.

Medium Green Soy Beans.

[Dry Matter.]

	Per Cent.
Ash,	5.46
Protein,	40.31
Fiber,	4.91
Nitrogen free extract,	27.68
Fat,	21.64

The above results are substantiated by those reported by Rein,[1] Langworthy[1] and W. O. Atwater,[2] showing the beans to be highly nitrogenous and to contain a large amount of oil. The protein of soy beans, according to the analyses of T. B. Osborne and G. F. Campbell,[3] consists (*a*) largely of glycinin, a globulin similar in properties to legumin but of somewhat different composition; (*b*) a small amount of a more soluble globulin, which resembles phaseolin in composition so far as could be ascertained in reactions; (*c*) 1.5 per cent. of legumelin, an albumen-like proteid; and (*d*) a small amount of proteose.

Winton[1] has shown that a sample of soy bean meal with a nitrogen free extract of 27.2 per cent. contained 9.7 per cent. of starch, sugar and dextrin expressed as starch.[4] Of the remainder, about 5 per cent. is pentosans[5] and 1 per cent. galactan,[6] leaving 11.5 per cent. undetermined. As glycinin, the chief proteid, contains 17.53 per cent. of nitrogen (factor 5.70 instead of 6.25) the undetermined extract matter should be even greater than appears. Kellner and Inoyue[1] deny the presence of any appreciable amount of starch, while Morawski and Stingl[7] claim the starch is converted by an active diastatic enzyme into sugar and dextrin. By precipitating an alcoholic extract of the beans with ether, Levallois[8] obtained a sugar which does not reduce Fehling solution, ferments readily with yeast and upon oxidization with nitric acid yields mucic and oxalic acid.

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1 *Loco citato.*
2 Conn. Storrs Exp. Sta. Rpt., 14 (1901), p. 178.
3 Conn. State Exp. Sta. Rpt., 21 (1897), pp. 374–382.
4 Determined by the diastase method, without previous washing.
5 Hatch Exp. Sta. Rpt., 15 (1903), p. 79.
6 Hatch Exp. Sta. Rpt., 9 (1897), p. 95.
7 Chem. Centbl., 1886, p. 724; Abs. Amer. Jour. Pharm.
8 Compt. Rend. Acad. Sci., Paris, 93, p. 281; Abs. Amer. Jour. Pharm.

3. Soy Bean Oil.

In order to study the effect of the protein and of the oil respectively it was necessary to extract the oil as thoroughly as possible, and to feed the cake and the oil in separate experiments. The extraction was carried out by the V. D. Anderson Company of Cleveland, O., who state[1] that the beans were rolled (not ground), heated to 100° to 150° F. (38° to 66° C.), and the oil removed by torsional pressure. They claim that heating at so low a temperature does not cook the product and thus prevents the liberation of glutinous matter. An analysis of the resulting cake indicates that from 55 to 60 per cent. of the oil was removed. The oil was passed through a filter press, fitted with cloth, but was not refined otherwise.

(a) *Physical Tests.*

The oil was clear and of a dark amber color, with an odor similar to that of other vegetable oils. As analytical data relative to soy bean oil is rather limited, it seemed advisable, for comparison and general information, to include most of the figures available. The specific gravity as recorded by different observers is stated below: —

Temperature (Degrees C.).	Specific Gravity.	Observer.
15	0.9206	E. B. Holland.
15	0.9242	De Negri and Fabris.[2]
15	0.9270	Morawski and Stingl.[2]
15	0.9240	Morawski and Stingl.[3]
15	0.9240	Shukoff.[1]
	0.9240[4]	

The result by the writer was obtained with a hydrometer, and is noticeably lower than the others. This is probably due to differences in method of oil production. Morawski and Stingl

[1] In correspondence with Dr. Lindsey.

[2] J. Lewkowitsch, Chemical Technology and Analysis of Oils, Fats and Waxes, third edition, Vol. II., pp. 506–508.

[3] Chem. Ztg., 1886, p. 140; Abs. Amer. Jour. Pharm.

[4] Average.

extracted at least part of the oil on which they worked with ether. A more accurate determination, by means of an ordinary picnometer, proved unsatisfactory at the low temperature desired because of the viscid nature of the material.

The specific viscosity was reported by F. W. Farrell[1] as 8.43, using a Boverton-Redwood viscosimeter. This indicates the rate of flow at 70° F., as compared with a like volume of water at the same temperature.

The refractive index N_D and mean dispersion $N_F - N_C$ were determined at several temperatures by an Abbé refractometer with a water jacket.

Temperature (Degrees C.).	Refractive Index.	Mean Dispersion.	Observer.
20	1.4749	.00938	E. B. Holland.
25	1.4730	.00934	E. B. Holland.
40	1.4675	.00922	E. B. Holland.

The Valenta test, or turbidity point of equal volumes of oil and glacial acetic acid, was 60° C. This test is based on solubility.

(b) Chemical Tests.

In the chemical examination of the oil the usual methods, with only slight modifications, were followed, unless otherwise stated, and they are too well known to need description.

Saponification (Koettstorfer) Number.	Acid Number.	Ether Number.	Observer.
191.95	1.27	190.68	E. B. Holland.
192.50	–	–	De Nigri and Fabris.
192.90	4.54[2]	188.36	Morawski and Stingl.
192.50	–	–	Morawski and Stingl.
190.60	–	–	Shukoff.
207.9–212.6[3]	–	–	W. Korentschewski and A. Zimmermann.[4]
192.13[5]			

[1] Of the Emerson Laboratory, Springfield, Mass.
[2] Calculated from an acidity of 2.28 per cent. as oleic acid.
[3] Excluded from the average.
[4] Vyestnik Obshch. Hig., Sudeb. i. Prakt. Med. 5 (1905), pp. 690–693; Abs. Exp. Sta. Rec., 18, p. 858.
[5] Average.

The saponification number of our sample agreed closely with the average. The acid number indicates a slight acidity, but this cannot be considered abnormal in an oil with such a high percentage of unsaturated acids if exposed to light and air for any length of time.

Where there is no appreciable amount of unsaponifiable matter, monoglycerides or diglycerides, additional data can be accurately calculated by formulæ[1] from the numbers just given. Of these, the Zulkowski formula for total fatty acids (T) from the ether number (e) is one of the most important.

$$T = 1 - .0002257\,e \text{ or } 95.70 \text{ per cent.}$$

If the saponification number of the fat (191.95) be divided by the per cent. of total fatty acids (95.70), the neutralization number (n) of the fatty acids is obtained (200.57), from which the mean molecular weight (m) can be determined as usual.

$$m = \frac{56158}{n} \text{ or } 279.99$$

Glycerol (G) can be calculated in a similar manner to the total fatty acids.

$$G = .0005465\,e \text{ or } 10.42 \text{ per cent.}$$

The acid number (a) can be converted into percentage of acidity (A), expressed as oleic or the acid of any other molecular weight.

$$A = \frac{282.272\,a}{56158} \text{ or } .63 \text{ per cent. as oleic acid.}$$

Employing the mean molecular weight (279.99) obtained above, the acidity would be the same. Neutral fat and unsaponifiable matter can be determined by difference, 100 less the percentage of acidity (.63), or 99.37 per cent.

The per cent. of acidity (A) can also be calculated from the acid number (a) and the neutralization number of the free fatty acids, or in case that has not been determined, from the

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[1] The derivation of these formulæ will be given in another article.

neutralization number of the total fatty acids (n). The substitution of the latter value will not always hold true.

$$A = \frac{a}{n} \text{ or } .63 \text{ per cent.}$$

The percentage of fatty acids (N) and glycerol (G) in the neutral fat (F) can be calculated by similar formulæ from the molecular weight (m) of the fatty acids of the neutral fats, or, less accurately, from the mean molecular weight of the total fatty acids.[1]

$$N = F \times \frac{3\ m}{3\,m + C_3H_2} = 95.07 \text{ per cent.}$$

The total fatty acids are equal to the sum of the fatty acids in the neutral fat (95.07) and the free fatty acids (.63), or 95.70, the same result previously obtained.

$$G = F \times \frac{92.064}{3\,m + C_3H_2} \text{ or } 10.42 \text{ per cent.}$$

The last three formulæ appear to have no greater merit than those first given and are rather more difficult to apply.

A direct determination of neutral fat and unsaponifiable matter gave the same results as the calulated.

Free fatty acids,	.63
Neutral fat and unsaponifiable matter,	99.37
Unsaponifiable matter,	.03
Neutral fat,	99.34

Briefly, the process consisted of treating 2 grams of oil with an excess of dry sodium carbonate in the presence of a small quantity of alcohol, stirring thoroughly. After the evaporation of the alcohol, quartz sand was added and the mixture transferred to an S. & S. capsule, extracted with dry ethyl ether in a continuous extractor and the dried extract considered neutral fat and unsaponifiable matter. The difference was free acids. The unsaponifiable matter was determined by saponifying 10 grams of oil with glycerol-soda, dissolving the resulting soap in warm water, filtering and washing. The dried residue was extracted

[1] In this case the molecular weights are the same, even to the second decimal, when the unsaponifiable matter is included in the neutral fat.

with ether, which dissolved the unsaponifiable matter. The amount was very small and presumably phytosterol. Morawski and Stingl[1] report .22 per cent. unsaponifiable matter.

The percentage of insoluble acids including unsaponifiable matter (Hehner number) is reported by only two analysts.

Insoluble Acids.	Neutralization Number.	Mean Molecular Weight.	Observer.
95.31	200.22	280.48	E. B. Holland.
95.50	-	-	Morawski and Stingl.
95.40[2]	-	-	-

Solidification of the insoluble acids was rather difficult, owing to the high percentage of liquid fatty acids, which Lane[1] reports as 80.26 per cent. The solid acids are said to be largely palmitic. The neutralization number and mean molecular weight agree closely with the calculated results for total fatty acids, and such should be the case in the absence of any appreciable amount of soluble acids.

The iodine number, as recorded by every observer, shows a high content of unsaturated acid.

Iodine Number.	Observer.	Iodine Number.	Observer.
130.77	E. B. Holland.	121.30	Morawski and Stingl.
121.30	De Nigri and Fabris.	124.00	Shukoff.
122.20	Morawski and Stingl.	123.90[2]	

The result obtained on the Massachusetts sample by Wijs' solution was somewhat higher than the others, indicating an oil of slightly different composition. The liquid acids are probably a mixture of oleic and linolic acids, as the high iodine number (130.77) is equivalent to 152 per cent. of olein, thus proving the presence of an unsaturated acid of a greater iodine absorption than oleic, — presumably linolic. Assuming that the total stated by Lane is reasonably accurate, the amount of each acid can be calculated by means of their theoretical absorption. Let x and y represent the percentages of oleic and linolic

[1] From Lewkowitsch. [2] Average.

acids, with iodine numbers of 89.963 and 181.22, respectively, then: —

$$x + y = .8026$$
$$89.963\,x + 181.22\,y = 130.77$$
$$x = 16.08 \text{ per cent. oleic acid.}$$
$$y = 64.18 \text{ per cent. linolic acid.}$$

The above results indicate that there is approximately four parts of linolic to one part of oleic acid present.

The soluble fatty acids as determined by difference — total 95.70 less insoluble 95.31 — were .39 per cent. The Reichert-Meissl number was .19, which indicates a low volatile acid content, thus substantiating the previous result. In both cases the amount was insufficient to permit an accurate determination of the neutralization number and the mean molecular weight.

Soy bean oil is greatly affected by heat; if held at 100° C., for several hours the chromogenic bodies are destroyed and a noticeable percentage of the oil volatilized. Upon saponifying with glycerol-soda, the mixture takes on a dark red color, which fades as the soap sets.

According to the classification of Lewkowitsch, based on iodine number, soy bean oil is a semi-drying oil of the cotton-seed oil group. In composition it resembles cotton-seed, sesame and corn oils.

Our chemical data can be summarized as follows: —

Saponification number, . 191.95
Acid number, . . . 1.27
Ether number, . . . 190.68

99.37 per cent. neutral fat,[1] { 95.07 per cent. fatty acids. / 10.42 per cent. glycerol.
.03 per cent. unsaponifiable matter.
.63 per cent. free fatty acids.

95.70 per cent. total fatty acids, . . Neutralization number, 200.57, . . Mean molecular weight, 279.99, . . {
- .39 per cent. soluble fatty acids.
- .19 Reichert-Meissl number.
- .11 per cent. volatile fatty acids.[2]
- 95.31 per cent. insoluble fatty acids,[1] . { palmitic acid. / oleic acid. / linolic acid.
- Neutralization number, 200.22.
- Mean molecular weight, 280.48.

[1] The unsaponifiable matter is included in this percentage and in the resulting calculations.

[2] Calculated from the Reichert-Meissl number and the neutralization number of the total fatty acids.

METHODS FOR FAT ANALYSIS.

BY E. B. HOLLAND, M.SC.

During the past ten years the Massachusetts experiment station has conducted a series of feeding experiments, to ascertain, among other things, the effect of different concentrates upon the composition of the resulting butter fat. In connection with this work, which required a great many fat analyses, it was found necessary to study the methods thoroughly in order to simplify when possible, to bring to a like basis and above all to insure uniform results under known conditions of manipulation. The intent of this article is to give only the methods adopted, with a few supplementary notes. What originality there may be is reasonably evident if one compares the methods stated with those usually prescribed. It has been largely, however, the adapting of valuable suggestions from many careful analysts[1] though few references are cited.

Apparatus was one of the first things that required attention, especially flasks. A form and size were desired that would be suitable for all ordinary tests, and a 300 cubic centimeter Erlenmeyer flask, of uniform height and cork requirement, has satisfactorily filled that need. Such a flask occasionally calls for a slight increase in quantity of solvent, but that is to be expected. Normal graduated ware on the basis of the true cubic centimeter at 4° C. was adopted as the standard. The flasks are graduated for capacity and the burettes and pipettes for delivery at 20° C., and all graduations are verified.

The solutions are standardized at 20° C. and are brought to that temperature before being used. Tempering should be carefully observed, especially with alcoholic and acetic acid solutions having a high coefficient of expansion.

[1] Allen, Brown, Blyth, Leach, Leffmann and Beam, Lewkowitsch, Prescott, Sadtler, Sherman, Wiley, Wright, Zulkowski and others.

The methods that follow will be treated under the following headings: —

1. Saponification (Koettstorfer) number.
2. Acid number.
3. Ether (ester) number.
4. Calculated data from saponification, acid and ether numbers.
5. Reichert-Meissl number.
   (*a*) Mean molecular weight.
   (*b*) Neutralization number.
6. Soluble fatty acids.
   (*a*) Neutralization number.
   (*b*) Mean molecular weight.
7. Insoluble fatty acids and unsaponifiable matter.
   (*a*) Neutralization number.
   (*b*) Mean molecular weight.
   (*c*) Iodine number.
8. Calculated data from the fatty acids.
9. Iodine number.
10. Calculated data from the iodine number.
11. Neutral fat and unsaponifiable matter.
12. Unsaponifiable matter.

1. Saponification (Koettstorfer) Number.

The saponification number indicates the milligrams of potassium hydrate required for the complete saponification of 1 gram of an oil, fat or wax.

Reagents. — Alcoholic potash solution, 40 grams of potassium hydrate, free from carbonate, to 1,000 cubic centimeters of 95 per cent. alcohol,[1] free from acid and aldehyde. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

Ninety-five per cent. alcohol, free from acid and aldehyde.

N/2 hydrochloric acid solution.

Phenolphthalein solution, 1 gram to 100 cubic centimeters of alcohol, neutralized.

Method. — Into a 300 cubic centimeter Erlenmeyer flask are

[1] All alcohol used as a solvent in fat analysis or in preparation of the reagents should be treated several days with caustic lime and redistilled. This insures the removal of acid, aldehyde and a portion of the water. The distillate should be preserved in glass and protected from direct sunlight. Such alcohol permits of a more distinct end reaction in titration. A very dry alcohol sometimes requires the addition of a small quantity of water in the preparation of alcoholic potash.

brought 5 grams of fat together with 50 cubic centimeters of alcoholic potash, accurately measured with a burette, and 50 cubic centimeters of alcohol. The flask is connected with a condensing tube and heated on asbestos board at low ebullition until saponification is complete, about thirty minutes. When cool, the solution is titrated with N/2 hydrochloric acid, using a few drops of phenolphthalein as indicator. The temperature of the solution during titration should be adequate to maintain the soap in solution but not to greatly exceed that requirement. Absorption of carbonic acid from the air should be carefully guarded against at all times, especially during the process of cooling. Several blank determinations should be conducted with every series of tests. The difference between the acid titration of the blank and of the test gives the alkali required by the fat.

One cubic centimeter of N/2 acid is equivalent to 28.079 milligrams of potassium hydrate.

Limit of error, .50 saponification number.

Synopsis of Reaction.

$$\underset{\text{fat}}{C_3H_5(RO_2)_3} + \underset{\text{alkali}}{3\ KOH} = \underset{\text{salt}}{3\ RO_2K} + \underset{\text{glycerol.}}{C_3H_5(OH)_3}$$

Titration of excess alkali.

R in the graphic formula of the fatty acids represents C and H in different amounts, according to the acid, but usually in the proportion of C_nH_{2n-1}, except in the case of unsaturated acids.

Supplementary Notes. — The term "saponification or saturation equivalent," as employed by Allen and others, indicates the grams of fat that are saponifiable with one equivalent of potassium hydrate in grams (56.158). In other words, the grams of fat saponifiable with 1 liter of N/1 potassium hydrate.

$$\text{Saponification equivalent } (s_1) = \frac{56158}{s} \text{ or } \frac{\text{mg. of fat}}{\text{c.c. N/1 alkali}}$$

$$\text{Saponification number } (s) = \frac{56158}{s_1}$$

The lower the molecular weight of the fatty acids (or esters) the more alkali will be required to satisfy 1 gram, and the higher will be the saponification number. Fats and oils containing a considerable amount of the glycerides of the lower (volatile) fatty acids are characterized by a saponification number exceeding 200.

2. Acid Number.

The acid number indicates the milligrams of potassium hydrate required to neutralize the free fatty acids in 1 gram of an oil, fat or wax.

Reagents. — Ninety-five per cent. alcohol, free from acid and aldehyde.

N/10 potassium (or sodium) hydrate solution.

Phenolphthalein solution, 1 gram to 100 cubic centimeters of alcohol, neutralized.

Method. — Ten grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask together with 100 cubic centimeters of alcohol. The flask is connected with a condensing tube and heated on asbestos board at low ebullition for five minutes to insure solution of the free fatty acids. When cool the solution is titrated[1] with N/10 alkali, using a few drops of phenolphthalein as indicator. The pink coloration will not remain permanent because of the saponification of neutral esters and the decolorizing action of the carbonic acid absorbed from the air on shaking. Allowing the solution to cool, however, previous to titration will practically prevent saponification. The indicator also appears more sensitive to cool than to hot solutions. Undue shaking should be avoided. Several blank determinations should be run on the alcohol with every series of tests and deducted. A purified alcohol should be nearly neutral, or it can be readily made so, if desired, before being used.

One cubic centimeter of N/10 alkali is equivalent to 5.6158 milligrams of potassium hydrate.

Limit of error, .10 acid number.

Synopsis of Reaction. — Solution of free fatty acids in alcohol.

$$3\ RO_2H + 3\ KOH = 3\ RO_2K + 3\ H_2O$$

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[1] Note directions relative to titrating saponification number of fat and neutralization number of insoluble acids.

Supplementary Notes. — Koettstorfer expresses the acidity by the cubic centimeter of N / 1 potassium hydrate required for 100 grams of fat as "degrees of acidity." Stockmeier reports "degrees of rancidity" in the same manner. N/10 alkali and 10 grams of fat are, however, more convenient quantities with which to work.

1° rancidity = .56158 acid number.
1° acid number = 1.78069° rancidity.

Rosaniline develops with free fatty acids a red color due to the formation of rosaniline oleate, and is known as the Jacobsen test.

The acid number of oils and fats varies with the purity, age and the amount of hydrolysis and of oxidation they have undergone. Contact with fermenting or decaying matter tends to rapidly increase the amount. Rancidity develops more readily in liquid oils in which olein predominates than in the solid fats, which are composed more largely of palmitin and stearin. Fresh animal fats are practically free from acid, while vegetable oils seem to contain a small amount.

3. Ether (Ester) Number.

The ether number indicates the milligrams of potassium hydrate required for the saponification of the neutral esters in 1 gram of an oil, fat or wax.

The ether number is represented by the difference between the saponification and acid numbers, and in cases where there are no free fatty acids present, is identical with the saponification number.

Supplementary Notes. — Natural fats, both animal and vegetable, contain practically only triglycerides, — neutral glycyl esters. These glycerides may occur, however, to some extent as complex molecules instead of simple.

Lewkowitsch asserts that the presence of free fatty acids indicates previous hydrolysis of the triglycerides, and hydrolysis conditions the presence of monoglycerides and diglycerides, therefore the so-called ether number loses its definite character as free acids increase.

4. Calculated Data from Saponification, Acid and Ether Numbers.

Glycerol. — In the saponification of any triglyceride, 3 molecules or 168.474 parts of potassium hydrate combine with 1 molecule of fat, setting free 1 molecule or 92.064 parts of glycerol, therefore 1 gram of potassium hydrate is equal to .5465 of a gram of glycerol.

$$\underset{\text{fat}}{C_3H_5(RO_2)_3} + \underset{\text{alkali}}{3\ KOH} = \underset{\text{glycerol}}{C_3H_5(OH)_3} + \underset{\text{salt}}{3\ RO_2K}.$$

The percentage of glycerol (G) can be calculated from the ether number (e) by means of the formula: —

$$G = .0005465\ e. \quad (1)$$

This method is not applicable in the case of fats containing monoglycerides and diglycerides, aldehyde bodies or appreciable amounts of unsaponifiable matter.

Total Fatty Acids. — In the saponification of a fat, 3 molecules or 54.058 parts of water are required for every molecule or 92.064 parts of glycerol separated.

$$\underset{1}{C_3H_5(RO_2)_3} + \underset{54.048}{3\ H_2O} = \underset{92.064}{C_3H_5(OH)_3} + \underset{-}{3\ RO_2H}.$$

The percentage of total fatty acids (T) in 1 part of fat can be calculated from the percentage of glycerol (G) by means of the formula: —

$$T = 1 + \frac{54.048}{92.064} G - G \text{ or } 1 - \frac{38.016}{92.064} G$$

and substituting the value of glycerol in terms of ether number (e): —

$$T = 1 - \frac{38.016}{92.064} \times .0005465\ e \text{ or } 1 - .0002257\ e. \quad (2)$$

Neutralization Number and Mean Molecular Weight of Total Fatty Acids. — The neutralization number (n) and mean molecular weight (m) of the total fatty acids can be calculated from the ether (e) and saponification (s) numbers by means of the formulæ: —

$$n = \frac{s}{1 - .0002257\ e} \quad (3)$$

$$m = \frac{56158}{n} \quad (4)$$

Mean Molecular Weight of Fatty Acids in Neutral Fat. — The molecular weight (m) of the acids in the neutral fat can be calculated from the ether number (e) and the percentage of neutral fat (F) — determined either gravimetrically or by difference[1] — by the formula: —

$$m = \frac{3 \times 56158 \times F}{e} \text{ or } \frac{168474\ F}{e}$$

$$m = 3(m - H) + C_3H_5 \text{ or } 3(m - 1.008) + 41.04 \text{ or } 3\ m + 38.016$$

$$3\ m + 38.016 = \frac{168474\ F}{e}$$

$$m = \frac{56158\ F}{e} - 12.672 \quad (5)$$

Fatty Acids in Neutral Fat. — The fatty acids (N) in neutral fat can be calculated from the percentage of neutral fat (F) and the mean molecular weight (m) of the fatty acids in the neutral fat:[2] —

$$N = F \times \frac{3\ m}{3\ m + C_3H_2} \quad (6)$$

The total fatty acids are equal to the sum of the fatty acids in the neutral fat and the free fatty acids.

Glycerol. — The glycerol (G) can be calculated in a manner similar to the fatty acids in the neutral fat.

$$G = F \times \frac{92.064}{3\ m + 38.016} \quad (7)$$

Free Fatty Acids. — The acid number (a) can be readily converted into percentage of free fatty acids (A) expressed as oleic,

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[1] The unsaponifiable matter is a source of error.

[2] A close approximation can usually be obtained by using the mean molecular weight of the total fatty acids.

as an assumed acid with a molecular weight determined by formula (4), or as the acid of any other molecular weight.

$$A = \frac{a \times m}{56158} \quad (8)$$

When the free acid is known or the predominant acid is a mixture, it is often desirable to report acidity in terms of that acid. In such cases it is preferable to calculate the percentage directly from the titration by factor .0001 of the molecular weight of the acid (mono basic) for an N/10 solution, or .001 for N/1.

The per cent. of acidity (A) can also be calculated from the acid number (a) and the neutralization number (n) of the total fatty acids.[1]

$$A = \frac{a}{n} \quad (9)$$

Neutral Fat and Unsaponifiable Matter. — The neutral fat and unsaponifiable matter can be determined by difference, — 100 less per cent. of free fatty acids.

5. Reichert-Meissl Number.

The Reichert-Meissl number[2] indicates the cubic centimeters of N/10 potassium hydrate solution required to neutralize that portion of the volatile fatty acids which is obtained from 5 grams of an oil, fat or wax by the Reichert distillation process.

Leffmann-Beam Modification.

Reagents. — Glycerol-soda solution, 100 cubic centimeters of sodium hydrate solution (equal parts of soda and water filtered), free from carbonate, to 900 cubic centimeters of pure glycerol.

Sulfuric acid solution, 1 to 4.

N/10 potassium (or sodium) hydrate solution.

Phenolphthalein solution, 1 gram to 100 cubic centimeters of alcohol, neutralized.

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[1] Strictly it should be the neutralization number of the free fatty acids. The number of cubic centimeters of N/1 alkali required can be substituted in place of the values a and n.

[2] The Reichert number is that obtained from 2.5 grams of fat, and the proportion of acids volatilized is somewhat greater than with 5 grams, Reichert-Meissl number.

Pumice stone; the stone is prepared by dropping it at white heat into distilled water and leaving it until required.

Method. — Into an Erlenmeyer flask of 300 cubic centimeters capacity are brought 5 grams of fat, carefully avoiding getting any fat on the sides of the flask; 20 cubic centimeters of glycerol-soda are added and heated over a naked flame, rotating continuously, until the saponification is complete, as shown by the mixture becoming perfectly clear. The soap when cold should be white and free from globules of fat. Many small pieces of pumice stone, 135 cubic centimeters of recently boiled distilled water and 5 cubic centimeters of sulfuric acid solution are added, and the flask connected with a Liebig condenser[1] and heated carefully on gauze until a transparent oily layer of insoluble fatty acids forms on the surface; 110 cubic centimeters are then distilled over in as near thirty minutes as possible and received in a sugar flask. The distillate is passed through a dry dense filter, to remove all traces of the higher fatty acids which may have passed over with the volatile acids and appear in the distillate as oily drops or white solid particles. After mixing thoroughly, 100 cubic centimeters are pipetted into a small flask and titrated with N/10 alkali, using 5 drops[2] of phenolphthalein as indicator, avoiding entirely the addition of water. The pink coloration should hold at least five minutes. Extreme care should be exercised in preventing the absorption of carbonic acid at all times during the process. Blank tests should be conducted with every new lot of reagents. The titration reading, minus the blank, increased by a tenth and calculated to exactly a 5-gram basis, represents the Reichert-Meissl number.

Limit of error, .25 Reichert-Meissl number.

Synopsis of Reaction.

$$\underset{\text{fat}}{C_3H_5(RO_2)_3} + \underset{\text{alkali}}{3\ NaOH} = \underset{\text{salt}}{3\ RO_2Na} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

The added glycerol acts as a transmitter of heat and has a boiling point of 290° C.

$$2\ RO_2Na + H_2SO_4 = 2\ RO_2H + Na_2SO_4.$$

Titration of the volatile acids.

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[1] A vertical condenser with a rapid circulation of cold water is advisable.

[2] A definite quantity is necessary if the mean molecular weight is to be determined.

Supplementary Notes. — As this method is only an arbitrary one it is essential to adhere strictly to the conditions of operation as laid down if comparative results are to be obtained, and by so doing over 90 per cent. of the soluble acids in butter can be secured in the distillate. Repeated distillation yields higher results, but is accompanied by decomposition of non-volatile acids.

Butyric, caprivic, caprylic and capric are the only fatty acids that can be distilled under ordinary pressure without decomposition. Lauric is almost insoluble in water but is volatile in a current of steam.

Most of the natural fats and oils contain but a small amount of volatile (soluble) fatty acids, generally below 1 Reichert-Meissl number. Among the prominent exceptions are butter fat and porpoise, dolphin, croton, cocoanut and palm nut oils.

(*a*) *Mean Molecular Weight.*

The titrated volatile acids[1] resulting from the determination of the Reichert-Meissel number are evaporated in a tared platinum dish and dried to constant weight in an air bath at 100° C. From the weight of the salts and of the alkali present in them the mean molecular weight (m) can be readily calculated by the following formula: —

$$m = \frac{40.058\,[\text{salts} - (\text{c.c. N/10 NaOH} \times .0040058)]}{\text{c.c. N/10 NaOH} \times .0040058} + 18.016$$

$$m = \frac{10000\,[\text{salts} - (\text{c.c. N/10 NaOH} \times .0040058)]}{\text{c.c. N/10 NaOH}} + 18.016$$

Blank determinations should be run with every new lot of reagents, both by distillation (Reichert-Meissl number) and by evaporation of the titrated portion (salts), and deducted in the calculation. To check the N/10 solution a definite quantity should be evaporated with an excess of sulfuric acid and calcined. If the weight obtained is greater than the alkali converted to sulfate, due to impurities, the factor .0040058 should be increased sufficiently to offset it.

Limit of error, 1 molecular weight.

[1] Using N/10 sodium hydrate, prepared from caustic alkali made from metallic sodium so as to insure freedom from impurities.

(*b*) *Neutralization Number.*

The neutralization number (n) of the volatile fatty acids can be readily calculated from the mean molecular weight (m) by means of the formula: —

$$n = \frac{56158}{m}$$

6. Soluble Fatty Acids.

The soluble fatty acids indicate the percentage of fatty acids in an oil, fat or wax that is soluble in water.[1] The percentage of soluble fatty acids can be readily calculated by difference, — total fatty acids less the insoluble.

(*a*) *Neutralization Number.*

The neutralization number indicates the milligrams of potassium hydrate required to saturate 1 gram of soluble fatty acids. The difference between the saponification number of the fat and the product of the percentage of insoluble fatty acids times their neutralization number indicates the milligrams of potassium hydrate required to neutralize the soluble fatty acids in 1 gram of fat, which, divided by the percentage of soluble fatty acids, gives the neutralization number of the soluble fatty acids.

(*b*) *Mean Molecular Weight.*

The molecular weight (m) of the soluble fatty acids can be calculated from the neutralization number (n) by means of the formula: —

$$m = \frac{56158}{n}$$

7. Insoluble Fatty Acids and Unsaponifiable Matter (Hehner Number).

The Hehner number indicates the percentage of insoluble fatty acids and unsaponifiable matter in an oil, fat or wax.

Reagents. — Glycerol-soda solution, 100 cubic centimeters of sodium hydrate solution (equal parts of soda and water fil-

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[1] This may mean either hot or cold water, according to the method employed.

tered), free from carbonate, to 900 cubic centimeters of pure glycerol.

Hydrochloric acid solution of a strength that approximately 45 cubic centimeters will neutralize 20 cubic centimeters of the glycerol-soda solution.

Ether.

Method. — Into a tared 300 cubic centimeter Erlenmeyer flask are brought 5 grams of fat together with 20 cubic centimeters of glycerol-soda solution, and heated over a naked flame, rotating continuously, until the saponification is complete, as shown by the mixture becoming perfectly clear. Care should be taken not to overheat and discolor the fat. Fifty cubic centimeters of hydrochloric acid solution are now added and the flask loosely stoppered[1], heated on a water bath, rotating occasionally, until the separated fatty acids form a transparent oily layer on the upper surface of the clear liquid. This requires several hours and must not be shirked. The flask and contents are cooled in ice water, and after the fatty acids solidify the solution is decanted through a fat-free filter, using care not to break the insoluble cake; 150 cubic centimeters of hot water are added, thoroughly agitated, and heated as above, cooled, and the solution filtered. This process is continued until the washings are free from acid, about six times. The flask containing the cake of insoluble fatty acids is inverted and allowed to stand in a cool place over night and drain. A convenient filter stand for both filtration and draining is illustrated by Wiley.[2] The next day the small particles of fat adhering to the filter are dissolved in the least possible amount of ether and the solution run into the flask. The ether is driven off in a water bath below 70° C., and the insoluble acids dried in an air bath at 100° C. The final drying period should not exceed two hours.

There are two compensating errors that usually result from this method, which are volatilization of fatty acids and oxidization of unsaturated acids. The latter is especially serious, and may render of questionable value a determination of the iodine

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[1] A condenser is necessary if the soluble acids are to be determined directly.

[2] Foods and Food Adulterants, United States Department of Agriculture, Bureau of Chemistry, Bulletin No. 13, p. 457.

absorption of the insoluble acids. Drying in a vacuum oven below 70° C., in a current of carbonic acid gas or in a vacuum desiccator will practically prevent oxidization as well as volatilization.

Limit of error, .25 per cent. insoluble acids.

Synopsis of Reaction. — Similar to those of the Reichert-Meissl number.

Supplementary Notes. — Most fats and oils contain from 95 to 97 per cent. of insoluble acids. Some notable exceptions are stated under the Reichert-Meissl number.

(*a*) *Neutralization Number.*

The neutralization number indicates the milligrams of potassium hydrate required to saturate 1 gram of insoluble fatty acids.

Reagents. — Ninety-five per cent. alcohol, free from acid and aldehyde.

N/2 potassium (or sodium) hydrate solution.

Phenolphthalein solution, 1 gram to 100 cubic centimeters of alcohol, neutralized.

Method. — The dried insoluble fatty acids resulting from the determination of the Hehner number are treated with 100 cubic centimeters of alcohol, connected with a condensing tube and heated on asbestos board at low ebullition until the solution is complete, about five minutes. When cool the solution is titrated with N/2 alkali, using a few drops of phenolphthalein as indicator. The temperature during titration should be sufficient to retain the fatty acids in solution but not greatly in excess. Blank determinations should be run on the alcohol with every series of tests and deducted. If preferred, the alcohol can be neutralized previous to its use.

One cubic centimeter N/2 alkali is equivalent to 28.079 milligrams of potassium hydrate.

Limit of error, 1 neutralization number.

Synopsis of Reaction. — See Acid number.

(*b*) *Mean Molecular Weight.*

The molecular weight (m) of the insoluble fatty acids can be calculated from the neutralization number (n) by means of the formula: —

$$m = \frac{56158}{n} \text{ or } \frac{2000 \times \text{wt. of acids}}{\text{c.c. N/2 alkali}}.$$

(*c*) *Iodine Number.*

The iodine number indicates the percentage of iodine chloride absorbed by the insoluble fatty acids, expressed in terms of iodine.

The same process, on a weighed amount of insoluble fatty acids, is followed as in the case of an oil or fat. Particular attention should be paid to the separation and drying of the insoluble fatty acids, so as to prevent oxidization of the unsaturated acids.

8. Calculated Data from the Fatty Acids.

Glycerides. — The percentage of triglyceride (Gl) can be calculated from the percentage of any fatty acid (A) by means of the molecular weight (m) of the fatty acid.

$$Gl = \frac{3\ m + C_3H_2}{3\ m} \times A.$$

From the above formula the following factors were deduced for the acids enumerated below: —

Lauric acid,	$C_{12} H_{24} O_2$,	1.0632
Myristic acid,	$C_{14} H_{28} O_2$,	1.0555
Palmitic acid,	$C_{16} H_{32} O_2$,	1.0495
Stearic acid,	$C_{18} H_{36} O_2$,	1.0446
Oleic acid,	$C_{18} H_{34} O_2$,	1.0449
Linolic acid,	$C_{18} H_{32} O_2$,	1.0452

9. Iodine Number.

The iodine number indicates the percentage of iodine chloride absorbed by an oil, fat or wax, expressed in terms of iodine.

Hubl Method (Wijs' Solution).

Reagents. — Carbon tetrachloride, dry and free from oxidizable products.

Iodine solution according to Wijs[1]: 13 grams of resublimated iodine to 1,000 cubic centimeters of glacial acetic acid (99.5 per cent.), free from oxidizable products. After the iodine is completely dissolved the solution is treated with pure dry chlorine gas[2] until the iodine has been converted into monochloride. The completion of the reaction is indicated by a distinct change, the solution becoming transparent, cherry red, and the titer with thiosulfate doubled. As it is desirable to have a slight excess of iodine it is advisable to retain a small quantity of untreated solution to add in case of necessity.

N/10 sodium thiosulfate (hyposulfite) solution: 24.830 grams of sodium thiosulfate are dissolved in water and made up to a liter at 20° C.

Potassium bichromate solution: 3.8657 grams of dry potassium bichromate, free from sodium bichromate, are dissolved in water and made up to a liter at 20° C. This solution will keep indefinitely, without changing, and is used for standardizing the thiosulfate solution; 100 cubic centimeters of potassium bichromate solution will liberate 1 gram of iodine from a potassium iodide solution.

Potassium iodide solution: 165 grams of neutral potassium iodide, free from iodine and iodate, to 1,000 cubic centimeters of water. Iodate is said to be frequently present in commercial potassium iodide and yields free iodine with hydrochloric acid.

Starch paste: 1 gram to 200 cubic centimeters of water. The solution is prepared by boiling ten minutes.

Process of Standardizing the Thiosulfate Solution. — Twenty cubic centimeters of potassium bichromate solution are accurately measured into a 300 cubic centimeter Erlenmeyer flask and 10 cubic centimeters of potassium iodide solution and 5 cubic centimeters of concentrated hydrochloric acid added. Thiosulfate solution is run in gradually until the brownish yellow

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[1] Wijs' solution, with the same active reagent (iodine monochloride), has largely replaced that of Hubl because of its far greater stability and more rapid absorption.

[2] Well washed, and then dried by being passed through concentrated sulfuric acid.

color (iodine) has been largely destroyed, then 2 cubic centimeters of starch paste are added and the titration continued until the blue particles have entirely disappeared from the resulting bright green solution. As five times the titration is equivalent to 1 gram of iodine, the iodine value of 1 cubic centimeter of thiosulfate is easily calculated.

In theory, 1 cubic centimeter N/10 $Na_2S_2O_3$ 5 aq. is equivalent to .012697 of a gram of iodine.

The following is the reaction: —

$$K_2Cr_2O_7 + 14\ HCl + 6\ KI = 2\ CrCl_3 + 8\ KCl + 6\ I + 7\ H_2O$$
$$6\ I : K_2Cr_2O_7 :: 1 : x.$$
$$761.82 : 294.50 :: 1 : .38657 \text{ g. in a 100 c.c.}$$

Method. — One gram of fat (.2 of a gram of a drying or fish oil, .3 of a gram of a semidrying oil, or .4 of a gram of nondrying oil) is brought into a 300 cubic centimeter Erlenmeyer flask and 10 cubic centimeters of carbon tetrachloride added. After complete solution, 30 cubic centimeters of iodine solution, accurately measured with a burette, are added and the flask well stoppered and allowed to stand two hours[1] in a cool, dark place, with occasional shaking. A rapid bleaching of the solution indicates insufficient iodine. A considerable excess is said to be necessary for the attainment of constant results. The temperature should not exceed 20° C., as heat seems to cause a secondary reaction and certainly destroys the accuracy of the determination. Moistening of the stopper with potassium iodide solution will prevent loss of iodine by volatilization. At the end of the absorption period 100 cubic centimeters of cold, recently boiled distilled water and 10 cubic centimeters of potassium iodide solution are added to the contents of the flask, and the excess of iodine titrated with sodium thiosulfate solution. The thiosulfate is run in gradually, with constant shaking, until the brownish yellow color of the solution has been largely destroyed, then 2 cubic centimeters of starch paste are added and the titration continued until the blue particles have entirely disappeared. Towards the end of the reaction the flask should be stoppered and shaken violently, so that any iodine in the carbon tetra-

[1] According to Wijs, one hour is sufficient for any oil or fat and fifteen to thirty minutes for nondrying and semidrying oils.

chloride will be taken up by the potassium iodide. The "bleached" condition should hold for at least five minutes, though the blue color may develop again in time, due to the splitting off of iodine. Several blank determinations should be run with every series of tests. The difference between the titration of the blank and that of the excess iodine is the thiosulfate equivalent of the fat, which multiplied by the factor (obtained as above) and divided by the weight of fat gives the percentage of iodine absorbed.

Limit of error, .25 iodine number.

Synopsis of Reaction. — Solution with carbon tetrachloride. Formation of chloro-iodo additive compounds with unsaturated acids and their glycerides.

Solution of the excess iodine with potassium iodide and titration with sodium thiosulfate, using starch paste as indicator.

$$2\ Na_2S_2O_3 + 2\ I = Na_2S_4O_6 + 2\ NaI.$$

10. Calculated Data from the Iodine Number.

Theoretically the unsaturated fatty acids belonging to the oleic and ricinoleic series absorb 2 atoms of the halogen, linolic series 4 atoms, linolenic series 6 atoms, etc. The glycerides act similarly to the free acids and absorb three times as many atoms (triglycerides). In fats and nondrying oils olein is the prominent unsaturated glyceride and linolein in drying oils. In those cases where only one such acid or glyceride is present its percentage can be readily calculated from the iodine number, dividing by the theoretical absorption.

$$\text{Oleic acid} = \frac{2\ I}{C_{18}\ H_{34}\ O_2} = \frac{2 \times 126.97}{282.272} = .89963$$

$$\text{Olein} = \frac{6\ I}{C_3H_5(C_{18}\ H_{33}\ O_2)_3{}^1} = \frac{761.82}{884.822} = .86098$$

In a similar manner linolic acid combines with 1.81220 parts of iodine and linolein with 1.73380.

Where there are two unsaturated acids (or glycerides) present (x and y) of known absorption (c and d), if the percentage of the mixture (P) and the iodine number (I) of the fat have

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[1] $3(C_{18}H_{34}O_2) + C_3H_2$.

been determined, the per cent. of each acid (or glycerides) can be calculated by formula: —

$$x + y = P$$

$$cx + dy = .01\ I$$ [2]

$$x = \frac{.01\ I - dP}{c - d}$$

11. Neutral Fat and Unsaponifiable Matter.

The neutral fat and unsaponifiable matter indicates the percentage of these substances in an oil, fat or wax.

Reagents. — Sodium carbonate, anhydrous powder, free from caustic alkali.

Ethyl ether, anhydrous and free from alcohol.

Method. — Into a 3-inch porcelain dish are brought 2 grams of fat together with 1 gram of sodium carbonate and 5 cubic centimeters of alcohol, and the contents stirred thoroughly. After evaporation of the alcohol 25 grams of quartz sand are added, and the mixture transferred to a S. & S. capsule and extracted with ether in a continuous extractor. The extract is dried for one hour in an air bath at 100° C., and considered neutral fat and unsaponifiable matter. Drying[1] in a vacuum oven below 70° C. is preferable. Unnecessary heating should be avoided, as it causes oxidization and sometimes volatilization.

Limit of error, .15 per cent.

Synopsis of Reaction. — Neutralization of free fatty acids with sodium carbonate.

Extraction of neutral fat and unsaponifiable matter with ether.

Free Fatty Acids. — Free fatty acids can be determined by difference, — 100 less per cent. of neutral fat and unsaponifiable matter.

12. Unsaponifiable Matter.

The unsaponifiable matter of an oil, fat or wax is that portion which does not combine with caustic alkali to form soap, thereby insoluble in water but soluble in ether.

Reagents. — Glycerol-soda solution, 100 cubic centimeters of

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[1] See "method" under Insoluble Acids for suggestions on drying.

[2] The factor .01 converts the iodine number to the same basis as the figures for theoretical absorption stated on previous page.

sodium hydrate solution (equal parts of soda and water filtered) free from carbonate, to 900 cubic centimeters of pure glycerol.

Ethyl ether, anhydrous and free from alcohol.

Method.[1] — Into a 300 cubic centimeter Erlenmeyer flask are brought 10 grams of fat together with 40 cubic centimeters of glycerol-soda solution, and heated over a naked flame, rotating continuously, until the saponification is complete, as shown by the mixture becoming perfectly clear. The soap is dissolved in slightly warm water, filtered through a dense fat-free filter paper and washed thoroughly. The filter paper and contents are dried and extracted with ethyl ether in a continuous extractor. The extract is dried for two hours in an air bath at 100° C., and considered unsaponifiable matter. The use of a separatory funnel might facilitate matters and would probably yield slightly higher results, as soap is somewhat soluble in ether.

Limit of error, .05 per cent.

Synopsis of Reaction. — Saponification with glycerol-soda. Removal of the soap and other soluble materials with water. Solution of unsaponifiable matter with ether.

Supplementary Notes. — Unsaponifiable matter includes hydrocarbons, mineral oils (petroleum and shale oils), tar oils (neutral coal oils), paraffin, ceresin, rosin oils, the solid fat alcohols of the ethane series (cetyl, octodecyl, ceryl and myricyl) and of the aromatic series (cholesterol, isocholesterol, phytosterol and sistosterol), and possibly some coloring matter. The natural base of wax, monatomic alcohols of ethane series, unlike glycerol, is insoluble in water. Cholesterol is the characteristic solid alcohol of animal fats and oils and phytosterol of the vegetable.

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[1] Not applicable for volatile hydrocarbons.

THE ACIDITY, SULFITE CONTENT AND COLOR OF GLUTEN FEED.

BY P. V. GOLDSMITH, B.SC.

1. Process of Manufacture.

Gluten feed is the name applied to the finely ground endosperm (body of the corn) after the removal of the starch and corn germ. The corn is first soaked in quite dilute sulphurous acid, which softens the grain sufficiently to allow the separation of the various parts; the dilute acid also serves to check excessive fermentation. After soaking for the requisite length of time the corn is coarsely ground and passed through a series of separators, shakers and presses, which process results in a reasonably distinct separation of germ, starch, gluten and hulls. The gluten, together with that portion of the starch which cannot be separated by mechanical means, and the hulls are mixed with the evaporated steep water from the steeping vats, and the mixture dried and ground is the gluten feed of commerce. This so-called steep water, in which the corn was at first soaked, contains much of the more readily soluble material of the corn, and when mixed with the feed after evaporation imparts to it a dark color.

Most of the feeds offered for sale at the present time possess a sharp acid taste and a bright yellow color. The claim has been made that they contain an excess of injurious dyes as well as excessive amounts of sulphurous acid. The object of this investigation has been to determine: —

The nature of the acidity.

The amount of sulphurous acid present.

The presence and source of the added color.

2. Acidity.

The acidity of gluten feeds is manifest to the taste as well as in titration with standard alkali. The following table gives the acidity of a number of feeds collected on the Massachusetts market in 1908.

In determining total acidity, 5 grams of the feed were transferred to a bottle of approximately 500 cubic centimeters capacity, together with 100 cubic centimeters of distilled water. The bottle was then placed in the shaker for fifteen minutes, after which the solution was filtered and an aliquot titrated against N/10 NaOH, using phenolphthalein as an indicator.

(*a*) *Total Acidity* (*calculated as* H_2SO_4).

[Blank .08 cubic centimeter.]

Laboratory Number.	Color.	Taste.	Acidity (Per Cent.).
370,	Medium,	Slight acid,	.62
371,	Medium,	No acid,	.15
391,	Medium,	Distinct acid,	.72
392,	Medium,	No acid,	.31
393,	Medium dark,	Sharp acid,	.91
394,	Dark,	Sharp acid,	.96
395,	Medium light,	No acid,	.06
459,	Dark,	Acid,	.55
460,	Medium,	Sharp acid,	.86
461,	Light,	Slight acid,	.73
462,	Dark,	Sharp acid,	1.21
463,	Medium,	Slight acid,	.74
506,	Very light,	No acid,	.06
513,	Dark,	Slight acid,	.66
514,	Light,	No acid,	.20
539,	Light,	No acid,	.17
568,	Dark,	Sharp acid,	.86
602,	Medium,	Slight acid,	.57
603,	Medium,	Slight acid,	.70
604,	Medium,	Slight acid,	.63
637,	Light,	No acid,	.38
657,	Dark,	Acid,	.59
687,	Medium,	Sharp acid,	.90
697,	Medium,	No acid,	.31
770,	Dark,	Sharp acid,	.95
795,	Medium,	Slight acid,	.63
796,	Medium,	Sharp acid,	1.02

Color and taste were observed previous to determining acidity.

From the table one notes a range in total acidity of the feeds tested varying from .06 to 1.21 per cent. The high percentages were found only in a few instances, the majority giving a range of .30 to .80 per cent.

By noting color and taste in connection with the determination of total acidity it was found that those feeds possessing a dark or deep yellow color gave, in the majority of cases, a sharp acid taste, and also a relatively high percentage of acid. The relation which exists between depth of color and per cent. of total acidity may be explained as follows: in the process of manufacture there is, as heretofore stated, a certain amount of steep water added to the gluten previous to drying. This steep water carries a relatively high per cent. of acid, which must be neutralized by the addition of soda or lime. It is the bleaching action of the alkali which affects the depth of color; if an insufficient amount of alkali were added to neutralize the acid present there would be a relatively high acidity of the feed, together with a comparatively deeper color, and *vice versa*. It should be noted in connection with the above that while the addition of the steep water to the gluten gives it naturally a darker color, yet this should not be confused with the deep yellow color above referred to, due to the artificial coloration.

(*b*) *Determination of Chlorides.*

Chlorides and sulfates were determined quantitatively in the watery extract of many different samples.

Method for Chlorides. — To 5 grams of the sample were added 100 cubic centimeters of distilled water, as in the determination of total acidity. After shaking, the solution was filtered and 20 cubic centimeters of the filtrate transferred to a porcelain dish and titrated against N/10 sodium hydrate for total acidity, using phenolphthalein as indicator. A few drops of soda were then added to insure a slight excess, and the solution brought to dryness on a water bath, after which the dish was transferred to a gauze top burner and the contents charred at a low red heat. The finely pulverized contents were next taken up with distilled water, filtered, and the insoluble residue well washed with distilled water. The determination of chlorine was made in the filtrate after the usual method, by titration with standard silver nitrate solution, blank determinations being made in every case. The following table gives the chlorine content of several products, calculated as hydrochloric acid: —

Number of Product.	Total Acidity calculated as Hydrochloric Acid.	Chlorine calculated as Hydrochloric Acid.
A,	.04	.036
B,	.14	.026
C,	.79	.077
462,	.90	.090

A, sample of corn gluten prepared by writer, without steep water.
B, sample of gluten feed from factory, without color and steep water.
C, sample of gluten feed from factory, without color plus steep water.
462, sample of gluten feed from collection, with color and steep water.

Samples A and B show an average chlorine content of .03 per cent. calculated as hydrochloric acid, which represents a normal chloride content of a gluten without steep water. By comparing this with sample C it will be noted that the percentage of chlorides is somewhat increased by the addition of the steep water. This is not surprising when the fact is considered that the steep water carries with it a relatively high per cent. of the soluble constituents of the corn, and that it is concentrated before being added to the feed. It is evident, however, that the amount of chlorine calculated as hydrochloric acid, as found in the watery extract, is very small when compared with the percentage of total acidity. In the case of sample 462 it equals .09 per cent., as compared with .90 per cent. of total acidity. Furthermore, this is on the assumption that all the water-soluble chlorides in the feed are in the form of free hydrochloric acid, which is not probable for —

1. Any free hydrochloric acid would be readily neutralized by the addition of soda or lime and appear as a salt.

2. Watery solutions of gluten feed, when evaporated to dryness and again taken up with distilled water, show no loss in acidity.

3. On distillation no free hydrochloric acid could be detected.

4. Free hydrochloric acid or other mineral acids, if present even in quite small amounts, would give an acid reaction with methyl orange. (See Indicators.)

(c) *Determination of Sulfates.*

Sulfates were determined in the watery extracts of several products in the usual way,[1] blank determinations being run in every case.

Number of Sample.	Total Acidity calculated as Sulphuric Acid.	Sulfates calculated as Sulphuric Acid.
A,	.06	.0001
B,	.20	.0005
C,	1.06	.0020
462,	1.21	.1550

For explanation of numbers see Determination of Chlorides.

It is evident from the above results that the addition of the steep water causes an increase in the water-soluble sulfate content of the feed. This is accounted for by the fact that the steep water carries more or less of sulfite which is readily oxidized, appearing as sulfate. It is doubtful if any sulfate exists in the feed as free sulphuric acid from the fact that it would be readily neutralized, and that it would react acid to methyl orange even though it be present in small quantities.

(d) *Phosphoric Acid and Composition of Ash.*

A water extract of a gluten feed was prepared by bringing 50 grams of the sample on a filter and washing with warm distilled water until the filtrate equaled 500 cubic centimeters. This was evaporated to dryness on a water bath and carefully ashed. An analysis of the ash gave the following results: —

	Per Cent.
Silica,	Not determined.
Iron and alumina oxides,	.012
Magnesium oxide,	.400
Calcium oxide,	.080
Potassium oxide,	.540
Sodium oxide,	.070
Sulphuric anhydrid (SO_3),	.120
Chlorine,	.039
Phosphoric acid (P_2O_5),	1.010

[1] Precipitation with barium chloride.

The results of the analysis show the ash of the water solution to contain relatively high per cents. of phosphoric acid, potassium oxide and magnesium oxide. It is difficult to state in just what way these various elements are combined; it is probable that they exist in part, at least, in organic combination. From the relatively high per cents. of potassium oxide, magnesium oxide, phosphoric acid and the presence of calcium oxide, it may be inferred that the phosphorus in corn exists in a similar combination as that in wheat bran, namely, as phytin, — a soluble phospho-organic compound containing potassium, magnesium and calcium.[1] Phytin is soluble in water and insoluble in alcohol and ether. Whether or not this compound, if present, bears any relation to the acidity is yet to be determined. It is probable, however, that in the concentration of the steep water the phytin, if present, would undergo a decomposition, in which case phosphoric acid would undoubtedly be formed. It is doubtful if any *free* phosphoric acid exists in the feed; it would probably be present as a salt.

(e) *Volatile Organic Acids.*

To determine whether the acidity was due in part to free volatile organic acids, such as lactic, butyric or acetic, etc., distillations of the watery extract were made *in vacuo* at a maximum temperature of 100° C. under 12 millimeter pressure. In no case was there more than a mere trace of acid detected in the distillate, indicating that the amount of free volatile acids in the feed is small. The residue from the distillation was a resinous material, dark brown in color and had a sharp, biting taste. Distillations *in vacuo,* in presence of dilute sulphuric acid, also gave negative results, indicating that little or none of the acidity of gluten feeds is due to the salts of the volatile acids.

(f) *Acidity and Indicators.*

The following table gives the acidity of a number of gluten feeds, using both phenolphthalein and methyl orange as indicators: —

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[1] Isolated from wheat bran by Patten and Hart, Bulletin No. 250, New York Experiment Station.

Acidity calculated as Sulphuric Acid.

Number of Feed.	Acidity to Phenolphthalein.	Acidity to Methyl Orange.	Number of Feed.	Acidity to Phenolphthalein.	Acidity to Methyl Orange.
432, . . .	.10	-	448, . . .	2.24	-
433, . . .	.14	-	449, . . .	1.11	-
434, . . .	.79	-	450, . . .	.84	-
435, . . .	.06	-	451, . . .	.92	-
436, . . .	.77	-	452, . . .	1.38	-
437, . . .	.08	-	453, . . .	.50	-
438, . . .	1.09	-	454, . . .	.03	-
439, . . .	.06	-	455, . . .	.18	-
440, . . .	1.48	-	456, . . .	.08	-
441, . . .	.06	-	457, . . .	1.09	-
442, . . .	.70	-	458, . . .	1.60	-
443, . . .	.92	-	459, . . .	.78	-
444, . . .	.06	-	460, . . .	1.53	-
445, . . .	1.06	-	461, . . .	.08	-
446, . . .	1.06	-	462, . . .	2.11	-
447, . . .	.87	-			

The several titrations indicate that in every case the water solutions of the feed gave a neutral or alkaline reaction with methyl orange. Methyl orange as an indicator possesses rather strong acid properties, *i.e.,* it forms compounds that are quite stable and which require strong acids to decompose them, hence it is much more sensitive to free inorganic acids than to those of an organic nature, some of the latter being entirely unable to replace the acid radical of the indicator.

3. Sulfites.

In the process of manufacture of gluten feed there is, as has been heretofore stated, a certain amount of sulphurous acid added to facilitate the separation of the various parts of the corn. Since sulfites are of a poisonous character it was important to determine whether they were present in the finished feed in sufficiently large amounts to cause any serious results when fed to animals. Sulfites were determined after the usual method, by distilling a considerable amount (50 grams) with dilute phosphoric acid into bromine water. The excess of bromine was then boiled off and the sulphuric acid formed determined by precipitation with barium chloride. The distillation was conducted in the presence of carbon dioxide, which served to prevent oxidization. Dilute copper sulfate solution[1] was used to purify the sulphur dioxide. Since it was necessary to employ relatively large amounts of the sample for distillation, it was found convenient to place the distilling flask on an oil bath to prevent burning. The following table gives the result of several determinations: —

Number of Sample.	Sulphur Dioxide (Per Cent.).
1,	.0050
2,	.0008
3,	.0040
4,	.0006
5,	none

Blank .0005 in each case.

The results of these various analyses show that the amount of sulphurous acid in the samples of gluten feeds tested was small, and it can be assumed that practically all of the sulphurous acid originally added has been driven off or oxidized to sulphuric acid. Formerly the United States government allowed the addition of sulphur dioxide to foods at the rate of 350 milligrams per kilogram, or .035 of a gram per 100.[2] This decision was later amended,[3] pending determination by the referee board, and at present calls for the labeling of all foods containing even small amounts of sulphur dioxide.

4. Coloring Matter.

In the work presented on coloring matters no attempt has been made to determine the individual dye or combination of dyes used, but rather to ascertain whether the added color was one of vegetable or coal tar origin. The method for the detection of artificial coloring matter in gluten feeds recommended by Gudeman[4] is not applicable in those cases where the sub-

[1] Winton and Bailey, Journal American Chemical Society, Vol. XXIX., No. 10, 1499.
[2] Food inspection decision No. 76, July 13, 1907.
[3] Food Inspection decision No. 89, Feb. 28, 1908.
[4] Journal American Chemical Society, Vol. XXX., No. 10 (1908), 1623.

stance on heating becomes solid or semisolid, due to the formation of a starch paste, hence a slight modification was employed.

Method. — To 25 to 50 grams of the sample add 150 cubic centimeters of absolute alcohol[1] and 5 cubic centimeters 1 to 1 ammonia; digest with reflux condenser for three-fourths to one hour, filter, acidify with 10 per cent. hydrochloric acid, add about a square inch of woolen cloth and boil from three-fourths to one hour, to effect a good transfer of color. The wool sample is next washed thoroughly in water, boiled for several minutes in very dilute solution of hydrochloric acid and then again in water, to remove the acid. The color in the wool sample is next dissolved by boiling it in a 1–50 ammonia solution, after which the sample is removed and the bath again made acid, when the second wool sample is added and the boiling of the second acid bath prolonged from one-half to one hour. "The dyeing of the second wool sample, ranging from a bright canary yellow to a deep reddish yellow, is positive proof of added coal tar color."[2] Of 30 samples of gluten feed collected on the Massachusetts market in 1908, 26, or over 80 per cent., were found to contain added aniline color. This coloring is lawful provided the fact is so stated on the food label, as is now the case with most of the gluten products placed on sale.

5. Conclusions.

1. Water solutions of gluten feed react acid to phenolphthalein (.1 to 2.11 per cent. calculated as sulphuric acid) and alkaline or neutral to methyl orange, which would indicate the absence of any appreciable amount of free mineral acid (sulphuric and hydrochloric). The direct determination of the sulfates and chlorides shows them to be present only in small amounts.

2. An analysis of the ash of the water solution shows it to contain considerable potassium, magnesium and phosphoric acid, together with lesser amounts of calcium and sodium. The presence of the several alkalies offers additional evidence of the absence of free mineral acids.

3. The presence of such considerable amounts of potassium, magnesium and phosphoric acid in the extract leads one to sur-

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[1] Jenkins of Connecticut State Station recommends the use of alcohol in first acid bath.

[2] Gudeman in Journal American Chemical Society, Vol. XXX., No. 10 (1908), 1623.

mise that the phosphorus exists in the corn as phytin or a similar organic compound, and that the latter may have been decomposed in the process of evaporating the steep water.

4. Pending further investigation, the acidity of gluten feeds is believed to be due primarily to some form of phosphorus, to a much less degree to the acid salt of sulphuric acid, as well as to traces of sulfites and organic acids. It is advised that the acidity be sufficiently neutralized so that no more than .5 per cent. is shown (calculated as sulphuric acid) when titrated against normal alkali with phenolphthalein as indicator.

5. The gluten feeds examined showed traces only of sulfites, and hence it is concluded they are not present in sufficient amount to be regarded as in any degree injurious to animals.

6. About 80 per cent. of the gluten feeds collected in Massachusetts during 1908 were found to contain aniline (coal tar) dye. It is not believed that the amount present was sufficient to be considered injurious. It is thought, however, that it would be decidedly preferable to omit the color.

In conclusion, the writer wishes to express his thanks to Dr. J. B. Lindsey, Dr. R. D. MacLaurin and Mr. E. B. Holland for their criticisms of the above-described work.

ANIMAL RESIDUES AS A FOOD FOR FARM STOCK.

BY J. B. LINDSEY.

1. Meat and Fish Meals.

As a result of the preparation of beef extract according to the formula of J. von Liebig, which was first undertaken in Uruguay in 1863, there was placed upon the German market a large amount of dried extracted material, — *Fleischfuttermehl,* — which was soon recognized as a superior protein food for all kinds of farm stock. C. Voit,[1] as a result of investigations reported in 1869, showed that, contrary to the generally held opinion, this extracted beef was quite fully digested. The first feeding experiments were carried out to demonstrate its value for farm animals in Uruguay in 1872, after plans submitted by Liebig.[2] Since 1872 numerous brands of beef and fish meals have been offered for sale in Europe, and a great variety of experiments with horses, cattle, sheep, and swine have been made, a most excellent summary of which may be found by consulting Shenke's valuable publication.[2]

The consensus of opinion — based upon the above-mentioned experiments — has been that such material when properly prepared is highly digested, and furnishes an excellent source of protein for dairy stock, horses, sheep, swine and poultry. An exception is made to residues made from decayed or badly diseased animals (*Kadavermehl*). European meat meals of the best grade have been shown to contain an average of 72 to 73 per cent. protein, 13 to 14 per cent. fat, 3.5 to 4.5 per cent. ash (263 analyses), and to be 90 or more per cent. digestible.

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[1] Ueber Untersuchungen der animal. und vegetab. Nahrung. München, Sitzungsber. d. math.-phys. Klasse, 1869.

[2] Landw. Versuchsstationen 59 Bd., 1903; also Die Futtermittel des Handels von V. Shenke, p. 737, pub. by P. Paray, Berlin.

European fish meal is guaranteed to contain 59 per cent. protein, 2 per cent. fat, and has been found to be fully 90 per cent. digestible.

Kellner recommends 3 to 4 ounces daily for young pigs and calves, which amount may be increased to 16 ounces, depending upon the size of the animal and the richness of the other foods in nitrogenous matter. Milch cows may be fed as high as 2 pounds daily without any objectionable taste being noted in the milk or butter. Sheep and horses do not take the meal readily, but its consumption can be brought about by mixing it with other grains; about one-half pound daily is recommended.[1]

In the United States up to the present time the various residues from slaughterhouses and fish factories have been utilized chiefly as sources of plant food. Of late the large packers have endeavored to popularize such material in place of or as a supplement to protein concentrates of vegetable origin. Large amounts of meat scraps and meals are consumed in the rapidly increasing poultry industry, and several brands of specially prepared or digester tankage and dried blood are recommended and offered for sale although not generally distributed in local markets.

Tankage for animal feeding is prepared "from scraps of meat of cattle and hogs (lungs, tendons, bones, etc.), cooked for four hours in large steel tanks under 25 to 40 pounds' pressure. . . . The tankage is then pressed, to remove the excess of water and fat, after which the feed is dried and ground." The highest grade contains about 50 to 60 per cent. protein, 10 to 15 per cent. fat and 6 to 10 per cent. bone ash, and has a noticeable odor. It is recommended chiefly as a supplement to corn for feeding pigs, in the proportion by weight of 1 part tankage to 5 to 10 parts corn. While a proportion of 1 to 5 has given slightly better results, the opinion is expressed by several experimenters that so large a proportion of tankage is not as profitable as the smaller amount.[2] It seems probable that 1 part tankage to 5 parts corn could be given advantageously to young pigs, and

[1] Kellner, Die Ernährung d. landw. Nützthiere, pp. 369-371.

[2] Iowa Experiment Station Bulletin No. 65; Purdue Experiment Station Bulletin Nos. 90 and 108; Michigan Experiment Station Bulletin No. 237; Nebraska Experiment Station Bulletin No. 94; South Dakota Experiment Station Bulletin No. 90; Virginia Experiment Station Bulletin No. 167.

the proportion of corn increased as the process of fattening progressed.

The Massachusetts station fed Swift's digester tankage to two dairy cows in place of twice the amount of high-grade distillers' grains (33 per cent. protein). One-half pound of tankage daily was first fed and the amount gradually increased to 1½ pounds per day; the total grain ration consisting of 4 pounds wheat middlings, 1 pound distillers' grains and 1½ pounds tankage, or 5 pounds molasses beet pulp, 2 pounds middlings and 1½ pounds tankage. Neither of the animals made any objections to the tankage when mixed with the other grains, in spite of its noticeable odor. Frequent samples of milk were examined, both cold and at a lukewarm temperature, but it was not possible to detect any flavor or odor that could be attributed to the meat product. It is hardly considered advisable, however, to feed such material to dairy stock.

2. Dried Blood for Stock.

Dried blood for feeding purposes is prepared by heating the fresh blood of cattle and swine in large tanks at 212° F. The excess of water is removed from the coagulated mass by means of heavy presses and the material then passed through steam dryers and eventually ground and bagged. As thus treated it appears as a dry, friable powder of dark color and with only a slight odor.

One finds comparatively few experiments described and little said in agricultural publications relative to the value of blood meal for animal nutrition. Kellner[1] states that "when it is prepared without being overheated, it has proved itself to be a very easily digested protein food stuff, suitable for all farm animals, readily consumed and to be fed in the same amounts as meat meal. It is found to be quite satisfactory as a constituent of fodder bread and biscuit and of the less valuable molasses feeds."

In the United States several stations[2] report feeding trials with blood combined with carbonaceous foods (corn), in which

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[1] Already cited.

[2] Missouri Agricultural College Bulletin Nos. 14, 19; Wisconsin Experiment Station Reports, 1886, 1887, 1888, 1889.

it is shown that the addition of the blood produced a more rapid and healthy development of the body and tended to increase the proportion of lean meat.

The Kansas station[1] has found a teaspoonful of soluble blood flour added to each feeding of milk to be quite efficacious in checking mild cases of scours in calves.

Observations at the Massachusetts Station with Blood Meal.

The station procured a quantity of Armour's blood meal and made the following observations: (1) composition; (2) digestibility; (3) its value as a source of protein in place of cottonseed meal.

(1) *Composition* (*Per Cent.*).

	Armour's Blood Meal.	Foreign Samples for Comparison.		
		Blood Meal.	Meat Meal (High Grade).	Fish Meal.
Water,	11.12	9.00	10.80	12.80
Ash,	3.18	4.20	3.80	32.60
Protein,	84.64	83.90	72.30	52.50
Fiber,	.69	–	–	–
Extract matter,	–	–	–	–
Fat,	.37	2.50	13.10	2.10
Totals,	100.00	99.60	100.00	100.00

The small percentage of fiber in the American brand was due evidently to scattered splinters or to sacking. It resembles closely the foreign article, except that the latter contains more fat. Blood meal is the highest grade protein concentrate suitable for animal feeding.

(2) *Digestibility.*

The detailed data of this experiment have been already published.[2] The blood was fed to two sheep in combination with hay and corn meal. The sheep digested 95.14 per cent. of the dry matter of the blood. The protein appeared to have been less thoroughly digested, namely, 84 per cent. It is probable that the protein digestibility was somewhat depressed by the meta-

[1] Bulletin No. 126, p. 184.

[2] Seventeenth report of the Hatch Experiment Station, pp. 45–77.

bolic by-products. Judging from the digestibility of the total dry matter of the blood it may be safely concluded that the blood protein must be quite thoroughly utilized by farm animals. Kellner[1] found the protein in blood meal to be 92 per cent. digested; Wildt[2] secured protein coefficients of from 61 to 72 per cent. on samples of blood which had been overheated.

(3) *Blood Meal v. Cotton-seed Meal for Dairy Cows.*

Object of the Experiment. — To compare the total protein of dried blood with an equal amount of protein in cotton-seed meal upon the yield of milk and milk ingredients, and to note its economy and suitability as a protein concentrate for dairy stock.

Plan of the Experiment. — Four cows, Blanche, Brighty, Dora and May, were divided into two lots and fed by the usual reversal method. The care and weighing of the animals, method of feeding and sampling of milk were the same as in the alfalfa meal experiment (pages 158–166).

Data concerning Cows.

Name.	Breed.	Last Calf dropped.	Served.	Milk Yield at Beginning of Experiment (Pounds).
		1903.	1903.	
Blanche,	Grade Jersey,	Aug.,	Dec. 31,	26–27
Brighty,	Grade Jersey,	Aug.,	Dec. 24,	24–25
Dora,	Grade Jersey,	Aug.,	Nov. 23,	24–25
May,	Grade Jersey,	Aug.,	-	27–28

Duration of Experiment, 1903.

Dates.	Blood Meal Ration.	Cotton-seed Meal Ration.
October 17 through November 13,	Blanche and Brighty,	Dora and May.
November 21 through December 18,	Dora and May,	Blanche and Brighty.

It will be seen that the experiment proper lasted four weeks, with an interval of seven days between the two halves.

[1] Already cited.

[2] Landw. Jahrbücher 6 Bd., 1877, p. 177.

Total Rations consumed by Each Cow (Pounds).

Blood Meal Ration.

Cows.	First-cut Hay.	Bran.	Hominy Meal.	Blood Meal.	Cotton-seed Meal.
Blanche,	616	84	112	35	-
Brighty,	504	84	112	28	-
Dora,	504	84	112	28	-
May,	616	84	112	35	-
Totals,	2,240	336	448	126	-

Cotton-seed Meal Ration.

Cows.	First-cut Hay.	Bran.	Hominy Meal.	Blood Meal.	Cotton-seed Meal.
Blanche,	616	84	84	-	70
Brighty,	504	84	84	-	56
Dora,	504	84	84	-	56
May,	616	84	84	-	70
Totals,	2,240	336	336	-	252

Average Daily Ration consumed by Each Cow (Pounds).

Character of Ration.	First-cut Hay.	Wheat Bran.	Hominy Meal.	Blood Meal.	Cotton-seed Meal.
Blood meal,	20	3	4	1.13	-
Cotton-seed meal,	20	3	3	-	2.25

The first-cut hay consisted largely of Kentucky blue grass together with some clover. The bran and hominy were of good average quality. The blood obtained of Armour & Co. was especially prepared for cattle feeding, and tested 84.64 per cent. protein; the cotton-seed meal was bright in color and tested 45.36 per cent. protein. It will be seen that twice as much cotton-seed meal as blood was fed, the corresponding amounts furnishing approximately like amounts of digestible protein. The deficiency of carbohydrate material in the blood was made up by the addition of an extra pound of hominy meal. The average basal ration consisted of 20 pounds hay, 3 pounds bran and 3 pounds hominy, while the addition was 1 pound hominy and 1.13 pounds blood, against 2.25 pounds cotton-seed meal.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Blood meal,	25.14	2.46	3.79	8.45	.61	15.31	1:5.5
Cotton-seed meal,	25.27	2.49	3.84	8.19	.72	15.24	1:5.5

The above figures were obtained by the use of average digestion coefficients applied to actual analyses of the several feed stuffs. The calculations indicate that both rations furnished practically the same amount of digestible nutrients, and that the ratio between the carbo-hydrates and the protein was the same. If any difference was to result from the feeding effect of the two rations, one would expect it to be favorable to the blood ration, for the reason that blood and hominy would require somewhat less energy for their digestion than would a like amount of cotton-seed meal.

Herd Gain in Live Weight.

Character of Ration.	Pounds.
Blood meal,	+122
Cotton-seed meal,	—8

The blood meal ration favored a noticeable increase in live weight.

Total and Daily Yields (Pounds).

Blood Meal Ration.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent.
Blanche,	737.26	26.33	103.36	36.42	42.49
Brighty,	668.66	23.88	97.02	37.65	43.93
Dora,	678.05	24.22	90.45	30.85	35.99
May,	695.99	24.85	101.06	35.77	41.73
Totals,	2,779.96	-	391.89	140.69	164.14

Total and Daily Yields (Pounds) — Concluded.

Cotton-seed Meal Ration.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent.
Blanche,	712.40	25.44	102.23	36.40	42.47
Brighty,	601.27	21.47	91.15	36.44	42.51
Dora,	685.92	24.50	90.40	31.07	36.25
May,	755.02	26.97	109.02	38.66	45.10
Totals,	2,754.61	-	392.80	142.57	166.33

The results secured show that the yields of milk, total solids and fat were practically identical in each period.

Food Cost of Milk and Butter.

Character of Ration.	Total Food Cost of Milk.	Cost of One Hundred Pounds of Milk.	Cost of One Pound of Butter.
Blood meal,	$29 00	$1 04	$0 177
Cotton-seed meal,	28 18	1 02	169
Percentage increased cost when blood meal was fed,	-	2.00	5.00

The milk and butter produced by the blood meal ration cost slightly more than that produced by the cotton-seed meal ration. This was due to the fact that 1.13 pounds of blood and 1 pound of hominy cost 4.2 cents, as against 3.26 cents, the cost of 2.25 pounds of cotton-seed meal.

Dry and Digestible Matter required to produce Milk and Butter (Pounds).

Character of Ration.	Dry Matter.			Digestible Nutrients.		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
Blood meal,	101.26	7.18	20.01	61.64	4.37	12.18
Cotton-seed meal,	102.75	7.21	19.85	61.96	4.35	11.97

Hay was figured at $15; bran, $22; hominy, $24; cotton-seed meal, $29; and blood, $55 a ton.

Practically the same amounts of dry and digestible matter were required to produce equal amounts of milk, milk solids and milk fat.

Effect of Blood Ration on Milk Flavor and on Animals.

Frequent samples of milk were taken in sterilized milk bottles, carried to the laboratory and tasted, both cold and lukewarm. It was not possible to detect any objectionable flavor which could be attributed to the blood. The blood ration in no way interfered with the normal condition of the animals, all of which consumed it readily.

The only disturbance noted in the experiment was that of the cow Brighty while being fed the cotton-seed meal ration. She was attacked with indigestion on November 29 and was out of the experiment until December 12, when she again returned to her normal condition and milk flow. She was continued from December 12 until January 1, thus completing her four weeks' record, although the experiment for the remainder of the herd ceased December 18.

3. Conclusions.

1. Dried blood contains some 85 per cent. of protein, and when properly prepared (not overheated) has proved itself to be highly digestible and well suited as a concentrated protein nutrient for farm stock.

2. For cows in milk it may be fed in amounts varying from 1 to 2 pounds daily, mixed with concentrates of vegetable origin. A satisfactory combination for a day's ration consists of 2 to 3 pounds of wheat bran, 2 to 3 pounds of corn or hominy meal and 1.5 pounds of dried blood. Other mixtures can be made containing blood as a constituent.

3. It is believed to be the part of economy to first utilize blood as an animal food rather than to apply it directly as a fertilizer.

4. The present price of prepared blood, its lack of distribution in local markets and the ignorance of the consumer concerning its merits as a food have thus far prevented its general use for feeding purposes.

ALFALFA MEAL v. WHEAT BRAN FOR MILK PRODUCTION.

October to December, 1906.

BY J. B. LINDSEY.

The merits of alfalfa hay, when early cut and well cured, are fully recognized by feeders of farm stock. Considerable alfalfa hay is ground and offered as a food for poultry and as a substitute for wheat bran. The station has made a comparative study of the merits of ground alfalfa and bran for milk production, and briefly presents the results secured.

Composition of Alfalfa (Per Cent.).

	Alfalfa Meal used in Experiment.	Alfalfa Hay for Comparison.	Wheat Bran used in Experiment.	Average for Wheat Bran.
Water,	10.06	9.56	11.61	10.00
Protein,	13.01	13.24	15.60	16.30
Fat,	1.28	3.36	4.28	4.40
Fiber,	32.32	31.07	9.40	10.00
Extract matter,	35.39	34.13	52.98	53.10
Ash,	7.94	8.64	6.13	6.20
Totals,	100.00	100.00	100.00	100.00

The alfalfa meal was put out by the Ralston Purina Company, which stated that it was made from a good quality of alfalfa hay. Alfalfa hay, the composition of which is given in the second column for comparison, was grown at the New Jersey experiment station and was pronounced a representative sample.

Alfalfa differs chemically from bran in containing rather less protein, decidedly less extract matter and correspondingly more fiber. Both have a high ash percentage, which renders them well suited as foods for young stock.

Digestibility of Alfalfa.

This station has not conducted digestion experiments with alfalfa as so many excellent investigations have been made elsewhere, especially in Kansas and Utah. The resulting average coefficients follow: —

	Number Different Lots.	Number Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Alfalfa,	21	39	62	53	72	47	72	43
Wheat bran,	4	10	66	-	77	39	71	63

Organic Matter digestible in 2,000 Pounds.

	Protein.	Fiber.	Extract Matter.	Fat.	Total.
Alfalfa,	190.6	292.0	491.4	28.9	1,002.9
Wheat bran,	251.0	78.0	754.0	55.4	1,138.4

It will be seen that bran furnishes noticeably more digestible protein, extract matter and fat than alfalfa; the latter has a much larger percentage of digestible fiber. Fiber requires more energy for its digestion than the other groups of nutrients. Bran contains over 100 pounds more total digestible organic nutrients to the ton, and, other things being equal, should be regarded, ton for ton, as a more economical food for milk production.

Feeding Experiment with Cows.

Alfalfa Meal v. Wheat Bran.

Object of the Experiment. — To compare the effect of alfalfa meal with wheat bran (*a*) upon the general health and condition of the animal, (*b*) upon the yield of milk, milk solids and milk fat, and (*c*) to note the economy of alfalfa as compared with bran as a food for dairy stock.

Plan. — Six cows, all of which were new milch in the late summer, were divided as evenly as possible into two lots of three each. In the first half of the trial three of the cows received the alfalfa meal ration for six consecutive weeks (one week preliminary) at the same time the other three received the wheat bran ration. In the second half of the trial the conditions were reversed.

Data concerning Cows.

Names.	Breed.	Age (Years).	Last Calf dropped.	Milk Yield at Beginning of Experiment (Pounds).
			1906.	
Blanche,	Jersey, grade,	11	Sept.,	24
Daisy,	Jersey, grade,	9	Aug.,	20
May,	Jersey, grade,	11	Aug.,	23
Samantha,	Jersey-Holstein,	4	Sept.,	28
Fancy,	Jersey, grade,	6	Aug.,	19
May Rio,	Jersey, pure,	4	Aug.,	21

Duration of the Experiment.

Dates.	Alfalfa Meal Ration.	Wheat Bran Ration.
October 13 through November 16,	Samantha, Fancy, May Rio.	Blanche, Daisy, May.
November 24 through December 28,	Blanche, Daisy, May,	Samantha, Fancy, May Rio.

General Care and Feeding. — The experiment was conducted in the station barn especially set apart for such work. Each animal was kept in a roomy stall, well carded and turned daily into a yard for exercise. The daily feed was given in two portions, and water was kept continuously before each animal. All of the cows were in good condition at the beginning of the trial.

Weighing. — Each animal was weighed for three consecutive days at the beginning and end of each half of the trial. The weight was taken in the afternoon, as the cows were brought in from the yard, previous to feeding and watering.

Sampling Feeds. — The coarse fodders were sampled at the beginning, middle and end of each half of the trial, dry matter determinations made at once, and the several samples composited. The grains, including the alfalfa meal, were sampled daily into glass-stoppered bottles, and the composites tested for dry matter at the end of each half of the trial, and eventually completely analyzed. Sufficient of each of the several grains was purchased at one time to last during the entire experiment.

Sampling Milk. — The milk of each cow was sampled twice daily for five consecutive days and preserved in glass-stoppered bottles. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a small dipperful.

Character of the Feeds. — The hay and rowen were of excellent quality. The former was a mixture of Kentucky blue grass with some clover and the latter was largely grass rowen. The quality of the bran was not particularly satisfactory. It was bought by sample, and had the appearance of being a fairly clean, winter wheat product. As the experiment progressed it was found that some bags contained a considerable admixture of middlings and some wheat hulls. Towards the latter part of the second half of the trial the variation became so noticeable that Washburn Crosby's spring bran was substituted for the remainder of the experiment. The source and quality of the alfalfa meal have already been mentioned.

Effect of Alfalfa on General Condition.

The alfalfa meal was fed mixed with the other grains. The animals ate the mixture readily and kept in uniformly good health, as did those receiving the bran ration. The alfalfa ration produced rather more of a laxative effect than did the bran.

Total Feeds consumed (Pounds).

Alfalfa Meal Ration.

Cows.	First-cut Hay.	Rowen.	Alfalfa Meal.	Wheat Bran.	Gluten Feed.	Corn Meal.
Blanche,	455	280	175	-	35.0	105.0
Daisy,	420	210	175	-	52.5	52.5
May,	385	280	175	-	52.5	52.5
Samantha,	455	280	175	-	35.0	105.0
Fancy,	385	210	175	-	52.5	52.5
May Rio,	350	210	140	-	52.5	52.5
Totals,	2,450	1,470	1,015	-	280.0	420.0

Total Feeds consumed (Pounds) — Concluded.

Wheat Bran Ration.

Cows.	First-cut Hay.	Rowen.	Alfalfa Meal.	Wheat Bran.	Gluten Feed.	Corn Meal.
Blanche,	455	280	-	175	35.0	105.0
Daisy,	420	210	-	175	52.5	52.5
May,	385	280	-	175	52.5	52.5
Samantha,	455	280	-	175	35.0	105.0
Fancy,	385	210	-	175	52.5	52.5
May Rio,	350	210	-	140	52.5	52.5
Totals,	2,450	1,470	-	1,015	280.0	420.0

Average Daily Ration consumed by Each Cow (Pounds).

Character of Ration.	First-cut Hay.	Rowen.	Alfalfa Meal.	Wheat Bran.	Gluten Feed.	Corn Meal.
Alfalfa meal,	11.7	7.0	4.8	-	1.3	2.0
Wheat bran,	11.7	7.0	-	4.8	1.3	2.0

It will be seen that the basal ration consisted of hay, rowen, gluten feed and corn meal, to which were added an average of 4.8 pounds of alfalfa meal or wheat bran, so that a definite amount of the alfalfa was compared with a like amount of the bran.

Dry Matter and Digestible Nutrients in the Daily Rations (Pounds).[1]

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Alfalfa,	23.87	1.88	4.20	8.08	.35	14.51	1:6.9
Wheat bran,	23.79	2.01	3.64	8.66	.44	14.75	1:6.6

The total amount of dry matter in the two rations was practically identical, while the total digestible nutrients consumed show but slight variations. The chief difference consisted in the excess of fiber in the alfalfa meal ration. One would

[1] Calculated from actual analyses and average digestion coefficients.

naturally assume that a little less milk and milk products would be produced by the alfalfa meal ration, because of the increased energy required to digest the excess of fiber.

Herd Gain in Live Weight.

Character of Ration.	Pounds.
Alfalfa meal,	119+
Wheat bran,	165+

Both herds made a substantial gain; the bran ration gave the better results.

Yield of Milk and Milk Ingredients (Pounds).

Wheat Bran Ration.

Cows.	Total Milk.	Daily Milk per Cow.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Blanche,	756.12	21.60	106.23	36.29	42.34
Daisy,	599.56	17.13	91.61	34.41	40.15
May,	798.65	22.82	113.49	40.41	47.15
Samantha,	736.73	21.05	114.49	42.88	50.03
Fancy,	629.00	17.97	89.57	30.82	35.96
May Rio,	546.53	15.61	79.79	30.50	35.58
Totals,	4,066.59	19.36	595.18	215.31	251.21

Alfalfa Ration.

Cows.	Total Milk.	Daily Milk per Cow.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Blanche,	734.87	21.00	106.63	36.67	42.78
Daisy,	532.90	15.23	85.96	32.99	38.49
May,	717.14	20.49	108.00	37.94	44.26
Samantha,	797.77	22.79	114.88	42.68	49.79
Fancy,	631.74	18.05	97.29	28.62	33.39
May Rio,	588.23	16.81	80.23	30.00	35.00
Totals,	4,002.65	19.06	592.99	208.90	243.71
Percentage gain of bran over alfalfa ration.	1.6	1.6	.4	3.1	3.1

The above statement indicates that the bran ration gave results slightly superior to the alfalfa meal ration, namely, 1.6 per cent. more milk and 3.1 per cent. more butter, but during the entire period of thirty-five days the cows did not respond readily to either ration. The reason for this was due probably, in part, to the fact that bran or alfalfa (feeds having a comparatively low digestibility) made up nearly 60 per cent. of the grain ration, and partly because of the wide nutritive ratio of the rations. Both rations eventually tended to produce a slow accumulation of body fat rather than to stimulate the flow of milk (note gains in live weight). Incidentally it may be stated that the writer does not consider it economical, as a rule, to use more than 25 to 40 per cent. of bran in rations intended for milk production. The former amount may be employed when the remainder of the ration is composed of rather bulky concentrates, and the latter with heavy concentrates, such as combinations of cotton-seed and corn meals.

Average Composition of the Herd Milk.

Character of Ration.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Alfalfa meal, ...	14.81	5.22	9.59
Wheat bran, ...	14.63	5.29	9.34

The variations in the quality of the milk are not sufficiently pronounced to warrant any particular deductions.

Dry and Digestible Matter required to produce Milk and Milk Ingredients (Pounds).

Character of Ration.	Dry Matter.			Digestible Nutrients.		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
Wheat bran, .	122.87	8.40	23.20	76.22	5.21	14.40
Alfalfa, . .	125.22	8.45	23.99	76.11	5.14	14.58

It apparently required substantially equal amounts of digestible matter to produce equal amounts of milk and milk products.

Food Cost of Milk and Butter.

Character of Ration.	Total Milk.	One Hundred Pounds Milk.	One Quart Milk (Cents).	One Pound Butter (Cents).
Wheat bran,	$49 01	$1 21	2.72	19.5
Alfalfa,	53 07	1 32	2.97	21.8
Percentage decreased cost of bran over alfalfa ration.	9.20	9.20	9.20	9.0

The several feed stuffs were figured at the same price per pound, excepting the wheat bran and alfalfa; the former cost $22 and the latter $30 a ton in the market. On this basis the alfalfa ration would increase the cost of milk and butter some 9 per cent. If the bran and alfalfa were figured at the same price a ton, the food cost of the product would vary very slightly.

Approximate Fertilizer Ingredients in Rations.

Wheat Bran Ration.

104.54 pounds nitrogen, valued at 18½ cents a pound, equals	$19 34
79.36 pounds potash, valued at 4¼ cents a pound, equals	3 37
48.52 pounds phosphoric acid, valued at 4 cents a pound, equals	1 94
	$24 65

Alfalfa Ration.

82.32 pounds nitrogen, valued at 18½ cents a pound, equals	$15 23
68.30 pounds potash, valued at 4¼ cents a pound, equals	2 90
21.02 pounds phosphoric acid, valued at 4 cents a pound, equals	84
	$18 97

Owing to the excess of fertilizer ingredients, especially nitrogen, in the wheat bran, the bran ration would furnish a somewhat richer manure. This fact should not be entirely lost sight of in comparing the merits of the two feeds.

Conclusion.

1. Wheat bran contained nearly 3 per cent. more protein and very much less fiber than did alfalfa meal; bran also has fully 100 pounds more digestible matter to the ton, and noticeably more of the elements of fertility.

2. The present experiment indicates that, pound for pound, wheat bran was slightly superior to alfalfa for the production of milk. Both feeds act as slight laxatives, and are well suited to dilute or distribute the heavy concentrates.

The results secured from a single experiment should not be regarded as conclusive. The composition and digestibility of the alfalfa meal, as well as the feeding experiment described, all point in the same direction, and strongly indicate that the above conclusions are correct. It is believed that if the grain ration had consisted of alfalfa and corn meal, or bran and corn meal, — that is, if gluten feed had been excluded from the ration, — the results would have been more favorable to the bran. The gluten feed supplied a sufficiency of protein, and had it been omitted its loss would have been more noticeable in case of the alfalfa ration.

The writer can see no advantage in replacing bran by alfalfa meal, for the reason that the quality of the latter as measured by the grade of the hay employed is likely to vary considerably. Late-cut alfalfa has a low digestibility, and will prove decidedly inferior to a good quality of bran. Mairs[1] made an experiment to compare bran and alfalfa meal and drew the following conclusions: (1) "The results of this test do not warrant the recommendation of alfalfa meal as a substitute for wheat bran as a feed for dairy cows at the present market prices (bran $20 a ton, alfalfa meal $23)." (2) "The alfalfa meal was less palatable, and resulted in a decreased milk production in every case." (3) "*At the same price per ton,* alfalfa meal produced milk in one case for a cent less and in another case at the same price per hundred pounds."

The writer noted that the quality of the alfalfa meal used by Mairs was superior to the average alfalfa hay.

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[1] Pennsylvania Experiment Station, Bulletin No. 80.

VARIATION IN PEAS.

F. A. WAUGH AND J. K. SHAW.

A preliminary report of these studies in variation of peas was made last year.[1] Since that time the experiments have been continued and many interesting data secured. The work was done largely by Mr. C. S. Pomeroy.

Primarily these experiments were designed to give some accurate knowledge of variation in a common variety of garden

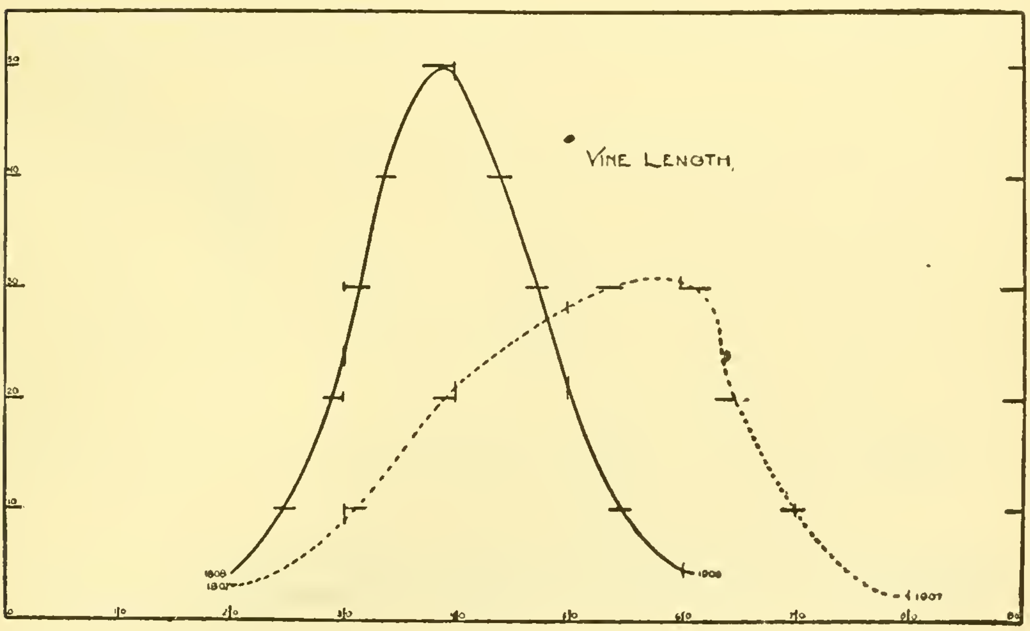

Fig. 1.

peas, Nott's Excelsior. Hitherto our knowledge of such matters has been too meager and inexact to have any scientific value or to supply a proper basis for progress in practical plant breeding. As the work has gone on other problems have come up, including

[1] Massachusetts Agricultural Experiment Station, Report 20; p. 65 (1908).

questions in heredity and in correlation of characters. In this year's work there has been nothing developed in the correlation

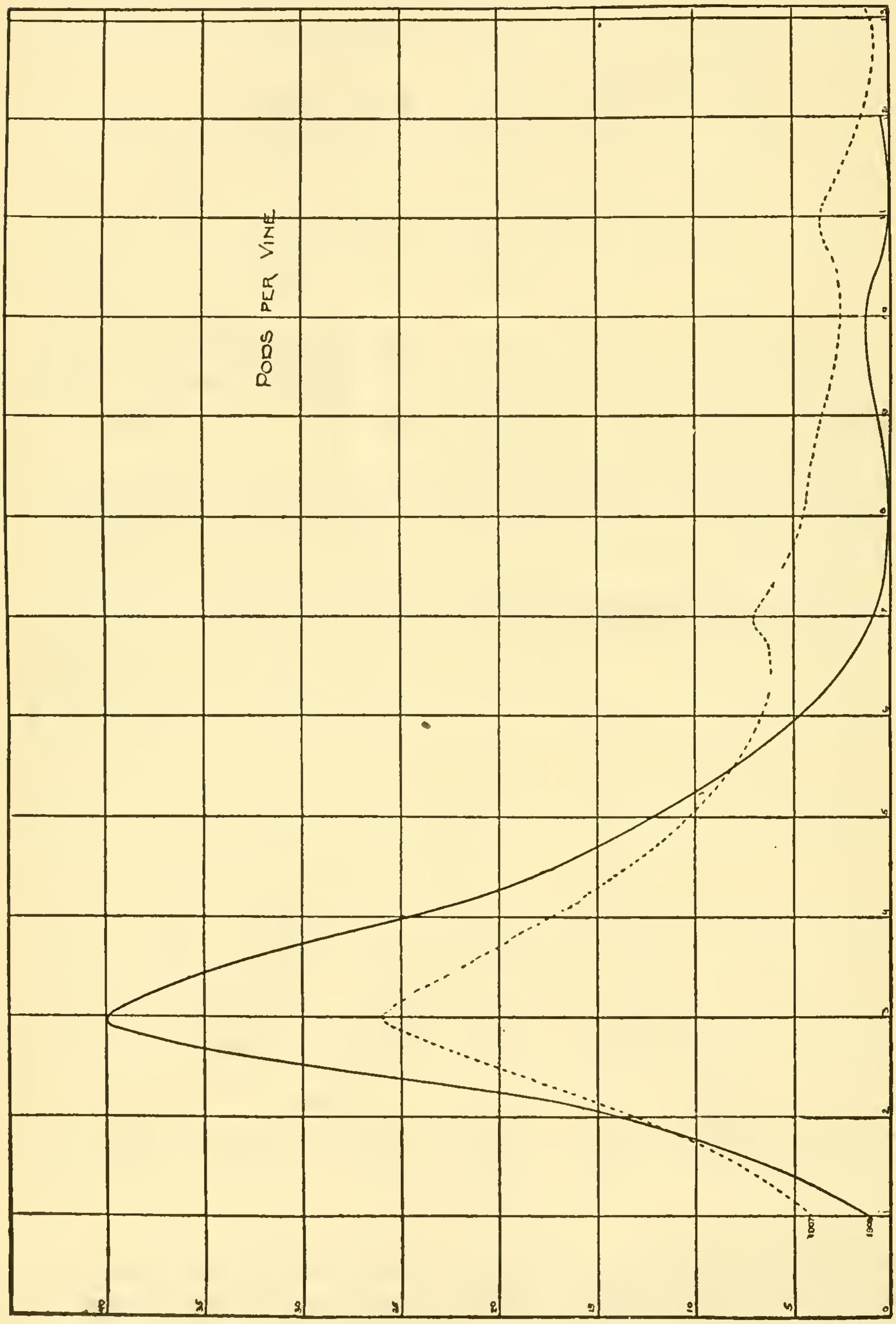

Fig. 2.

studies of sufficient importance to make a report necessary, but some data are given herewith as to the other two subjects, viz., variation and heredity.

Studies in Variation.

In our last report figures and diagrams were given to show the amount and range of variation in several qualities, namely, (1) length of vine, (2) number of pods per vine and (3) number of peas per pod. It will now be of interest to compare the variation of 1908 with that shown in 1907, remembering that the plants of 1908 were the progeny of those grown in 1907.

Before taking up the figures, attention should be called to the fact that the very dry summer of 1908 shows its effects very

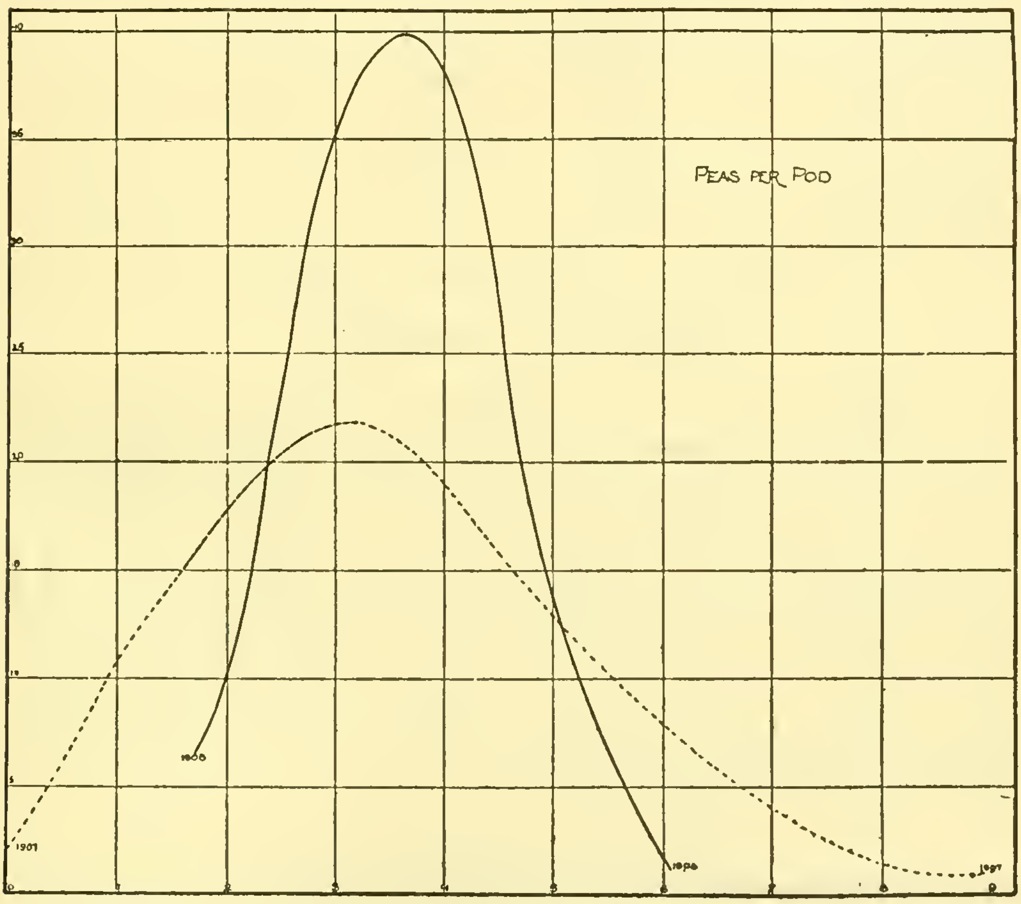

Fig. 3.

plainly in these figures. Inasmuch as the crop was grown on dry, gravelly land these effects of drought were intensified. The length of vines was therefore much shorter, the number of pods generally less and the peas per pod fewer, than in 1907. This need not affect the amount and character of variations, however. When the data are exhibited graphically, as in Figs. 1, 2 and 3, the curves of 1907 and of 1908 ought to show some plain correspondence.

An inspection of the graphs will show that this is the actual result. The curves for 1908 show smaller plants with fewer pods, but there is, nevertheless, a very striking similarity in the scope and character of variation in the two years. (See Figs. 1, 2 and 3.)

The general character of the results may also be seen from the following table: —

Variation in Peas.

	Length of Vine (Centimeters).	Number of Pods per Vine.	Length of Pod (Centimeters).	Number of Peas per Pod.
Minimum, 1907, . . .	20.000	1.000	2.00	-
Minimum, 1908, . . .	19.000	1.000	2.00	-
Maximum, 1907, . . .	88.000	13.000	9.50	9.00
Maximum, 1908, . . .	61.000	12.000	8.00	8.00
Average, 1907, . . .	54.700	4.680	6.88	3.46
Average, 1908, . . .	38.218	3.908	6.10	3.44

179 vines studied in 1907; 225 vines studied in 1908.

Differences in Variability.

A striking feature in this experiment — as in most others of a similar sort — comes out in the marked differences of variability in different groups of progeny. For example, if we consider the total product in peas per vine, we may compute that the progeny of parent C showed more than double the amount of variation found among the progeny of parent B or J. These figures are so interesting that they are given in full in the following table. (Coefficient of variability is equal to standard deviation divided by the mean.)

Coefficients of Variability.

	Vine Length.	Pods per Vine.	Peas per Pod.	Total Peas.
Parent A, . . .	12.1	25.3	6.73	40.6
Parent B, ...	14.1	10.1	6.41	23.7
Parent C, ...	11.8	52.1	6.80	49.0
Parent D, ...	15.8	8.1	8.20	41.7
Parent E, ...	20.2	9.1	28.30	46.2
Parent G, ...	14.7	16.7	25.00	31.3
Parent H, ...	15.1	8.0	6.80	40.2
Parent J, ...	10.1	6.3	9.98	23.9
Parent K, ...	8.8	7.4	5.67	27.7

Studies in Heredity.

From the beginning of this experiment careful studies in heredity have been planned. As this year's report covers only the second generation of peas no very conclusive results could be expected. It must be confessed, however, that the figures for this year not only lack conclusiveness but they are decidedly confusing. It was to be expected, of course, that the progeny of prolific vines would be more prolific than those from unprolific vines, and that plants which in 1907 gave a large number of peas per pod would yield progeny in 1908 with relatively large numbers of peas per pod. As a matter of record, this reasonable expectation of heredity was not fulfilled to a degree which would satisfy any practical plant breeder.

The measure of heredity is best computed by the methods introduced by Galton, and improved by Pearson in England, and now used largely among scientific plant breeders in America. This method involves somewhat complicated mathematics, which we need not take up here.[1] It will be sufficient if we explain that absolutely perfect inheritance (which never occurs) would be represented by the integer 1, and that various degrees of heredity would be measured by decimal fractions or percentages running down from 1 to 0. It may be said, further, that careful studies of most subjects where heredity is known to operate normally show coefficients varying from .15 to .52 or .53, but a coefficient as large as .50 seems to be rare. In human beings, for example, heredity seems to run at about .30. Certain computations will even show slightly negative results; but unless the figures are large, such negative coefficients indicate only that heredity has been practically obliterated with respect to the individuals and the characters under examination.

The coefficients of heredity shown in the pea progeny of 1908 were as follows: —

Coefficients of Heredity.

Length of vine,	+.170
Pods per vine,	+.158
Peas per pod,	—.083
Total peas per vine,	+.035

[1] Any one wishing to study this method of measuring heredity may consult E. Davenport's Principles of Breeding, p. 486.

While these are average results, there were, as always, some exceptional cases of individual vines which showed a marked ability to transmit their individual characters to their offspring. The selection of such prepotent plants is evidently an important matter in plant breeding. In order to exhibit this difference we have computed a coefficient of heredity for each parent and for each character under study, as shown in the following table. These computations were made from the following formula: —

$$C = \frac{1}{\sigma D}$$

In this formula

C = Coefficient of heredity.
σ = Standard deviation of offspring.
D = Difference between numerical value of the parent character and mean of the same character in the progeny.

Coefficients of Heredity.

	Vine Length.	Pods per Vine.	Peas per Pod.	Total Peas.
Parent A,	.0068	.145	8.33	.0066
Parent B,	.0085	.011	54.34	.0269
Parent C,	.0106	.104	.43	.0063
Parent D,	.0086	.512	7.14	.0125
Parent E,	.0042	3.003	.41	.0158
Parent G,	.0605	.327	.68	.0075
Parent H,	.0071	.490	4.00	.0067
Parent J,	.0095	5.555	2.08	.0274
Parent K,	.0250	14.285	8.70	.0675

In examining this table it must be understood that only the coefficients in the same vertical columns are directly comparable with one another.

It will be seen that with respect to length of vine parents G, K and C were the most prepotent; that with respect to the production of pods parents K, J and E were the most prepotent; that in the matter of peas per pod parents B, K and A were the most prepotent; that as to total peas parents K, J and B take the lead.

One very striking point in this comparison lies in the fact that individual parents vary so much in the transmission of different characters. For example, parent B stands at the head in the transmission of the character "peas per pod" and at the foot for "pods per vine." Similar lack of correspondence is seen in many other cases. These facts, however, surprising though they may seem at first sight, really conform to the more modern theories of heredity, in which it is understood that different characters are often transmitted as independent units.

Nevertheless, some interesting observations on the other side should not be overlooked. Parent K, for example, stands at the head in the transmission of two of the qualities studied, and stands second for the other two. Parent J also stands second in the transmission of two characters. On the other hand, parent C shows the minimum power of transmission in one character and stands next to the foot in two others. Parent E falls to the minimum place in two characters, though ranking fairly high in the other two. From these figures it would appear fair to give K the sweepstakes prize for all-round prepotency.

THE INFLUENCE OF STOCK ON CION IN THE GRAFTAGE OF PLUMS.

BY F. A. WAUGH.

One of the most interesting questions in the whole field of horticulture is that of the mutual influences of stock on cion or of cion on stock in the common practice of graftage. This question has long been the subject of speculation and study in the horticultural world, but really definite results have been so hard to secure that the whole field still presents more of doubt than of certainty. Several years ago the writer, then connected with the Vermont Agricultural Experiment Station, began a series of experiments in cross-grafting plums, designed to throw some light on these problems. These experiments have been continued in one form or another ever since, and are still under way in the department of horticulture, Massachusetts experiment station.

In one particular experiment, begun in 1898, the comparisons proved most convincing and instructive. In this case five different varieties of plums were grafted upon four different kinds of stocks, and very distinct modifications resulted, both from the influence of cion on stock and of stock on cion. These results have been reported from time to time in the publications of the Vermont experiment station.[1] The trees in this experiment were planted in orchard form on the grounds of the Vermont experiment station, where a number of them are still standing. Through the kind permission of the officers of that station (Director J. L. Hills and Horticulturist Wm. Stuart) the present writer has been enabled to renew his studies on the trees still living. During the summer of 1908 a large number of measure-

[1] Vermont experiment station report 13; pp. 333–354 (1900); 14; pp. 257–269 (1901); 15; pp. 249–260 (1902); 18; pp. 300–305 (1905).

ments were made by Mr. C. S. Pomeroy, then assistant in horticulture in the Massachusetts experiment station, and these measurements form the basis of the detailed comparisons following.

It will be proper to preface these notes further by saying that the measurements herein reported are arbitrarily confined to the one variety Milton, as grafted on (*a*) Americana stocks, (*b*) Wayland stocks, (*c*) Marianna stocks, (*d*) peach stocks. Other varieties cross-grafted on these same stocks showed substantially the same modifications.

Form of Leaf.

Critical examination shows that the trees were profoundly modified in many directions by the stocks on which they were grafted. One of the characters chosen for special study was the form and size of the leaf. The average size of leaves, taken from several hundred measurements, is shown in the following table: —

Length and Breadth of Leaves.

	Length (Millimeters).	Breadth (Millimeters).
On Americana, ...	72.05	27.20
On Wayland, ...	73.50	28.22
On Marianna, ...	74.40	34.02
On peach, ...	76.30	31.56

These measurements show at once the greater relative and positive breadth of the leaves of trees growing in Marianna stocks.

In order to show more clearly the variation in form, — a modification distinctly manifest to the eye, — measurements of breadth were taken not only at the middle of each leaf, but also at distances from the base equal to one-tenth the total leaf length and two-tenths and three-tenths the total length. Similarly, breadth measurements were made one-tenth, two-tenths and three-tenths of the leaf length from the tip. The numerical averages of these measurements need not be given here since the results may be so much more easily understood from the graphic presentation in Fig. 1. Here the averages are presented as actual leaf forms, so that each diagram shows the average form of leaf in its respective class. Where it is understood that these averages are taken from a large number of measurements, and

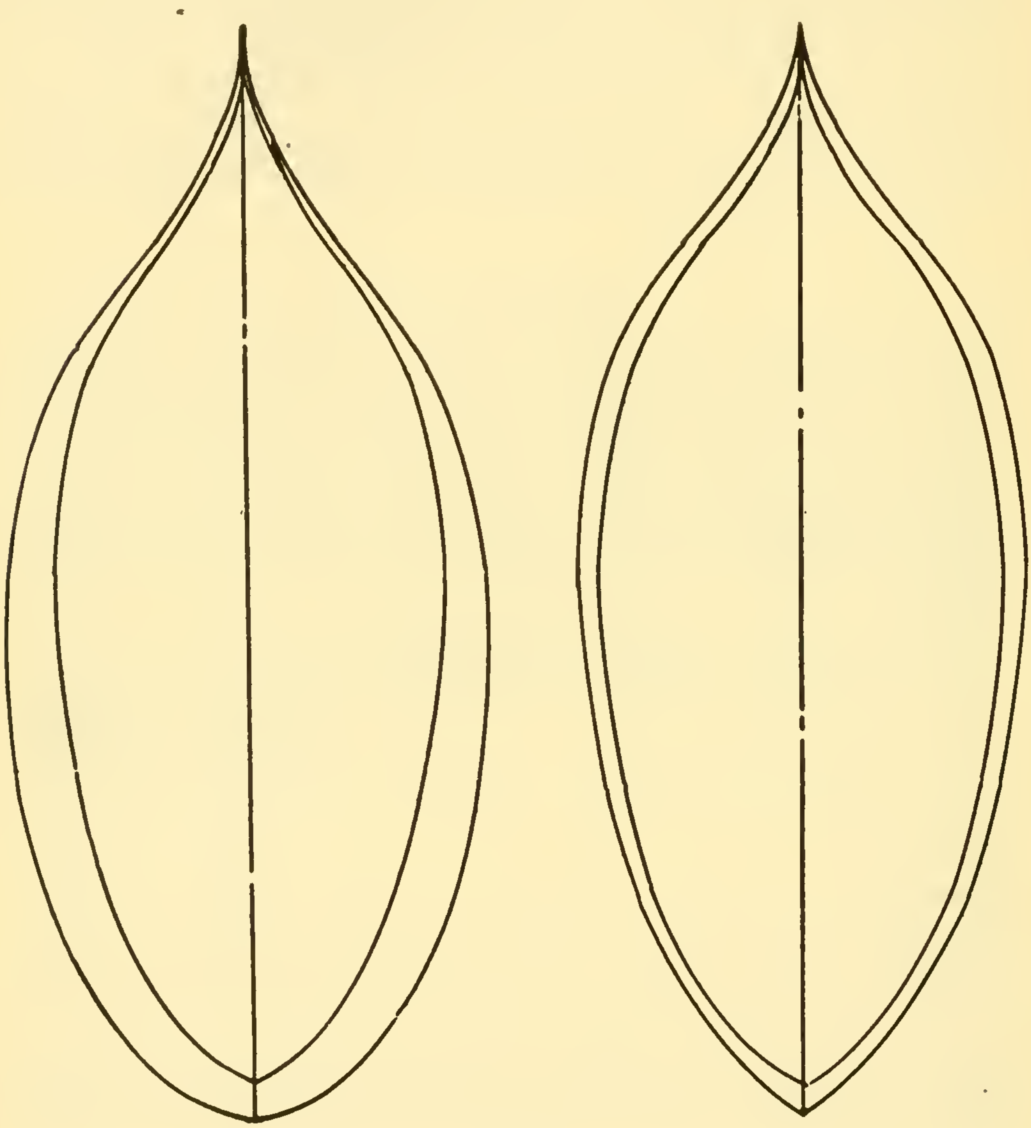

FIG. 1.

that the modifications are due, so far as can possibly be seen, solely to the influence of the stocks on which the trees are growing, it will be manifest that a distinct addition is made to the knowledge of this subject.

Marginal Serrations.

Not only are the leaves in different lots different in size and form, but they differ also in color. This difference, though easily demonstrated to the naked eye, cannot be so easily measured and recorded statistically. There is also a remarkable difference in the marginal serrations in leaves from trees on different stocks. Tracings of typical leaf margins are compared in Fig. 2. By measuring the length of a large number of leaf

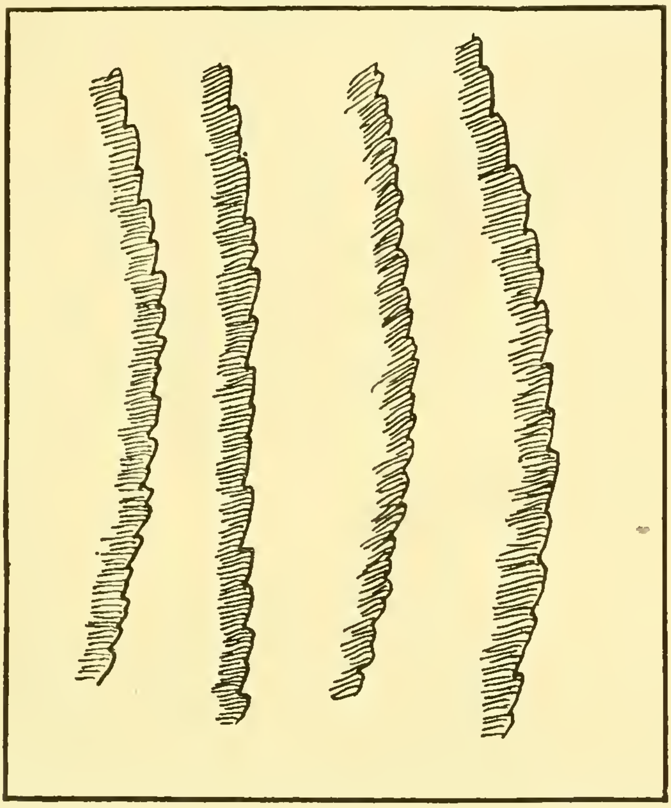

FIG. 2.

serrations in each lot, averages have been secured which will serve for numerical comparison. In order to secure these measurements with reasonable accuracy the leaf margins were considerably magnified. On this account the units used in the following comparison are arbitrary and need not be regarded. (They were approximately one-eightieth of an inch.)

Comparison of Marginal Serrations.

	Average.	Standard Deviation.
On Americana,	38.00	9.32
On Wayland,	35.08	8.11
On Marianna,	31.02	5.39
On peach,	34.75	6.65

The "standard deviation" shown in the right-hand column above will be easily understood by students of plant variation. Roughly, it may be taken as the average deviation from the mean.

The figures show, therefore, that the marginal serrations on Milton plum leaves are much larger and much more variable when Milton plum is worked on Americana stocks than when it is worked on Wayland, Marianna or peach. On Marianna the serrations are finest and least variable.

Now, leaf margin characters are generally taken by botanists to be of special importance in determining species and varieties. That is, they are thought to be relatively constant. Moreover, leaf margin characters are of special significance in the genus Prunus, to which all the true plums belong. These curious modifications, therefore, due almost certainly to the influence of the various stocks, show conclusively that such influences may be profound and far-reaching.

Rate of Growth.

The horticulturist will be more interested in the rate of growth than in marginal serrations. Here, also, the influences of the various stocks are traceable. Unfortunately, our measurements include only three of the stocks in the experiment, the peach being omitted. The average annual growth, taken in centimeters, together with the standard deviation, is shown below: —

Annual Growth.

	Average (Centimeters).	Standard Deviation (Centimeters).
On Americana,	103.45	35.62
On Wayland,	106.14	56.54
On Marianna,	149.30	57.90

It is seen at once that the annual growth of Milton plum on Marianna stocks is much greater than on Americana or Wayland, with somewhat greater variation. These averages, with their respective deviations, may be more convincingly shown, at least to students used to modern plant breeders' methods, by representing them graphically. In Fig. 3 are shown three curves, each representing the variation in one of the lots measured for annual growth. These curves bring out more forcibly than the arithmetical averages the remarkable differences in

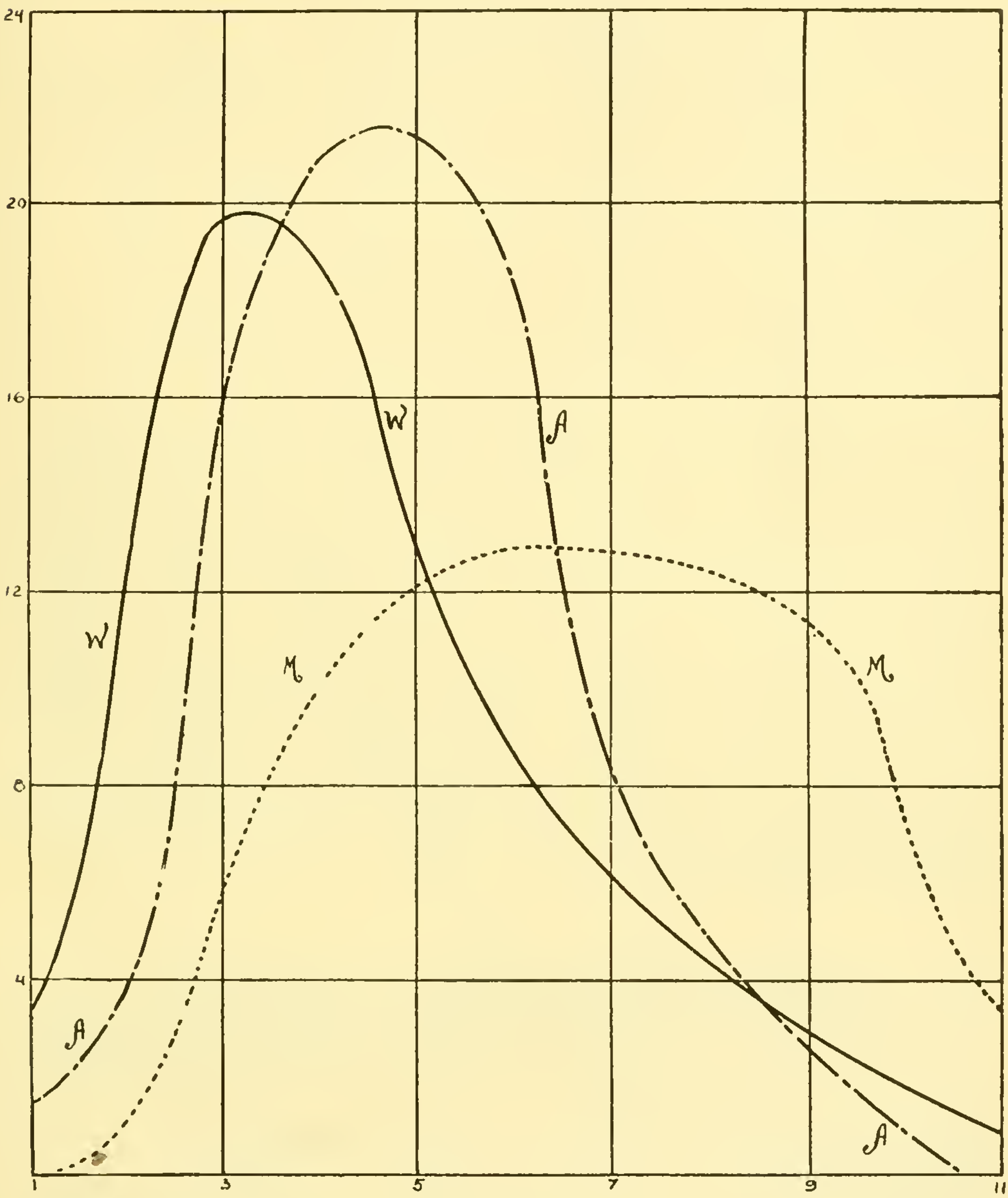

Fig. 3.

growth between the different lots, more especially between the trees on Marianna and those on the other two stocks.

Just in passing it may be observed that the two lots on Americana and on Wayland have behaved much alike in all respects from the beginning, while the lot on Marianna roots has shown the most marked changes.

The difference in growth may be shown further by the difference in the length of internodes (or joints) in the wood. A large number of measurements were made of the internodes of one-year-old wood, with the following results: —

Length of Internodes.

	Average (Centimeters).	Standard Deviation (Centimeters).
On Americana, ...	9.60	6.85
On Wayland, ...	10.92	8.87
On Marianna, ...	15.80	10.47

These figures show a much ranker, more vigorous growth in trees on Marianna stocks than on the others. There is also a greater amount of variation. The striking differences in the growth of internodes, however, are again shown most forcibly by representing all the measurements graphically, as is done in Fig. 4.

This difference in growth comes out in every point where measurements can be taken. For example, the diameter of a large number of branches was measured on two-year-old, on three-year-old and on four-year-old wood. The average measurements are shown below: —

Caliper Measurements of Branches (Centimeters).

	Two Years.	Three Years.	Four Years.
On Americana, ...	3.92	5.55	7.63
On Wayland, ...	3.90	5.19	7.25
On Marianna, ...	4.76	6.19	8.13

These measurements of the diameter of branches reveal once more the fact that Milton plum trees grow much more vigorously on Marianna roots than on Americana or Wayland.

Summary.

These studies show, by careful and accurate measurements, and by more thorough methods than any hitherto applied to this subject, that distinct modifications do occur in plum trees due

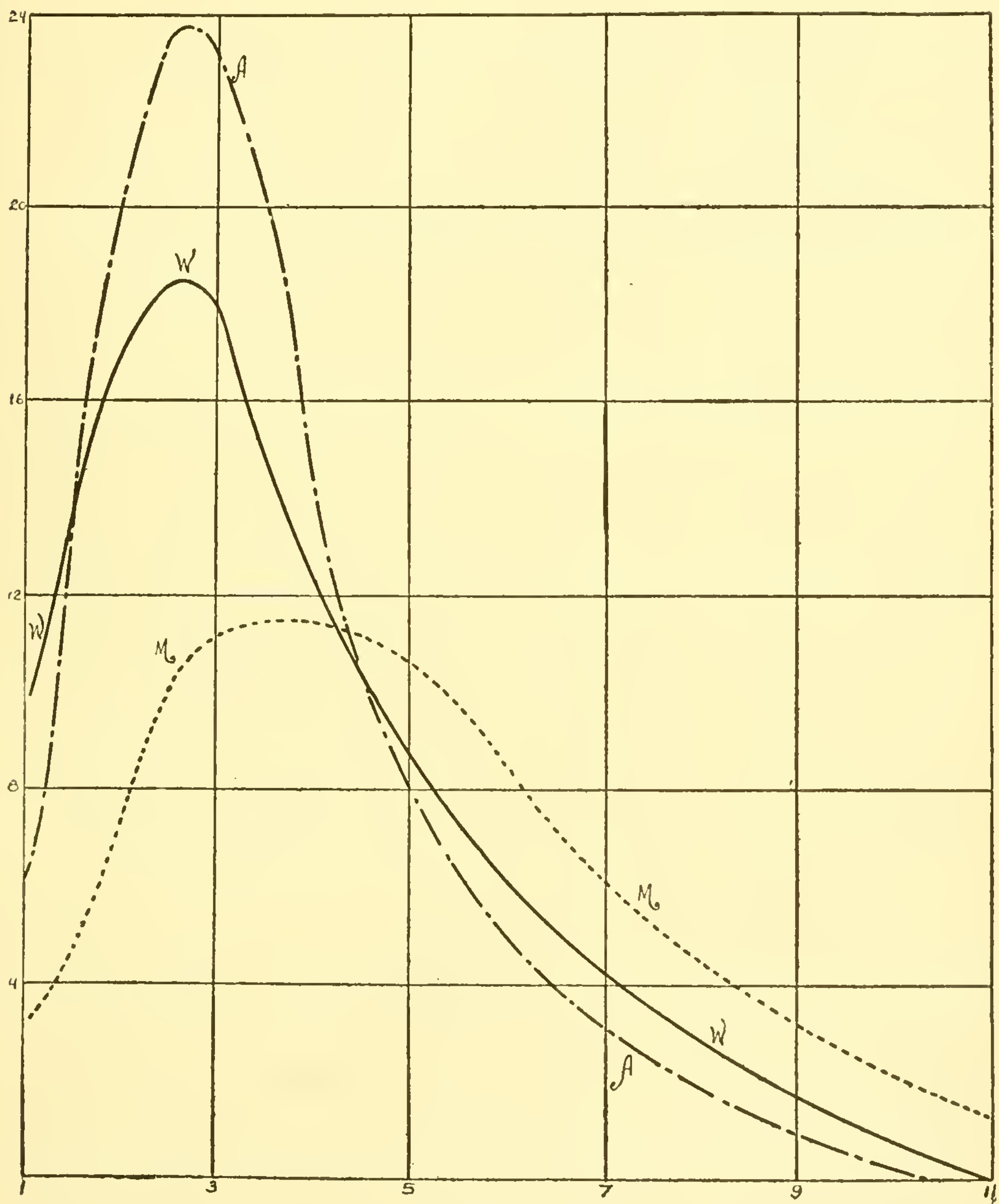

Fig. 4.

to the influence of the stocks in which they are grafted. These influences appear to extend to all characters of leaf, twig, habit of growth, etc. Unfortunately, the present writer has not been able to make equally careful observations of the fruit; but in general terms it may be said that the fruit is modified also. The Marianna stock in particular seems to produce the most obvious changes in the growth of plums worked on it. In the experiments here under observation these changes are as follows: —

1. Broader leaves.
2. Finer marginal serrations.
3. Greater annual growth.
4. Larger internodes.
5. Greater diameter of branches.
6. Greater variability in all characters.

CATTLE POISONING FROM ARSENATE OF LEAD.

JAS. B. PAIGE, D.V.S.[1]

Ever since farmers began using arsenic compounds for the destruction of insect pests there has been considerable discussion as to the possibilities and probabilities of farm animals becoming poisoned from eating the poisoned foliage of the sprayed plants or the grass grown under trees that have been treated with arsenical preparations. This discussion began with the use of Paris green and London purple, used for the destruction of potato bugs and codling moths, and has more recently included the use of the many insecticides the most of which contain some form of arsenic. As early as 1889 Prof. A. J. Cook of the Michigan Agricultural Experiment Station, giving the results of extensive experiments to test the efficiency of Paris green, London purple and white arsenic as insecticides, in a paper read at the meeting of the Society for the Promotion of Agricultural Science at Toronto, says: " Thus we have demonstrated that the arsenites are effective against the codling moth, that in their use there is no danger of poisoning the fruit, and when used properly no danger to the foliage nor to stock that may be pastured in the orchard."

With the advent of arsenate of lead as an insecticide, in 1893, the question arose as to the dangers to stock pastured in fields where this insecticide had been used, or of the dangers of using the hay from such fields.

In " Agriculture of Massachusetts " for 1897 Mr. A. H. Kirkland, a scientist in the employ of the Gypsy Moth Commission of the State Board of Agriculture, reported a single experiment with a horse, to determine if there was danger to ani-

[1] Albert L. Whiting, of the class of 1908, had charge of the animals and attended to the feeding of the arsenate of lead while the experiment was in progress.

mals that ate the grass taken from under trees that had been sprayed with a strong mixture of arsenate of lead. The experiment consisted in taking sufficient grass for two large feeds for a horse and spreading it under a pear tree that was later sprayed with a liberal quantity of arsenate of lead, in the proportion of 20 pounds to 150 gallons of water. Not satisfied that the amount of the mixture dripping from the tree on the grass was sufficient to make the test conclusive, the grass was thoroughly drenched with the mixture direct from the nozzle of the spraying machine. The treated grass was fed to a 1,200 or 1,300 pound horse during the afternoon and evening of the same day that it was sprayed. Two days later the animal was found to be well and hearty, and reported by the teamsters to be in better condition than before the grass had been eaten. The burning effect of the spray upon the foliage of the pear tree proved that there was considerable soluble arsenic present, which would render the arsenate of lead much more poisonous to animals than a properly prepared arsenate of lead that contained but little soluble arsenic.

During the past two or three years, since the revival of the gypsy moth work in the eastern part of the State, numerous letters received at the experiment station, as well as newspaper articles and reports from veterinarians, have suggested that farm animals were being poisoned from the ingestion of grass and foliage of shrubs sprayed with arsenate of lead, used in the destruction of the gypsy moth.

To determine whether or not this was the case the experiment station began a series of experiments in 1907 to ascertain what effect arsenate of lead would have upon cattle when given in small doses for a long time or when given in large single doses.

The cattle used in the experiment were animals that had been condemned as tuberculous by the inspectors of the Cattle Bureau of the State Board of Agriculture. These were placed at the disposal of the experiment station by the courtesy of Dr. Austin Peters, Chief of the Cattle Bureau, and were in every instance subjected to a careful post-mortem examination, to note the effects of the arsenate of lead and to determine whether or not tuberculosis was present.

The arsenate of lead used in the experiment was manufactured by the Bowker Insecticide Company of Boston, and sold under the trade name of Disparene. Its composition, according to John P. Street of the Connecticut Experiment Station, Bulletin No. 157, September, 1907, is as follows: —

Original Material.

Water,	46.47
Arsenic oxide (AS_2O_5),	13.87
Lead oxide (PbO),	35.11
Soluble impurities (other than AS_2O_5 PbO),	4.34
Insoluble impurities (by difference),	.21
Soluble arsenic oxide,	.39
Water Free: —	
Arsenic oxide (AS_2O_5),	25.91
Lead oxide (PbO),	65.59
Total impurities,	8.50

Before the actual feeding of the arsenate of lead was begun all available literature thought likely to give some information bearing on the experiment was reviewed, but nothing of importance other than that already mentioned was discovered to indicate the probable poisonous dose, the effects of administration or the pathological changes produced. The fact that the compound is a comparatively new one (1893), and is used almost exclusively as an insecticide, probably accounts for the absence of any mention of it in the latest works on toxicology. Even "Merck's Index" for 1907 fails to include it in its list of drugs and chemicals.

As previously mentioned, the experiment was carried on to determine the effects produced by long-continued administration of small doses of the compound, such as an animal might get by eating for a long time foliage, grass or hay carrying but limited quantities of the arsenate of lead, and the effects of large amounts given at one dose.

Five mature cows were used in the experiment, that were designated by the numerals 1 to 5. For purposes of reference the details of the experiment with each animal are published in full. A general summary follows the details.

Record of No. 1 (Red Grade).

November 16, weight 600 pounds; November 23, weight 597 pounds.

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
1907.					
Nov. 12 to Dec. 1, .	1	In grain, .	20	- -	November 26 samples of milk and urine taken for analysis.
Dec. 1 to Dec. 4, .	1	On rowen, .	3	- -	- -
Dec. 4 to Dec. 8, .	1	In potato, .	3	Off feed.	- -
Dec. 8 to Dec. 12, .	-	-	-	Refused all food,	Paraplegia developed and continued until time of death.
Dec. 12 to Dec. 14,	1	In beet and apple.	3	Purging violently; feces bloody and coated with mucus.	- -
Dec. 14 to Dec. 22,	-	-	-	Refused food and water.	Died at 10.30 A.M.
			29		

December 23, 9.30 A.M., autopsy. Principal lesions: lungs extensively tuberculous; extensive fibrous inflammation of serous coat of first stomach; small intestines engorged with dark blood but free from evidences of inflammation, such as infiltration, or presence of bloody exudate on mucous surfaces; liver enlarged and filled with dark blood. The muscular tissue under skin showed numerous ecchymoses.

When first brought to the veterinary hospital, although in fair flesh, the animal showed fairly well-defined physical symptoms of pulmonary tuberculosis; with the development of the disease there was a gradual loss of weight. The loss of appetite, violent purgation and paraplegia were evidently due to poisoning with the arsenate of lead.

A chemical analysis of small samples of milk and urine taken on November 26, after 15 grams of lead arsenate had been administered, failed to reveal the presence of either lead or arsenic.

Record of No. 2 (Jersey).

November 16, weight 540 pounds; November 23, weight 545 pounds.

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
1907.					
Nov. 12 to Dec. 15,	.5	In grain, .	16.5	Off feed; slight paraplegia.	From November 23 there was a gradual loss of weight.
Dec. 19, . .	-	-	-	Purging violently; eating a small amount.	- -
			16.5		

December 23, owing to emaciation and paralysis, animal was killed, and autopsy held. Principal lesions: lungs badly tuberculous; mucous membrane of fourth stomach thickened, infiltrated and reddened. Portions of liver, kidney and spleen submitted to chemical examination were found to contain an abundance of lead and traces of arsenic.

Record of No. 3 (Collins Shorthorn).

December 14, weight 1,015 pounds. Dry, and not in calf.

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
Dec. 11, 1907, to Jan. 18, 1908.	2	In grain, on rowen and in gelatine capsule inside roots.	76	-	Normal respiration deep and labored.
1908. Jan. 18 to Feb. 4,	3		51	-	Increase to 3 grams caused no noticeable change.
Feb. 4 to Feb. 10,	4	Capsule in roots.	24	Slightly off feed and purging.	Repeated attempts made to increase dose to 3 or more grams, without success.
Feb. 10 to Feb. 16,	2	Capsule in roots.	14	Violent purging, continuing to February 27. Feces liquid and tinged with blood at times.	February 15 to 20 little or no food or water taken.
Feb. 16 to Mar. 22,	-	-	-	February 27, less purging; appetite returning; March 1, taking nearly full amounts of feed and water.	Improvement in flesh and spirit quite marked; unsteadiness and inclination to remain recumbent quite noticeable; continued throughout experiment.
Mar. 22 to Mar. 24,	3	Capsule in roots.	6	-	-
Mar. 25,	1½	Capsule in roots.	1½	-	-
Mar. 26 to Mar. 27,	3	Capsule in roots.	6	-	-
Mar. 28,	1½	Capsule in roots.	1½	-	-
Mar. 29 to Apr. 4,	-	-	-	Refused food and water.	-
Apr. 5 to Apr. 6,	2	Capsule in roots.	4	-	-
Apr. 6 to May 19,	-	-	-	-	April 25, sample of urine collected for chemical analysis; May 4, feeding well; May 18, all food withheld.
May 19,	50.4	On hay,	50.4	-	Ten pounds of hay sprinkled with mixture of 56 grams of arsenate of lead in water; allowed to dry, then fed in two portions; all but 1 pound of hay eaten.
May 20,	-	-	-	Off feed and purging.	-
May 21 to June 1,	-	-	-	Violent purging; feces liquid and bloody; refused to eat or drink to any extent.	-
June 1 to June 8,	-	-	-	Feces approaching normal; still refuses food and water.	-
			234.4		

Animal killed June 8, 1908; autopsy at time of slaughter. Body fairly well nourished, weight 900 pounds (estimated). No external lesions except on prominent parts that came in contact with the cement floor. About one pail full of watery material, brown in color, escaped from mouth after death. An abundance of fat found on removal of skin; muscle tissue red in color and well developed. On opening abdominal cavity no alterations found. Urino-genital organs normal in size and texture. Bladder contained about one pint of straw-colored urine. Kidneys firm, and gross portions represented nothing abnormal. Ureters pervious. First, second, third and fourth stomachs all contained food material in abundance, consisting of well-masticated hay and grain. First and fourth stomachs contained an abundance of watery fluid; second stomach contained 15 to 20 shingle nails, somewhat eroded; contents of third stomach not as dry and hard as usually found, still sufficiently firm to retain shape when removed from organ. Mucous membranes firm and adherent in all parts; that of the fourth stomach slightly reddened. Intestines, both large and small, smooth and glistening on outer portion; walls not thickened but somewhat reddened. Mucous membrane firm and dark in color. Contents thin and semifluid. Liver dark red, firm and well filled with blood. Vessels open. Gall bladder large and distended with one quart of dark green, ropy bile. Bile duct pervious. Spleen firm and free from any gross lesions. Lymphatics and blood vessels of the abdominal cavity showed no abnormalities. Thoracic cavity, heart and lungs free, and pleural surfaces smooth and glistening. Lungs light and puffy and of a dark pink color. On manipulation six or eight hard areas, size of English walnut, found in lung substance. On section these hard areas were found to contain yellow caseous material, surrounded with thick wall of fibrous tissue. Lungs on section found filled with air. Air tracts contained some frothy material. Pericardium smooth and normal in thickness; on section found to contain one ounce of serous fluid. Heart muscle firm and uniformly red in color. Little blood present in any of the cavities. Bronchial and mediastinal lymph glands size of English walnuts, hard and firm, and on section dotted throughout with yellow areas and distinctly calcareous. Trachea and œsophagus normal. Mouth contained about one pound of coarse, partially masticated hay, apparently returned from stomach at or shortly prior to time of death. Tongue, teeth and throat organs free from lesions.

Diagnosis: tuberculosis and slight gastro-enteritis.

Temperature Chart of No. 3 (Collins Shorthorn).

One week, February 24 to March 1.

Date.	Temperature (Degrees F.) and Time of Day.					Pulse.
1908.	7 A.M.	11.30 A.M.	4 P.M.	6 P.M.	10 P.M.	
Feb. 24,	–	100	–	101.3	–	50, weak, thready.
Feb. 25,	100.3	–	101.3	–	102	46, weak, soft.
Feb. 26,	102.3	–	–	103.0	–	54, weak, thready.
Feb. 27,	103.2	–	–	102.0	–	55, weak, thready.
Feb. 28,	101.0	–	–	102.0	–	–
Feb. 29,	–	–	–	100.2	–	–
Mar. 1,	–	–	–	101.2	–	–

Record of Tuberculin Test of No. 3 (Collins Shorthorn), May 3 and 4.

Normal Temperature (Degrees F.), 10 P.M.	U. S., B. A. I. Tuberculin, 10 P.M.	Temperature (Degrees F.) after Injection.							
		A.M.			P.M.				
		6.30	8.30	10.30	12.30	2.30	4.30	6.30	8.30
101.4	2 c. c.	104.3	105.2	105.2	103.2	105.1	106.1	105	104.4

Record of No. 4 (Black Jersey).

January 18, weight estimated at 600 pounds. In fair flesh, giving liberal quantity of milk. Slight physical symptoms of tuberculosis.

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
1908.					
Jan. 18,	28.35	In gelatin capsule.	28.35	– –	Dose administered as pill at 9.45 A.M.
Jan. 19,	–	–	–	Purging; feces thin and much mucus present.	– –
Jan. 20,	–	–	–	Violent purging; feces bloody; milk decreased. Temperature 11 A.M. 101.1; 7 P.M. 102.	– –
Jan. 21,	–	–	–	Feces approaching normal. Temperature 11 A.M. 101.4; 7 P.M. 101.2.	– –
Jan. 22,	–	–	–	Recurrence of purgation; eating and drinking but little. Temperature 11 A.M. 102; 7 P.M. 102.	– –
Jan. 23,	–	–	–	Less purging; milk flow slightly increased. Temperature 6.30 P.M. 101.3.	– –

Record of No. 4 (Black Jersey) — Concluded.

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
1908.					
Jan. 24,	-	-	-	Little or no purgation; appetite improving.	- -
Jan. 25 to Mar. 22,	-	-	-	Gradual improvement from day to day.	- -
Mar. 22 to Mar. 26,	2.00	In grain,	8.00	- -	- -
Mar. 26,	1.00	In grain,	1.00	- -	- -
Mar. 27 to Apr. 19,	2.00	In grain,	48.00	- -	- -
Apr. 19 to Apr. 22,	-	-	-	- -	Milk taken for chemical analysis.
Apr. 22 to Apr. 24,	2.00	In grain,	4.00	- -	- -
Apr. 24,	1.00	In grain,	1.00	- -	Urine taken for analysis.
Apr. 25 to May 3,	2.00	In grain,	16.00	- -	- -
May 3,	1.00	-	1.00	- -	Tuberculin tested.
May 4,	-	-	-	- -	- -
May 5 to May 17,	2.00	In grain,	26.00	- -	- -
May 18,	-	-	-	- -	All food withheld.
May 19,	19.80	On hay,	19.80+	- -	Ten pounds of hay drenched with mixture of 28.35 grams of lead arsenate in water, allowed to dry and fed in two portions, morning and night; three pounds not eaten.
May 20 to May 28,	-	-	-	Passing dark, bloody, liquid feces; refuses food and water, except small quantities of grain and a very little water near last date; purgation very slight on 27 and 28.	From time arsenate was given in small doses animal unsteady on hind legs and inclined to remain lying much of the time.
			153.15+		

May 28 animal slaughtered and autopsy made. Principal lesions: small tubercular nodule in lobe of lung; indications of the irritant and poisoning action of arsenate of lead few. Blackening of the gums about the incisor teeth quite pronounced in this animal; not found in any of the others.

Record of Tuberculin Test of No. 4 (Black Jersey), May 3 and 4.

Normal Temperature (Degrees F.) 10 P.M.	U. S., B. A. I. Tuberculin.	Temperature (Degrees F.) after Injection.						
		A.M.			P.M.			
		6.30	8.30	10.30	12.30	2.30	4.30	6.30
102	2 c. c.	105.3	108	106.2	106.3	106.3	106.3	105.4

Tuberculin tests were made by senior students of veterinary class.

Record of No. 5 (Fawn Jersey).

February 24, weight 600 pounds (estimated).

Date.	Grams per Day.	How given.	Total in Grams.	Symptoms.	Remarks.
1908. Feb. 24, . .	56.70	In capsule, .	56.70	–	Dose given as pill at 11.30 A.M.

On February 25, during early part of forenoon ate considerable hay and grain. At night all food and water refused. Purgation violent; feces liquid and contained liberal quantities of blood and mucus; blood clots abundant.

On February 26, early morning, marked shivering of body muscles; unsteady on feet, more especially hind feet; breathing deep, labored and stertorous. During the morning marked symptoms of paraplegia appeared, which became so aggravated that animal at times had great difficulty in maintaining standing position. Toward evening all of the above symptoms were more marked, and those of intestinal pain became prominent, such as stepping about uneasily, looking at the flanks, switching of the tail, moaning, etc. Throughout the night of the 26th and the early morning hours of the 27th the symptoms of intestinal irritation, pain and paralysis became more pronounced. Purgation continued to the time of death. There was but a small amount of urine passed. Death occurred at 9 o'clock on the morning of the 27th.

Autopsy six hours after death. No lesions of external parts except on withers, where there were found two or three surface abrasions. Animal six or seven years old, body somewhat emaciated, estimated weight 550 to 575 pounds. On removal of skin only a moderate amount of fat found; muscles poorly nourished and dark in color. All surface veins distended with dark, slightly clotted blood. Muscle and subcutaneous tissues corresponding in location to surface lesions on withers, dark in color and infiltrated with blood and serum. Submaxillary lymphatic gland on right side the size of a large orange. On section, enclosed in fibrous walls three-eighths of an inch in thickness was one ounce of thick, yellow, creamy pus. Two post-pharyngeal lymphatic glands enlarged to size of small orange, hard and tense, and on section found to contain infiltration of yellow caseous material, slightly calcareous.

On opening the abdominal cavity but a small amount of fluid found (one or two ounces). No foreign material or displacements observed. Serous surface of second stomach reddened and slightly coated with fibrinous exudate. On opening first stomach an abundance of moist, yellowish-green food material, consisting of well-masticated hay and grain, was found. Mucous membrane adherent and light in color. On section of second stomach it was found to contain little or no food material; the mucous membrane was moist, thickened and gelatinous, due to an infiltration with bloody, fibrinous exudate. The third stomach was full of ingesta, well distributed between the leaves and of normal consistence. Mucous membrane throughout slightly thickened and red in color. The fourth stomach somewhat distended, the serous covering showing superficial blood vessels filled with dark blood. On section, contents fluid and blood stained. The small intestines externally were reddened and slightly ecchymotic. Mucous membrane injected with dark blood, thickened and gelatinous. Intestinal contents fluid, having the color of a mixture of chocolate and milk. The serous and mucous surfaces of the large intestines were free from any lesions, the contents moist and dark in color. Only a moderate amount of ingesta present.

The liver, apparently normal in size, presented a smooth, glistening surface with well-rounded borders. The consistence was normal. The incised surfaces were moderately dark in color, with ducts free and open. The gall bladder contained about two ounces of liquid bile, green in color. Gall duct pervious. Spleen surface smooth and glistening, firm to the touch. On sectioning cut surfaces reddish brown in color, with stroma and pulp apparently normal.

The kidneys were firm in consistence, with the capsule free and detachable. The internal portion appeared normal, the medullary and cortical parts distinct and unchanged. Ureters pervious. Bladder empty and contracted. Membrane pale.

The thoracic cavity contained a few ounces of serous fluid. Lungs not adherent to chest wall. Lung surfaces smooth and moist, free from fibrous exudate. On palpation several small hard areas were discovered scattered throughout the lung substance. On section the tissue was found red in color, and contained considerable quantities of dark blood. The bronchi and bronchial tubes contained small amounts of frothy material. The hardened portions found on palpation were found to consist of masses of caseous material enclosed in fibrous walls. On cutting these tumor-like masses there was evidence of calcareous infiltration. The bronchial and mediastinal lymphatic glands were enlarged and streaked with yellow caseous matter, and somewhat calcareous.

The pericardium externally was free from evidences of inflammation and contained one-half an ounce of serous fluid. Heart muscle firm and red in color. The cavities of the left side contained small clots of dark blood, those of the right side were empty. Valves smooth and white. The trachea, larynx, pharynx, tongue, oral and nasal cavities were free from lesions.

Diagnosis: tuberculosis and acute gastro-enteritis.

Chemical Analyses.[1]

As indicated in the tabulated records, several samples of material from different sources were collected for chemical examination, to determine the presence or absence of either of the essential constituents of arsenate of lead.

From cow No. 1 both urine and milk were analyzed after the animal had received, in small daily doses, 15 grams of the arsenate. Neither arsenic nor lead was present. It should be noted in connection with this analysis that only a few ounces of urine and milk were sent for examination. At the suggestion of the chemist, in the collection of all later samples larger amounts of material were taken.

From cow No. 2 were furnished samples of tissue, consisting of portions of the liver, kidneys and spleen. The parts from the different organs were analyzed as a composite specimen, which was found to contain abundance of lead and traces of arsenic.

From cows Nos. 3 and 4 samples of milk and urine were taken on April 22, 24 and 25. No. 3 had been receiving small doses of the arsenate since December 11, and had taken a total of 184 grams. No. 4 supplied both milk and urine for analysis. She had received one dose of 28.35 grams on January 18, and several smaller doses subsequently aggregating in all 90.35 grams. Under date of May 29, 1908, the chemist reported on the three specimens as follows: —

The sample of milk forwarded by you on the date of April 23, for a lead and arsenic test, has been analyzed. Neither of these poisons was found present in sufficient quantities to detect it by ordinary

[1] These analyses were made at the experiment station laboratories by H. D. Haskins, in charge of the Fertilizer Division.

chemical methods. The two samples of urine also submitted for lead and arsenic tests have been analyzed. Both of these samples showed a reaction for lead and arsenic, but not to the extent that I had anticipated; only small quantities of either of these poisons were found present. I did not attempt a quantitative determination in either case, but should judge that the sample from the red cow (No. 3) showed the larger amounts of both arsenic and lead.

The fact that a young calf, to which large quantities of the milk of cow No. 4 were fed, showed no symptoms of illness, is further evidence that arsenic and lead were not present in the milk.

Brief Summary of Symptoms.

Chronic Poisoning. — Loss of appetite, refusal of water, purgation, with feces liquid and nearly black in color, containing an abundance of mucus and blood, the latter either disintegrated or in clots, suppression of urine, progressive paraplegia, emaciation, with hair harsh and rough. There appears to be but little disturbance of the temperature functions, the maximum reading obtained being only 103.2° F. The pulse becomes somewhat accelerated and of a thready character, but is not sufficiently altered to constitute an important symptom. There is dullness of the eye and general indications of depression when the symptoms enumerated above are most in evidence, but with the elimination of the poison from the system there is a gradual return of the normal body functions, as indicated by a cessation of purgation and a return of the appetite.

Acute Poisoning. — Attack sudden, characterized by shivering, refusal of food and water, back arched, skin dry and harsh, hair erect, abdominal pain, slight elevation of temperature, pulse thready and increased to 55 or 60 beats per minute, respirations accelerated and difficult. Following these symptoms in quick succession is purgation, with feces abundant, watery, dark in color and bloody. The urine is scanty and passed only at long intervals. Paresis develops early, with the other symptoms, and is progressive, affecting the posterior portions of the body most. At this stage of development of the symptoms the head is moved about nervously, the eyeballs are retracted and glassy, there is more or less champing of the jaws, and at irregular intervals the animal suffers from convulsions, from which it falls and struggles violently. In fatal cases purgation continues, the pain becomes intense, the expression of the face more anxious, pulse faster and weaker, paralysis more marked and the convulsions more frequent and severe. Partial coma precedes death. In this stage the symptoms are less urgent, and there may be involuntary passage of urine and regurgitation of material from the stomach.

A comparison of the symptoms of acute and chronic poisoning with arsenate of lead with those of arsenic and lead, as given for cattle in Nunn's "Veterinary Toxicology," indicates that when the arsenate of lead is given the symptoms are a combination of those enumerated under both arsenic and lead poisoning. The lesions found upon post-mortem examination are perhaps to be attributed more to the action of the arsenic than the lead, particularly so in chronic cases, in which no indications of the fatty degenerations of chronic lead poisoning were observed.

Diagnosis. — The symptoms of arsenate of lead poisoning are not sufficiently unlike those of poisoning with other similar compounds, such as the salts of copper, antimony, zinc, etc., to render a diagnosis probable without a previous history of the animals having had access to the arsenate of lead in some form. With this previous history to assist and suggest the clew, in conjunction with the symptoms, a correct diagnosis should be made without difficulty.

The post-mortem findings are not sufficiently characteristic to insure a positive diagnosis without recourse to a chemical examination to prove the presence of the arsenic and lead.

Prognosis. — A careful study of the details of the experiments with the five cows, already given, shows that one should be exceedingly careful in giving a prognosis. Even in those cases in which the drug was administered in large quantities, and the symptoms became very urgent and pronounced, there was a recession of them, and a return to a condition of health after a period of convalescence of variable duration. In the cases in which there was an administration of small quantities of the compound for a long period of time, and a full development of symptoms of a serious character, there was not a fatal termination. If on account of a partial nonsusceptibility, or a rapid elimination of the lead and arsenic from the system, death does not follow shortly after the full development of the symptoms of purgation, paresis, abdominal pain, etc., a favorable prognosis may be given.

Treatment. — In these experiments no attempts were made to discover new means of treatment, or to try those already used, to overcome the poisonous effects of either lead or arsenic. The appearance of the symptoms of both lead and arsenic poisoning would indicate the use of a combination of the antidotes ordinarily employed in the treatment of arsenic and lead poisoning cases, together with such means as would tend toward prevention. For the latter, the discovery and removal of the source of the compound is all that is necessary. In the treatment of animals in which the symptoms are urgent, indicating acute poisoning, administration of those things that afford mechanical protection to the mucous membranes is indicated, such as mixtures composed of wheat flour, linseed meal, slippery elm, milk, eggs, etc. To render the unabsorbed lead or arsenic contained in the stomach insoluble or inert, sulfate of magnesia, sodium sulphide or flowers of sulphur may be given to act upon the lead, and peroxide of iron, dialized iron or hydrated magnesia to act upon the arsenic. Little can be done to counteract the action of the lead or arsenic that has already become absorbed into the blood. The poisonous effects of that absorbed are to be counteracted by general treatment having a tendency to prevent heart failure, etc. The hypodermic administration of atropine and nitroglycerine may be employed. To hasten the elimination of the poisons from the system, saline purgatives in small doses and mild diuretics should be used. In those cases of chronic poisoning, where lead has accumulated in the tissues, the administration of iodide of potassium in small, frequently repeated doses favors the elimination of it with the bile and urine. The paroxysms of colic should be relieved by hypodermic administration of morphia or the oral administration of chloral.

Liability of Poisoning. — Having demonstrated the possibilities of producing poisoning in cattle by giving arsenate of lead, the question naturally arises as to the probabilities of its happening in localities where this substance is used in liberal quantities as an insecticide. Manufacturers of arsenate of lead and entomologists recommend using about 3 pounds to 100 gallons of water for spraying. Mr. A. H. Kirkland has told me that frequently, for the destruction of gypsy moths, mixtures of 20 to 25 pounds of arsenate of lead to 100 gallons of water are used, and that it is applied either as a spray or a stream from the machines, depending largely upon the height of the trees that are being sprayed. Where the moths are numerous, and are found upon the foliage of shrubs in wood lands, these as well as the trees are sprayed. The amount of drip from sprayed trees depends very largely upon how the arsenate mixture is applied. If applied in the form of a spray, with care, less escapes from the foliage to the ground or grass beneath the sprayed trees than when applied in a stream. During the past summer the writer visited several sections in the gypsy moth district, and observed that the foliage of shrubs under trees that had been sprayed some weeks before still had a sufficient amount of arsenate of lead adhering to be easily seen by the naked eye, and was informed by one engaged in the moth work that it adhered to the foliage so tenaciously that sufficient remained after several heavy rains to kill the caterpillars.

It is at once apparent that the amount of the poison used in spraying that will accumulate upon the grass under sprayed trees will vary very greatly according to the method of application, the velocity of the wind and other circumstances, and could hardly be expected to be the same in two cases of treatment.

As stated in Bulletin No. 131 of the Colorado Experiment Station, "Arsenical Poisoning of Fruit Trees," by Dr. Wm. P. Headden, all of the arsenate applied to the foliage must eventually reach the ground, either by being washed by rains from the leaves or carried with them when they fall from the tree. Three sprayings in a season, using 10 gallons of a mixture of 6 pounds of the arsenate to 100 gallons of water for a tree, mean that eventually there will find its way to the soil 1.8 pounds of pasty lead arsenate, equivalent to .9 of a pound of dry arsenate.

A mixture of 10 pounds of arsenate of lead to 100 gallons of water contains 45.3 grams of the arsenate to the gallon. In the case of cow No. 1, 29 grams, administered at the rate of a gram per day, produced violent symptoms of poisoning. With animal No. 2, 16.5 grams, given in daily doses of one-half gram per day, caused violent purging, loss of appetite and paresis. No. 3 took

151 grams in 2, 3 and 4 gram doses daily before equally marked symptoms of poisoning appeared. With No. 4, 28.35 grams given at one dose in capsule at 9.45 A.M. produced toxic effects in less than twenty-four hours, from which the animal did not recover completely for six or seven days. In the case of No. 5, 56.70 grams caused death in sixty-nine and one-half hours. A study of the records of the five animals shows that frequently repeated small doses of the arsenate have the same effect in the end as do large non-fatal doses given at one time. In feeding the lead arsenate paste it was found necessary to adopt every conceivable means to induce the cows to take it after a few doses had been given. At first when mixed with the hay or grain it was readily eaten, but after a short time the animals would carefully separate every particle of the paste from the hay or grain and leave it uneaten. It was for this reason that it was found necessary to conceal it in capsules enclosed in pieces of roots to insure its being eaten. When the hay that had been drenched with 1 and 2 ounces of lead arsenate in water was allowed to become thoroughly dried, it was readily eaten by the cows that had previously refused the fresh paste, even when thoroughly mixed with hay and grain, or enclosed without capsule inside of pieces of roots and apples. The fresh arsenate had an odor of acetic acid that was not noticeable in that contained in the dried hay.

To determine approximately how much hay would become covered with the drip in the spraying of a medium-sized tree the grass was cut on an area 35 feet in diameter under a tree near the veterinary hospital, thoroughly hayed and weighed. It was a moderately heavy growth of herds grass and weighed when dried 50 pounds. Allowing for a drip of 1 gallon in 10 of a mixture of 10 pounds of the arsenate to 100 gallons of water, each 10 pounds of the total of 50 would carry 9.06 grams of the arsenate paste, or practically one-half of that amount of the dried arsenate.

It would hardly be expected, taking into consideration the results obtained by feeding carefully weighed amounts of the arsenate, that a 10-pound feed of such hay would produce serious effects, but the continuous feeding of it for several days in succession would certainly do so, and judging from the experience had in the feeding of treated hay animals would eat sufficient to cause fatal poisoning.

Susceptibility. — In so far as it was possible to ascertain there did not appear to be among the animals used in the experiment an individual susceptibility to the action of the poison. In some of the cows more was required to produce toxic effects than in others, but this seems to be accounted for more on the ground of weight and vigor than on that of individual susceptibility.

It is of interest to note in this connection the effect of arsenic or lead on the different species of farm animals. Nunn, quoting Kaufmann, gives the toxic dose of arsenic for each of the domestic animals, when administered by the mouth, as follows: —

	Grams.
Horse,	10 to 45
Ox,	15 to 45
Sheep,	5
Dog,	.1 to .15
Pig,	.5 to 1
Fowl,	.1 to .15
Pigeon,	.5

For acetate of lead the toxic dose, according to the same authority, is: —

	Grams.
Horse,	500 to 750
Cattle,	50 to 100
Sheep,	30
Pig,	8
Dog,	10 to 25

The harmless effects of the arsenate of lead fed to a horse by Mr. Kirkland, referred to in another part of this bulletin, is in all probability to be accounted for, in part at least, by the natural nonsusceptibility of the animal to the action of lead, to which the ruminants appear to be particularly susceptible.

THE PERIODICAL CICADA IN MASSACHUSETTS.

BY C. W. HOOKER.

The old order of cicadæ includes some five hundred members, and of these North America has her full share, more than one hundred being represented. Four species are commonly found in Massachusetts: *Cicada septendecim* L., the periodical cicada, or seventeen-year locust; *Cicada canicularis* Harr., the dogday harvest fly; *Cicada sayi* and *Cicada linnei*. Recent investigation by Smith and Grossbeck has shown that what have been called *Cicada pruinosa* Say and *Cicada tibicen* L. are really two altogether different species, which they have named *Cicada sayi* and *Cicada linnei*. Two others, *Cicada rimosa* Say and *Cicada* (*Tettigia*) *hieroglyphica* Say, also occur in Massachusetts, but are not common. *Cicada septendecim* L. comes every seventeen years about the first of June, while the rest are seen every year, *Cicada canicularis* coming with the beginning of dogdays, *Cicada linnei* a little later and *Cicada sayi* in August.

The periodical cicada — *Cicada septendecim* L. — is peculiarly colored and may be easily recognized. The eyes, legs and larger veins of the wings are of a peculiar reddish-yellow or orange color, the abdomen is marked with bands of the same color, and the rest of the body is jet black. The other cicadas of Massachusetts have in common a general greenish-brown color above and whitish below, but can be readily distinguished by the descriptions of Smith and Grossbeck in "Entomological News" (April, 1907, pp. 116–129).

The periodical cicada is known to occur quite generally through all that part of the United States east of the Rocky Mountains. None have been taken in Maine or New Hampshire, and only two occurrences are recorded in Vermont. There is a specimen, however, in the collection of the Massachusetts

Agricultural College which is labelled Orono (Me.), in the handwriting of Prof. C. H. Fernald; but Professor Fernald has no recollection of it, and is of the opinion that it probably came from some other place, for this would be the only known case of its occurrence in that State. The rest of New England has parts of several well-defined broods which are more or less important. There are now, in all, according to the latest enumeration — Marlatt — thirty broods, — seventeen seventeen-year broods, with a general northern distribution, and thirteen thirteen-year broods, which occur in the southern States.

Massachusetts has the honor, or misfortune, of possessing the earliest known record — 1633 — of the occurrence of the periodical cicada. Yet even then the Indians were well acquainted with this periodical visitor, using it as food, and it has probably been used in like manner for centuries. Massachusetts is credited with four broods, and a fifth, just beyond the southwestern boundary, from which members have probably entered the State, though none have been actually reported. These can be easily located from the following table: —

Marlatt Numbers.	Year next due.	Occurrence in New England.	Riley Numbers.	Walsh-Riley Numbers.	Fitch Numbers.	Smith's Register.
II., .	1911	New York and Connecticut near Massachusetts State lines.	XII.	VIII.	1	1843
VIII., .	1917	Dukes, ...	XX.	XIV.	2-8	1849
X., .	1919	Bristol, Rutland, Vt., . .	XXII.	XVI.	4	1851
XI., .	1920	Bristol, Franklin, Hampshire (Mass.), Connecticut, Rhode Island.	I.	I.	9	1852
XIV., .	1923	Barnstable, Plymouth, . .	VIII.	VI.	3	1855

1855. (Riley, VIII.) Brood XIV.

Barnstable, Plymouth. (1906.) 1923.

Occurrence.

Plymouth, 1633; Manomet Point, Wareham, Onset, Sandwich to Dennis, 1770 to 1906.

This brood occurs in Massachusetts in Barnstable and Plymouth counties, its first occurrence in 1633 being the earliest recorded in this country. It appeared near Plymouth in 1633, soon after the arrival of settlers, arousing considerable fear and apprehension.

The following account is given in Nathaniel Moreton's "New England's Memoriall," and the facts as given are corroborated by Governor Bradford, Rev. Wm. Hubbard and Mr. Prince, in Prince's "Annual." Speaking of a sickness which broke out in and near Plymouth in Massachusetts in 1633, he says: "It is to be observed that the Spring before this Sickness, there was a numerous company of Flies, which were like for bigness unto Wasps or Bumble-bees. They come out of little holes in the ground and did eat up all the green things, and made such a constant yelling noise as made all the woods ring of them, and ready to deaf the hearers; they were not any of them heard or seen by the English in the Country before this time. But the Indians told them that sickness would follow and so it did, very hot in the months of June, July and August of that Summer," viz., 1633. He says: "Toward Winter the sickness ceased," and that it was "a kind of a pestilent Fever."

How widely this brood was distributed at this time cannot be stated, but careful study of more recent appearances shows that this, like most other broods, is slowly but surely decreasing in size. At present it is the largest in Massachusetts, and seems to have held its ground most successfully; this may be due to the more favorable natural conditions of the country it occupies. The brood is, generally speaking, shut into the western part of Barnstable County, — on the west by the neck at Buzzards Bay and Sandwich, and on the east by the neck at Barnstable harbor and Yarmouth. Most of the brood is enclosed within these two bounds, but with a little overflow on each side. On the west this overflow extends as far as Manomet Point and Cook's Pond. In 1804 the brood appeared in great numbers 1½ miles west of Plymouth, but no further record of this part of the brood can be found, and it probably soon died out. On the eastern side the overflow extends at least into Dennis.

The brood made its last appearance in 1906. In order to ascertain the exact distribution and abundance of this brood, Dr. H. T. Fernald, through the co-operation of the State Board of Agriculture, sent circulars to each town where the cicada might be expected to appear, and from the information received in this way, and from other sources, the following statement has been prepared: —

Places.	Remarks.	Observer.
Manomet,	Very numerous.	H. M. Russell. E. A. Back.
Cook's Pond,	A few.	T. R. Watson.
Wareham,	A few; heard not seen.	H. J. Franklin.
Onset,	A few.	J. C. Hammond.
Bourne,	Very numerous, flying even into one's face.	H. J. Franklin. D. D. Nye.
Wing's neck (Bourne),	Very numerous; flying even into one's face.	D. D. Nye.
Sandwich,	Very numerous.	J. C. Hammond. H. J. Franklin.
Mashpee,	Very numerous.	J. C. Hammond. H. J. Franklin.
West Falmouth,	Very numerous; woods ring with their voices.	D. R. Wicks.
Falmouth,	Very numerous.	H. J. Franklin.
East Falmouth,	Very numerous.	H. J. Franklin.
North Falmouth,	Very numerous; "Psyche," December, 1906.	C. W. Johnson.
Barnstable,	Very numerous.	H. J. Franklin.
West Barnstable,	Very numerous; no great damage.	J. C. Hammond. J. Bursley.
Osterville,	Very numerous; "Psyche," December, 1906.	C. W. Johnson. A. H. Armstrong.
Yarmouth,	Reported.	-
Dennis,	- - -	J. C. Hammond.

Letters were also sent to the following places, but no cicadas were reported: Truro, Eastham, Chatham, Harwich, West Brewster, Carver, Rochester, Acushnet, Plympton, Lakeville, Halifax, Dartmouth, Berkley, Hanson, Seekonk, West Duxbury, Attleborough, Campello, Franklin, Stoughton, Mansfield, Pembroke, Norwood, Westwood, Walpole, Bridgewater, West Bridgewater, Bellingham, Norwell, Millis, Canton.

From this it will be seen that the brood is generally distributed between Manomet, Wareham and Dennis, being strongest between Sandwich, Bourne, Falmouth and Osterville. In this central part the brood seems to be as strong as ever, but along the outside, in what I have called the overflow, it is gradually running out. It must be remembered, however, that these cicadas in Plymouth and Barnstable counties form only a part of this brood.

In 1889 Riley and Howard gave its extent as follows: —

The region commences in southeastern Massachusetts, extends south across Long Island and along the Atlantic coast of New Jersey, Delaware and Maryland, as far as Chesapeake Bay; then up the Susquehanna in Pennsylvania to a point a little below Harrisburg; thence northwest in Ohio, embracing the southwestern corner of the State and the northwestern portion of Kentucky, and then upward through southwestern Indiana, ending in central Illinois.

1849. (Riley, XX.) Brood VIII.

Dukes. 1917.

Occurrence.

Martha's Vineyard: 15 square miles of Central Plains, 1833 to 1900.

This is one of the smallest broods and covers a quite compact territory, the greater part of which lies in central and western Pennsylvania and eastern Ohio, with a few localities in northern West Virginia and southwestern New York. Two widely separated swarms listed from Illinois and South Carolina are extremely doubtful, and both are probably based on confusion of some of the annual species with the periodical cicadas. The Massachusetts part of this brood, occurring in Dukes, is also widely separated, but is fully established and has been well recorded since the time of Harris. Dr. Harris records their first appearance in Martha's Vineyard in 1833, while Smith's "Register" gives the next in 1849, and Geo. H. Luce of West Tisbury, Mass., states that they were there in 1849–66–83 and 1900. In the "American Naturalist," October, 1883, G. E. Bessey writes: —

> While driving across "the plains" of the central part of Martha's Vineyard, in the last few days of June of this year, I observed large numbers of the periodical cicadas. The scrub-oaks, which here cover the whole ground, were literally alive with them. The insects were confined to a narrow belt, not exceeding half or three-quarters of a mile in width and of unknown length.

At its last appearance, in 1900, it seemed desirable to ascertain the accuracy of previous observations and learn whether this isolated colony was holding its own. Through the kindness of Mr. Luce it was learned that "the brood was a well-known one and as much in evidence as ever. They were quite numerous, but seemed to confine themselves to a district known as the plains district, — a tract of land covered with scrub-oak and very lightly wooded. They could be heard more than a mile, making a peculiar sound. As near as I could ascertain they covered about 15 square miles of territory. . . . By good evidence they were here in 1849. One old man said within his lifetime he had seen them five times."

The first recorded occurrence of this brood in 1833, by Dr. Harris, was evidently a case of retardation in development, due probably to unfavorable weather, for they should have appeared one year earlier, in 1832. It seems strange that this swarm in Dukes should be part of a brood whose nearest occurrence is in central Pennsylvania, while brood XIV., in Barnstable and Plymouth counties, is only about 4½ miles away, across Vineyard Sound. At their (brood XIV.) last occurrence, in 1906, the cicadas were very numerous at Falmouth, which is just across from Martha's Vineyard, and with a favorable wind it would seem as though the passage might easily be made. On inquiry, however, it was found that no cicadas appeared on the island in 1906.

1852. (Riley, I.) Brood XI.

Bristol, Franklin, Hampshire. 1920.

Occurrence.

Massachusetts: Hadley, 1818; Westfield, 1835; Deerfield, Freetown (near Fall River), 1767, 1784, 1801, 1818, 1835, 1852, 1869.

Connecticut: Glastonbury, 1818, 1835, 1852; Suffield, 1818, 1869, 1886.

Rhode Island: Coventry, East Greenwich, Washington, 1869, 1886, 1903.

This is a small brood, formerly limited, for the most part, to the valley of the Connecticut River in Massachusetts and Connecticut, with one colony in the vicinity of Fall River and another near Coventry, R. I., separated from the main swarm. The "Boston Magazine" records the appearance of this brood in Bristol County in 1784, while Dr. Fitch reports it as having occurred in Hadley in 1818 and at Westfield in 1835. It was reported from Deerfield and Bristol County by Dr. Smith from 1767 to 1852, and the genuineness of the brood was fully established in 1867. It is evident that the brood had once a wide distribution, for in the "American Journal of Arts and Sciences" for 1862, Vol. 33, we read: "That part of our State

— Connecticut — which lies east of the Connecticut River has a different period from the western side. On the 22d of June, 1835, while traveling through Tolland County, Conn., in a stage coach, I passed through woods swarming with this *Cicada septendecim*." Also in Alonzo B. Chapin's "History of Glastonbury" we read of their occurrence in Glastonbury in 1818, 1835 and 1852. This is the most southern point in the Connecticut valley at which this brood has been reported. With the exception of the swarm at Suffield, Conn., no record can be found of the appearance of this brood in the Connecticut valley since 1852, and none in the Massachusetts part since 1835. Mr. Geo. Dimmock, who has made a special study of the swarm at Suffield, says that "These cicadas, of which there are records going back about a century, seem to be dying out. In 1869 they were so abundant that small bushes and underbrush of the rather sparse woods in which they occur were weighted down by them." In 1886 and 1903 he was unable to visit that region, but "was informed that very few of the insects appeared in 1886, and none in 1903."

The Bristol County swarm was observed at Freetown, near Fall River, in 1818, 1835, 1852 and 1869. "In 1818 they were very numerous, in 1852 still less, and in 1869 were quite scattering as compared with 1818." Since which time there is no record of their appearance.

In Rhode Island there seem to have been three visitations of this brood; in 1869, 1868 and certainly in 1903, when they were very abundant. It appeared near Coventry, East Greenwich and Washington, in isolated places, but not continuously over an extensive area. As far as we know this brood was most widely distributed in 1818, when it extended from Hadley, Mass., to Glastonbury, Conn., with a widely separated swarm at Fall River. Since then there has been a steady decrease of numbers, due probably to the cutting off of wooded lowlands and the extension of cultivated land. In 1869 they appeared only at Fall River, Mass., Suffield, Conn., and near Coventry, East Greenwich and Washington, R. I.

In 1903 the only occurrence of this brood was near Coventry, R. I., none being found in Massachusetts or Connecticut, though close watch was kept. From this it would seem that the brood had died out in Massachusetts, but careful watch should be kept at the next occurrence, in 1920.

1851. (Riley, XXII.) Brood X.

Bristol. 1919.

Occurrence.

Rutland, Vt., 1851, 1868; Bristol County, Mass., 1834.

This is the largest brood of the seventeen-year broods, and equals, if not exceeds, in extent the largest thirteen-year brood, — brood IX. Its representation in Massachusetts, however, is, if authentic and still active, — which is very doubtful, — small and of no importance. The brood has been well recorded in the east from 1715 to 1902, the date of its last appearance. It occurs from Alabama and Wisconsin to Massachusetts, in greater or less numbers, and in 1851 and 1868 appeared at Rutland, Vt. According to Dr. Fitch, "What appears to be a detached branch of this brood occurs in the southeastern part of Massachusetts." It is probable, however, that there was some mistake about this occurrence.

1843. (Riley, XII.) Brood II.

New York and Connecticut near Massachusetts State Line. 1911.

Occurrence.

New York: Copake, 1877; Hillsdale (millions), 1894.

Connecticut: New Haven, 1724, 1894; Southington, 1894; New Britain, 1894; Farmington, 1894; Winsted, 1894.

This is one of the best-recorded broods, being distributed from New York and Connecticut to North Carolina, with isolated swarms in Indiana and Michigan. While no colony of this brood has been reported in Massachusetts, they come so close to the State line on the southwest that stragglers, at least, must have crossed into Massachusetts. At Copake, and especially at Hillsdale, N. Y., in 1894, there were vigorous colonies within 1½ miles of our State line, while in Connecticut, at Winsted, they came within 7 miles. Careful inquiry from the

Massachusetts towns along the southwestern boundary failed to bring out any appearance in this State. This was probably because only scattered members crossed into Massachusetts, and these, if recognized as cicadas, were probably confused with the annual species. That part of the State is also quite mountainous, and the cicadas would tend to go around rather than over the mountains, for as a rule they prefer the lowlands. In New York they are scattered down both banks of the Hudson below Troy, and in Connecticut, east as far as the Connecticut River. Professor Potter records their first occurrence in New Haven, Conn., in 1724, and since then they have occurred regularly every seventeen years. According to Lintner: —

> At its last appearance, in 1894, it was distributed throughout the Hudson valley below Troy, and especially at Hillsdale, near our State line, where millions were found. In Connecticut it was reported from the vicinity of New Haven, at Easthaven, near Lake Saltonstall, at Southington, New Britain, Farmington and Winsted, thus extending its range north nearly across the State of Massachusetts line. It doubtless occurred north of this locality, but no account of its appearance was received.

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Occurrence in great numbers 1½ miles west of Plymouth in 1804.

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General distribution of periodical cicada.

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An account of *Cicada septendecim,* its natural enemies and the means of preventing its injury, together with a summary of the distribution of the different broods. The most complete account, well illustrated, with good maps and bibliography.

XII. Lintner, J. A.: 12th report of the New York Entomologist, 1897, *Cicada septendecim,* pp. 272–289.

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XIII. "New England Farmer," October, 1855, p. 470; July, 1894, p. 551.

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Table for separating males of annual species of cicadas.

XXVI. Smith (J. B.) and Grossbeck (J. A.): "Entomological News," April, 1907, pp. 116–129, "Studies in Certain Cicada Species."
Most recent work on annual cicadas, with several good plates and descriptions, from which the cicadas common in Massachusetts can be easily recognized. Two new species, *C. sayi* and *C. linnei*, established, hitherto confused with *C. pruinosa* Say and *C. tibicen* L.

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MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

INTRODUCTION.

In accordance with the provisions of the amended act relative to the publication of the reports of the Massachusetts Agricultural College, passed by the Legislature of 1909, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. will contain the formal reports of the director, treasurer and heads of the departments, and papers of a technical character giving the results of investigations carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions, as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to persons on our general mailing list.

WM. P. BROOKS,
Director.

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PART I.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-SECOND ANNUAL REPORT.

Part I.

ORGANIZATION.

Committee on Experiment Department.

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Harriet Cobb, Stenographer, Department of Plant and Animal Chemistry, 35 East Pleasant Street.
Bridie E. O'Donnell, Stenographer, Department of Entomology, Hadley.

REPORT OF THE DIRECTOR.

The work of the station during the past year has followed the usual lines. There has been some increase in the amount of research work. This has been made possible by the increase in the amount received from the Adams fund for the current year. Especial attention is called to the fact that immediate results cannot in most cases be expected from such fundamental scientific investigations as are allowed under the Adams fund. A number of important problems are receiving most careful investigation and study. Among them, the more important are the following: —

Studies in milk secretion.
Molasses and digestion depression.
Why arsenicals burn foliage.
Plant breeding, and subsidiary thereto, variation in garden peas and apples.
Determination of physiological constants.
Investigation to determine the economic importance of digger wasps in relation to agriculture.
Studies of pyrallidæ and tortricidæ.
Experiments to determine the plant food requirements of asparagus.
Cranberry investigations to determine plant food requirements.
Relations of climate to plants in health and disease.
Cranberry insect work.

In some of the investigations, results, from which practical lessons which seem to be of importance even now, have been obtained; but no one of them has yet been carried to completion, and most of them are of such a nature that long and patient research will undoubtedly be essential before the fundamental laws which determine the results can be determined.

Particular attention is called to the fact that the passage of the Adams act has not in the slightest degree increased the amount of station funds available for more popular and directly practical station work. Indeed, in one direction the passage of the Adams act has imposed an additional tax upon other station funds, for the act provides that the expense of publication of the results of Adams fund research work cannot be paid from that fund. Such expense must be borne by other station funds. There has been no change in the amount of such funds available to this station, with the exception of an addition of $500 made about seven years ago, during the past twenty-one years. Meanwhile, there have been constantly increasing demands upon the station for work of various kinds, while there has inevitably been a tendency to broaden the scope of such experiments as are already carried on under these funds. The fertilizer control work, moreover, now encroaches upon ordinary station funds. The costs of the collection of samples, analytical work and the publication of the bulletin now considerably exceed the amount of license fees received. This topic will be more fully discussed later in the report, but is mentioned here simply to emphasize the fact that available station resources are not sufficient to cover the costs of such additions to our work as are called for. Poultry men, tobacco growers and cranberry growers, particularly, are urging the experiment station to undertake experiments for the promotion of these industries. Every possible economy has been used in the expenditure of station funds. A small amount has been made available for co-operative experiments with tobacco, and some work with cranberries will be undertaken during the coming year. The possibilities, however, of carrying on such work as the men engaged in these industries would like to see undertaken are comparatively small. The demands upon the station during the past twenty-one years have greatly increased, and they have never increased at a more rapid rate than within the past year. It would seem to be quite time, therefore, to ask for increased funds to provide for the growth in station work which the times demand.

Changes in Staff.

There has been no change in the heads of departments in the station staff during the past year. This fact has been favorable to station efficiency, although in this connection it may not be out of place to point out the fact that the rapid growth of the college has imposed much additional work upon the educational side upon most heads of departments in the station. This fact has necessarily reduced the time and energy available for station work, and the further growth of the college will force upon those responsible for station management a careful consideration of the question whether there should not be connected with the station a larger number of men who have had such training and experience, and who possess such natural ability, that they are competent, without immediate supervision, to originate and carry on investigations of the highest order.

The chemical research work of the station suffered a serious break in the resignation of Dr. R. D. MacLaurin. The place left vacant by his resignation has not been filled, but an additional assistant in chemistry is now employed, thus making it possible to push chemical research investigations which are in progress under Mr. Holland more rapidly than it has been possible to do heretofore.

The connection of Mr. F. A. Johnson with the experiments pertaining to cranberry insects has ceased during the past year. The station, however, has been fortunate in once more obtaining the services of Henry J. Franklin, Ph.D., for entomological work. Dr. Franklin will devote a large share of his time to cranberry insects, but will be placed in local charge of other experimental work with cranberries in the cranberry district. He will be available also for other entomological investigations as time permits.

Mr. P. V. Goldsmith has resigned during the past year to accept a more lucrative position as a sugar chemist. The two new assistants in chemistry are J. F. Merrill, B.Sc., and Carl D. Kennedy, B.Sc.

Buildings.

No important new buildings have been erected during the past year. We have, however, put up, by use of ordinary station funds, three portable brooder houses. These houses are of the Cornell University pattern. They are heated by gasoline and each will accommodate 200 chickens.

Extensive improvements have been made in the old station barn and stables. A large part of the old floor in the main barn has been torn out and a concrete floor put in its place. A cellar 25 by 56 feet in size has been made under the stables. This will provide greatly needed additional room for winter storage of fruits and vegetables. The old stable partitions and fittings have been removed, and a solid concrete floor has been laid over the old plank floor, while new stall partitions and fittings will take the place of the old. These improvements have been carried out with funds appropriated by the last Legislature.

Particular attention is called to the fact that additional room must be provided in our chemical laboratory. The provision of such room is made imperative by the demands made upon us for research work, the rooms upon one side of the laboratory being used in the fertilizer control and those on the other side in the feed and dairy control work. These rooms are fairly sufficient for the control work; but they do not provide either the space or the conditions essential for chemical research work. In spite of all possible efforts to prevent such results it is inevitable that the analytical work connected with the examination of fertilizers and feeds will sometimes load the air with fumes which might vitiate absolutely the research work going on, and this might mean a tremendous loss of time and the sacrifice of the results of much skilled work. To undertake to carry on research work under such risks must, of course, be extremely unsatisfactory; but even could such risks be avoided, the working conditions in a laboratory where control work is being prosecuted are not favorable to research work. Research work requires undisturbed quiet. In the presence of numerous men engaged in ordinary routine chemical work there must necessarily be a certain amount of movement and confusion. Research work side by side with routine control work cannot therefore be made to give the best results.

Plans for the provision of accommodations needed for research work have received the careful attention of the members of the station staff most concerned. It will be necessary, in order to carry out plans which will be at all adequate to our needs, to secure a special appropriation from the Legislature.

Station Activities.

Station activities have embraced work along all the different lines mentioned in our last annual report. These lines are experiment, research, dissemination of information and control work. As already pointed out, there has been little change in the amount of practical experimental work during the year. Research work has been somewhat increased, as has also been pointed out. In the lines of work which come under the head of dissemination of information there has been comparatively little change during the year, although some heads of departments have called attention to the fact that, since the organization of an extension department in the college, there is a slight decrease in the number of calls for information coming to the station. This has been noticeable chiefly in the number of letters of inquiry. It must be regarded as desirable, from the standpoint of station efficiency, that the members of the station staff should be relieved as far as may seem possible of the necessity of doing routine extension work. Such relief will mean more time and energy for investigational work, which must be regarded as the most important function of the experiment station.

The amount of control work during the past year has been greater than in any previous year. The increase has been due chiefly to the fact that a greater number of samples of fertilizers have been collected and a greater number of analyses of fertilizers carried out.

Attention is called to the fact that three of our neighboring New England States have seed laws. These laws must tend to prevent to some extent the sale of inferior seed in these States, and it would seem probable that since there must always be a certain amount of such seed, there will be increased probability that it will seek a market in those States not having seed laws. This, it seems likely, will mean an increase in the amount of inferior seed brought into Massachusetts for sale. The laws in our neighboring States have not yet been long in effect, and the tendency to which I have referred has not yet shown itself. Should it seem, however, that Massachusetts is becoming a dumping ground for inferior seed, it will clearly be the part of wisdom to endeavor to secure the enactment of a law for the protection of honest dealers (who, it is believed, are in a large majority in the State) and of the buyers and users of farm and garden seeds.

The investigation carried on by Dr. Burton N. Gates and the correspondence of the experiment station have made it perfectly apparent that both European and American foul brood are common among bees in various parts of the State. The existence of this disease threatens an industry which is already of considerable importance, and which might, with great advantage to our citizens, receive much greater attention. The passage of an act providing for an inspector of apiaries would be most desirable. The work of this inspector would be largely and no doubt chiefly educational. These diseases can be eradicated or controlled. Many beekeepers would no doubt undertake to rid their apiaries of disease could they be shown how to do the work. Under existing conditions, however, a beekeeper unfortunate enough to have either of the varieties of foul brood would have little encouragement to rid his apiary of the disease for the reason that he must anticipate re-infection from the apiaries of beekeepers who should neglect to carry out remedial treatment with the thoroughness essential to success. The inspector of apiaries, therefore, must be given authority to compel remedial treatment, or, if other measures fail, to destroy infected colonies. New York and Connecticut now have laws providing for such work as has been indicated, and it is quite time that Massachusetts also should enact such a law.

It seems probable that a national law covering the manufacture and sale of insecticides and fungicides will be enacted by the Congress now in session. Such a law has been under joint consideration by the Bureau of Entomology of the Department of Agriculture, a committee of Economic Entomologists and prominent manufacturers. A law was introduced into the last Congress, and has now been brought into such form that it seems to be fairly satisfactory to all interests involved. This law, of course, can be effective in the States only in governing interstate transactions, but since practically all manufacturers of insecticides and fungicides do an interstate business, the passage of the national law will probably prove effective in controlling the manufacture and trade in these materials.

Publications during 1909.

The new plan for the publication of the annual report of the station referred to in my last report became effective for the first time during the past year. Under this plan a larger proportion of the material published by the station will appear in the annual report than has been customary heretofore. Thus, for example, the two parts of the annual report for 1909 make a total of 300 pages, whereas the annual report for 1908 included 172 pages only. The amount of matter to be published in bulletin form is reduced by the change just referred to, and the number of such publications during the past year has been considerably less than in 1908. The total number of printed pages, including both bulletins and reports is, however, the same for the two years.

The amount of circular matter sent out is also practically the same, namely, 30 pages in 1909 and 32 pages in 1908. A full list of the publications for the year follows: —

Publications during 1909.

Annual report: —

Parts I. and II. 300 pages.

Bulletins: —

No. 128. Inspection of Commercial Feed Stuffs, P. H. Smith and P. V. Goldsmith. 56 pages.

No. 129. Beekeeping in Massachusetts, Burton N. Gates. 32 pages.

No. 130. A Summary of Meteorological Observations, J. E. Ostrander. 28 pages.

Circulars: —

No. 20. The Use of Lime in Massachusetts Agriculture, Wm. P. Brooks. 6 pages.

No. 21. The Control of Onion Smut, G. E. Stone. 2 pages.
No. 22. Poultry Manures, their Treatment and Use, Wm. P. Brooks. 4 pages.
No. 23. A Parasite of the Asparagus Beetle, H. T. Fernald. 4 pages.
No. 24. An Act to provide for the Protection of Dairymen. The Babcock Test, J. B. Lindsey. 8 pages.
No. 25. Cottonseed Meal, J. B. Lindsey. 8 pages.

Publications Available for Free Distribution.

Bulletins: —

No. 33. Glossary of Fodder Terms.
No. 41. Use of Tuberculin.
No. 68. Fertilizer Analyses.
No. 76. The Imported Elm-leaf Beetle.
No. 83. Fertilizer Analyses.
No. 84. Fertilizer Analyses.
No. 89. Fertilizer Analyses.
No. 90. Fertilizer Analyses.
No. 103. Fertilizer Analyses.
No. 113. Fertilizer Analyses.
No. 115. Cranberry Insects.
No. 117. Trade Values, and Fertilizer and Soil Analyses.
No. 121. Seed Separation and Germination.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 124. Bee Diseases in Massachusetts.
No. 125. Shade Trees.
No. 126. Insects Injurious to Cranberries, and how to fight them.
No. 127. Inspection of Commercial Fertilizers.
No. 129. Beekeeping in Massachusetts.
No. 130. Meteorological Summary — Twenty Years.
Technical Bulletin No. 2. The Graft Union.
Technical Bulletin No. 3. The Blossom End Rot of Tomatoes.
Index to bulletins and annual reports of the Hatch Experiment Station previous to June, 1895.
Index to reports and bulletins, 1888–1907.

Annual reports: —

Annual reports of the station for the following years are available: 10th (1898), 11th (1899), 12th (1900), 13th (1901), 14th (1902), 15th (1903), 16th (1904), 17th (1905), 20th (1908), and 21st, Parts I. and II. (1909).

Of some few other bulletins and reports we have a very limited supply. These will be furnished only in order to complete sets for libraries.

Examination of the above list makes it apparent that relatively few of our earlier bulletins can now be furnished. The publications printed by the station during the early years of its existence were naturally issued in comparatively small editions. The demand was limited. The growth of interest in improved methods in agriculture was not fully anticipated. It is now apparent that it would have been well had many of our bulletins and reports, which are of a character to make their contents of some permanent value, — even if only for purposes of library reference, — been issued in larger numbers. Many institutions, especially those devoted to agricultural education, and hundreds of individuals, are now vainly seeking to complete files of station publications. We cannot recall the past. Its mistakes are irremediable; but we should heed its lessons. The growth of interest in such matters as station reports and bulletins treat will continue, and the rate of such growth will be more rapid in the future than in the past. It would clearly seem unwise to figure our editions too close to present demand, and yet to this course we seem to be compelled on account of the pressure upon station funds, made greater by the last grant from the federal government, — the Adams fund, — since this fund provides means for increased research, while the act granting it expressly stipulates that no part of the fund shall be used in meeting the costs of publication of results. These costs are, therefore, an increased burden on funds already fully utilized in meeting the expenses of other lines of work.

It may be urged that under the conditions above outlined the amount of work in other lines should be decreased, but this is an alternative which the demands of the times render most difficult, and which I believe would be decidedly unwise. We are under constant pressure to undertake more experimental work and in new lines. The various special agricultural interests urge us to more fully recognize them. Poultrymen, asparagus growers, cranberry growers, tobacco growers, hothouse men and many others have their special problems, which they look to us, and rightly, to help them solve. We need more funds then, rather than less, for our experimental work, and hence the necessity of a more generous provision for publication. The size of our editions should be increased, but under existing appropriations this is impossible.

A committee of the American Association of Agricultural Colleges and Experiment Stations, after a most careful study of the whole subject of station publications, has recently made a report strongly urging, among other things, that, with a view to making provision for future demands, station publications should be electrotyped when issued. The adoption of this course now does not seem to me to be our most pressing necessity, but some such provision in the near future will no doubt be desirable.

The demand for general bulletins of information, referred to at some length in my last report, shows no sign of abatement. On the contrary, it is ever increasing. The information which may be furnished by such bulletins is greatly needed. Could it be placed in the hands of persons calling for it, marked improvement in agricultural methods might be confidently anticipated. I believe, however, that this demand should be chiefly met by private enterprise. Certainly it cannot be met by the station without special provision to cover its costs. Meeting it, however, would seem to be in the nature of extension rather than experimental work, and therefore, under the modern conception of respective functions, perhaps belongs rather to the college than to the station.

Letters of Inquiry.

The number of letters of inquiry annually received in the different departments of the experiment station continues to increase. During the past year the total number of such letters received and answered was 6,500. Attention to these letters consumes a very considerable proportion of the time and energy of members of the station staff, thus materially curtailing the amount of attention which can be given to investigation. The numerous letters of acknowledgment received from correspondents receiving suggestions and advice make it apparent that the assistance which the station is able to render by answering these letters is appreciated. The amount of work of this character which the public will call upon the Massachusetts Agricultural Experiment Station to do is sure to increase. This line of work is highly important and useful, and it would seem to be the part of wisdom to make special provision for it in order that station workers may be more free to devote themselves to investigation.

Lectures and Demonstrations.

Members of the station staff have been frequently called upon during the past year to deliver public lectures and to conduct demonstrations. The number of lectures and demonstrations given during the year was 56, while a large number of invitations to accept such engagements were, of necessity, declined. Work of this character makes heavy inroads upon the time of station workers, for it involves in the long run the use of much time in travel and in preparation. In so far, however, as station men have special knowledge of certain subjects, it seems desirable that they should address a reasonable number of important meetings, since in this way the results of the work of the station are carried to the public, while the lecturer on his part is brought into closer and wholesome touch with the public which he aims to serve.

Miscellaneous Analyses.

The chemist reports the usual large number of miscellaneous analyses. Work of this character done during the year may be summarized as follows: —

Water,	99
Milk,	389
Cream,	2,933
Feed stuffs,	98
Fertilizers and fertilizer materials,	234
Soils,	42
Miscellaneous substances,	45

This summary includes simply the analytical work carried out for individuals. The results of these analyses are of interest in most cases only to the persons sending in the material. It is recognized that this work has its value; but investigational work is of wider interest and of greater value. It has been our policy, therefore, and must continue to be our policy, to confine work of this kind to relatively narrow limits. Should we comply with all requests for work of this character, it is probable that the time of all the chemists at present employed would be very largely occupied in this work.

The most marked increase in demands for private analytical work is for soil analyses. There appears to be a widespread misconception as to the probable value to the individual of a chemical analysis of his soils. This subject was rather fully discussed in my last annual report; but it seems wise once more to repeat that the results of such analysis do not constitute a satisfactory basis for determining either the crop adaptation or the manurial requirements in the great majority of cases. No accurate count has been made, but it is believed that the number of requests for such analyses made during the past year has been at least 300. To have made this number of complete analyses would have required the continuous services of two chemists for a year; while to have determined simply the leading fertilizer elements must have required the full time of one chemist.

The leading soil types found in the State have already been analyzed repeatedly in most cases. Fertilizer requirements appear to be determined in the majority of instances more largely by the crop than by peculiarities in the chemical composition of the soil. It is particularly pointed out, therefore, that correspondents need only to state the type of soil, the character of the subsoil, the recent manurial treatment and the crop in order to give us a basis for suggestions in relation to the selection of fertilizers. Samples of soil, if sent, will not usually be analyzed, unless the type of soil or the conditions which have affected it appear to be of unusual character.

Control Work.

The amount of work connected with the execution of the fertilizer and feed laws increases from year to year. During the past year 1,042 samples of fertilizers have been examined in accordance with the requirements of the fertilizer law, and 946 samples of cattle feeds have been analyzed. Conditions as affecting the trade in feed stuffs have been on the whole satisfactory. The fertilizer inspection has, however, resulted in the discovery of a larger number of fertilizers not equal to guarantee than has been found in any previous year. It has not been thought best to make any prosecutions during the past year; but the particular attention of dealers is called to the fact that such conditions as existed this year must not continue, and that prosecutions will undoubtedly be necessary should serious shortages again occur. Details of the inspection work will be found in the report of the chemist.

Testing Pure-bred Cows.

Attention was called in the last report to the fact that a small increase in the scale of charges for testing pure-bred cows had been found necessary. There was at first some criticism of the station for making such an increase, but it is believed that the necessity for it was made clear to parties interested in the work. The new scale of charges now excites no opposition, while the amount of such work steadily increases. The fact that its results are profitable to the parties concerned is made sufficiently apparent by the fact that the number of cows offered for test continues to increase. The present scale of charges is believed to be sufficient to fairly cover the cost, and it must, therefore, be regarded as satisfactory both to the interested public and to the station.

Mailing Lists.

During the past year we have undertaken, by correspondence with postmasters throughout the State, to revise our general mailing list. The last revision was made two years ago; but as the result of the revision now in progress we have cancelled 1,441 addresses because of death or removal as reported by the postmasters. Postmasters have also reported over 2,000 changes in address. Before these changes are made, we shall address the individuals concerned, and shall re-enter them under new addresses only in those cases in which they reply to the postal card inquiry. It seems probable that the total number of addresses dropped from our list as the result of the revision will be at least 2,500. The facts stated make it apparent that postmasters do not as a rule comply with the postal regulations affecting station publications, and return them in the event of non-delivery. These facts make it very apparent also that frequent revision of mailing lists is a necessity if wasteful distribution of reports and bulletins is to be avoided. There is little doubt that our lists for other States and for foreign countries also need revision, and this work will be undertaken as soon as conditions make it possible.

The extent to which our general publications circulate is made apparent by the following statement of the numbers in our lists: —

Residents of Massachusetts,	13,098
Residents of other States,	2,102
Residents of foreign countries,	196
Newspapers,	512
Libraries,	288
Exchanges,	112

The number of additions to our general mailing lists on direct application of the parties concerned during the past year has been 1,500.

In addition to the above lists, our publications are sent to those on the general Washington list, which includes members of the faculties and station staffs in agricultural colleges and experiment stations. The total number of addresses on this list is 2,350.

We use also the following special mailing lists: —

Cranberry growers,	1,424
Beekeepers,	2,475
Meteorological,	373

Asparagus Substation, Concord.

The work at this substation has made very satisfactory progress. All details connected with the local execution of plans for planting, fertilization and culture have been, as heretofore, faithfully and skillfully looked after by Mr. Charles W. Prescott, from whom the land in use has been leased, and to whom the work has from the first been indebted for many valuable suggestions and services characterized by most unusual enthusiasm and devotion.

No new lines of work have been undertaken. Our principal investigations, it will be remembered, are of two general classes, — breeding experiments and fertilizer experiments.

Breeding Experiments. — During the past year good progress has been made in these experiments, which have for their object the production of more rust-resistant types of asparagus, which shall at the same time possess desirable market characteristics. The number of varieties in the experimental plots at the present time is 65. Mr. J. B. Norton, who began observations in Concord last year, has devoted practically all of his time during the past season to the asparagus breeding experiments. It will be remembered that in this work we enjoy the co-operation of the United States Department of Agriculture, and Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, under whose direct charge work of this description comes, has definitely assigned Mr. Norton to take local charge of the work in Concord. Mr. Norton succeeded during the past season in making numerous promising selections and a large number of artificial fertilizations. Some of the seed resulting from this work will be planted in Washington, and a close preliminary study of the plants produced will be made there during the coming winter. It is hoped to shorten the time needed for testing the value of different types by following this course. Those which seem promising will be taken to Concord for further testing and observation. It is a pleasure to testify to the enthusiasm and faithful industry of Mr. Norton, who, besides devoting himself to the breeding experiments, has proved very helpful in taking observations and making records on the fertilizer experiments as well. An exhaustive chemical study of the roots as affected by the varying fertilizer treatment is now in progress and appears to promise results of importance and great value.

Fertilizer Experiments. — The conditions in the fertilizer plots continue to be highly satisfactory. There was, it is true, considerable rust, as was the case almost everywhere in Concord last fall; but it did not begin as early in the fertilizer plots as in many beds in the district, and it is believed that the injury was not serious. No differences in the extent of rust injury which could be attributed to variations in fertilizer treatment could be detected. Cutting continued longer this year than last. The first cutting was on May 7, and the last on June 6. The quality of the product was especially good, as was perhaps only natural on a vigorous new bed. There were considerable differences in yield on the different plots; but the product will not be reported at this time, as it is not clear that the differences recorded were connected with varying fertilizer treatment. The preparation of the entire area, as was pointed out last year, was so thorough that the growth even on the plots receiving least fertilizer is still unusually vigorous.

Tent Experiments. — The fact was reported last year that it is the plan to conduct experiments for the purpose of determining the influence of tent shade as affecting (1) yield; (2) quality of product; (3) extent of injury from rust. It was, however, found that conditions in the different plots of the old asparagus bed, in which this work was begun, were not sufficiently uniform to warrant the continuance of the work on that bed. During the past season, however, a new bed has been set for the purpose of continuing these experiments.

Cranberry Substations.

It will be remembered that our cranberry work follows two principal lines of inquiry relating (1) to the fertilizer requirements of the crop; (2) to the insect enemies of cranberries.

The only work done in connection with insects during the past year has been of a preliminary nature, as during the early part of the season we did not enjoy the services of an entomologist who could be assigned to this work. The station, however, has been fortunate in concluding an engagement with Dr. Franklin, who conducted insect work which gave such valuable results two or three years ago. Dr. Franklin returns to this experiment station as an assistant in entomology; but it is our expectation that he will be put in local charge of all our experimental work with cranberries, although he will, as heretofore when connected with the station, devote his time principally to a study of insects in their relations to the crop. Dr. Franklin was unable to take up this work earlier than October 1, but he spent several weeks in the cranberry sections of the State laying plans and making preparations for the work of another year.

The past year has been characterized by a significant development in the relations of cranberry growers to our work. As a result of extended correspondence and conference, a committee representing the Cape Cod Cranberry Growers' Association came to the decision to solicit contributions towards the financial support of experimental work with cranberries. The committee prepared a circular letter asking for *pro rata* contributions, and this letter, in printed form, was sent to all known cranberry growers in the State. This letter follows: —

To the Cranberry Growers of Massachusetts.

A legislative committee appointed by the Cape Cod Cranberry Growers' Association has conferred with Messrs. Brooks, Preston and Damon of the State Experimental Station, and finds them heartily in sympathy with a plan for a substation to be located in the cranberry-growing district. They are willing to help us in every way if we will help ourselves by bearing a reasonable proportion of the expense. As cranberry growing is limited to certain areas, they do not feel justified in asking the State to bear the whole burden.

Such a station would investigate cranberry insects and their parasites, giving particular attention to the ravages of the fruit worm. It would also consider the various diseases of the cranberry, and would determine the best methods of spraying and flooding. Systematic experiments with fertilizers would be carried on with relation to their effect on the color, quantity, size and keeping qualities of the fruit, and to determine their retentive values in the soil. The propagation of new varieties, the destruction of weeds and mosses and the study of climatic conditions, with the probable assistance of the United States Weather Bureau, would all be included in this work. The station would, in short, be here to serve us.

We have every reason to believe that, by acting *promptly*, we can secure the services of Mr. Henry J. Franklin for this undertaking. Most of the growers are familiar with the earnest, conscientious investigations which he made during his connection with the Amherst station. His bulletin, "How to fight cranberry insects," and the mounted specimens which he prepared for us, prove his ability.

If every grower will contribute one cent for each barrel of berries that he shipped last year, we believe that, with the co-operation of the station, the necessary funds can be raised. If you are willing to contribute that amount, will you please fill in the enclosed postal card. We do not want the money now, and shall not ask for it unless a sufficient amount is pledged to insure the success of the plan. A prompt answer will be greatly appreciated.

A large number of growers responded favorably, and the total amount of money pledged toward the support of experimental work as a result of this movement was about $1,000.

It is with especial satisfaction that this action on the part of cranberry growers and its results are reported, for it is believed that this policy of self-help on the part of special interests has much to commend it. These interests may fairly be asked to contribute to the support of work especially designed to benefit them; but this is by no means the only reason for the approval of this policy. It means a greater interest on the part of the growers in the work which is going on, for human nature is so constituted that what costs something is valued more highly than that which is a free gift. This policy means, moreover, closer co-operation, wholesome supervision and helpful criticism. It is to be hoped that the results of this initial movement in the direction of private support of experimental work on the part of special interests will so commend themselves to cranberry growers that not alone will they be inclined to continue a measure of support, but that other special interests, recognizing the advantages of the system, may be led to adopt a similar plan of co-operation.

It must be at once recognized that, in order that the experiments contemplated in the interests of cranberry producers may be carried on under satisfactory conditions, it will be necessary to control a moderate area of cranberry land and the buildings necessary for handling the crop, and to provide moderate laboratory accommodations. Unless the work can be located in permanent quarters, fully under the control of the experiment station, it cannot possibly be prosecuted in a satisfactory manner. Two methods of acquiring control of such property as is needed are to be considered: (1) the needed land and buildings might be leased for a number of years; (2) the needed property might be acquired by purchase. The second of the two plans would seem to possess considerable advantages as compared with the first. Cranberry land ordinarily returns so large an income that the rental which would undoubtedly be expected by an owner would be large. Moreover, questions of possible damage to the property as a result of experimental work might arise, which would be difficult to settle in a satisfactory manner. Should the second plan be adopted there is little doubt that the net income derived from the crops produced would be sufficient to constitute a material contribution to the funds available to pay the costs of experimental work. If, therefore, the needed property can be purchased at a satisfactory price, the methods of support of experimental work would be largely settled. It would seem, therefore, to be extremely desirable either that growers unite in the purchase of the property to be placed at the disposal of the station, or that the State be asked to appropriate money for the purpose. It is quite impossible that the cost either of leasing the needed property or of purchasing it should be met by the use of ordinary station funds. Such funds are quite inadequate in amount to meet so large an added expenditure.

The co-operation of the United States government in certain lines of investigation has been asked for, and we are already assured of material assistance in the study of plant diseases and the climatic conditions which affect the crop.

Fertilizer Experiments. — The fertilizer experiments at Red Brook Bog, lying at Waquoit, have been continued. This includes 33 plots of one-twentieth of an acre which are subjected to varying fertilizer treatment. The use of fertilizers has been so planned that the results must ultimately afford a valuable basis for determining what should be the composition of cranberry fertilizers. It is recognized, of course, that conditions vary in different bogs, and that no one formula can possibly be the best under all conditions. Our object is to learn if possible the specific effects of different fertilizer elements. When these are understood, it will be possible to adapt the fertilizer to meet varying conditions in different bogs.

Most of the plots in our experiment gave a fairly good crop in 1909, but, owing to a misunderstanding on the part of men employed in harvesting the fruit upon portions of the bog outside the fertilizer plots, the product from a few of the plots was mixed, and a complete record of results would be impossible. There were, moreover, a few plots in which considerable damage was done by insects. The results, therefore, are not to be reported in detail at this time, but the following conclusions seem to be fully warranted as the result of observations and records so far made.

1. The use of some fertilizer will clearly prove profitable on many bogs. The average product on the no-fertilizer plots (7 in number) in our experiments this year was 7.5 bushels per plot, or at the rate of 150 bushels per acre. The average product on the fertilizer plots (19 in number) was 13.4 bushels per plot, or at the rate of 268 bushels per acre. The average product on the 10 plots to which a complete fertilizer was applied was at the rate of 306.5 bushels per acre. A complete fertilizer was made up by the mixture of nitrate of soda, acid phosphate and a potash salt.

2. The use of nitrate of soda greatly promotes the growth of vines, and seems also to be favorable to fruitfulness. Even with the smallest quantity of nitrate used in our experiments (at the rate of 200 pounds per acre) the growth of the vines has been very luxuriant, — so luxuriant that the fruit, although abundant, was poorly colored and probably inferior in keeping qualities. The vine growth was so rank that another year the rate at which nitrate is used will be greatly reduced. *It is believed that nitrate in excess of 100 pounds per acre will seldom be necessary.*

3. The influence of high-grade sulfate of potash appears to be decidedly favorable. It promotes fruitfulness, good color and high quality. The highest yield obtained on any of the plots (22½ bushels, which is at the rate of 450 bushels per acre) was produced where the maximum quantity of sulfate of potash was used in connection with a moderate amount of nitrate of soda and acid phosphate. The total fertilizer application to this plot was at the rates per acre: —

	Pounds.
Nitrate of soda, ...	200
Acid phosphate, ...	400
High-grade sulfate of potash, ...	400

4. Phosphoric acid appears in these experiments to have less effect than either of the other fertilizers employed, though it appears probable that when applied in soluble form, such as acid phosphate, it will be likely to promote early ripening, and will be favorable to fruit of relatively high color.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1909.

The United States Appropriations, 1908–09.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1909, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams fund), . . .	$15,000 00	$11,000 00
Cr.		
By salaries, ...	$12,734 18	$8,163 08
labor, ...	479 84	1,004 41
publications, ...	6 50	–
postage and stationery, ...	103 23	46 75
freight and express, ...	21 48	32 20
heat, light, water and power, ...	103 88	230 76
chemical supplies, ...	91 64	338 80
seeds, plants and sundry supplies, . .	362 92	302 75
fertilizers, ...	254 53	260 48
feeding stuffs, ...	241 28	–
library, ...	143 04	24 85
tools, implements and machinery, . .	–	–
furniture and fixtures, ...	244 00	50 00
scientific apparatus, ...	113 03	513 04
live stock, ...	10 25	–
traveling expenses, ...	20	31 26
contingent expenses, ...	15 00	–
buildings and land, ...	75 00	1 62
	$15,000 00	$11,000 00

State Appropriation, 1908–09.

To balance on hand,	$7,529 52	
Cash received from State Treasurer,	13,500 00	
from fertilizer fees,	5,210 00	
from farm products,	2,387 57	
from miscellaneous sources,	4,825 17	
		$33,452 26

Cash paid for salaries,	$8,616 19	
for labor,	8,155 03	
for publications,	1,837 45	
for postage and stationery,	992 11	
for freight and express,	853 48	
for heat, light, water and power,	423 66	
for chemical supplies,	336 41	
for seeds, plants and sundry supplies,	1,670 95	
for fertilizers,	586 10	
for feeding stuffs,	1,115 02	
for library,	318 71	
for tools, implements and machinery,	10 07	
for furniture and fixtures,	337 47	
for scientific apparatus,	566 61	
for live stock,	12 00	
for traveling expenses,	1,882 73	
for contingent expenses,	95 00	
for buildings and land,	604 77	
Balance,	5,538 50	
		$33,452 26

REPORT OF THE AGRICULTURIST.

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work in the department of agriculture in the experiment station has followed the usual lines during the past year. The most important investigations in progress have reference to what in general may be denominated fertility problems. They are designed to throw light upon various questions connected with the selection, use and methods of application of manures and commercial fertilizers. A considerable number of the experiments in progress has already continued for a number of years, and the results are becoming increasingly valuable, as they afford, with the passage of the years, surer indications as to the ultimate effects to be expected. The number of field plots on the station grounds used in the experiments the past year was 351.

Pot experiments have been continued and have been designed chiefly to throw light upon the relative values of different materials which may be used, respectively, as sources of nitrogen, phosphoric acid and potash. Tests of this character afford the surest indications as to the relative availability of different materials. The principal crops used in this work are Japanese barnyard millet, soy beans and dwarf Essex rape. We have used 346 pots during the past year. In some phases of our work, mainly as a check upon field results, we use closed plots, and the number of these in use the past season was 167.

The experiments in progress will not be taken up in detail in this report; but attention is called to some of the more striking results.

I. The experiments on Field A, which have for their object the determination of the relative value, as sources of nitrogen, of some of the leading materials which may be used to furnish that element, have been continued. These experiments were begun in 1890. The crops grown in order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, corn and clover for the last two years. These two crops have been considerably mixed with grass. The best crop of the year was produced where dried blood was used as a source of nitrogen, but the crop produced upon nitrate of soda was practically the same. On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen fertilizers and the no-nitrogen plots (total yield) was as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	100.50
Sulfate of ammonia,	87.14
Barnyard manure,	83.00
No nitrogen,	72.34

The relative standing of the different materials for the twenty years during which the experiments have continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.05
Dried blood,	92.34
Sulfate of ammonia,	86.47
No nitrogen,	70.99

On the basis of increase in crop as compared with the no-nitrogen plots the average of the twenty years shows the following relative standing: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	79.51
Dried blood,	73.62
Sulfate of ammonia,	53.36

It will be seen that the nitrate of soda has given a much larger average increase in crop than any of the other materials.

There would seem to be little doubt, therefore, that this material must be regarded as one of the most satisfactory of the nitrogen fertilizers, and since it can usually be purchased at a lower average cost per unit of nitrogen than other fertilizers containing that element, it would seem to be the part of wisdom to use it as largely as soil and crop conditions will permit.

II. The experiments on Field B, for determining the relative value for different crops of the muriate and high-grade sulfate of potash when used in equal amounts, have been continued. These experiments began in 1892. Five pairs of plots are under comparison. Up to 1899 the potash salts were used in quantities (varying in different years, but always in equal amounts on the two members of pairs of plots) ranging from 350 to 400 pounds per acre. Since 1900 the quantity used has been uniform on all the plots, and at the rate of 250 pounds per acre annually. In connection with the potash we have used the same amount of fine ground bone annually for each plot throughout the entire period of the experiment. The rate of application of the bone is 600 pounds per acre. The season of 1909 is the eighteenth year of these experiments. The crops during that year were corn on two pairs of plots, asparagus and rhubarb occupying each a portion of one pair of plots, raspberries and blackberries each occupying a portion of one pair, carrots on one pair of plots and cabbages on the other. The yield of berries was very small, on account of serious winterkilling. This was less on the sulfate of potash than on the muriate. On both pairs of plots occupied by corn the sulfate gave a heavier yield of grain, while the muriate gave a larger yield of stover. The difference in favor of the grain amounted to about 5 bushels. The difference in stover in favor of the muriate was at the rate of about 600 pounds per acre. The asparagus gave much the heavier crop on the muriate, at the rate of 6,002 pounds per acre on that salt against 3,257 pounds on the sulfate. The rhubarb gave a crop at the rate of 22,786 pounds per acre of stalks on the muriate and 28,349 pounds on the sulfate. The carrots gave a better yield on the sulfate, at the rate of 822.4 bushels per acre against 799.1 bushels on the muriate. The cabbages gave much the larger yield of hard heads on the sulfate, the figures being at the following rates per acre: —

	Pounds.
Muriate of potash: —	
Hard heads,	17,466
Soft heads,	6,878
High-grade sulfate of potash: —	
Hard heads,	21,966
Soft heads,	2,434

III. In Field C we have under comparison for use in connection with manure three different materials used as a source of nitrogen, — sulfate of ammonia, nitrate of soda and dried blood, — and the two potash salts, muriate and high-grade sulfate, each salt being used with each of the three nitrogen fertilizers and in connection with a liberal application of dissolved bone black, the same on all plots. The comparison of these different fertilizers in this field was begun in 1891, but up to the year 1898 they were used without manure. Since that time all plots receive annually a dressing of stable manure, at the rate of 30 tons per acre. A large variety of crops has been grown in this field. The crops the past year were asparagus, rhubarb, cauliflower and onions. Rhubarb and cauliflowers have given the heavier yields on sulfate of ammonia as a source of nitrogen; but both asparagus and onions have given smaller yields on this material than on either of the other nitrogen fertilizers. Nitrate of soda gave a yield of asparagus about 25 per cent. greater than sulfate of ammonia, while for onions the difference in favor of the nitrate of soda was in much greater proportion. With muriate as the source of potash, the yield of No. 1 onions on the different nitrogen fertilizers was at the following rates per acre: —

	Bushels.
Sulfate of ammonia,	359.2
Nitrate of soda,	565.1
Dried blood,	515.9

With sulfate of potash as the source of potash the rate of yield of No. 1 onions per acre for the different nitrogen fertilizers was as follows: —

	Bushels.
Sulfate of ammonia,	412.0
Nitrate of soda,	703.6
Dried blood,	557.5

The average yields on the different potash salts were at the following rates per acre: —

	Bushels.
Muriate of potash: —	
No. 1 onions,	480.10
Pickling onions,	77.80
Sulfate of potash: —	
No. 1 onions,	557.70
Pickling onions,	57.97

For rhubarb the muriate of potash gave the larger crop, at the rate per acre of 77,400 pounds, against 64,828.7 pounds on the sulfate.

The cauliflowers gave the better crop on the sulfate, the rates per acre being as follows: —

	Pounds.
Muriate of potash,	24,695
Sulfate of potash,	30,691

The asparagus gave the better yield on the sulfate, but the difference was small. The rates per acre were as follows: —

	Pounds.
Muriate of potash,	4,951.0
Sulfate of potash,	5,176.7

The results with onions and with cauliflowers are the most striking, and are in close agreement with results previously obtained. The cauliflower, like the cabbage, seems to be more certain to give a satisfactory crop on the sulfate than on the muriate on soils fairly retentive of moisture.

The crops on the plot in this field, where manure is used without fertilizers, are in most cases still nearly as good as on the plots where fertilizers are used in addition to the manure; but we would again point out that the history of this plot and its manurial treatment previous to its inclusion in this field were different from those of the other plots. Nevertheless, the fact that the crops on this plot still compare so favorably with those on the plots where fertilizer also is used raises the question whether the latter is a benefit.

IV. In the experiments comparing the different potash salts, which were begun in 1898, and in which these salts are used in quantities to furnish equal actual potash per acre annually, the crop the past year was hay, mixed timothy, red top and clovers. The average yield of the no-potash plots was at the following rates per acre: —

	Pounds.
Hay,	5,744
Rowen,	680

The average yield of all the potash plots, 35 in number, was at the following rates per acre: —

	Pounds.
Hay,	6,412.6
Rowen,	1,555.4

It will be noticed that the increase in the yield of hay was not very large, and that the yield without the potash was for both crops slightly in excess of 3 tons per acre. The rowen crop on the potash plots is much greater than on the no-potash plots because of the larger proportion of clover. The most striking result of the experiments, indeed, is the comparative failure of clover on the plots to which no potash was applied, and its great inferiority on the five plots to which kainit is annually applied. On these plots, and especially on the plots to which the kainit is applied, the yield of timothy was remarkably heavy, the proportion of this grass being much greater than on plots to which the other potash salts are applied.

V. In the field where ten of the leading materials which may be used as sources of phosphoric acid have been under comparison since 1897, the crop during the past year was soy beans. The phosphates used in this experiment are applied in connection with equal and liberal quantities of nitrogen and potash in available forms, at such rates as will furnish equal actual phosphoric acid per acre. The average yield of the three no-phosphate plots was at the rate of 6,668 pounds, or 27.8 bushels per acre. The average yield on the ten phosphatic fertilizers was at the rate of 1,835.2 pounds, or 30.6 bushels. The average increase on the phosphate plots as compared with the no-phosphate was at the rate of 167.2 pounds per acre. The highest increase, at the rate of 296 pounds per acre, was produced on the steamed bone meal. This increase is at the rate of 17.7 per cent. There was not a very wide difference between the crops produced on the different phosphates, and the most striking result of the experiment is the fact that the crop where no phosphate has been applied during the past thirteen years is nearly equal to the crops produced on the best of the phosphate plots. On the same plots last year, cabbage being the crop, the increase on the best phosphatic material of the year, bone meal, was 667 per cent. of the average crop produced on the no-phosphate plots. These facts serve to emphasize the point which I have previously many times referred to, that in considering the plant-food requirements of soils it is of the first importance that the crop be taken into consideration. For the successful cultivation of the cabbage on this soil a rapidly available form of phosphoric acid is essential; but for the soy bean, the application of phosphoric acid seems to have been relatively unimportant.

VI. The crop on the south corn acre, where manure at the rate of 6 cords to the acre annually has been under comparison since 1890 with an application per acre at the rate of 4 cords of manure and 160 pounds of high-grade sulfate of potash, during the past year was hay, mixed timothy, red top and clovers. The plots to which the large applications of manure alone have been made were materially larger than on the combination of a lesser amount of manure and potash. The following are the average rates per acre: —

	Pounds.
Manure alone: —	
Hay,	4,930
Rowen,	530
Manure and potash: —	
Hay,	3,670
Rowen,	490

The rowen crops of the past season were exceptionally small, on account of a very marked deficiency in rainfall. It is apparent, however, that although the combination of the lesser amount of manure and potash substantially equals the larger amount of manure for corn, which is grown in alternate two-year rotations with hay, it is not equal for the production of hay.

VII. On the north corn acre, where the combination of fertilizer materials rich in potash is under comparison with a combination of similar materials in different proportions, and furnishing less potash and much more phosphoric acid, the crop the past year was hay, mixed timothy, red top and clovers. This experiment was begun in 1891, and for the past fourteen years corn and hay, two years each, have regularly alternated. Owing to the very dry summer the field was cut but once. The average yields were at the following rates per acre: —

	Pounds.
On the fertilizer combination rich in phosphoric acid and relatively poor in potash,	5,094
On the fertilizer combination richer in potash and poorer in phosphoric acid,	5,320

The proportion of clover in the plots receiving the combination richer in potash is noticeably greater than on the other plots. The combination richer in potash in these experiments has shown itself substantially equal to the other combination for the production of corn, and superior for the production of hay.

VIII. The experiments for the production of hay, by using in rotation as top-dressing barnyard manure, wood ashes and a mixture of bone meal and potash, have been continued during the past year in the nine-acre field where these experiments have been under progress since 1893. The average yield on the entire area during the past year was at the rate of 5,036 pounds of hay. The yields on the different materials used in top-dressing were at the following rates per acre: —

	Pounds.
Barnyard manure,	5,394
Wood ashes,	4,708
Fine ground bone and potash,	5,160

The average yields to date under the different systems of top-dressing have been at the following rates per acre: —

	Pounds.
Barnyard manure,	6,373
Wood ashes,	5,805
Fine ground bone and potash,	6,164

The average yield of the nine acres, from 1893 to 1909 inclusive, has been at the rate of 6,150 pounds per acre. The average of the past year, it will be seen, is materially below the long-time average, a fact undoubtedly due to the deficiency of summer rainfall, previously referred to.

IX. In the experiments comparing winter application of manure with spring application of an equal quantity, put into large heaps in the field in the winter and spread in the spring, the crop this year has been hay, mixed timothy, red top and clovers. The two systems of applying manure are under comparison on five pairs of plots, and the experiment has been in progress since 1899. The average crops of the past season were at the following rates per acre: —

	Pounds.
Winter application of manure: —	
Hay,	7,045.0
Rowen,	460.6
Spring application of manure: —	
Hay,	6,482.0
Rowen,	659.2

It will be noted that the winter application has given a larger crop of hay, but that the manure applied in the spring has given a heavier yield of rowen. If we combine the hay and rowen crops, the average yields have been at the following rates per acre: —

	Pounds.
Winter application of manure,	7,505.6
Spring application of manure,	7,141.2

The field in which these experiments are located slopes considerably in a direction running lengthwise with the plots. The superiority of the results obtained where the manure is applied in winter becomes more strikingly evident when it is remembered that by following this system the labor cost is materially less than under the other, since when the manure is applied in the spring it must be handled twice.

X. The leading feature of the poultry experiments during the past year has been the continuation of the experiments comparing the dry with the moist-mash system of feeding. We have carried through six experiments, three during the winter and three during the summer, using in these experiments six different flocks of fowls. The results have been similar to those obtained last year. In the majority of the experiments the fowls receiving the moist mash have produced a greater number of eggs. The moist-mash feed has seemed to be superior to the dry feed in four out of the six experiments, and the number of eggs in most of these experiments has been materially greater than the number produced under the dry system of feeding. In the two experiments in which the dry system gave the greater number of eggs, the differences were relatively small. Averaging the six experiments, the results are as follows: —

Number of Eggs daily per 100 Hens.

Moist mash,	36.3
Dry feeds,	34.5

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

Research section: Edward B. Holland, Robert D. MacLaurin.[1]
Fertilizer section: Henri D. Haskins in charge.
Feed and dairy section: Philip H. Smith in charge.
Assistant chemists: Lewell S. Walker, James C. Reed, Philip V. Goldsmith,[2] C. D. Kennedy.[3]
Assistant in animal nutrition: Roy F. Gaskill.
Inspector: James T. Howard.[4]
Clerks and stenographers: Harriet M. Cobb, Alice M. Howard.

In the following pages is given a brief outline of the work carried on by the department for the year ending Dec. 1, 1909.

1. Correspondence.

The number of letters sent out during the year ending December 1, on the basis of stamps used, has been 5,641, some 841 more than in the preceding year. Comparatively few stamps are used for packages. The correspondence divides itself principally into (*a*) answering letters of inquiry, (*b*) the execution of the fertilizer and feed laws, (*c*) testing of cows, and (*d*) in the ordering of supplies.

[1] Resigned Sept. 1, 1909.
[2] Resigned Dec. 1, 1909.
[3] From October, 1909.
[4] From April 1, 1909.

2. Numerical Summary of Work in the Chemical Laboratory.

From Dec. 1, 1908, to Dec. 1, 1909, there have been received and examined 99 samples of water, 389 of milk, 2,933 of cream, 98 of feed stuffs, 234 of fertilizers and fertilizer materials, 42 of soils and 45 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 191 samples of milk, 157 of cattle feeds, 58 of fertilizers, 26 of soils and 534 of agricultural plants. There have also been collected and examined 1,042 samples of fertilizer in accordance with the requirements of the fertilizer law, and 946 samples of cattle feeds in accordance with the requirements of the feed law. The total for the year has been 6,794. This summary does not include work done by the research division.

In addition to the above, 25 candidates have been examined and given certificates to operate Babcock machines, and 4,071 pieces of Babcock glassware have been tested for accuracy of graduation, of which 43, or 1.06 per cent., were inaccurate.

3. Résumé of Work of the Research Section.

The research work was carried on jointly by Mr. E. B. Holland and Dr. R. D. MacLaurin. Mr. Holland has given attention particularly to a study of methods for the determination of insoluble acids in butter fats, and has co-operated with the entomological department relative to the burning of foliage by insecticides. Quite satisfactory progress has been made in both of these lines of work, but they are not sufficiently advanced to warrant any detailed publication. A paper on the stability of butter fat, prepared by Mr. Holland, appears elsewhere in this report.

Work on the constitution of fats and the chemistry of fat formation has been suspended by the resignation of Dr. MacLaurin. Dr. MacLaurin devoted substantially a year to the study of this subject, and has signified to the writer his intention of preparing his work for publication.

4. Work in Animal Nutrition.

Work to note the effect of molasses on the digestibility of the ration with which it is fed has been sufficiently advanced to warrant a paper on the subject, which appears elsewhere in this report.

Experiments on the most suitable varieties of corn for the silo have been in progress for a number of years. The results show that such varieties as the Leaming, Pride of the North, Rustler White Dent, Longfellow and Sanford White are more suitable for this latitude than Early Mastodon, Improved White Cap, Brewer's Dent, Wing's White Cap and Eureka. We have noted the degree of maturity by September 15, the yield of dry matter, the proportion of dry matter in stocks, ears, husks and leaves, as well as the degree of digestibility of most of the several varieties. The excess in yield of green material from the latter varieties consists largely of water. In case the coarse dents are field cured, the stalks will not cure out well, and as late as the middle of November contain a much larger amount of water than the smaller varieties. The detailed report of this experiment will probably be ready for publication in another year.

Digestion tests with alfalfa and red clover at the same stages of growth have been completed, but a large amount of laboratory work in connection with the samples still remains to be done before the final results can be obtained.

5. Résumé of Work of the Fertilizer Section.

Mr. H. D. Haskins, in charge, presents the following report: —

The activities of the fertilizer division have been confined chiefly to the fertilizer control work and the examination of fertilizers, soils, refuse by-products, etc., forwarded by farmers and others interested in agriculture. The results of the year's work would indicate that a larger number of private formulas and home-mixed fertilizers had been used by the Massachusetts farmers than ever before. The work of the collection and inspection of licensed fertilizers has also increased during the year. A larger number of fertilizers was licensed this year than during the past season, and the collection and analysis of samples reach the highest number ever attained during the history of fertilizer inspection work in Massachusetts.

(a) *Fertilizers licensed.*

During the year 431 distinct brands of fertilizers and agricultural chemicals have been licensed in Massachusetts. Licenses have been secured during the year by 78 manufacturers, importers and dealers, counting each branch of the American Agricultural Chemical Company as a separate company. Two more licenses were issued and 22 more brands were licensed than for 1908. The brands licensed this year may be classed as follows: —

Complete fertilizers,	306
Fertilizers furnishing potash and phosphoric acid,	9
Ground bone, tankage and dry ground fish,	51
Agricultural chemicals and organic compounds furnishing nitrogen,	65
Total,	431

(b) *Fertilizers collected.*

An effort was made during the season to cover a larger territory than heretofore, and to procure, so far as possible, representatives of every brand of goods sold in the State. As a general rule, fertilizers cannot be found plentifully in the open markets in Massachusetts until after April 1. Some of the fertilizer is used on early crops by the 15th or 20th of April, and by May 1 considerable of the fertilizer is in the ground. Our collecting season being relatively short, an extra man was delegated to gather samples during that portion of the season when the fertilizer was found most plentiful. The samples were in all cases taken by an authorized agent from the experiment station. Mr. James T. Howard, the assistant usually delegated to this work, assisted by Mr. C. W. Gaskill, covered the eastern portion of the State, while Mr. E. C. Hall looked after the collection in the Connecticut Valley and the central portion of the State. Samples were taken from over 280 different agents, and over 110 different towns were visited.

The total number of samples collected was 1,042, representing 458 distinct brands, — being 418 more samples than during the preceding year. Wherever possible an analysis has been made of a composite made up of equal weights of the same brand collected in various parts of the State. Samples have been taken with the usual care and discrimination, the collecting agents being instructed to sample at least 10 per cent. of the number of packages of each brand, and never less than five bags, without making a special note of the fact on the guarantee slip which is sent to the laboratory with each sample taken.

(*c*) *Fertilizers analyzed.*

The following analyses have been made in connection with the inspection of licensed fertilizers: —

Complete fertilizers,	384
Ground bone, tankage and fish,	61
Materials furnishing phosphoric acid, potash and lime, such as ashes,	16
Nitrogen compounds, such as nitrate of soda, sulfate of ammonia, blood, castor pomace, cottonseed meal and linseed meal,	68
Potash compounds,	34
Phosphoric acid compounds,	17

In addition to the above, 33 samples of fertilizer have been analyzed that were not licensed but which were goods manufactured for private use. These goods were sampled officially by our collecting agents from stock in the possession of the consumer. This makes a total of 613 analyses which have been made during the season of 1909.

In some instances, where the results of analysis of a composite sample showed a brand to be seriously deficient in plant food, a new sample has been prepared for analysis from each original sample taken, and separate analyses have been made. This was done to ascertain if the shortage was general, or confined to one or more lots of the same brand. Thirty-five such complete analyses were made during the season from 13 composite samples; 172 more analyses have been made than during the previous year.

(d) Trade Values of Fertilizing Ingredients.

	Cents per Pound.	
	1909.	1908.
Nitrogen: —		
In ammonia salts,	17	17½
In nitrates,	16½	18½
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade mixed fertilizers,	19	20½
Organic nitrogen in fine bone and tankage,[1]	19	20½
Organic nitrogen in coarse bone and tankage,[1]	14	15
Phosphoric acid: —		
Soluble in water,	4	5
Soluble in ammonium citrate (reverted phosphoric acid),	3½	4½
In fine ground bone and tankage,[1]	3½	4
In coarse bone and tankage,[1]	3	3
In cottonseed meal, linseed meal, castor pomace and ashes,	3	4
Insoluble (in neutral citrate of ammonia solution) in mixed fertilizers,	2	2
Potash: —		
As sulphate free from chlorides,	5	5
As carbonate,	8	8
As muriate (chloride),	4¼	4¼

The above schedule of trade values was adopted at a meeting of the station directors and chemists from the New England and New Jersey experiment stations, which was held in March, 1909. They represent the average cash pound cost, at retail, of the three essential elements of plant food in their various forms, as furnished by chemicals and unmixed raw materials, in the large markets during the six months preceding March 1, 1909. The trade values for nitrogen and phosphoric acid are somewhat lower than for the previous year.

The following table shows the average comparative commercial values, the retail cash prices and the percentages of difference of the licensed complete fertilizers analyzed in Massachusetts during the season of 1908 and 1909: —

Year.	Commercial Values.	Retail Cash Prices.	Difference.	Percentages of Difference.
1908,	$25 81	$36 20	$10 39	40.25
1909,	22 19	34 62	12 43	56 01

It must be remembered that the "commercial values" represent the retail price of the raw or unmixed materials, and that

[1] Fine and medium bone are separated by a sieve having circular openings one-fiftieth of an inch in diameter, the valuation of the bone being based upon the degree of fineness.

the manufacturer cannot sell mixed fertilizers at these figures. He must obtain an advance sufficient to cover costs of manufacture, bagging, agencies, credits, etc. The above differences do not represent his profits. These are much smaller, and are probably not excessive in the case of reliable firms. It is probable, however, that the cash buyer of high-grade unmixed goods can secure needed plant food in that form at a cost considerably lower than in licensed complete fertilizers, and that by intelligent selection he can procure materials from which can be made home mixtures at least equally effective with such fertilizers.

(c) *Summary of Analyses and Guarantees.*

Manufacturer.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	1	2	1	2	–
American Agricultural Chemical Company,	69	37	65	23	9	–
Armour Fertilizer Works,	10	4	6	4	2	–
Baltimore Pulverizing Company,	2	–	2	2	–	–
Beach Soap Company,	4	3	4	1	–	–
Berkshire Fertilizer Company,	6	4	6	2	–	–
Bowker Fertilizer Company,	31	19	32	15	–	–
Joseph Breck & Son,	3	1	3	2	–	–
Buffalo Fertilizer Company,	9	4	7	4	1	–
Coe-Mortimer Company,	9	3	6	4	2	–
Eastern Chemical Company,	1	–	1	1	–	–
Essex Fertilizer Company,	11	8	10	3	–	–
R. & J. Farquhar & Co.,	5	2	5	3	–	–
Hubbard Fertilizer Company,	3	2	3	1	–	–
Jordan Marsh Company,	1	–	–	–	1	–
Listers Agricultural Chemical Works,	7	7	7	–	–	–
James E. McGovern,	1	–	–	–	1	–
Mapes Formula and Peruvian Guano Company,	17	11	17	5	1	–
National Fertilizer Company,	12	6	12	6	–	–
Natural Guano Company,	1	–	1	–	1	–
New England Fertilizer Company,	6	3	5	2	1	–
Olds & Whipple,	6	5	6	1	–	–
Parmenter & Polsey,	6	3	6	3	–	–
R. T. Prentiss,	3	–	–	1	1	1
Pulverized Manure Company,	3	–	–	–	2	1
W. W. Rawson & Co.,	2	1	1	–	1	–
Rogers Manufacturing Company,	9	8	9	1	–	–
Rogers & Hubbard Company,	8	5	8	3	–	–
Ross Brothers Company,	3	1	2	1	1	–
N. Roy & Son,	1	–	1	1	–	–
Sanderson Fertilizer and Chemical Company,	7	1	5	6	–	–
M. L. Shoemaker & Co., Ltd.,	2	1	2	1	–	–
Swift's Lowell Fertilizer Company,	18	10	15	5	3	–
Whitman & Pratt Rendering Company,	5	3	5	2	–	–
Wilcox Fertilizer Works,	6	6	6	–	–	–
A. H. Wood & Co.,	3	–	–	2	1	–

The above table shows: —

1. That 296 distinct brands of complete licensed fertilizers were collected and analyzed.

2. That 138 brands (46.6 per cent. of the whole number analyzed) fell below the manufacturer's guarantee in one or more elements.

3. That 106 brands were deficient in one element.

4. That 30 brands were deficient in two elements.

5. That 2 brands were deficient in all three elements. In this connection it might be added that 80 brands were found deficient in nitrogen, 63 in potash and 28 in phosphoric acid.

6. That 45 out of the 296 brands analyzed (over 15 per cent. of the total number) showed a commercial shortage. The term "commercial shortage" means that the brands in question did not show the quantity and value of plant food guaranteed, although the excess of any element of plant food was figured in full value to offset the deficiencies.

7. That certain manufacturers are either extremely careless in mixing or else they do not allow a sufficient margin for variation in the composition of crude stock. In other words, they try to have their goods run too close to the minimum guarantee.

(*f*) *Commercial Shortages.*

The following table has been prepared to show the commercial shortages in the mixed fertilizers for the season of 1909, also to furnish a comparison with the previous year: —

Commercial Shortages.

COST.	Number of Brands.	
	1909.	1908.
Over $4 per ton,	4	–
Between $3 and $4 per ton,	2	3
Between $2 and $3 per ton,	5	1
Between $1 and $2 per ton,	14	7
Under $1, not less than 25 cents,	35	Not given.

The season of 1909 shows the largest number of deficiencies and commercial shortages which has probably ever occurred in this State. The largest number occurring are below $1 per ton, and yet many of the deficiencies are very serious, running 1 per cent. or over below the minimum guarantee. In the table of shortages, in all cases where an excess of plant food has occurred the commercial value of the excess has been used to offset the commercial shortage resulting from a deficiency in some of the other elements. This practice is certainly extremely fair to the manufacturer. We should not lose sight of the fact, however, that serious deficiencies or excesses change the essential character of a fertilizer. A prosecution in every case this year must, from necessity, have contained a certain element of unfairness, as some of the cases of the most serious deficiencies occurred where the licensee was not the manufacturer, and was, therefore, not directly responsible for the composition of the goods, which were manufactured by parties outside of the State. Therefore no prosecutions have been made for shortages. It seemed wise, after a careful review of the situation, to take up the matter with each manufacturer separately, and endeavor to secure an adjustment that would be as favorable as possible to the consumer. It is obviously not possible, however, to follow such a method year after year. *All manufacturers whose goods have fallen seriously below their guarantees have been advised, and all others are hereby informed, that such conditions cannot continue to exist, and that another season it will be necessary to prosecute violators of the statute.*

(*g*) *Grades of Fertilizer.*

The 323 brands of complete fertilizers may be divided into three groups: —

Low-grade fertilizers, having a commercial value of $18 or less per ton,	83
Medium-grade fertilizers, having a commercial value of between $18 and $24 per ton,	122
High-grade fertilizers, having a commercial value of over $24 per ton,	118

The following table has been compiled for the purpose of making a study of the three grades of goods: —

Grade of Fertilizer.	Number of Brands.	Per Cent. of Whole.	Average Composition.				Average Valuation.	Average Cost.	Excess of Selling Price over Valuation.	Percentage Difference.
			Per Cent. Nitrogen.	Per Cent. Available Phosphoric Acid.	Per Cent. Potash.	Pounds Available Plant Food in 100 pounds of Fertilizer.				
High, ...	118	36.53	3.94	7.62	8.00	19.56	$27 63	$39 05	$11 42	41.33
Medium, . . .	122	37.77	2.61	8.10	5.34	16.05	20 69	33 85	13 16	63.61
Low, ...	83	25.70	1.80	7.35	3.06	12.21	15 32	29 51	14 19	92.62

The above table shows: —

1. That the per cent. of nitrogen and potash is much higher in the high-grade goods than in the medium or low grade.

2. That with about a 32 per cent. advance in price over the low-grade fertilizers, the high-grade furnished more than 60 per cent. increase in available plant food.

3. With about 32 per cent. advance in price over the low-grade goods, the high-grade furnished over 80 per cent. increase in commercial value.

4. A ton of the average high-grade fertilizer furnishes about 43 pounds more of nitrogen, 5½ pounds more of available phosphoric acid and 99 pounds more of actual potash than does a ton of the low-grade goods.

5. The average high-grade fertilizer costs 15½ per cent. more than the medium-grade article; it furnishes about 22 per cent. more plant food and has about 35.5 per cent. greater commercial value.

6. The medium-grade fertilizers cost about 15 per cent. more than the low-grade and furnish over 35 per cent. greater commercial value.

7. The percentage of difference between cost and valuation in low-grade goods is more than double that for high-grade fertilizers.

Table showing the Pound Cost of Nitrogen, Potash and the Various Forms of Phosphoric Acid in the Three Grades of Fertilizer.

	Low-grade Fertilizer (Cents).	Medium-grade Fertilizer (Cents).	High-grade Fertilizer (Cents).
Nitrogen, ...	36.60	31.08	26.85
Potash (as muriate), ...	9.63	8.18	7.07
Soluble phosphoric acid, ...	7.71	6.54	5.65
Reverted phosphoric acid, ...	6.74	5.73	4.95
Insoluble phosphoric acid, ...	3.85	3.27	2.83

The above table shows: —

1. That nitrogen has cost 9.75 cents more per pound, available phosphoric acid about 2 cents more per pound and potash 2.56 cents more per pound in the average low-grade fertilizer than in the average high-grade goods.

2. That nitrogen has cost 4.23 cents, the available phosphoric acid over ¾ of a cent and the potash 1.11 cents more per pound in the average medium-grade fertilizer than in the average high-grade goods.

3. That every conclusion which can be drawn from the above table emphasizes the fact that the farmer cannot afford to purchase low-grade fertilizers.

(*h*) *Unmixed Fertilizers.*

Ground Bones. — Twenty-nine samples of ground bone have been analyzed during the inspection of 1909. Eleven of the brands have been found deficient in phosphoric acid and 8 in nitrogen; 8 brands had a commercial shortage ranging from a few cents to $2.95 per ton. The average retail cash price for bone has been $30.39 per ton, the average valuation $26.09 and the percentage difference 16.57.

Tankage. — Nine samples of tankage have been analyzed and show the usual variations in composition; only 1, however, has shown a serious shortage in nitrogen, and 1 tested low in phosphoric acid. There were no commercial shortages. The average retail cash price was $30.18, the average valuation $29.86 and the percentage difference 1.07. The average cost of nitrogen per pound in this material has been 17.1 cents in fine tankage and 13 cents in coarse tankage.

Dissolved Bone. — Three samples of dissolved bone have been analyzed, only 1 of which was found deficient in plant food. No commercial shortages were found. The average retail cash price was $26.67, the average valuation $20.69 and the percentage difference 28.90.

Dry Ground Fish. — Twenty samples of dry ground fish have been examined, of which 9 were found deficient in nitrogen and only 1 in phosphoric acid. Six brands showed a commercial shortage ranging from a few cents to $1.89 per ton. The average retail cash price was $38.96, the average valuation $36.13 and the percentage difference 7.83. Nitrogen from dry fish has cost, on the average, 23.88 cents per pound.

Wood Ashes. — Thirteen samples of ashes have been analyzed, of which 3 were found deficient in phosphoric acid and 6 in potash. Six of these samples showed a commercial shortage ranging from 32 cents to $1.10 per ton.

(1) *Nitrogen Compounds.*

Sulfate of Ammonia. — Three samples have been analyzed and found well up to the guarantee. The average cost of nitrogen per pound in this form has been 17.53 cents.

Nitrate of Soda. — Thirteen samples have been analyzed, only 2 being found deficient in nitrogen. The average cost of nitrogen per pound in form of nitrate of soda has been 17.11 cents.

Dried Blood. — Two samples of this material were examined and found deficient in nitrogen; each contained sufficient phosphoric acid, however, so that there was no commercial shortage. The average cost of nitrogen from blood has been 25.57 cents per pound.

Castor Pomace. — Four samples of castor pomace have been analyzed, 1 sample only being found deficient in nitrogen, and this equivalent to $2.36 per ton. The average cost of nitrogen in this form has been 23.67 cents per pound.

Linseed Meal. — Three samples of flax meal have been tested and the nitrogen guarantee has been maintained in each instance. The nitrogen from this source has cost, on the average, 26.47 cents per pound.

Cottonseed Meal. — Forty-three samples of cottonseed meal have been examined. This has been the product from six companies which have licensed this material to be sold as a fertilizer in Massachusetts during the past year. This material, like the castor pomace and linseed meal, is bought largely as a nitrogen source for tobacco. Seventeen out of the 43 samples analyzed show a nitrogen shortage ranging from a few cents to $2.39 per ton. Nitrogen from cottonseed meal has cost, on the average, 23.61 cents per pound.

(2) *Potash Compounds.*

Carbonate of Potash. — Three samples have been analyzed and all of them were found to be of good quality. Potash in this form has cost, on the average, 7.68 cents per pound.

High-grade Sulfate of Potash. — Nine samples have been analyzed and the potash guarantee was maintained in all but 3 of them. The pound of potash has cost in this form, on the average, 5.03 cents.

Potash-magnesia Sulfate. — Six samples have been analyzed and in every case the potash guarantee has been maintained. The pound of actual potash has cost in this form 5.41 cents.

Muriate of Potash. — Thirteen samples have been examined and only 2 samples have shown a potash shortage, amounting to a few cents per ton in value. The pound of actual potash in form of muriate has cost, on the average, 4.18 cents.

Kainit. — Three samples have been analyzed, all testing over the minimum guarantee in potash. The average pound cost of potash from kainit has been 6.13 cents.

(3) *Phosphoric Acid Compounds.*

Dissolved Bone Black. — Three samples have been examined and all were found of good quality. The pound of available phosphoric acid from this source has cost, on the average, 7.41 cents.

Acid Phosphate. — Seven samples have been analyzed and the available phosphoric acid guarantee was maintained in all but 1 instance. The pound of available phosphoric acid from this source has cost, on the average, 5.69 cents.

Basic Slag Phosphate. — Six samples have been examined and the available phosphoric acid in all but 1 sample has run somewhat under the amount guaranteed. There has been a commercial shortage in only one instance, however, as the deficiency was made up by an excess of insoluble phosphoric acid. The pound of available phosphoric acid (by Wagner's method) from slag has cost, on the average, 5.79 cents.

(*i*) *Miscellaneous Fertilizers, Soils and By-products for Free Analysis.*

As in the past, free analyses have been made for farmers and others interested in agriculture so far as our time and facilities would warrant. Work of this nature, however, has been done when it would not conflict with the official inspection of commercial fertilizers. Including the materials which have been tested for the various departments of the experiment station, 385 analyses have been made. They may be grouped as follows: 292 fertilizers and by-products used as fertilizers, 68 soils and 25 samples of miscellaneous materials. Information has been furnished each applicant at the time the results of analyses were reported as to the best method of using fertilizer materials, also as to their average commercial value. Information has also been furnished with soil analyses as to the best method of treating the soil, also as regards the fertilization of the same. Both the fertilizer materials and soil samples have been taken according to instructions furnished from this office, and are therefore in all cases representative samples. These analyses do not appear in our fertilizer bulletin.

The fertilizer section has, as in past years, been active in co-operative work with the Association of Official Agricultural Chemists, and also with the fertilizer branch of the American Chemical Society.

6. Résumé of Work of the Feed and Dairy Section.

Mr. P. H. Smith, in charge, submits the following report: —

(a) *The Feed Law.*

During the past year 946 samples of feed stuffs offered for sale in the Massachusetts markets were collected by the official inspector. These have been examined, and the results are being brought together for publication in bulletin form.

Practically no misrepresentation was detected, although in a number of instances feed stuffs lacked the guarantee and other information required by the statute. Wherever dealers appeared to be particularly careless in this respect the matter was put into the hands of an attorney for settlement, but thus far in every case a satisfactory agreement has been made without resorting to the courts. In the future it is the intention to prosecute where dealers cannot be brought by less drastic means to comply with the law. The requirements of the Massachusetts law are simple and explicit, and afford protection to the reputable dealer as well as to the consumer, therefore the continued evasion of the law by a few dealers is inexcusable and should not be tolerated.

The extent to which the national pure food law aids in preventing adulteration and misrepresentation where feeds enter into interstate commerce is perhaps not known and appreciated as it should be. State officials and others in close touch with the work can see that its effects are far reaching and of great assistance to those engaged in local control work.

Cottonseed meal, usually one of the cheapest sources of protein for the Massachusetts dairyman, has for the past season been quite satisfactory in quality. The results thus far obtained for new meal indicate that, on account of the short cotton crop of the present season, conditions will be much the same as for the season of 1906–07. In spite of the excessively high price many dealers have sold short, and considerable slightly inferior meal is being offered. This may be accounted for in part by the poor quality of the seed, but it is felt, in some instances at least, that hulls and linters are intentionally added.

(1) *Low-grade By-products should be sold under their True Names.*

On account of our increasing population and prevailing high prices, it is becoming more and more necessary to utilize all by-products having any substantial food value in the feeding of our domestic animals. While screenings, weed seeds, oat hulls, corn cobs, cottonseed hulls and other low-grade material may contain some nutriment, the foregoing statement should not be taken to indicate that a compounded feed containing one or more of these materials, together with some high-grade concentrate, is just as valuable as the high-grade concentrate itself. Where such a mixture is offered at its face value, and no misrepresentation attempted, it is certainly a legitimate article of trade, and should be so recognized. The writer firmly believes, however, that, in order that the consumer may purchase intelligently, the ingredients going to make up a compounded feed should be stated on each package, but no legislation absolutely prohibiting the sale of low-grade material should be enacted unless it can be shown that certain kinds of material are poisonous or injurious to the animal.

The molasses feeds, of which there is an increasing number, form an excellent outlet for certain kinds of low-grade material, — especially screenings, — the molasses rendering them more palatable. Most of the manufacturers now grind the grain screenings before using them as a constituent of these feeds.

There are various feeds now offered which contain more or less ground alfalfa. It is believed that feeders cannot afford to pay grain prices for alfalfa hay, even when fine ground; it is decidedly more economical to purchase the high-grade concentrates unmixed, and to depend upon home-grown English hay, alfalfa, clover hay and corn silage as sources of roughage.

(2) *Protein v. Carbohydrates.*

Many manufacturers claim that the experiment stations place too much emphasis upon the value of protein and too little emphasis upon the value of carbohydrates. This station has never questioned the value and necessity of liberal amounts of carbohydrates in the ration. The question is rather an economic one, especially for the New England feeder, who, under our climatic conditions, can easily raise a sufficient quantity of carbohydrates and must depend largely upon *purchased protein* to balance or round out the ration, particularly in the feeding of dairy animals.

(3) *Weight of Feed Stuffs.*

Up to this time we have paid but little attention to the weight of feed stuffs. Data recently brought together show that while the feed law states *explicitly* that the *net weight* of each package should be stated, the practice has been, except in a few instances, to state gross weight as net. When feed stuffs sold for $15 a ton and less, the difference in value between net and gross weight of sacked feeds amounted to comparatively little, but at the present time the "value difference" is much greater. In a few instances what appear to be a deliberate attempt to give short weight was noted, and consumers should be on their guard against such deception.

(4) *Uniform Feed Law.*

It was the writer's pleasure to attend, during September, a conference between a committee of the American Feed Manufacturers' Association and State control officials, held at Washington, in the interests of a uniform feed stuffs law. The decision of the conference was that such a law should be as simple as possible, and that a buyer of any feed stuffs should be informed of the following points: —

1. The number of net pounds in the package.
2. Name, brand or trademark.
3. Name and principal address of the manufacturer or jobber responsible for placing the commodity on the market.
4. Its chemical analysis expressed in the following terms: (*a*) minimum percentage of crude protein, (*b*) minimum percentage of crude fat, and (*c*) maximum percentage of crude fiber.
5. If a compound or mixed feed, the specific name of each ingredient therein.

The Massachusetts law does not require a guarantee of fiber or a statement of ingredients in a compounded feed, and it is felt that if the present law could be amended to contain these statements it would be materially strengthened.

(b) *The Dairy Law.*

The work required by this act is divided into three natural subdivisions: (1) the examination of candidates, (2) the testing of glassware, and (3) the inspection of machines.

(1) *Examination of Candidates.*

During the past year 25 candidates have been examined for proficiency in Babcock testing. Of these, 14 were students at the ten weeks' winter course and 3 were students in the regular college course: the other 8 held positions in different parts of the State. All candidates were at least fairly proficient and capable of doing good work. At the last session of the Legislature, section 4 of the dairy law (chapter 202 of the Acts of 1901) was so amended as to give the director of the experiment station power to revoke the certificate of an operator providing it is found that he is not doing satisfactory work. Following is the section as amended: —

SECTION 4.[1] No person shall, either by himself or in the employ of any other person, firm or corporation, manipulate the Babcock test or any other test, whether mechanical or chemical, for the purpose of measuring the butter fat contained in milk or cream as a basis for determining the value of such milk or cream, or of butter or cheese made from the same, without first obtaining a certificate from the director of the Massachusetts[2] agricultural experiment station that he or she is competent to perform such work. Rules governing applications for such certificates and the granting of the same shall be established by the said director. The fee for issuing the said certificate shall in no case exceed two dollars, shall be paid by the applicant to the said director, and shall be used in meeting the expenses incurred under this act. If the duly authorized inspector finds an operator who, after receiving his certificate of competency, is not, in the judgment of the inspector, correctly manipulating the Babcock or other test used as a basis for determining the value of milk and cream, or who is using dirty, untested or otherwise unsatisfactory glassware, he shall immediately report the case in writing to the director of the station. The director shall at once notify said operator in writing and give him

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[1] See chapter 425, Acts of 1909.

[2] Massachusetts substituted for Hatch. See chapter 66, Acts of 1907.

not less than thirty days to make the necessary improvements. At the expiration of that time the director may order a second inspection, the cost of which shall be borne by the operator or by the person, firm or corporation employing him, and if the required improvement has not been made, the director is empowered to notify in writing said operator, or the person, firm or corporation employing him, that his certificate of competency is revoked. In case of any subsequent violation the said director may revoke the certificate of competency without giving the notice aforesaid.

(2) *Testing Glassware.*

During the past year 4,071 pieces of glassware were examined, of which 43 pieces, or 1.06 per cent., were inaccurate. Following is a summary of the work for the nine years that the law has been in force: —

Year.	Number of Pieces tested.	Number of Pieces Condemned.	Percentage Condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
Totals,	25,639	1,844	7.19[1]

The passage of this law has prevented 1,844 pieces of inaccurately graduated glassware, representing 7.19 per cent., of the entire number tested, from coming into use.

(3) *Inspection of Babcock Machines.*

In 1901, at the time of the first annual inspection, there were in Massachusetts 40 creameries and milk depots using the Babcock test as a basis for fixing the value of milk and cream. Owing to the increasing demand for milk, many creameries have either suspended operations or have been bought up by

[1] Average.

the large Boston milk companies, so that at the present inspection (November, 1909) but 29 places were visited, of which 16 were creameries, 11 milk depots, 1 city milk inspector and 1 chemical laboratory. Ten of the creameries were co-operative and 6 proprietary. The 11 milk depots were in every case proprietary. Twenty-nine machines were inspected, of which 2 were condemned, but on second inspection a few weeks later they were found to have been put in good condition. Those in use are 11 Facile, 8 Agos, 6 Electrical, 3 Wizard and 1 Twentieth Century. The glassware, as a whole, was clean, and so far as noted was Massachusetts tested. It is believed, on account of worn bearings and carelessness in keeping them clean and well oiled, that an excess of steam is necessary in many cases to give the required speed. Care should be taken to see that steam machines do not overheat the tests, which should be read between 120° and 140° F.

The creameries and milk depots which pay by the test are as follows: —

Creameries.

Location.	Name.	President or Manager.
1. Amherst,	Amherst,	W. A. Pease, manager.
2. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
3. Belchertown,	Belchertown Co-operative,	G. B. Jackson, manager.
4. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
5. Cheshire,	Greylock Co-operative,	Carl Williams, manager.
6. Cummington,	Cummington Co-operative,	W. E. Partridge, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company.	W. O. Solomon, proprietor.
11. Monterey,	Berkshire Co-operative,	F. A. Campbell, manager.
12. New Salem,	New Salem Co-operative,	W. A. Moore, president.
13. North Brookfield,	North Brookfield,	H. A. Richardson, proprietor.
14. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
15. Shelburne,	Shelburne Co-operative,	Ira Barnard, manager.
16. Wyben Springs,	Wyben Springs Co-operative.	C. H. Kelso, manager.

Milk Depots.

Location.	Name.	President or Manager.
1. Boston, ...	D. W. Whiting & Sons, .	Geo. Whiting, manager.
2. Boston, ...	H. P. Hood & Sons, . .	W. N. Brown, manager.
3. Boston, ...	Boston Dairy Company, .	W. A. Graustein, president.
4. Boston, ...	Walker-Gordon Laboratory,	M. B. Small, manager.
5. Boston, ...	Oak Grove Farm, . . .	Alden Brothers, proprietors.
6. Cambridge, . . .	C. Brigham Company, .	J. R. Blair, manager.
7. Cheshire, ...	Ormsby Farms, . . .	W. E. Penniman, manager.
8. Dorchester, . . .	Elm Farm Milk Company, .	J. H. Knapp, manager.
9. Sheffield, ...	Willow Brook Dairy, . .	G. W. Patterson, manager.
10. Southboro, . . .	Deerfoot Farm Dairy, . .	S. H. Howes, manager.
11. Springfield, . . .	Tait Brothers, . . .	Tait Brothers, proprietors.
12. Springfield, . . .	Emerson Laboratory, . .	H. C. Emerson, proprietor.
13. Springfield, . . .	Milk inspector, . . .	Stephen C. Downs.

Attention is called to the article on the "Babcock Test," published in Circular No. 24 of this station, and to the article on "Reading the Babcock Test," printed elsewhere in this report.

(*c*) *Milk, Cream and Feeds sent for Free Examination.*

The experiment station will analyze samples of milk, cream and feeds sent for examination in so far as the time and resources at its command permit, and in addition will furnish such information as is likely to prove of value in interpreting the results of such analysis. Under the dairy law the station has the right to charge the cost of the analyses of milk and cream; charges, however, are not made unless the number of analyses required is considerable. Only in exceptional cases should material intended for free chemical examination be sent except by previous arrangement. Upon application full instructions for sampling and directions for shipping will be furnished, which will often obviate the necessity of sending another sample in place of the one improperly taken.

(*d*) *Analysis of Drinking Water.*

Since the establishment of the station in 1882, sanitary analyses of drinking water have been carried out for parties within the State. Beginning Jan. 1, 1903, free analyses were discontinued, and a charge of $3 a sample made. The reason for this change was the fact that many parties abused the privilege, and also because work of this character interfered with legitimate experiment station work. The above charge must be paid when the sample of water is sent. During the year 91 samples have been tested and the results promptly reported.

In order to secure an analysis application must first be made, whereupon a suitably encased glass jar, together with full instructions for collecting and forwarding the sample, will be forwarded by express. An analysis of water sent in shippers' jars will not be undertaken, neither will bacteriological nor mineral analyses be made. The object in offering to make an examination of water is to enable the citizens of the State, depending upon wells and springs, to ascertain at a minimum expense whether their supply is free from such objectionable matter as is likely to gain entrance from sink, barn or privy. Such an examination is referred to as a sanitary analysis.

Lead pipe should never be employed for carrying drinking water; in case it is in use it should be removed at once, and galvanized iron or iron coated with asphaltum substituted. *Lead is a poison* and after it has entered the system it is eliminated only with the greatest difficulty.

(*e*) *Miscellaneous.*

In addition to the work already described, this division has conducted investigations and made other analyses as follows: —

1. It has co-operated with the Official Dairy Instructors and Investigators Association in a study of the Babcock test, the results of which are published elsewhere in this report.

2. It has made an investigation on the use of the Zeiss immersion refractometer in the detection of watered milk, the results of which are likewise published in the present report.

3. It has co-operated with the Association of Official Agri-

cultural Chemists in a study of methods for the determination of the various ingredients in condensed milk.

4. It has co-operated with the Association of Official Agricultural Chemists in a study of methods for the determination of total nitrogen.

5. In connection with the experimental work of this and other departments of the experiment station, this division has made partial analyses of 191 samples of milk, 157 samples of cattle feeds and 520 samples of agricultural plants.

(*f*) *Testing of Pure-bred Cows.*

The work of testing cows for the various cattle associations has increased considerably during the past year. At the present time two men are kept on the road a greater part of the time on work in connection with the Jersey, Guernsey and Ayrshire tests. The rules of the above associations require the presence of a supervisor once each month at the farms where animals are on test. The milk yields noted by the supervisors at their monthly visits are used in checking up the records reported by the owners to the several cattle clubs. The Babcock tests obtained at that time are likewise reported and used as a basis for computing the butter-fat yield for that month.

The Holstein-Friesian tests are of much shorter duration, usually seven or thirty days, and require the presence of a supervisor during the entire test. These tests give rather irregular employment to a number of men during the winter months. On account of the uncertainty of the work such men are difficult to obtain, but thus far it has not been necessary for the experiment station to refuse an application.

During the past year 1 seven-day and 33 yearly Guernsey, 5 seven-day and 66 yearly Jersey, and 8 yearly Ayrshire tests have been completed. For the Holstein-Friesian association 77 seven-day, 3 fourteen-day, 8 thirty-day and 1 sixty-day tests have been completed. There are now on test for yearly records 80 Jerseys, 29 Guernseys, 9 Ayrshires and 1 Holstein.

REPORT OF THE BOTANISTS.

G. E. STONE; G. H. CHAPMAN, ASSISTANT.

The routine work of the botanist for the past year has been similar to that of other years. Correspondence relating to various diseases and special problems has occupied much time, and investigations of various problems have been taken up.

In carrying out the details connected with the routine work and investigations we have had the assistance of Mr. G. H. Chapman, and in the keeping of records, seed testing and correspondence, Miss J. V. Crocker has been of much assistance. Mr. R. D. Whitmarsh, who is pursuing graduate studies at the college, has aided materially in the diagnosis of diseases and in other ways about the laboratory.

Diseases More or Less Common to Crops during the Year.

The season of 1909 was exceptionally dry, like that of 1908, and vegetation suffered materially. Some rain fell in the early spring months, but the average precipitation was below the normal. The summer was remarkably free from thunderstorms. The growing season opened later than usual and vegetation was a week or two behind throughout the whole season, some crops not maturing as well as in other seasons.

Little or no winter injury was observed to vegetation, but late frosts in the spring affected asparagus in some localities. The injury was in some respects similar to a trouble which has been previously reported on as being associated with a fungus (*Fusarium*).

Some cases were noted of defoliation of apple trees by frost blisters, caused by the effects of late spring frosts.

Besides the usual number of fungous diseases commonly met with, the following may be mentioned as being more or less abundant, and worthy of note for other reasons.

The past season has been a favorable one for rusts in general. Apple rust (*Puccinia*), which is seldom present, was more or less abundant, as in the season of 1908, and affected both foliage and fruit. Certain varieties seemed to be more susceptible than others. Some bad cases of bean rust (*Uromyces*) were noted here and there. This rust, like the one on the apple, is seldom troublesome with us. Hawthorns were affected more severely than usual with rust, resulting in some damage to nursery stock. The wild species of hawthorn is seldom immune to rust, but there is usually no complaint of nursery stock rusting. Quince rust (*Gymnosporangium*), which is always to be found, was more abundant than usual. Some severe cases of rust (*Phragmidium*) were also noted on the rose, and powdery mildew (*Sphærotheca*) was quite prevalent.

Peach leaf curl (*Exoascus*) was occasionally observed, but was not troublesome.

A bacterial wilt of the eggplant, which is more common in the south, was reported once or twice.

One severe case of beet scab (*Oöspora*) was also observed. In this particular case the soil had been limed, which substantiates the fact that liming the soil increases scab materially. While with us the beet is not so susceptible to scab as the potato, care should be taken not to plant beets where scab is abundant, and special precautions should be taken in applying lime to the soil.

Potatoes were generally free from troubles, but some cases of *Rhizoctonia* were observed; also a bacterial rot of the tuber.

Dropsical swelling of pear twigs, a more or less unusual trouble, was reported at different times, and the Baldwin fruit spot, which appears to be more common in dry than wet seasons, has been quite prevalent.

The leaf spot of apple (*Phyllosticta*) was very abundant early in the season and caused considerable defoliation.

More or less severe injury has resulted to peach and plum trees the last year or two from what is known as "gummosis." This disease is apparently caused, at least in many cases, by leaving the old "mummied" fruit affected with Monilia on the trees over winter. These "mummied" plums, contaminated with fungi, come in contact with the branches and cause "gummosis." This trouble is now being studied in the laboratory and field.

The blossom-end rot of tomatoes, a dry-season disease, was quite common, causing considerable injury. A liberal supply of soil moisture during the period of setting fruit is the best remedy for this trouble.

The downy mildew of the cucumber and melon (*Plasmopara*) occurred as usual during August and September, affecting both out-of-door crops and those under glass, while *Anthracnose* (*Colletotrichum*) was not so destructive as in some seasons.

The leaf spot caused by *Alternaria* was quite general on the foliage and fruit of the muskmelon and watermelon, but a large field of rust-resistant melons was found on September 7 to be absolutely free from any blight. Since spraying melons for blight has proved to be of little value, it is desirable to use types which are immune to the blight. The best method of growing melons in this climate consists in selecting an early, sandy soil, with warm exposure. The soil should be thoroughly tilled, and the plants set out early, blight-resisting varieties being used. A location as free as possible from frequent dews should be selected, and manure in the hills is superior to fertilizers, since it gives the plant better soil conditions. It is best to start the plants early in pots or strawberry boxes under glass, and transplant to the open field. Native muskmelons are far superior to the half-matured imported product, and a ready market awaits the successful grower.

Shade-tree Troubles.

The rainfall during the early spring months revived vegetation in general from the effects of the severe drought of the preceding season. This stimulated trees and shrubs to assume a healthy appearance and produce a good crop of foliage. The succeeding months, however, were very dry, and considerable defoliation of shade and fruit trees occurred in June and July. The long period of drought resulted in a premature coloration of the foliage, and consequent early defoliation.

Occasional high winds, with lack of soil moisture, caused sun scorch, particularly to maples. Some of the defoliation, particularly that of the elm, was caused by squirrels, and some was due to a natural shedding of the twigs. *Dothidella ulmi,* a leaf-spot fungus occasionally found on elms, was unusually abundant rather early in the season, and this was also responsible for much loss of foliage.

The Italian poplar was more severely affected with the rust (*Melampsora*) than usual, and the twigs and leaves of the ash suffered from a similar fungus to an unusual extent. Horse-chestnut foliage was badly affected with a leaf spot (*Phyllosticta*), and a black spot (*Rhytisma*) more or less common every year on the white maple was unusually abundant. It was more common on the white maple than usual, and the leaves of the red maple were literally covered with it.

Ivy (*Ampelopsis*) was affected with a leaf spot. In some localities quite a few maple trees were killed by sun scald, while others were scalded only on their southern exposure. Following this outbreak of sun scald, *Nectria,* a fungus of saprophytic habit, developed freely.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

The work of the department of entomology during the year 1909 has differed little from that of preceding years. Correspondence, as usual, has required much time, and many inquiries involve considerable investigation where some of the less familiar insects are concerned. This has been particularly true during the past season, the number of insects concerned having been larger than usual, though serious injury from their attacks has been rather conspicuously absent.

Experimental work in some subjects has been continued from previous years, while in others it has been temporarily suspended. The construction of the new entomological building has necessitated giving up the use of the present greenhouse, as this was liable to removal to its new site at any time, and when this should occur any experiments under glass would necessarily come to an end. For this reason further tests of the resistance of muskmelons to fumigation have been discontinued for the present, but it should be possible to resume them another year. Studies on the number and relative importance of the different broods of the codling moth have been continued, but the orchard in which these have been made thus far has now been taken for other uses, and has been so treated that it is no longer available for this purpose. Unless another orchard, under conditions suitable for the work, can be obtained, this line of investigation will, therefore, have to be dropped, although in order to reach satisfactory results it should be continued for at least four or five years more.

Experiments on methods for the control of the cabbage maggot have been repeated again, but without satisfactory results, the maggots, though more abundant than during the two years preceding, being still too scarce to give results which could be considered entirely trustworthy.

Observation of the dates of appearance of the young of our common scales have been continued, adding the records of another year to those already in hand. This work will also need to be continued for a number of years in order to provide data of sufficient value for general use.

The experiments for the control of the onion thrips have proceeded far enough to show that spraying the onions after this insect has appeared on them is, at best, only a partial remedy. One of the results of the work of this pest is to curl the leaves of the onion, and the insects at once gather on the inner side of the curled surface, so that many of them cannot be reached by the spray, though those which are reached in this way are destroyed. A study of the life history of these insects shows that they pass the winter at the top of the ground in protected places, such as are furnished by dead grass around the onion fields, in rubbish heaps and similar places; and a few attempts to destroy them by burning over the grass and rubbish around the fields have been followed by a reduction in the abundance of the insect the next spring. This method of control has not as yet been tested long enough to prove that the result was actually due to the treatment rather than to merely natural causes, but, in any case, it seems to be the most promising way we have yet found to check this insect, and it should be repeated until its value has been fully determined.

Perhaps the most important entomological event of the year at the station was the discovery of an egg parasite of the common asparagus beetle, which was found actively at work about the first of June. Observations on this insect, its habits and life history, have been published as Circular No. 23 of the station, and also in the "Journal of Economic Entomology."

The control of wire worms, attacking seed corn in the ground soon after it has been planted, is important, as these pests, when abundant, often necessitate the replanting of many acres. Experiments to prevent the attacks of this insect have been carried on by Mr. Ralph H. Whitcomb of Amherst, and his ingenuity has discovered that when the corn, when planted, has been covered with tar as a repellant for crows, as is quite generally done in this locality, and then treated with a mixture of Paris green and dust until a greenish color is perceptible, it will not be eaten by wire worms. These experiments will be repeated the coming year.

Within the last twenty years Massachusetts has been invaded by several injurious insects which naturally belong farther south. Among these may be mentioned the elm-leaf beetle, San José scale, common asparagus beetle and the twelve-spotted asparagus beetle. How far north these pests can spread and be injurious is as yet unknown, but it is certain that there are limits to this spread, and for at least some of those named it seems quite certain that these limits may probably be found within this State. It is not a particular degree of latitude which marks the barrier to their further spread northward, but rather climatic conditions, and these are modified by elevation. In other words, the limiting lines of distribution appear to be isothermal in their nature, though their exact character is as yet unsettled. It may be the average winter temperature, the minimum winter temperature or some other factor which settles whether an insect shall be a pest at any given place near its northern limit. In any case, the determination of this cause, and the resulting conclusion that an insect will or will not become injurious at a given place, will be of much importance. As an example of this it may be stated that such evidence as is now available, though as yet too little to be conclusive, suggests the belief that in Massachusetts the elm-leaf beetle will not be likely to be of much importance in those parts of the State which are more than a thousand feet above sea level, except, perhaps, near the southern edge of the State, where the altitude is to some extent offset by the more southern latitude. To work out problems of this nature fuller meteorological data are needed, as well as more observations of the distribution of the insects themselves, and studies of this kind have been in progress for several years, and will be continued.

Parasitism as one of nature's methods for the control of injurious forms has long been recognized. It has been utilized in numerous cases by man, who has conveyed parasites from one country to another to attack their hosts, which have already been by accident thus transferred. Perhaps the most gigantic experiment of this kind is that now being conducted by the Bureau of Entomology of the United States Department of Agriculture and those in charge of the gypsy moth work in Massachusetts, in importing from the old world the parasitic and other enemies of the gypsy and brown-tail moths, in the hope that they may become established in this country and bring these pests under control.

No one seems to know, however, how effective parasites really are; conceding their importance, we have only the most general statements on the subject, and almost the only paper giving more than these is a short one by Dr. L. O. Howard, entitled "A Study of Insect Parasitism."

It would seem most desirable to substitute statistics for guesswork on a subject so important as this, and therefore the scope of parasitism by the insects of a restricted group, the conditions favoring and checking it, and all the factors entering into the problem have been taken up for prolonged study, and it is hoped that tangible results may in time replace the vague generalizations on this subject which, thus far, are all that have been available.

Investigations on spraying have been continued since the last report, but with disappointing results. As was stated last year, the first step was to obtain pure spraying materials, and it was supposed that these were available, as reliable manufacturers offered them as such. To be certain, however, these were analyzed, and the results showed that the materials were not as pure as was necessary for the purpose, making it necessary to make these materials at the station. This has held up the work to some extent, for while considerable time was spent in applying the materials to various plants, and watching the results, the later discovery of the unreliability of the materials used has made valueless the experimental work done with them. New spraying materials made here must, therefore, be obtained to use in these experiments, in order to obtain the results needed as a basis for the study of the commercial materials which is to follow, and at present the work is at a standstill till these materials can be prepared. It is expected, however, that they will be available for use during the coming summer.

THOMAS SLAG. A SHORT HISTORICAL REVIEW.

BY J. B. LINDSEY.

Thomas slag, or basic phosphatic slag, is a by-product in the modern method of steel manufacture from ores containing noticeable quantities of phosphorus. The process of removing the phosphorus from the ore was discovered by the English engineers Gilchrist and Thomas, and, briefly stated, consists in adding to the so-called converter containing the molten ore a definite quantity of freshly burnt lime, which, after a powerful reaction, is found to be united with the phosphorus, and swims upon the surface of the molten steel in the form of a slag.

Composition of the Slag.

The composition of the Thomas or Belgian slag varies according to the character of the ore and the success of the process for removing the impurities. The following figures show such variations:[1] —

	Per Cent.
Phosphoric acid,	11–23
Silicic acid,	3–13
Calcium oxide (lime),	38–59
Ferrous and ferric oxides,	6–25
Protoxide of manganese,	1–6
Alumina,	.2–3.7
Magnesia,	2–8
Sulphur,	.2–1.4

More or less metallic iron is enclosed in the coarse slag which is generally thoroughly removed from the ground material by the magnet.

[1] Agricultur Chemie von Adolf Mayer, II Band, 2te Abtl., 6 Auflage pp. 138, 139.

Manurial Value of Slag recognized.

The manurial value of the slag was not recognized for a long time; finally experiments revealed that a considerable portion of its phosphoric acid was soluble in dilute citric and carbonic acids, which led to successful field experiments. The only preparation of the slag for fertilizing purposes, when its value was first recognized, consisted in having it finely ground in especially prepared mills, so that 75 per cent. would pass through a sieve with perforations of .17 millimeter diameter. This requirement was suggested by M. Fleischer, who used the slag with much success in improving the condition of marsh and meadow lands.

Methods for determining Availability and Adulteration.

Previous to 1890, by means of pot experiments as well as by laboratory investigations, Wagner demonstrated that the phosphoric acid in different slags of the same degree of fineness varied in its availability from 30 to 90 or more per cent., and, further, that many brands were adulterated with Belgian or other insoluble mineral phosphates.

The previous method, therefore, of determining the value of a slag by the percentage of total phosphoric acid present and the degree of fineness, was of secondary importance.

In order to detect adulteration with mineral phosphates, Wagner originally used a dilute solution of citrate of ammonia and free citric acids.[1] The phosphoric acid in all of the mineral phosphates was sparingly soluble in such a reagent, while an unadulterated high-grade slag gave up 80 to 90 parts of its phosphoric acid. Further investigations on various soils with many brands of slag made it clear that the results obtained from pot experiments corresponded quite well with those secured by means of the citric acid solution. This may be illustrated as follows:—

[1] Chemiker Zeitung No. 63, 1895; also Düngungsfragen Heft I., p. 16, von P. Wagner, 1896.

Brand of Slag.	Phosphoric Acid available in Citric Acid Solution.	Phosphoric Acid available in Pot Experiments.
1,	100	100
2,	85	80
3,	81	72
4,	72	72
5,	73	66
6,	76	63
7,	39	40
8,	48	38
9,	42	38
10,	45	31
11,	38	30

Results similar to the above were secured by Maercker,[1] who stated that "the results removed all doubt that the citrate solubility and plant experiments were so nearly proportioned that one had the same right to value the slag according to its content of phosphoric acid soluble in citrate solution as to value a superphosphate by its content of water soluble phosphoric acid."

As a result of these investigations, the union of German experiment stations, at its meeting at Kiel in September, 1896, adopted the method of determining the relative value of the slag according[2] to its phosphoric acid solubility in a 2 per cent. citric acid solution, and did away with the previous standard of total phosphoric acid and fineness.

Wagner as well as Maercker repeatedly called attention to the fact that experiments both in the laboratory and with plants gave positive evidence that those slags of *like phosphoric acid content* which were *richest in silicic acid* gave the best results. G. Hoyermann, working independently, came to similar conclusions. At the present time, according to Wagner, practically all of the iron works treat the molten slag as it flows from the converter with hot quartz sand, with the result that the avail-

[1] Landw. Presse 1895, No. 82.

[2] Method slightly modified from the original. Present method described in Konig's Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe. Dritte Auflage, pp. 173, 174.

ability of the phosphoric acid is improved from 10 to 30 per cent.[1]

Chemical Combination of Phosphoric Acid in Slag.

The form in which the phosphoric acid exists in the slag has never been fully explained. It was formerly supposed that it was combined with lime as a tetra-calcium phosphate, and that this latter compound, being less stable than tri-calcium phosphate, under the influence of dilute acids became easily available to the plants by being decomposed into the calcium salt of the dissolving acid and bi-calcium phosphate. The tetra-lime phosphate, however, has never been made artificially,[2] although it has been recognized by the aid of the microscope in the slag, and exists as a mineral under the name of isoklas.

More recent investigations having shown, as already indicated, that those slags richest in silicic acid of like phosphoric acid content gave the best results, the conclusion followed that a part of the lime must be in the form of lime silicate. It is now generally held, especially by Wagner,[3] that the phosphoric acid is combined in the slag as a double salt of tri-calcium phosphate and calcium silicate, and that in this form the roots are able to utilize it. It is also believed probable that some of the phosphoric acid is more or less united with iron as a basic iron phosphate.

The Use of Phosphatic Slag.

Basic slag has been shown to work especially well upon sour marsh and meadow lands, upon porous, well-aired soils rich in humus, as well as upon sandy soils deficient in lime.

When a rapid development of the crop is not desired, the slag may be used exclusively in place of acid phosphate. On the other hand, in cases when it is feared that the crop will not mature early enough, upon heavy, cold land and in high altitudes, where the season is short, acid phosphate should be given the preference.

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[1] Already cited, p. 28; also, Anwendung Künstlicher Düngemittel, vierte Auflage von Wagner, pp. 74, 75.

[2] Hilgenstock: Jahresber. Chem. Technologie, 1887, p. 282, after Adolf Mayer, already cited.

[3] Wagner, already cited.

The phosphoric acid in slag is comparable in its quickness of action to nitrogen in barnyard manure, tankage and green crops; and the phosphoric acid in acid phosphate to the action of nitrogen in nitrate of soda. A combination of slag and sulfate of potash (500 pounds slag and 150 pounds potash) has been found to work especially well upon grass land, and to be very favorable to the development of clover.

Quantity of Slag per Acre.

If the soil is particularly deficient in phosphoric acid, one can use as high as from 800 to 900 pounds of slag to the acre, plowed in and supplemented with 200 pounds of acid phosphate in the hill or drill.

If, on the contrary, the soil is naturally rich in phosphoric acid, or has been made so by large additions of slag for a series of years (1,000 or more pounds yearly), then it is necessary only to replace from year to year the amount removed by the crop. In such cases Maercker states that one part of phosphoric acid in basic slag is as valuable as an equal amount in acid phosphate.

EFFECT OF PORTO RICO MOLASSES ON DIGESTIBILITY OF HAY AND OF HAY AND CONCENTRATES.

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

I. INTRODUCTION.

In New England, cane molasses brought in tank steamers from Porto Rico has been freely offered for a number of years at from 12 to 15 cents a gallon of 12 pounds in barrel lots. The material is dark in color but quite satisfactory in quality. It has been found to contain from 20 to 28 per cent. of water (average 24 per cent.), about 3 per cent. of protein (largely as amids), 6 to 7 per cent. of ash, and the balance of sugars and allied substances. The following analyses made at this station represent the composition of three different samples of Porto Rico molasses: —

		1904. Sample.		1905. Sample.		1906. Sample.	
Water,			24.40		28.50		24.98
Ash,			7.13		6.04		5.57
Crude Protein,	Albuminoids,	1.24	3.17	.96	2.82	–	2.19
	Amids,	1.93		1.86		–	
Extract Matter,	Cane sugar,	29.72	65.30	36.26	62.64	37.86	67.26
	Invert sugar.	25.03		19.38		20.48	
	Undetermined,	10.55		7.00		8.92	
			100.00		100.00		100.00

It may be remarked that two analyses of the ash have shown traces of phosphoric acid and 3.66 and 4.84 per cent. of potash, the latter being by far the most predominant ash constituent. Beet molasses has been shown to contain rather more ash than cane molasses.

It can be assumed with safety that molasses, being soluble in water, is easily digested and assimilated when fed in reasonable amounts. If fed in excess it is likely to affect adversely the heart and kidneys, and to appear undigested in the urine.[1] It is a well-known fact that the addition of starch, sugar and similar substances causes a distinct depression in the digestibility of the material with which they are fed.[2] Various reasons have been advanced to account for this depression, which has as yet not been definitely proved. In case of beet molasses, Kellner [3] has shown an average digestion depression of 9 per cent., and he states that the value of beet molasses for cattle and sheep consists in its 55 per cent. of digestible carbohydrates (1,100 pounds to the ton).

Lehmann,[4] as a result of three digestion experiments (nine single trials) with sheep, obtained an average digestion depression of 11 per cent., which he deducts from the 71 per cent. of total organic matter in beet molasses, thus securing 60 per cent., or 1,200 pounds, of digestible organic matter to the ton.

Grandeau and Aleken have shown that molasses when fed to horses also causes a noticeable digestion depression. Alquier and Drouineau, in reviewing the work of both French and German investigators, state that in case of horses the addition of 3 pounds of molasses per 1,000 pounds live weight caused a depression of 4.5 per cent., while with ruminants the feeding of 4 pounds of molasses per 1,000 pounds live weight produced an average depression of only 3 per cent. in the digestibility of the foods with which it was fed.[5]

Patterson [6] reported, in case of two steers, when molasses constituted some 12 per cent. of the total dry matter of the ration, an improvement of 24 per cent. in the digestibility of the hay. Molasses fed to four steers in combination with hay and grain, and comprising 14 per cent. of the total dry matter of the ration, improved the condition of the hay and grain ration 14.5 per cent. (coefficients of digestibility of the dry matter of the hay

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[1] Kellner, Arbeiten der D. Landw. Ges. 152 Heft., 1909, p. 16.

[2] Kellner, Die Ernahrung Landw. Nutzthiere, fünfte Auflage 1909, pp. 50, 51. Numerous references are cited by Kellner.

[3] Landw. Versuchs. 53 Bd., pp. 220 and 233, 234, 304 and 342, 343; 55 Bd., p. 384.

[4] Landw. Jahrbücher, Vol. XXV., Ergänzungsband II., 1896.

[5] Ann. Sci. Agron., 2 série, 1904, Tome 1, pp. 249-254.

[6] Molasses Feeds, Bulletin 117, Maryland Experiment Station.

and grain without molasses, 55.1 per cent.; with molasses, 63.1 per cent.). Patterson's results are quite the opposite of all previous work along this line.

II. EXPERIMENTS AT THE MASSACHUSETTS EXPERIMENT STATION.

Experiments relative to the effect of Porto Rico molasses on digestibility have been in progress at intervals at this station since 1905. Different amounts of molasses have been added to a basal ration of hay, of hay and corn meal, and particularly of hay and gluten feed. The experiments made during the winter of 1905 and 1906 have been published in detail.[1] The numerous other experiments are here reported for the first time.

Sheep were employed in all cases; in Series XI. and XII. grade Southdown wethers were used, and in Series XIII. and XIV. one and two year old Shropshires were employed.

The hay was cut in 2-inch lengths before being fed, and was largely Kentucky blue grass, with an admixture of some clover and sweet vernal grass. The gluten feed represented the dried residue of Indian corn (Zea mais) in the manufacture of corn-starch, and consisted of the hulls and glutinous part of the corn, together with that portion of the starch and broken germs which could be removed by mechanical means. It was free from any indication of decomposition. The corn meal consisted of the ground corn kernels.

The sheep were fed twice daily, — about 7 o'clock in the morning and 5 in the afternoon. The molasses was mixed with about its weight of water and sprinkled over the hay, or was mixed with the grain and eaten without the addition of water. The food was given in galvanized-iron pans which fitted closely into the wooden stalls in which the sheep were confined.[2] Particles of cut hay that were thrown out of the box were carefully brushed up and returned. Any waste remaining at the end of the period was preserved and analyzed. Water in galvanized-iron boxes was always before the sheep. The fæces were collected twice daily, preserved in wide-mouth glass-

[1] Nineteenth report of the Hatch Experiment Station, pp. 126-149.

[2] Illustrated in eleventh report of the Massachusetts State Experiment Station, 1893, p. 148.

stoppered bottles and taken to the laboratory every twenty-four hours. The daily sample was poured upon a newspaper, well mixed and an aliquot part (usually 1/10) weighed into a crystallization dish and dried at 60° C. After this drying was completed the samples were allowed to stand at ordinary temperature for a number of days, and were reweighed, mixed, ground, placed in glass-stoppered bottles and eventually analyzed. Nitrogen was determined in the dry sample but not in the fresh fæces, as is frequently done at the present time. The entire period lasted fourteen days, seven of which were preliminary, the fæces being collected during the last seven. The sheep were kept in roomy stalls during the first three days, and then harnessed and placed in the digestion stalls for the last eleven days of the trial.

The results of the different experiments are first presented, together with a discussion of the same. The full data follows the discussion.

A. Hay and Molasses.

Summary of Results.

Series XII., Period III.

[800 grams hay, 100 grams molasses and 10 grams of salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Old Sheep II., ...	69.05	–	–	87.26
Old Sheep III., ...	100.99	41.31	80.29	101.58

From the above coefficients it would appear that Sheep II. digested only 69 per cent. of the total dry matter of the molasses, while Sheep III. digested the entire amount fed. It can, however, be safely assumed that molasses, being quite soluble in water, is easily digested and entirely resorbed in the digestion tract. Only minute traces of reducing substances have been recognized in the fæces.

(b) Depression noted (Grams).

Old Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	476.72	23.31	53.52	179.27	208.31	10.67
Digested of 800 grams hay plus 100 grams molasses, ...	527.44	23.17	51.88	177.82	265.30	9.27
Minus 100 grams molasses fed, assumed to be all digested, ...	73.45	5.35	2.79	-	65.31	-
Remains for 800 grams hay digested when fed with molasses, ...	453.99	17.82	49.09	177.82	199.99	9.27
Difference or depression, ...	—22.73	—5.49	—4.43	—1.45	—8.32	—1.40

Old Sheep III.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	476.72	23.31	53.52	179.27	208.31	10.67
Digested of 800 grams hay plus 100 grams molasses, ...	550.90	25.52	55.76	184.40	274.65	10.56
Minus 100 grams molasses fed, assumed to be all digested, ...	73.45	5.35	2.79	-	65.31	-
Remains for 800 grams hay digested when fed with molasses, ...	477.45	20.17	52.97	184.40	209.34	10.56
Difference or depression, ...	+.73	—2.14	—.55	+5.13	+1.03	—.11

When the hay was fed by itself the nutritive ratio of the digestible ingredients was 1 : 7.7, and when fed with molasses, 1 : 9; molasses constituted 9.5 per cent. of the dry matter of the hay-molasses ration. In case of Sheep II. the 100 grams of molasses created a very marked depression in the digestibility of the several ingredients of the hay, namely, 21.09 (22.73) grams of dry matter, equal to 4.7 per cent. In case of Sheep III. there appears to have been a very slight gain in the digestibility of the hay.

Series XIII., Period I.

[600 grams hay, 100 grams Porto Rico molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep I, ...	99.77	48.08	52.40	102.01
Sheep II, ...	96.34	47.36	23.65	100.66
Average, ...	98.06	47.70	38.03	101.34

(*b*) *Depression noted* (*Grams*).

Sheep I.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	354.34	18.07	40.41	110.27	178.99	6.54
Digested of 600 grams hay plus 100 grams molasses,	427.10	20.89	42.16	113.00	243.99	7.05
Minus 100 grams molasses, all digested,	72.93	5.87	3.34	-	63.72	-
Remains for 600 grams hay digested when fed with molasses,	354.17	15.02	38.82	113.00	180.27	7.05
Difference,	—.17	—3.05	—1.59	+2.73	+1.28	+.51

Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	354.54	18.07	40.41	110.27	178.99	6.54
Digested of 600 grams hay plus 100 grams molasses,	424.60	20.85	41.20	112.62	243.13	6.79
Minus 100 grams molasses, all digested,	72.93	5.87	3.34	-	63.72	-
Remains for 600 grams hay digested when fed with molasses,	351.76	14.98	37.86	112.62	179.41	6.79
Difference,	—2.67	—3.09	—2.55	+2.35	+.42	+.25

The nutritive ratio of the hay when fed by itself was 1 : 7.5, and of the molasses-hay ration, 1 : 8.6; the dry matter of the molasses constituted some 12 per cent. of the dry matter of the hay-molasses ration. A slight depression only is noted, being rather more pronounced in case of Sheep II. The depression falls upon the ash and protein. An apparent slight improvement in digestibility is noted in case of the fiber and extract matter. Sheep I. gained 3 pounds in live weight, and Sheep II. maintained equilibrium.

Series XI., Period III.[1]

[800 grams hay, 150 grams molasses and 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV.,	107.09	92.16	40.43	102.76
Paige Sheep V.,	90.93	80.02	10.17	95.80

[1] Already published in nineteenth report of this station, p. 145.

The coefficients indicate that in one case the molasses depressed the digestibility of the hay and in one case it actually improved it.

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Paige Sheep IV., . . .	+7.60	—.71	—2.52	+8.03	+2.60	+.42
Paige Sheep V., . . .	—9.73	—1.81	—3.80	—.04	—3.95	+.19

The nutritive ratio of the hay ration was as 1 : 9.9, and of the hay-molasses ration, 1 : 10.7 ; molasses constituted 13.2 per cent. of the dry matter of the total ration. In this case the results are contradictory, in one case increasing and in the other depressing the digestibility of the hay. Each sheep lost 2 pounds in weight during the seven days.

Series XIII., Period III.

[600 grams hay, 200 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep I, ...	88.96	59.34	21.57	94.76
Sheep II, ...	74.67	52.41	-	89.72

(*b*) *Depression noted* (*Grams*).

Sheep I.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	357.06	18.22	40.72	111.13	180.37	6.60
Digested of 600 grams hay plus 200 grams molasses, ...	486.81	25.24	42.20	111.76	300.89	6.75
Minus 200 grams molasses, assumed to be all digested, ...	145.86	11.83	6.86	-	127.18	-
Remains for 600 grams hay digested when fed with molasses, ...	340.95	13.41	35.34	111.76	173.71	6.75
Difference or depression, ...	—16.11	—4.81	—5.38	+.63	—6.66	+.15

Sheep II.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay when fed alone,	357.06	18.22	40.72	111.13	180.37	6.60
Digested of 600 grams hay plus 200 grams molasses, ...	465.99	24.42	40.71	100.14	294.48	6.25
Minus 200 grams molasses, assumed to be all digested, ...	145.86	11.83	6.86	-	127.18	-
Remains for 600 grams hay digested when fed with molasses, ...	320.13	12.59	33.85	100.14	167.30	.25
Difference or depression, ...	—36.96	—5.63	—6.87	—10.99	—13.07	—.35

The nutritive ratio of the hay when fed alone was 1:7.5, and of the hay-molasses ration, 1: 10.1; molasses constituted 21.4 per cent. of the dry matter of the hay ration. The digestion depression is very noticeable, especially with Sheep II. The average depression for both sheep was 13.56 grams of dry matter and 10.63 grams of organic matter per 100 grams of molasses. The total average depression was equivalent to 18.2 per cent. of the dry matter of the molasses consumed. The feeding of 200 grams of molasses caused an average loss of 7.4 per cent. in the digestibility of the hay. No particular change was noted in the live weight of either animal.

Series XI., Period IV.[1]

[800 grams hay, 250 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV.,	91.89	47.38	-	95.35
Paige Sheep V.,	88.21	57.54	-	95.30

(*b*) *Depression noted (Grams).*

Average, Sheep, IV. and V.

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 800 grams hay when fed alone,	404.56	23.19	32.51	132.44	208.07	8.03
Digested of 800 grams hay plus 250 grams molasses,	566.92	31.20	32.04	136.99	358.65	8.06
Minus 250 grams molasses, all digested,	180.30	15.24	7.10	-	157.96	-
Remains for 800 grams hay digested when fed with molasses,	386.62	15.96	24.94	136.99	200.69	8.06
Difference or depression,	−17.94	−7.23	−7.57	+4.55	−7.38	+.03

The nutritive ratio of the hay-molasses ration was 1: 11.2, and molasses constituted 20.6 per cent. of the dry matter of the total ration. The results show that 17.94 (17.60) grams less hay were digested when 250 grams of molasses were fed than when the hay was fed by itself; or 100 grams of molasses caused

[1] Already reported, *loco citato*, pp. 146, 147.

a depression in the hay of 7.2 (7.02) grams of dry matter and 4.1 grams of organic matter. The depression was equivalent to 9.9 per cent. of the dry matter of the molasses fed. The total molasses likewise caused a loss of 4.4 per cent. in the digestibility of the dry matter of the hay.

General Summary.

In the table below the results of the several experiments with hay and molasses are brought together for comparison. The results of one experiment by Kellner are also stated.

Ration.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Depression per 100 Grams Fresh Molasses fed. Dry Matter (Grams).	Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay.	Gain or Loss in Live Weight (Pounds).
800 grams hay, . .	-	-	—21.09	—15.60	-	-	—1.0
100 grams molasses, .	1:9.0	9.50	+3.36	+5.50	-	-	±
600 grams hay, . .	-	-	—0.12	+2.93	-	-	+3.0
100 grams molasses, .	1:8.6	12.0	—2.62	+0.47	-	-	±
600 grams hay, . .	-	-	+5.21	+6.90	-	-	—2.0
150 grams molasses, .	1:10.7	13.2	—6.27	—5.07	-	-	—2.0
600 grams hay, . .	-	-	—8.04	—5.63	-	-	—.75
200 grams molasses, .	1:10.1	21.4	—18.45	—15.64	8.2	7.4	+1.25
800 grams hay, . .	-	-	-	-	-	-	+4.50
250 grams molasses, .	1:11.2	20.6	—7.10	—4.10[1]	9.9	4.4	+3.00
800 grams hay,[2] . .	-	-	-	-	-	-	-
100 grams molasses, .	1: 9.3	9.2	-	—14.4	22.4[3]	3.4	-

The nutritive ratio of the different lots of hay varied from 1 : 7.5 to 1 : 9.9; the addition of different amounts of molasses naturally widened the ratio, variations being noted of from 1 : 8.6 to 1 : 11.2. So far as one is able to judge, the different ratios were without effect on depression. Our own experiments indicate that when cane molasses constituted from 10 to 13 per cent. of the dry matter of the total ration it was without pronounced effect on the digestibility of the hay. In case of one trial with one sheep the depression was very marked, but in the other five single trials with different sheep the influence was slight, or one trial was contradictory of the other. The same

[1] Average, two sheep.
[2] Kellner's results in Landw. Vers., 55 Bd. S. 384.
[3] Organic matter of molasses fed.

results hardly hold true in case of Kellner's trial with two sheep, in which beet molasses composed 9.2 per cent of the dry matter of the ration. Here one notes a depression of 14.4 grams of organic matter per 100 grams of molasses. The two sheep gave closely agreeing results.

In our own case, when molasses composed some 20 per cent. of a hay-molasses ration the depression was quite noticeable, averaging in case of four single trials with four different sheep 10.14 grams of digestible dry matter and 7.37 grams of digestible organic matter for each 100 grams of molasses fed. These latter trials show a loss or depression equivalent to from 9.9 to 18.2 per cent. of the dry matter of the molasses fed; or, otherwise expressed, the molasses caused a loss of from 4.4 to 7.4 per cent. in the digestibility of the hay. The feeding of 20 per cent. of cane molasses did not cause as great a depression as did the feeding of 9.2 per cent. of beet molasses (Kellner's results). It is doubtful, however, if these varying results are due to the different kinds of molasses.

In experiments of this sort one is obliged to take into account individuality, the effect of food upon different individuals, as well as the condition of the animal at the time of the trial. Positive conclusions cannot be drawn unless the evidence is very pronounced. Why it is that two animals, both apparently in good condition, should give contrary results it is difficult to explain. Thus, in the above table note that molasses appeared to have caused a depression of 21.09 grams dry matter with one sheep and an increase of 3.36 grams with another; also, in another case 100 grams of molasses caused an increase of 5.21 grams and in another case a decrease of 6.27 grams in the digestibility of the hay.

B. Hay, Corn Meal and Molasses.

Two experiments were conducted in each case with two sheep, using 100 and 200 grams of molasses. Unfortunately, in each experiment one of the sheep suffered from indigestion and did not complete the trial.

Summary of Results.

Series XIII., Period VI.

[500 grams hay, 150 grams corn meal, 100 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Protein.	Extract Matter.
Sheep III., ...	85.20	78.60	19.24	91.29

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and corn meal when fed without molasses, ...	407.18	15.67	42.30	89.07	249.23	10.94
Digested of hay and corn meal plus 100 grams molasses, ...	469.12	20.37	42.96	87.99	307.01	10.74
Minus 100 grams molasses, all digested, .	72.70	5.98	3.43	-	63.69	-
Remains for hay and corn meal digested when fed with molasses, ...	396.42	14.39	39.53	87.99	243.72	10.79
Difference or depression, ...	—10.76	—1.28	—2.77	—1.08	—5.51	—.15

The nutritive ratio of the hay and corn-meal ration was 1 : 8.6, and of the hay-corn-meal-molasses ration, 1 : 9.7; molasses constituted 11 per cent. of the dry matter of the total ration. The depression observed is 10.79 (10.76) grams of dry matter and 9.51 grams of organic matter per 100 grams of molasses.

Series XIII., Period VIII.

[500 grams hay, 150 grams corn meal, 200 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep II., ...	75.26	23.11	60.44	84.90

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and corn meal when fed without molasses,	414.44	12.97	21.90	110.60	258.01	10.94
Digested of hay and corn meal plus 200 grams molasses,	423.99	22.83	26.04	98.41	365.67	11.02
Minus 200 grams molasses, all digested,	145.56	11.89	6.85	-	126.21	-
Remains for hay and corn meal digested when fed with molasses,	378.43	10.94	19.19	98.41	238.86	11.02
Difference or depression,	—36.01	—2.03	—2.71	—12.19	—19.15	+.08

Molasses constituted 20 per cent. of the dry matter of the total ration; the nutritive ratio of the hay-corn-meal ration was 1 : 17.9, and of the hay-corn-meal-molasses ration 1 : 18.4.[1] The depression was very noticeable, being 18 grams of dry matter and 17 grams of organic matter per 100 grams of molasses.

C. Hay, Gluten Feed and Molasses.

Numerous experiments were carried out to note the effect of different amounts of molasses upon a combination of hay and gluten feed, the latter being a rich protein concentrate. Hay, gluten feed and molasses is a much more suitable ration than is one composed only of hay and molasses, or of hay, corn meal and molasses.

In calculating the depression caused by the molasses, the digestibility of the hay-gluten-feed ration was first determined. The amount of molasses fed was assumed to be all digested and was deducted from the total amount digested of the hay-gluten-feed-molasses ration, the remainder being the hay and gluten feed digested when fed with the molasses. The difference between the hay-gluten-feed digested when fed without the molasses

[1] A new lot of hay was used in this experiment; it contained only 7.19 per cent. of protein, as against 12.24 per cent. in the hay used to secure the coefficients for the digestibility of the hay and corn meal, and which were applied to the hay-corn-meal and 100 grams molasses ration. The low protein content of the hay accounts for the very wide nutritive ratio of the present hay-corn-meal-molasses ration. The coefficients of the hay-corn-meal ration, applied in case of the present experiment, were those obtained with the hay having the high protein content. Had an experiment been made with the low protein hay-corn-meal ration it is possible the coefficients might have been lower than the ones actually used, in which case a less depression would have been obtained than the one actually found.

and when fed with the molasses shows the depression exerted by the latter. The coefficients of digestibility for the hay and for the hay-gluten-feed rations will be found in a table with the other data.

Summary of Results.

SERIES XIV., PERIOD VI.

[500 grams hay, 150 grams gluten feed, 50 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III., ...	38.19	-	-	66.08
Sheep IV., ...	9.73	-	-	38.47

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III., ...	—23.13	—4.10	—4.26	—4.83	—10.90	—.33
Sheep IV., ...	—33.78	—3.44	—5.48	—7.26	—19.77	—.26

(*c*) *Average, Sheep III. and IV.* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams English hay and 150 grams gluten feed when fed without molasses, ...	409.17	16.27	48.74	103.26	232.16	10.16
Digested of hay and gluten feed plus 50 grams molasses, ...	418.14	15.56	46.55	97.21	248.96	9.87
Minus 50 grams molasses, all digested, .	37.42	3.06	2.23	-	32.13	-
Remains for hay and gluten feed digested when fed with molasses, ...	380.71	12.50	44.32	97.21	216.83	9.87
Difference or depression, ...	—28.46	—4.32	—4.42	—6.05	—18.49	—.30

The nutritive ratio of the hay-gluten-feed ration was 1 : 7.3, of the hay-gluten-feed-molasses ration, 1 : 8. The rather wide ratio of the hay-gluten-feed ration was due to the low protein content of the hay. Molasses constituted only 6 per cent. of the dry matter of the total ration. The average depression was 59.72 (56.92) grams of dry matter and 52.18 (49.32) grams of organic matter per 100 grams of fresh molasses fed, and equaled about 76 per cent. of the dry matter of the molasses fed. The feeding of 50 grams of molasses caused an apparent depression, or loss of 6.9 per cent. in the digestibility of the hay-gluten-feed-ration. The cause of this excessive depression for so small an amount of molasses is not clear. The sheep substantially maintained their weight during the experiment.

Series XIV., Period VII.

[500 grams hay, 150 grams gluten feed, 100 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III., ...	66.37	19.61	-	86.02
Sheep IV., ...	42.92	34.36	-	65.48

(*b*) *Depression noted (Grams).*

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III., ...	—25.32	—4.96	—6.08	—6.73	—9.03	+.18
Sheep IV., ...	—42.96	—4.01	—5.83	—11.97	—22.29	—.40

(*c*) *Average, Sheep III. and IV. (Grams).*

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 hay and 150 grams gluten feed when fed without molasses, .	411.92	16.36	49.29	103.69	233.77	10.25
Digested of hay and gluten feed plus 100 grams molasses, ...	453.04	18.04	47.85	94.34	282.69	10.14
Minus 100 grams molasses, assumed to be all digested, ...	75.26	6.17	4.51	-	64.58	-
Remains for hay and gluten feed digested when fed with molasses, ...	377.78	11.87	43.34	94.34	218.11	10.14
Difference or depression, ...	—34.14	—4.49	—5.95	—9.35	—15.66	—.11

The nutritive ratio of the hay-gluten-feed ration was 1 : 7.3, and of the hay-gluten-feed-molasses ration, 1 : 8.6; molasses constituted 11.3 per cent. of the dry matter of the total ration. The average depression found was 35.56 (34.14) grams of dry matter and 31.07 grams of organic matter per 100 grams of molasses, and is equivalent to 47 per cent. of the molasses fed. The feeding of 100 grams of molasses caused a loss of 8.3 per cent. in the digestibility of the hay-gluten-feed ration. Sheep IV. showed considerably more depression than Sheep III.; the former sheep lost ½ pound and the latter gained 2 pounds in weight during the seven days of the trial.

Series XII., Period V.

[600 grams hay, 200 grams gluten feed, 100 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV.,	52.27	51.30	-	70.31
Paige Sheep V.,	48.88	77.53	-	69.70
Average,	50.58	64.42	-	70.01

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Paige Sheep IV.,	—37.14	—2.35	—6.91	—7.75	—19.83	—.35
Paige Sheep V.,	—35.39	—1.44	—7.06	—8.16	—19.53	+.76

(c) Average, Sheep IV. and V. (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay and 200 grams gluten feed when fed without molasses,	515.72	15.39	82.23	145.12	262.16	10.87
Digested of hay and gluten feed plus 100 grams molasses,	552.83	18.83	78.03	137.16	307.72	11.08
Minus 100 grams molasses, all digested,	73.37	5.34	2.79	-	65.24	-
Remains for hay and gluten feed digested when fed with molasses,	479.46	13.49	75.24	137.16	242.48	11.08
Difference or depression,	—36.26	—1.90	—6.99	—7.96	—19.68	+.21

The nutritive ratio of the hay-gluten-feed ration was 1 : 5.2, and of the hay-gluten-feed-molasses ration, 1 : 6; molasses represented 9.4 per cent. of the dry matter of the total ration.

The average depression was 36.32 grams of dry matter and 34.42 grams of organic matter per 100 grams of molasses fed, and equaled 50 per cent. of the dry matter of the molasses fed. The feeding of 100 grams of molasses caused a depression, or loss of 7 per cent. in the digestibility of the hay-gluten-feed ration.

Both sheep were in good condition during the experiment; Sheep IV. showed an apparent gain of 4 pounds and Sheep V. a loss of 3.5 pounds. Such variations would hardly be expected.

Series XIV., Period IX.

[500 grams hay, 150 grams gluten feed, 150 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep IV., ...	56.63	30.24	-	76.86

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams hay and 150 grams gluten feed when fed without molasses, .	423.47	16.91	49.53	107.16	241.60	9.90
Digested of hay and gluten feed plus 150 grams molasses, ...	487.01	19.75	44.90	97.32	315.49	9.55
Minus 150 grams molasses, all digested, .	112.20	9.39	6.68	-	96.13	-
Remains for hay and gluten feed digested when fed with molasses, ...	374.81	10.36	38.22	97.32	219.36	9.55
Difference or depression, ...	−48.66	−6.55	−11.31	−9.84	−22.24	−.35

The nutritive ratio of the hay-gluten-feed ration was as 1 : 7.5, and of the hay-gluten-feed-molasses ration, 1 : 9.7 ; molasses composed 16 per cent. of the dry matter of the ration. The depression noted was 33.52 grams of dry matter and 29.16 grams of organic matter per 100 grams of molasses fed, and is likewise equivalent to practically 45 per cent. of the dry matter of the molasses consumed. The feeding of 150 grams of molasses caused a loss of 11.9 per cent. in the digestibility of the hay-gluten-feed ration. This sheep made a gain of 5 pounds in one week according to our weights.

SERIES XIV., PERIOD IV.

[500 grams hay, 150 grams gluten feed, 200 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Sheep III., ...	77.58	47.22	24.19	88.30
Sheep IV., ...	74.18	48.27	1.05	85.21

(*b*) *Depression noted* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep III., ...	—33.41	—6.55	—6.52	—6.46	—14.98	—.18
Sheep IV., ...	—38.47	—6.42	—8.51	—6.00	—18.93	—.04

(*c*) *Average, Sheep III. and IV.* (*Grams*).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 500 grams hay and 150 grams gluten feed when fed without molasses, .	408.00	16.23	48.55	103.02	231.48	10.13
Digested of hay and gluten feed plus 200 grams molasses, ...	521.08	22.16	49.64	96.79	342.53	9.97
Minus 200 grams molasses, all digested, .	149.02	12.41	8.60	-	128.01	-
Remains for hay and gluten feed digested when fed with molasses, ...	372.06	9.75	41.04	96.72	214.52	9.97
Difference or depression, ...	—35.94	—6.48	—7.51	—6.23	—16.96	—.16

The ratio of the hay-gluten-feed-molasses ration was as 1 : 9.3, against 1 : 7.4 in case of the hay-gluten-feed ration, and 20.4 per cent. of the dry matter of the entire ration consisted of molasses. The depression was 18.67 (17.97) grams of dry matter and 15.43 (14.73) grams of organic matter per 100 grams of molasses, which was equal to 25 per cent. of the dry matter of the molasses fed. The feeding of 200 grams of molasses caused a loss or depression of 7.60 per cent. in the digestibility of the 650 grams of hay-gluten-feed ration. Sheep III. lost 2 pounds and Sheep IV. 3.5 pounds in live weight during the trial.

SERIES XII., PERIOD VII.

[600 grams English hay, 200 grams gluten feed, 200 grams molasses, 10 grams salt.]

(*a*) *Coefficients for Molasses.*

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV., ...	76.78	76.59	-	85.72
Paige Sheep V., ...	73.71	81.06	-	84.21

(*b*) *Depression noted (Grams).*

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Sheep IV., ...	—34.18	—2.51	—7.66	—6.19	—18.70	+.94
Sheep V., ...	—38.70	—2.03	—6.70	—10.55	—20.67	+1.30

(*c*) *Average, Sheep IV. and V. (Grams).*

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams hay and 200 grams gluten feed when fed without molasses, .	517.35	15.43	82.53	145.51	262.94	10.91
Digested of hay and gluten feed plus 200 grams molasses, ...	628.13	23.88	80.94	137.14	374.17	12.03
Minus 200 grams molasses, all digested, .	147.22	10.72	5.59	-	130.91	-
Remains for hay and gluten feed when fed with molasses, ...	480.91	13.16	75.35	137.14	243.26	12.03
Difference or depression, ...	—36.44	—2.27	—7.18	—8.37	—19.68	+1.12

The nutritive ratio of the hay and gluten-feed ration was 1 : 5.2, and with the addition of 200 grams molasses, 1 : 6.7 ; molasses composed 17.2 per cent. of the dry matter of the total ration. The depression observed was 18.2 grams of dry matter and 17.05 grams of organic matter per 100 grams of molasses fed, and is equivalent to 25 per cent. of the dry matter of the molasses fed. The feeding of 200 grams of molasses caused a loss of 7 per cent. in the digestibility of the hay-gluten-feed ration. Both sheep lost in weight during the experiment, Sheep IV. losing 4 pounds and Sheep V. 5 pounds. This is not what would be expected from animals receiving more than a maintenance ration. Sheep IV. passed through the experiment in good condition. Sheep V. began to show signs of indigestion shortly after the beginning of the period proper, and the disturbance became so pronounced that the experiment was discontinued at the end of the sixth day. The results show that he digested a little less than Sheep IV.

This and the trial immediately preceding show similar results; namely, an equal depression and a loss in weight, in spite of the fact that the several animals were receiving more than a maintenance ration.

Series XI., Period VIII.

[600 grams hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Extract Matter.
Paige Sheep IV.,	76.50	64.12	86.93
Paige Sheep V.,	72.53	65.25	84.80
Average,	74.52	64.59	85.87

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Digested of hay and gluten feed when fed without molasses,	524.97	18.75	81.88	148.40	264.22	11.74
Digested of hay and gluten feed plus molasses,	660.31	29.58	79.47	139.96	399.66	11.61
Minus 250 grams molasses fed, assumed to be all digested,	181.68	16.75	7.16	-	157.77	-
Hay and gluten feed digested when fed with molasses,	478.63	12.83	72.31	139.96	241.89	11.61
Difference or depression,	—46.34	—5.92	—9.57	—8.44	—22.33	—.13

The nutritive ratio of the hay-gluten-feed ration was 1 : 5.3, and of the hay-gluten-feed-molasses ration, 1 : 7.1; molasses constituted 20.2 per cent. of the dry matter of the total ration. The average depression for both sheep was 18.5 grams of dry matter and 16.1 grams of organic matter per 100 grams of molasses, and equals 25.5 per cent. of the dry matter of the molasses fed.

The feeding of 250 grams of molasses caused a loss of 8.8 per cent. in the digestibility of the hay-gluten-feed ration. Each sheep lost 3 pounds in live weight during the seven days.

Series XII., Period XI.

[600 grams English hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Young Sheep II., ...	70.10	39.63	-	82.92

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams English hay and 200 grams gluten feed when fed without molasses, ...	498.12	15.47	74.29	139.31	256.86	11.84
Digested of hay and gluten feed plus 250 grams molasses, ...	628.12	20.82	71.91	131.24	393.59	10.56
Minus 250 grams molasses, all digested, .	185.45	13.50	7.05	-	164.90	-
Remains for hay and gluten feed digested when fed with molasses, ...	442.67	7.32	64.86	131.24	228.69	10.56
Difference or depression, ...	—55.45	—8.15	—9.43	—8.07	—28.17	—1.28

The ratio of the hay-gluten-feed-molasses ration was as 1 : 7.6, and of the hay-gluten-feed ration 1 : 5.7; molasses constituted 20.4 per cent. of the dry matter of the total ration. The depression observed was 22 (22.2) grams of dry matter and 18.8 (19) grams of organic matter for each 100 grams of molasses fed, and was equivalent to about 30 per cent. of the dry matter of the molasses. The feeding of 250 grams of molasses caused a loss of 11.1 per cent. in the digestibility of the hay and gluten feed. The sheep passed through the trial in good condition, and neither gained nor lost in live weight.

Series XII., Period X.

[600 grams English hay, 200 grams gluten feed, 300 grams molasses, 10 grams salt.]

(a) Coefficients for Molasses.

	Dry Matter.	Ash.	Crude Protein.	Extract Matter.
Paige Sheep IV., ...	87.09	74.25	-	92.60

(b) Depression noted (Grams).

	Dry Matter.	Ash.	Crude Protein.	Fiber.	Extract Matter.	Fat.
Digested of 600 grams English hay and 200 grams gluten feed when fed without molasses,	523.59	15.63	83.44	147.41	266.00	11.04
Digested of hay and gluten feed plus 300 grams molasses,	715.92	27.57	82.21	146.52	447.82	11.80
Minus 300 grams molasses, all digested,	220.83	16.08	8.39	-	196.36	-
Remains for hay and gluten feed digested when fed with molasses,	495.09	11.49	73.82	146.52	251.46	11.80
Difference or depression,	—28.50	—4.14	—9.62	—.89	—14.54	+.76

The nutritive ratio of the hay-gluten-feed ration was as 1 : 5.2, and of the hay-gluten-feed-molasses ration, 1 : 7.6 ; molasses constituted some 23.5 per cent. of the dry matter of the total ration. The depression was 9.48 grams of dry matter and 8.1 grams of organic matter for each 100 grams of molasses fed, and was equivalent to 13 per cent. of the dry matter of the molasses. The feeding of 300 grams of molasses caused a loss of 5.4 per cent. in the digestibility of the hay-gluten-feed ration. The sheep kept in good condition during the experiment, but showed an apparent loss in live weight of 8 pounds. This is believed to be an error, although in a general way it confirms the results of previous trials, which indicate that when molasses constitutes more than 15 per cent. of the dry matter of the total ration a loss of live weight results, although more than a maintenance ration is being fed.

General Summary.

Effect of Molasses upon Digestibility of Hay and Gluten Feed.

In the following table an attempt has been made to summarize the principal results of feeding different amounts of molasses upon the digestibility of a ration composed of hay and gluten feed. The results obtained by Lehmann[1] and by Garland[2] are also appended.

[1] *Loco citato.*

[2] Berichte des landw. Institutes der Univ. Halle, XV. Heft, pp. 23-25.

Our Own Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Depression per 100 Grams Molasses fed. Dry Matter (Grams).	Depression per 100 Grams Molasses fed. Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay and Gluten Feed.	Gain or Loss in Live Weight. (Pounds.)
500 grams hay, 150 grams gluten, 50 grams molasses	1:8.0	6.0	59.72	52.18	76.0	6.9	—1.00, —.50
500 grams hay, 150 grams gluten, 100 grams molasses	1:8.6	11.3	35.56	31.07	47.0	8.3	—.50, +2.00
600 grams hay, 200 grams gluten, 100 grams molasses	1:6.0	9.4	36.32	34.42	50.0	7.0	+4.00, —3.50
500 grams hay, 150 grams gluten, 150 grams molasses	1:9.7	16.0	33.50	29.16	45.0	11.9	+5.00
500 grams hay, 150 grams gluten, 200 grams molasses	1:9.3	20.4	18.67	15.43	25.0	7.6	—2.00, —3.50
600 grams hay, 200 grams gluten, 200 grams molasses	1:6.7	17.2	18.20	17.05	25.0	7.0	—4.00, —5.00
600 grams hay, 200 grams gluten, 250 grams molasses	1:7.1	20.2	18.56	16.1	25.5	8.8	—3.00, —3.00
600 grams hay, 200 grams gluten, 250 grams molasses	1:7.6	20.4	22.0	18.8	30.0	11.1	-
600 grams hay, 200 grams gluten, 300 grams molasses	1:7.6	23.5	9.5	8.1	13.0	5.4	—8.00

Lehmann's Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Dry Matter (Grams).	Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay and Gluten Feed.	Gain or Loss in Live Weight. (Pounds.)
500 grams hay, 300 grams cottonseed meal, 200 grams molasses	1:3.3	18.0[1]	19.75	22.2	28.5[1]	8.2	-
500 grams hay, 300 grams palm-nut cake, 300 grams molasses	1:9.5	24.0[1]	8.8	11.6	15.0[1]	6.1	-
500 grams hay, 300 grams cottonseed meal, 400 grams molasses	1:4.4	32.0[1]	7.0	7.4	9.5[1]	6.0	-

Garland's Results.

RATION.	Nutritive Ratio.	Per Cent. Molasses in Dry Matter of Ration.	Dry Matter (Grams).	Organic Matter (Grams).	Depression equals Per Cent. of Molasses fed (Dry Matter).	Percentage Loss in Digestibility of Hay and Gluten Feed.	Gain or Loss in Live Weight. (Pounds.)
476 grams hay and grain, 68 grams molasses	1:5.7	11.0	-	13.8	16.7	3.8	-

[1] Estimated, assuming that the molasses contained 78 per cent. of dry matter, the hay 88 per cent. and the concentrates 92 per cent.

The nutritive ratio of the two hay and gluten-feed rations with which the molasses was fed varied from 1 : 5.5 to 1 : 7.5, hence the nutrients may be considered satisfactorily proportioned. After the addition of the molasses the rations were widened from 1 : 6 to 1 : 9.7; most of them could not be considered unduly wide. In two of the three experiments reported by Lehmann the rations were quite narrow, due to the presence of so much cottonseed meal. So far as one is able to judge, the width of the ration did not bear any direct relation to the depression observed. In all of the experiments reported molasses constituted from 6 per cent. to approximately 32 per cent. of the dry matter of the total ration.

It is noted that when molasses made up from 9 to 16 per cent. of the dry matter of the ration, the depression averaged 32.1 grams of organic matter per 100 grams of fresh molasses; when molasses composed about 20 per cent. of the dry matter of the ration, in case of eight single trials, it averaged approximately 15.5 grams of organic matter per 100 grams of molasses. The average of all of our experiments, excepting the first, show a depression of 21.8 grams of organic matter per 100 grams of fresh molasses. Lehmann's experiments show that when beet molasses composed 18 per cent. of the dry matter of the ration, the depression was 22.2 grams of organic matter per 100 grams of molasses. This depression decreased to 7.4 grams of organic matter per 100 grams of molasses when molasses composed some 30 per cent. of the dry matter of the ration.

Results of a similar character are secured when one calculates the depression on the basis of the percentage of the dry matter of the molasses fed. When it composed 9 to 16 per cent. of the dry matter of the total ration, the depression or loss was equivalent to nearly 50 per cent. of the amount fed. When, however, 20 per cent. of the dry matter of the total ration consisted of molasses, the depression equaled only 24 per cent. In case of Lehmann's results, the depression decreased from 28.5 to 9.5 per cent.

The percentage loss in digestibility of the feeds with which the molasses was fed proved to be reasonably constant. The average percentage loss in case of twelve experiments, including nine of our own and three of Lehmann's, was 7.86. In most cases the variations do not depart widely from this average. The smaller amounts of molasses in most cases caused practically as much absolute depression as the larger amounts.

The amount of hay and gluten-feed fed to the different sheep was probably a little less than a maintenance ration; this was intended in order that, when from 100 to 300 grams of molasses were added, the total amount would not be more than the animal could consume.

With molasses composing 6 to 11.3 per cent. of the dry matter of the ration, one notes, on the whole, comparatively little change in the live weight, but when this was increased to some 20 per cent., the live weight of each sheep shows a pronounced decrease in almost every case, although the total ration was certainly in excess of maintenance requirements. The reason for this loss in weight cannot be explained. Occasional qualitative tests for sugar in the fæces were made with negative results. The urine was not collected, but it is believed that sugar would not have thus escaped unassimilated. The loss of digestible material through depression hardly seems sufficient to account for it. A possible explanation lies in the fact that each sheep was given 2,500 grams of water daily, usually considered a liberal allowance. In most of the cases showing a loss in weight the sheep drank the entire amount, but the attendant, contrary to instructions, failed to supply more. It may be that the molasses induced an increased thirst, and required more water for its complete metabolism than was supplied, and the intake of water being relatively less than the outgo caused a temporary loss of weight. In one case, however, where the 2,500 grams of water were entirely consumed, the sheep neither gained nor lost in weight. It is to be regretted, however, that this oversight occurred.

General Conclusions.

(a) *Hay and Molasses.*

1. Our own experiments indicate that molasses had relatively little effect in depressing the digestibility of the hay when the amount fed did not exceed 10 to 13 per cent. of the dry matter of the total ration.

2. When molasses composed 20 per cent. of the dry matter of the total ration, the depression averaged 7.37 grams of organic matter per 100 grams of fresh molasses, and the molasses caused substantially a loss of 6 per cent. in the digestibility of the hay.

(*b*) *Hay, Corn Meal and Molasses.*

3. In case of two single trials the depression was from 9.5 to 17 grams of organic matter per 100 grams of molasses.

(*c*) *Hay, Gluten Feed and Molasses.*

4. When relatively small amounts of molasses were fed the depression was higher *per 100 grams of molasses* than when relatively large amounts were fed.

5. When relatively small amounts of molasses were fed the loss expressed in dry matter *as percentage of molasses fed* was higher than when relatively large amounts of molasses were consumed.

6. The feeding of small amounts of molasses have in most cases caused as much depression of the feeds with which they were fed as large amounts, the loss averaging substantially 8 per cent.

Why molasses seemed to exert less depression on the hay than on a ration composed of hay and a concentrate is difficult of explanation.

D. *The Cause of the Depression produced by Molasses.*

Our own numerous experiments, as well as those of other investigators, have shown that molasses exerts a distinct depression upon those feed stuffs with which it is fed. This depression appears to vary, depending upon the character of the feed, the amount of molasses fed and the individuality and condition of the animal. The addition of considerable amounts of sugar and starch have been shown to produce similar results.[1]

The cause or causes of this depression have never been fully demonstrated. Kellner [2] offers a partial explanation substantially as follows: —

[1] See the numerous experiments of Henneberg and Stohmann, Kühn and Fleischer, E. Wolff, etc., in the Journal für Landw. and in the Landw. Versuchssta.

[2] *Loco citato*, fünfte Auflage, pp. 50, 51.

(*a*) The cause or partial cause of the depression of the proteid matter is due to the increased excretion of metabolic by-products in the fæces. It has been definitely proved that for every 100 grams of digested dry matter there is excreted .4 to .5 of a gram of nitrogen, or 2.5 to 3.1 grams of protein, hence the additional carbohydrates increase the digestible dry matter and cause the excess excretion of metabolic nitrogen, which is calculated as undigested nitrogen.

(*b*) According to Hirschler [1] an increase of the carbohydrates or of lactic acid in the ration checks the action of putrefactive bacteria, *i.e.*, those acting upon the proteid matter, and G. Gothwald [2] has confirmed this for herbivorous animals.

(*c*) It being known that the easily soluble and digestible carbohydrates are large yielders of lactic and butyric acids in the processes of digestion, it seems at least possible that it is these acids, when present in sufficient quantities, which check the further action of the micro-organisms, and prevents their attacking the more difficult digestible carbohydrates, such as the fiber, pentosans, gums, etc.

Alquier and Drouineau [3] state that in case of ruminants the depression is caused because the food remains for a long time in the digestive tract, and is subjected to the action of various micro-organisms. These organisms follow the line of the least resistance, and attack the sugars and other soluble carbohydrates, leaving the cellulose, ligno-cellulose and pentosans, which they would attack and dissolve more freely were the soluble carbohydrates not present in excess; hence the depression falls largely upon these latter compounds.

It is further explained that in case of the horse the action of molasses in causing the depression is not due primarily to the action of micro-organisms for the reason that the food remains so short a time in the intestines, but to the alkaline salts, — potash and soda, — which cause an increased action of the intestines (peristalsis). Grandeau's work is cited, in which, in an average of four trials with four different horses the first fæces appeared sixteen hours after the feeding of molasses, while

[1] Zeitschrift für physiol. Chem. 10 Bd. 1886, p. 306; also 39 Bd. p. 99; Abs. from Kellner.
[2] Journal für Landw. 39 Jahrgang, 1888, p. 325.
[3] Ann. de Sci. Agron. 2 Serie, 1904. Tome I., pp. 252–258.

twenty-seven hours elapsed before the first fæces from a normal ration were excreted.

Observations at this Station.

In order to note the effect of molasses in increasing peristalsis, thereby causing a less complete digestion of the food, a number of observations were made using lampblack as an indicator.

October 21, at 4 P.M., Sheep III., receiving hay, gluten feed, salt and *200 grams of molasses,* was fed in addition 10 grams of lampblack. The first indication in the fæces appeared at 1 P.M. on the following day, — twenty-one hours after feeding. The lampblack could be observed in the fæces until 4 P.M. of October 25, — some four days thereafter.

October 27, at 4 P.M., and October 28, at 7 A.M., Sheep II., receiving a ration of hay, gluten feed and salt, was given in addition a total of 10 grams of lampblack. Indications of the lampblack first appeared at 2 P.M. on the following day, October 28, — twenty hours after the first feeding. At the same time Sheep IV., receiving hay, gluten feed, salt and *200 grams of molasses,* was given in addition 15 grams of lampblack, which first appeared in the fæces at 4 P.M. of the following day, — twenty-two hours later.

November 6, at 5 P.M., and November 7, at 7 A.M., Sheep I., receiving a ration of hay, gluten feed and salt, was fed in addition with 10 grams of lampblack, which first appeared in the fæces at noon on November 7, — nineteen hours later. This lampblack was noticed in the fæces until noon of November 12, nearly six days (one hundred and thirty-nine hours) after the first was given.

November 6, at 5 P.M., and November 7, at 7 A.M., Sheep IV., receiving a ration of hay, gluten feed, salt and *200 grams of molasses,* was given in addition a total of 15 grams of lampblack. It first appeared at 7 A.M., November 7, — fourteen hours later, — and disappeared at 7 A.M., November 12, — one hundred and thirty-four hours later.

November 7, at 4 P.M., and November 8, at 7 A.M., Sheep II., receiving a ration of hay, gluten feed and salt, was given in addition 10 grams of lampblack. The first indication of lampblack was at 7.30 A.M., November 8, — fifteen and a half hours later, — and it had entirely disappeared from the fæces on November 13, at 4 P.M., — six days later.

November 7, at 4 P.M., and November 8, at 7 A.M., Sheep III., receiving hay, gluten feed, salt and *200 grams of molasses*, received in addition a total of 15 grams of lampblack. The first colored fæces were noted November 8, at 2 P.M., — twenty-two hours later, — and the color disappeared November 13, at 4 P.M., — after a lapse of six days.

The above data placed in tabular form are as follows: —

Sheep Number.	Normal Ration. Lampblack appeared (Hours).	Molasses Ration. Lampblack appeared (Hours).	Normal Ration. Lampblack disappeared (Hours).	Molasses Ration. Lampblack disappeared (Hours).
II.,	20.0	-	-	-
I.,	19.0	-	139.0	-
II.,	15.5	-	144.0	-
IV.,	-	22.0	-	-
III.,	-	21.0	-	96
IV.,	-	14.0	-	134
III.,	-	22.0	-	144
Average,	18.2	19.7	141.5	139

It is evident that these results do not show sufficient variation to warrant a conclusion that the molasses exerted any peristaltic action. It is to be admitted that the lampblack did not prove as sharp an indicator as was desired. It is intended to make additional observations of a similar character, using another indicator, and also to continue our inquiry relative to the cause of the depression.

Data of the Experiments.

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

Series.	Periods.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XI.	III., IV.,	English hay,	8.20	8.69	32.14	48.56	2.41
XI.	V., VII., VIII.,	English hay,	6.75	12.23	33.45	44.67	2.90
XI.	VII.,	Gluten feed,	1.67	24.98	7.22	63.34	2.79
XI.	III., IV.,	Porto Rico molasses,	8.45	3.94	–	87.61	–
XI.	VIII.,	Porto Rico molasses,	9.22	3.94	–	86.84	–
XII.	III., IV., V., VII., X., XI., XIV.,	English hay,	6.75	12.23	33.45	44.67	2.90
XII.	IV., V., VII., X., XI., XIV.,	Gluten feed,	1.53	26.22	6.30	63.35	2.60
XII.	III., V., VII., X., XI.,	Porto Rico molasses,	7.28	3.80	–	88.92	–
XIII.	I., II., III., IV., V., VI.,	English hay,	6.46	12.24	29.24	49.49	2.57
XIII.	VII., VIII.,	English hay,	6.43	7.19	34.08	49.82	2.48
XIII.	II., IV., VI., VII., VIII.,	Corn meal,	1.58	10.45	2.10	81.22	4.65
XIII.	I.,	Porto Rico molasses,	8.05	4.58	–	87.37	–
XIII.	III.,	Porto Rico molasses,	8.11	4.70	–	87.19	–
XIII.	VI.,	Porto Rico molasses,	8.23	4.72	–	87.05	–
XIII.	VIII.,	Porto Rico molasses,	8.17	4.71	–	87.12	–
XIV.	XI.,	English hay,	7.13	7.75	32.64	50.01	2.49
XIV.	III., IV., V., VI., VII., IX.,	English hay,	6.82	7.67	30.35	52.79	2.37
XIV.	III., IV., V., VI., VII.,	Gluten feed,	4.12	27.22	7.81	56.54	4.31
XIV.	IV.,	Porto Rico molasses,	8.33	5.77	–	85.90	–
XIV.	VI.,	Porto Rico molasses,	8.18	5.95	–	85.87	–
XIV.	VII.,	Porto Rico molasses,	8.20	5.99	–	85.81	–
XIV.	IX.,	Porto Rico molasses,	8.37	5.95	–	85.68	–

Composition of Fæces (Per Cent.).

[Dry Matter.]

Series.	Periods.	Sheep Number.	Feed or Ration.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
X.	VI.	IV.	English hay,	11.61	9.90	30.66	44.91	2.92
X.	IX.	V.	English hay,	11.23	9.24	31.93	44.49	3.11
XI.	V.	IV.	English hay,	11.18	14.10	24.20	46.24	4.28
XI.	V.	V.	English hay,	10.49	13.17	26.51	45.74	4.09
XI.	VI.	II.	English hay,	10.80	14.70	23.99	46.27	4.24
XI.	VI.	III.	English hay,	10.57	14.03	25.31	45.74	4.35
XI.	VII.	IV.	Hay and gluten feed,	10.55	15.33	22.35	47.20	4.57
XI.	VII.	V.	Hay and gluten feed,	10.63	15.05	22.84	46.84	4.64
XI.	III.	IV.	Hay and molasses,	12.16	10.72	29.32	44.87	2.93
XI.	III.	V.	Hay and molasses,	11.83	10.53	30.33	44.47	2.84
XI.	IV.	IV.	Hay and molasses,	13.66	11.47	27.13	44.86	2.83
XI.	IV.	V.	Hay and molasses,	12.87	11.49	28.95	43.94	2.75
XI.	VIII.	IV.	Hay, gluten feed and molasses,	11.15	16.36	21.26	47.44	3.79
XI.	VIII.	V.	Hay, gluten feed and molasses,	10.82	16.21	22.09	47.15	3.73
XII.	IV.	IV.	Hay and gluten feed,	12.27	15.50	21.65	45.97	4.61
XII.	IV.	V.	Hay and gluten feed,	11.75	15.22	22.83	45.30	4.90
XII.	XIV.	II.Y.	Hay and gluten feed,	9.98	18.48	22.31	45.44	3.79
XII.	III.	II.	Hay and molasses,	11.91	14.82	23.00	45.80	4.47
XII.	III.	III.	Hay and molasses,	12.11	14.64	22.47	46.42	4.36
XII.	V.	IV.	Hay, gluten feed and molasses,	11.31	16.00	21.55	47.13	4.01
XII.	V.	V.	Hay, gluten feed and molasses,	10.57	15.94	22.89	46.79	3.81
XII.	VII.	IV.	Hay, gluten feed and molasses,	11.31	16.42	21.64	47.01	3.62
XII.	VII.	V.	Hay, gluten feed and molasses,	10.88	15.68	23.11	46.94	3.39
XII.	X.	IV.	Hay, gluten feed and molasses,	12.35	17.70	19.83	46.31	3.81
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	11.44	17.38	22.04	45.62	3.52

Composition of Fæces (Per Cent.).

[Dry Matter.]

Series.	Periods.	Sheep Number.	Feed or Ration.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XIII.	V.	I.	English hay,	9.32	14.24	24.35	48.01	4.08
XIII.	V.	II.	English hay,	9.03	13.59	26.55	46.88	3.95
XIII.	IV.	III.	English hay and corn meal,	8.71	15.09	25.44	46.89	3.87
XIII.	VII.	II.	English hay and corn meal,	10.71	14.60	26.46	44.38	3.85
XIII.	I.	I.	English hay and molasses,	10.88	14.79	23.92	46.68	3.73
XIII.	I.	II.	English hay and molasses,	10.75	15.12	23.80	46.51	3.82
XIII.	III.	I.	English hay and molasses,	10.88	15.52	23.05	46.94	3.61
XIII.	III.	II.	English hay and molasses,	10.21	14.71	26.21	45.38	3.49
XIII.	VI.	III.	Hay, corn meal and molasses,	8.87	15.69	24.52	47.18	3.74
XIII.	VIII.	II.	Hay, corn meal and molasses,	9.81	13.34	27.78	45.95	3.12
XIV.	XI.	I.	English hay,	11.16	10.65	27.78	46.91	3.50
XIV.	XI.	II.	English hay,	10.45	10.17	29.55	46.65	3.18
XIV.	III.	I.	English hay and gluten feed,	11.51	13.51	23.65	47.92	3.41
XIV.	III.	II.	English hay and gluten feed,	11.46	12.89	25.07	47.15	3.43
XIV.	V.	III.	English hay and gluten feed,	10.89	13.12	25.28	47.19	3.52
XIV.	V.	IV.	English hay and gluten feed,	11.85	13.31	24.34	46.68	3.82
XIV.	IV.	III.	Hay, gluten feed and molasses,	12.16	14.01	24.20	46.63	3.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	12.84	14.84	22.54	46.61	3.17
XIV.	VI.	III.	Hay, gluten feed and molasses,	11.58	13.62	24.60	46.98	3.22
XIV.	VI.	IV.	Hay, gluten feed and molasses,	11.63	13.21	23.70	48.15	3.31
XIV.	VII.	III.	Hay, gluten feed and molasses,	11.85	14.38	25.18	45.63	2.96
XIV.	VII.	IV.	Hay, gluten feed and molasses,	11.38	13.27	24.88	47.23	3.24
XIV.	IX.	IV.	Hay, gluten feed and molasses,	12.37	15.25	23.19	46.18	3.01

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Series.	Period.	Sheep Number.	English Hay.	Gluten Feed.	Molasses.	Fæces.
X.,	VI.	IV.	88.35	-	-	93.35
X.,	IX.	V.	89.77	-	-	95.08
XI.,	V.	IV.	88.65	-	-	92.22
XI.,	V.	V.	88.65	-	-	92.14
XI.,	VI.	II.[1]	88.97	-	-	93.54
XI.,	VI.	III.[1]	88.97	-	-	93.52
XI.,	VII.	IV.	88.55	90.03	-	93.47
XI.,	VII.	V.	88.55	90.03	-	93.61
XI.,	III.	IV.	88.15	-	71.49	92.84
XI.,	III.	V.	88.15	-	71.49	93.14
XI.,	IV.	IV.	87.22	-	72.12	92.33
XI.,	IV.	V.	87.22	-	72.12	92.16
XI.,	VIII.	IV.	88.92	92.02	72.67	92.50
XI.,	VIII.	V.	88.92	92.02	72.67	92.36
XII.,	IV.	IV.	87.50	-	89.88	92.49
XII.,	IV.	V.	87.50	-	89.88	92.23
XII.,	XIV.	II.Y.	90.65	91.13	-	94.37
XII.,	III.	II.[1]	87.80	-	73.45	92.05
XII.,	III.	III.[1]	87.80	-	73.45	92.16
XII.,	V.	IV.	87.85	89.68	73.37	91.41
XII.,	V.	V.	87.85	89.68	73.37	91.42
XII.,	VII.	IV.	88.07	90.14	73.61	92.95
XII.,	VII.	V.	88.07	90.14	73.61	92.70
XII.,	X.	IV.	89.25	90.87	73.61	93.51
XII.,	XI.	II.Y.	90.57	89.98	74.18	93.87

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Series.	Period.	Sheep Number.	English Hay.	Gluten Feed.	Corn Meal.	Molasses.	Fæces.
XIII.,	V.	I.	90.07	-	-	-	93.65
XIII.,	V.	II.	90.07	-	-	-	93.65
XIII.,	IV.	III.	89.65	-	89.32	-	94.14
XIII.,	VII.	II.	89.12	-	90.36	-	94.31
XIII.,	I.	I.	88.62	-	-	72.93	93.35
XIII.,	I.	II.	88.62	-	-	72.93	93.58
XIII.,	III.	I.	89.30	-	-	72.93	93.74
XIII.,	III.	II.	89.30	-	-	72.93	93.67
XIII.,	VI.	III.	90.10	-	90.64	72.70	93.34
XIII.,	VIII.	II.	89.05	-	90.24	72.78	93.65
XIV.,	XI.	I.	90.05	-	-	-	93.41
XIV.,	XI.	II.	90.05	-	-	-	93.49
XIV.,	III.	I.	88.42	90.75	-	-	93.13
XIV.,	III.	II.	88.42	90.75	-	-	93.11
XIV.,	V.	III.	89.45	91.15	-	-	94.16
XIV.,	V.	IV.	89.45	91.15	-	-	91.26
XIV.,	IV.	III.	89.27	91.00	-	74.51	92.38
XIV.,	IV.	IV.	89.27	91.00	-	74.51	92.48
XIV.,	VI.	III.	89.47	91.52	-	74.84	93.99
XIV.,	VI.	IV.	89.47	91.52	-	74.84	94.01
XIV.,	VII.	III.	89.72	93.24	-	75.26	93.74
XIV.,	VII.	IV.	89.72	93.24	-	75.26	93.79
XIV.,	IX.	IV.	90.25	91.27	-	74.80	93.36

[1] Old sheep.

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

SERIES.	Periods.	Sheep Number.	Feed or Ration.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drunk daily.
X.	VI.	IV.	English hay, ...	678	32.15	1,138
X.	IX.	V.	English hay, ...	699	31.41	1,924
XI.	V.	IV.	English hay, ...	610	26.11	1,781
XI.	V.	V.	English hay, ...	623	27.02	1,642
XI.	VI.	II.	English hay, ...	613	26.21	1,694
XI.	VI.	III.	English hay, ...	608	28.80	1,544
XI.	VII.	IV.	English hay, ...	460	20.82	1,498
XI.	VII.	V.	English hay, ...	459	20.01	1,318
XI.	III.	IV.	Hay and molasses, . . .	674	31.10	1,725
XI.	III.	V.	Hay and molasses, . . .	745	32.86	1,995
XI.	IV.	IV.	Hay and molasses, . . .	738	33.34	2,114
XI.	IV.	V.	Hay and molasses, . . .	855	34.12	2,014
XI.	VIII.	IV.	Hay, gluten feed and molasses,	635	25.84	1,843
XI.	VIII.	V.	Hay, gluten feed and molasses,	655	25.86	1,953
XII.	IV.	IV.	Hay and gluten feed, . .	455	40.70[1]	1,382
XII.	IV.	V.	Hay and gluten feed, . .	639	41.72[1]	1,351
XII.	XIV.	II.Y.	Hay and gluten feed, . .	1,020	23.86	2,436
XII.	III.	II.	Hay and molasses, . . .	628	26.99	1,836
XII.	III.	III.	Hay and molasses, . . .	581	24 41	1,927
XII.	V.	IV.	Hay, gluten feed and molasses,	593	24.70	2,071
XII.	V.	V.	Hay, gluten feed and molasses,	688	24.97	1,786
XII.	VII.	IV.	Hay, gluten feed and molasses,	683	24.26	1,770
XII.	VII.	V.	Hay, gluten feed and molasses,	862	24.82	2,167
XII.	X.	IV.	Hay, gluten feed and molasses,	743	23.76	2,429
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	945	29.90	2,500
XIII.	V.	I.	English hay, ...	508	21.91	2,214
XIII.	V.	II.	English hay, ...	531	23.02	2,193
XIII.	IV.	III.	Hay and corn meal, . . .	516	18.91	2,500
XIII.	VII.	II.	Hay and corn meal, . . .	442	17.64	2,369
XIII.	I.	I.	Hay and molasses, . . .	468	19.02	1,631
XIII.	I.	II.	Hay and molasses, . . .	450	19.29	1,649
XIII.	III.	I.	Hay and molasses, . . .	528	20.79	1,414
XIII.	III.	II.	Hay and molasses, . . .	620	23.02	1,536
XIII.	VI.	III.	Hay, corn meal and molasses, .	588	20.36	2,150
XIII.	VIII.	II.	Hay, corn meal and molasses, .	526	21.59	2,159
XIV.	XI.	I.	English hay, ...	633	24.55	2,292
XIV.	XI.	II.	English hay, ...	722	26.62	2,251
XIV.	III.	I.	Hay and gluten feed, . .	389	17.21	2,246
XIV.	III.	II.	Hay and gluten feed, . .	451	19.84	2,407
XIV.	V.	III.	Hay and gluten feed, . .	469	19.64	2,385
XIV.	V.	IV.	Hay and gluten feed, . .	378	17.90	1,639
XIV.	IV.	III.	Hay, gluten feed and molasses,	560	23.81	2,470
XIV.	IV.	IV.	Hay, gluten feed and molasses,	508	21.81	2,450
XIV.	VI.	III.	Hay, gluten feed and molasses,	591	22.36	2,212
XIV.	VI.	IV.	Hay, gluten feed and molasses,	455	21.00	1,269
XIV.	VII.	III.	Hay, gluten feed and molasses,	744	22.79	2,464
XIV.	VII.	IV.	Hay, gluten feed and molasses,	513	22.15	2,338
XIV.	IX.	IV.	Hay, gluten feed and molasses,	827	22.85	2,089

[1] One-fifth of sample.

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

Series.	Period.	Sheep Number.	Feed or Ration.	Beginning.	End.	Gain or Loss.
X.	VI.	IV.	English hay, ...	156.00	155.50	—.50
X.	IX.	V.	English hay, ...	133.25	137.75	+4.50
XI.	V.	IV.	English hay, ...	142.00	144.00	+2.00
XI.	V.	V.	English hay, ...	122.00	121.50	—.50
XI.	VI.	II.	English hay, ...	154.00	150.00	—4.00
XI.	VI.	III.	English hay, ...	146.50	145.00	—1.50
XI.	VII.	IV.	Hay and gluten feed, . .	141.50	141.00	—.50
XI.	VII.	V.	Hay and gluten feed, . .	118.50	120.00	+1.50
XI.	III.	IV.	Hay and molasses, . . .	144.00	142.00	—2.00
XI.	III.	V.	Hay and molasses, . . .	124.00	122.00	—2.00
XI.	IV.	IV.	Hay and molasses, . . .	145.50	150.00	+4.50
XI.	IV.	V.	Hay and molasses, . . .	122.50	125.50	+3.00
XI.	VIII.	IV.	Hay, gluten feed and molasses,	145.00	142.00	—3.00
XI.	VIII.	V.	Hay, gluten feed and molasses,	125.50	122.50	—3.00
XII.	IV.	IV.	Hay and gluten feed, . .	121.50	119.00	—2.50
XII.	IV.	V.	Hay and gluten feed, . .	110.50	108.50	—2.00
XII.	XIV.	II.Y.	Hay and gluten feed, . .	94.50	91.50	—3.00
XII.	III.	II.	Hay and molasses, . . .	108.00	107.00	—1.00
XII.	III.	III.	Hay and molasses, . . .	125.00	125.00	-
XII.	V.	IV.	Hay, gluten feed and molasses,	121.00	125.50	+4.50
XII.	V.	V.	Hay, gluten feed and molasses,	115.50	112.00	—3.50
XII.	VII.	IV.	Hay, gluten feed and molasses,	127.00	123.00	—4.00
XII.	VII.	V.	Hay, gluten feed and molasses,	115.00	110.00	—5.00
XII.	X.	IV.	Hay, gluten feed and molasses,	128.00	120.00	—8.00
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	95.50	95.50	-
XIII.	V.	I.	English hay, ...	81.25	85.00	+3.75
XIII.	V.	II.	English hay, ...	78.50	78.50	-
XIII.	IV.	III.	Hay and corn meal, . . .	83.00	83.50	+.50
XIII.	VII.	II.	Hay and corn meal, . . .	80.00	80.00	-
XIII.	I.	I.	Hay and molasses, . . .	76.50	79.50	+3.00
XIII.	I.	II.	Hay and molasses, . . .	72.50	72.50	-
XIII.	III.	I.	Hay and molasses, . . .	83.25	82.50	—.75
XIII.	III.	II.	Hay and molasses, . . .	79.50	80.75	+1.25
XIII.	VI.	III.	Hay, corn meal and molasses, .	79.75	84.50	+4.75
XIII.	VIII.	II.	Hay, corn meal and molasses, .	79.00	77.00	+2.00
XIV.	XI.	I.	English hay, ...	90.00	88.50	—1.50
XIV.	XI.	II.	English hay, ...	90.50	88.50	—2.00
XIV.	III.	I.	Hay and gluten feed, . .	91.25	91.00	—.25
XIV.	III.	II.	Hay and gluten feed, . .	87.25	86.25	—1.00
XIV.	V.	III.	Hay and gluten feed, . .	92.25	88.00	—4.25
XIV.	V.	IV.	Hay and gluten feed, . .	95.00	93.00	—2.00
XIV.	IV.	III.	Hay, gluten feed and molasses,	93.50	91.50	—2.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	101.00	97.50	—3.50
XIV.	VI.	III.	Hay, gluten feed and molasses,	88.50	87.50	—1.00
XIV.	VI.	IV.	Hay, gluten feed and molasses,	96.50	96.00	—.50
XIV.	VII.	III.	Hay, gluten feed and molasses,	85.50	87.50	+2.00
XIV.	VII.	IV.	Hay, gluten feed and molasses,	101.00	101.50	+.50
XIV.	IX.	IV.	Hay, gluten feed and molasses,	95.50	100.25	—4.75

Coefficients employed for the Hay, Hay and Corn Meal and Hay and Gluten Feed, which were applied to the Preceding Feeds and Feed Combinations when fed together with Molasses in Order to show the Depression exerted by the Latter.

Series.	Period.	Sheep Number.	Ration.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XI.	III.	IV., V.	Hay and molasses,	57.98	40.52	53.61	59.06	61.41	47.76
XI.	IV.	IV., V.	Hay and molasses,	57.98	40.52	53.61	59.06	61.41	47.76
XI.	VIII.	IV.	Hay, gluten feed and molasses,	72.64	47.18	72.87	77.20	73.86	56.49
XI.	VIII.	V.	Hay, gluten feed and molasses,	73.67	48.78	74.33	77.57	75.03	57.46
XII.	III.	II., III.	Hay and molasses,	67.87	49.17	62.31	76.30	66.39	52.37
XII.	V.	IV., V.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	VII.	IV., V.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	X.	IV.	Hay, gluten feed and molasses,	73.00	40.16	73.75	77.35	75.07	54.50
XII.	XI.	II.Y.	Hay, gluten feed and molasses,	68.86	39.23	65.37	72.14	72.00	57.95
XIII.	I.	I , II.	Hay and molasses,	66.64	52.63	62.09	70.93	68.02	47.87
XIII.	III.	I., II.	Hay and molasses,	66.64	52.63	62.09	70.93	68.02	47.87
XIII.	VI.	III.	Hay, corn meal and molasses,	69.43	50.13	61.00	66.18	74.76	61.12
XIII.	VIII.	II.	Hay, corn meal and molasses,	71.38	42.16	47.45	71.55	77.77	63.11
XIV.	IV.	III.	Hay, gluten feed and molasses,	68.00	44.00	66.00	68.00	72.00	61.00
XIV.	IV.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	VI.	III.	Hay, gluten feed and molasses,	68.00	44.00	66.00	68.00	72.00	61.00
XIV.	VI.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	VII.	III.	Hay, gluten feed and molasses,	68.00	44.00	66.00	68.00	72.00	61.00
XIV.	VII.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00
XIV.	IX.	IV.	Hay, gluten feed and molasses,	72.00	46.00	70.00	73.00	76.00	62.00

Calculation of Coefficients.

Series X., Period VI., Sheep IV.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay fed,	706.80	55.27	60.50	228.65	344.57	17.81
321.50 grams manure excreted,	300.12	34.84	29.71	92.02	134.78	8.76
Grams digested,	406.68	20.43	30.79	136.63	209.79	9.05
Per cent. digested,	57.54	36.96	50.89	59.76	60.88	50.81

Nutritive ratio of ration, 1: 11.9.

Series X., Period IX., Sheep V.

English Hay.

800 grams English hay fed,	718.16	59.97	63.20	229.02	349.17	16.80
314.13 grams manure excreted,	298.67	33.54	27.60	95.37	132.88	9.29
Grams digested,	419.49	26.43	35.60	133.65	216.29	7.51
Per cent. digested,	58.41	44.07	56.33	58.36	61.94	44.70
Average per cent. for both sheep,	57.98	40.52	53.61	59.06	61.41	47.76

Series XI., Period V., Sheep IV.

English Hay.

800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
261.10 grams manure excreted,	240.79	26.92	33.95	58.27	111.34	10.31
Grams digested,	468.41	20.95	52.79	178.96	205.46	10.26
Per cent. digested,	66.05	43.76	60.86	75.44	64.85	49.88

Series XI., Period V., Sheep V.

English Hay.

800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
270.20 grams manure excreted,	248.96	26.12	32.79	66.00	113.87	10.18
Grams digested,	460.24	21.75	53.95	171.23	202.93	10.39
Per cent. digested,	64.90	45.44	62.20	72.18	64.06	50.51
Average per cent. for both sheep,	65.48	44.60	61.53	73.81	64.46	50.20

Average nutritive ratio of rations for two sheep, 1: 7.5.

Series XI., Period VI., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
900 grams English hay fed, . .	800.73	54.05	97.93	267.84	357.69	23.22
262.10 grams manure excreted, .	245.17	26.48	36 04	58.82	113.44	10.40
Grams digested, ...	555.56	27.57	61.89	209.02	244.25	12.82
Per cent. digested, ...	69.38	51.01	63.20	78.04	68.29	55.21

Series XI., Period VI., Sheep III.

English Hay.

900 grams English hay fed, . .	800.73	54 05	97.93	267.84	357.69	23.22
288 grams manure excreted, . .	269.34	28.47	37.79	68.17	123.20	11.72
Grams digested, ...	531.39	25.58	60.14	199.67	234.49	11.50
Per cent. digested, ...	66.36	47.33	61.41	74.55	65.56	49.53
Average per cent. for both sheep, .	67.87	49.17	62.31	76.30	66.39	52 37

Average nutritive ratio of rations for two sheep, 1: 7.7.

Series XI., Period VII., Sheep IV.

Hay and Gluten Feed.

600 grams English hay fed, . .	531.30	35.86	64.98	177.72	237.33	15.41
200 grams gluten feed fed, . .	180.06	3.01	44.98	13.00	114.05	5 02
Amount consumed, ...	711.36	38.87	109.96	190.72	351.38	20.43
208.20 grams manure excreted, .	194.60	20.53	29.83	43 49	91.85	8.89
Grams digested, ...	516.76	18.34	80.13	147.23	259.53	11.54
Per cent. hay and gluten feed digested.	72.64	47.19	72.87	77.19	73.86	56.40

Series XI., Period VII., Sheep V.

Hay and Gluten Feed.

Amount consumed as above, . .	711.36	38.87	109.96	190.72	351.38	20.43
200.10 grams manure excreted, .	187.31	19.91	28.19	42.78	87.74	8.69
Grams digested, ...	524.05	18.96	81.77	147.94	263.64	11.74
Per cent. hay and gluten feed digested.	73.67	48.78	74.36	77.57	75.03	57.46

Average nutritive ratio of rations for two sheep, 1: 5.4.

Series XI., Period III., Sheep IV.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay fed,	705.20	57.83	61.28	226.65	342.45	17.00
150 grams molasses fed,	107.24	9.06	4.23	–	93.95	–
Amount consumed,	812.44	66.89	65.51	226.65	436.40	17.00
311 grams manure excreted,	288.73	35.11	30.95	84.66	129.55	8.46
Grams digested,	523.71	31.78	34.56	141.89	306.85	8.54
Minus hay digested,	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested (grams),	114.84	8.35	1.71	8.03	96.55	.42
Per cent. digested,	107.09	92.16	40.43	–	102.76	–

Series XI., Period III., Sheep V.

Porto Rico Molasses.

Amount consumed as above,	812.44	66.89	65.51	226.65	436.40	17.00
328.60 grams manure excreted,	306.06	36.21	32.23	92.83	136.10	8.69
Grams digested,	506.38	30.68	33.28	133.82	300.30	8.31
Minus hay digested,	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested (grams),	97.51	7.25	.43	–	90.00	.19
Per cent. digested,	90.93	80.02	10.17	–	95.80	–
Average per cent. for both sheep,	99.01	86.09	25.30	–	99.28	–

Average nutritive ratio of rations for two sheep, 1: 13.6.

Series XI., Period IV., Sheep IV.

Porto Rico Molasses.

800 grams English hay fed,	697.76	57.22	60.64	224.26	338.82	16.82
250 grams molasses fed,	180.30	15.24	7.10	–	157.96	–
Amount consumed,	878.06	72.46	67.74	224.26	496.78	16.82
333.40 grams manure excreted,	307.83	42.05	35.31	83.51	138.09	8.87
Grams digested,	570.23	30.41	32.43	140.75	358.69	7.95
Minus hay digested,	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested (grams),	165.67	7.22	—.08	8.31	150.62	–
Per cent. digested,	91.89	47.38	–	–	95.35	–

Series XI., Period IV., Sheep V.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above, . .	878.06	72.46	67.74	224.26	496.78	16.82
341.2 grams manure excreted, . .	314.45	40.47	36.13	91.03	138.17	8.65
Grams digested, ...	563.61	31.99	31.61	133.23	358.61	8.17
Minus hay digested, . . .	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested (grams), . .	159.05	8.80	.10	.79	150.54	.14
Per cent. digested, ...	88.21	57.74	–	–	95.30	–
Average per cent. for both sheep, .	90.05	52.56	–	–	95.33	–

Average nutritive ratio of rations for two sheep, 1: 16.

Series XI., Period VIII., Sheep IV.

Porto Rico Molasses.

600 grams English hay fed, . .	533.52	36.91	65.25	178.46	238.32	15.47
200 grams gluten feed fed, . .	184.04	3.07	45.97	13.29	116.57	5.13
250 grams molasses fed, . . .	181.68	16.75	7.16	–	157.77	–
Amount consumed, ...	899.24	55.83	118.38	191.75	512.66	20.60
258.40 grams manure excreted, .	239.02	26.65	39.10	50.82	113.39	9.06
Grams digested, ...	660.22	29.18	79.28	140.93	399.27	11.54
Minus hay and gluten feed digested,	521.24	18.44	81.05	–	262.12	–
Molasses digested (grams), . .	138.98	10.74	–	–	137.15	–
Per cent. digested, ...	76.50	64.12	–	–	86.93	–

Series XI., Period VIII., Sheep V.

Porto Rico Molasses.

Amount consumed as above, . .	899.24	55.83	118.38	191.75	512.66	20.60
258.60 grams manure excreted, . .	238.84	25.84	38.72	52.76	112.61	8.91
Grams digested, ...	660.40	29.99	79.66	138.99	400.05	11.69
Minus hay and gluten feed digested,	528.63	19.06	82.70	–	266.27	–
Molasses digested (grams), . .	131.77	10.93	–	–	133.78	–
Per cent. digested, ...	72.53	65.25	–	–	84.80	–
Average per cent. for both sheep, .	74.52	64.69	–	–	85.87	–

Average nutritive ratio of rations for two sheep, 1: 7.1.

Series XII., Period IV., Sheep IV.

Gluten Feed and Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
600 grams English hay,	525.00	35.44	64.21	175.61	234.52	15.23
200 grams gluten feed,	179.76	2.75	47.13	11.32	113.88	4.67
Amount consumed,	704.76	38.19	111.34	186.93	348.40	19.90
Minus 203.52 grams manure excreted,	188.24	23.10	29.18	40.75	86.53	8.68
Grams digested,	516.52	15.09	82.16	146.18	261.87	11.22
Per cent. gluten feed and hay digested.	73.29	39.51	73.79	78.20	75.16	56.38

Series XII., Period IV., Sheep V.

Gluten Feed and Hay.

Amount consumed as above,	704.76	38.19	111.34	186.93	348.40	19.90
Minus 208.62 grams manure excreted,	192.41	22.61	29.28	43.93	87.16	9.43
Grams digested,	512.35	15.58	82.06	143.00	261.24	10.47
Per cent. gluten feed and hay digested.	72.70	40.80	73.70	76.50	74.98	52.61
Average per cent. for both sheep,	73.00	40.16	73.75	77.35	75.07	54.50

Series XII., Period XIV., Sheep II. (Young.)

Gluten Feed and Hay.

550 grams English hay,	498.58	33.65	60.98	166.78	222.72	14.46
250 grams gluten feed,	227.83	3.49	59.74	14.35	144.33	5.92
Amount consumed,	726.41	37.14	120.72	181.13	367.05	20.38
238.64 grams manure excreted,	226.20	22.57	41.80	50.47	102.79	8.57
Grams digested,	500.21	14.57	78.92	130.66	264.26	11.81
Minus hay digested,	328.66	17.48	37.80	121.53	144.01	7.84
Gluten feed digested (grams),	171.55	-	41.12	9.13	120.25	3.97
Per cent. hay and gluten feed digested.	68.86	39.23	65.37	72.14	72.00	57.95

Series XII., Period III., Sheep II. (Old).

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
800 grams English hay, . . .	702.40	47.41	85.90	234.95	313.76	20.37
100 grams Porto Rico molasses, .	73.45	5.35	2.79	-	65.31	-
Amount consumed, ...	775.85	52.76	88.69	234.95	379.07	20.37
Minus 269.86 grams manure excreted,	248.41	29.59	36.81	57.13	113.77	11.10
Grams digested, ...	527.44	23.17	51.88	177.82	265.30	9.27
Minus hay digested, . . .	476.72	23.31	53.52	179.27	208.31	10.67
Molasses digested (grams), . .	50.72	—.17	—1.64	—1.45	56.99	—1.40
Per cent. digested, ...	69.05	-	-	-	87 26	-

Series XII., Period III., Sheep III.

Porto Rico Molasses.

Amount consumed as above, . .	775.85	52.76	88.69	234.95	379.07	20.37
Minus 244.09 grams manure excreted,	224.95	27.24	32.93	50.55	104.42	9.81
Grams digested, ...	550.90	25.52	55.76	184.40	274.65	10.56
Minus hay digested, . . .	476.72	23.31	53.52	179.27	208.31	10.67
Molasses digested (grams), . .	74.18	2.21	2.24	5.13	66.34	—.11
Per cent. digested, ...	100.99	41.31	80.29	-	101.58	-

Series XII., Period V., Sheep IV. (Paige).

Porto Rico Molasses.

600 grams English hay, . . .	527.10	35.58	64.46	176.31	235.46	15.29
200 grams gluten feed, . . .	179.36	2.74	47.03	11.30	113.62	4.66
100 grams Porto Rico molasses, .	73.37	5.34	2 79	-	65.24	-
Amount consumed, ...	779.83	43.66	114.28	187.61	414.32	19.95
246.97 grams manure excreted, .	225.76	25.53	36.12	48.65	106.40	9.05
Grams digested, ...	554.07	18.13	78.16	138.96	307.92	10.90
Minus hay and gluten feed digested,	515.72	15.39	82.22	145.12	262.05	10.87
Molasses digested (grams), . .	38.35	2.74	—4.06	—6.16	45.87	.03
Per cent. digested, ...	52.27	51.31	-	-	70.31	-

Series XII., Period V., Sheep V.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	779.83	43.66	114.28	187.61	414.32	19.95
249.67 grams manure excreted,	228.25	24.13	36.38	52.25	106.80	8.70
Grams digested,	551.58	19.53	77.90	135.36	307.52	11.25
Minus hay and gluten feed digested,	515.72	15.39	82.22	145.12	262.05	10.87
Molasses digested (grams),	35.86	4.14	—4.32	—9.76	45.47	.38
Per cent. digested,	48.88	77.53	-	-	69.70	-
Average per cent. for two sheep,	50.58	64.42	-	-	70.01	-

Series XII., Period VII., Sheep IV. (Paige).

Porto Rico Molasses.

600 grams English hay,	528.42	35.67	64.63	176.76	236.05	15.32
200 grams gluten feed,	180.28	2.76	47.27	11.36	114.21	4.69
200 grams Porto Rico molasses,	147.22	10.72	5.59	-	130.91	-
Amount consumed,	855.92	49.15	117.49	188.12	481.17	20.01
242.64 grams manure excreted,	225.53	25.51	37.03	48.80	106.02	8.16
Grams digested,	630.39	23.64	80.46	139.32	375.15	11.85
Minus hay and gluten feed digested,	517.35	15.43	82.53	145.51	262.94	10.91
Molasses digested (grams),	113.04	8.21	—2.07	—6.19	112.21	.94
Per cent. digested,	76.78	76.59	-	-	85.72	-

Series XII., Period VII., Sheep V.

Porto Rico Molasses.

Amount consumed as above,	855.92	49.15	117.49	188.12	481.17	20.01
248.17 grams manure excreted,	230.05	25.03	36.07	53.16	107.99	7.80
Grams digested,	625.87	24.12	81.42	134.96	373.18	12.21
Minus hay and gluten feed digested,	517.35	15.43	82.53	145.51	262.94	10.91
Molasses digested (grams),	108.52	8.69	—1.11	—10.55	110.24	1.30
Per cent. digested,	73.71	81.06	-	-	84.21	-
Average per cent. for two sheep,	75.25	78.83	-	-	84.97	-

Series XII., Period X., Sheep IV. (Paige).

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
600 grams English hay,	535.50	36.15	65.49	179.12	239.21	15.53
200 grams gluten feed,	181.74	2.78	47.65	11.45	115.13	4.73
300 grams Porto Rico molasses,	220.83	16.08	8.39	–	196.36	–
Amount consumed,	938.07	55.01	121.53	190.57	550.70	20.26
237.57 grams manure excreted,	222.15	27.44	39.32	44.05	102.88	8.46
Grams digested,	715.92	27.57	82.21	146.52	447.82	11.80
Minus hay and gluten feed digested,	523.59	15.63	83.44	147.41	266.00	11.04
Molasses digested (grams),	192.33	11.94	—1.23	—.89	181.82	.76
Per cent. digested,	87.09	74.25	–	–	92.60	–

Series XII., Period XI., Sheep II. (Young).

Porto Rico Molasses.

600 grams English hay,	543.42	36.68	66.46	181.77	242.75	15.76
200 grams gluten feed,	179.96	2.75	47.19	11.34	114.00	4.68
250 grams Porto Rico molasses,	185.45	13.50	7.05	–	164.90	–
Amount consumed,	908.83	52.93	120.70	193.11	521.65	20.44
299.04 grams manure excreted,	280.71	32.11	48.79	61.87	128.06	9.88
Grams digested,	628.12	20.82	71.91	131.24	393.59	10.56
Minus hay and gluten feed digested,	498.12	15.47	74.29	139.31	256.86	11.84
Molasses digested (grams),	130.00	5.35	—3.38	—8.07	136.73	—.28
Per cent. digested,	70.10	39.63	–	–	82.92	–

Series XIII., Period V., Sheep I.

English Hay.

700 grams English hay,	630.49	40.73	77.17	184.36	312.03	16.20
Minus 219.10 grams manure excreted,	205.19	19.12	29.22	49.96	98.51	8.37
Grams digested,	425.30	21.61	47.95	134.40	213.52	7.83
Per cent. digested,	67.46	53.06	62.14	72.90	68.43	48.33

Series XIII., Period V., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
700 grams English hay, . . .	630.49	40.73	77.17	184.36	312.03	16.20
Minus 230.19 grams manure excreted,	215.57	19.47	29.30	57.23	101.06	8.52
Grams digested, ...	414.92	21.26	47.87	127.13	210.97	7.68
Per cent. digested, ...	65.81	52.20	62.03	68.96	67.61	47.41
Average per cent. for two sheep, .	66.64	52.63	62.09	70.93	68.02	47.87

Series XIII., Period IV., Sheep III.

English Hay, Corn Meal.

500 grams English hay, . . .	448.25	28.96	54.87	131.07	221.84	11.52
150 grams corn meal, . . .	133.98	2.12	14.00	2.81	108.82	6.23
Amount consumed, ...	582.23	31.08	68.87	133.88	330.66	17.75
189.06 grams manure excreted, .	177.98	15.50	26.86	45.28	83.45	6.89
Grams digested, ...	404.25	15.58	42.01	88.60	247.21	10.86
Per cent. digested, ...	69.43	50.13	61.00	66.18	74.76	61.12

Series XIII., Period VII., Sheep II.

English Hay, Corn Meal.

500 grams English hay, . . .	445.60	28.65	32.04	151.86	222.00	11.05
150 grams corn meal, . . .	135.54	2.14	14.16	2.85	110.09	6.30
Amount consumed, ...	581.14	30.79	46.20	154.71	332.09	17.35
176.37 grams manure excreted, .	166.33	17.81	24.28	44.01	73.82	6.40
Grams digested, ...	414.81	12.98	21.92	110.70	258.27	10.95
Per cent. digested, ...	71.38	42.16	47.45	71.55	77.77	63.11

Series XIII., Period I., Sheep I.

Porto Rico Molasses.

600 grams English hay, . . .	531.72	34.34	65.08	155.47	263.15	13.67
100 grams Porto Rico molasses, .	72.93	5.87	3.34	–	63.72	–
Amount consumed, ...	604.65	40.21	68.42	155.47	326.87	13.67
Minus 190.20 grams manure excreted,	177.55	19.32	26.26	42.47	82.88	6.62
Grams digested, ...	427.10	20.89	42.16	113.00	243.99	7.05
Minus hay digested, . . .	354.34	18.07	40.41	110.27	178.99	6.54
Molasses digested (grams), . .	72.76	2.82	1.75	2.73	65.00	.51
Per cent. digested, . . .	99.77	48.04	52.40	–	102.01	–

Series XIII., Period I., Sheep II.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above, . .	604.65	40.21	68.42	155.47	326.87	13.67
Minus 192.90 grams manure excreted,	180.05	19.36	27.22	42.85	83.74	6.88
Grams digested, ...	424.60	20.85	41.20	112.62	243 13	6.79
Minus hay digested, . . .	354.34	18.07	40.41	110.27	178.99	6.54
Molasses digested (grams), . .	70.26	2.78	.79	2.35	64.14	.25
Per cent. digested, ...	96.34	47.36	23.65	–	100.66	–
Average per cent. for two sheep, .	98.06	47.70	38.03	–	101.34	–

Series XIII., Period III., Sheep I.

Porto Rico Molasses.

600 grams English hay, . . .	535.80	34.61	65.58	156.67	265.17	13.78
200 grams Porto Rico molasses, .	145.86	11.83	6.86	–	127.18	–
Amount consumed, ...	681.66	46.44	72.44	156.67	392.35	13.78
Minus 207.86 grams manure excreted,	194.85	21.20	30.24	44.91	91.46	7.03
Grams digested, ...	486.81	25.24	42.20	111.76	300.89	6.75
Minus hay digested, . . .	357.06	18 22	40.72	111.13	180.37	6.60
Molasses digested (grams), . .	129.75	7.02	1.48	.63	120.52	.15
Per cent. digested, ...	88.96	59.34	21.57	–	94.76	–

Series XIII., Period III., Sheep II.

Porto Rico Molasses.

Amount consumed as above, . .	681.66	46.44	72.44	156.67	392.35	13.78
Minus 230.24 grams manure excreted,	215.67	22.02	31.73	56.53	97.87	7.53
Grams digested, ...	465.99	24.42	40.71	100.14	294.48	6.25
Minus hay digested, . . .	357.06	18.22	40.72	111.13	180 37	6.60
Molasses digested (grams), . .	108.93	6.20	.01	10.99	114.11	.35
Per cent. digested, ...	74.67	52.41	–	–	89.72	–
Average per cent. for two sheep, .	81.82	55.88	21.57[1]	–	92.24	–

[1] One sheep.

Series XIII., Period VI., Sheep III.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
500 grams English hay,	450.50	29.10	55.14	131.73	222.95	11.58
150 grams corn meal,	135.96	2.15	14.21	2.86	110.43	6.32
100 grams Porto Rico molasses,	72.70	5.98	3.43	–	63.29	–
Amount consumed,	659.16	37.23	72.78	134.59	396.67	17.90
203.60 grams manure excreted,	190.04	16.86	29.82	46.60	89.66	7.11
Grams digested,	469.12	20.37	42.96	87.99	307.01	10.79
Minus hay and corn meal digested,	407.18	15.67	42.30	89.07	249.23	10.94
Molasses digested (grams),	61.94	4.70	.66	–	57.78	–
Per cent. digested,	85.20	78.60	19.24	–	91.29	–

Series XIII., Period VIII., Sheep II.

Porto Rico Molasses.

500 grams English hay,	445.25	28.63	32.01	151.74	221.82	11.04
150 grams corn meal,	135.36	2.14	14.15	2.84	109.94	6.29
200 grams Porto Rico molasses,	145.56	11.89	6.85	–	126.81	–
Amount consumed,	726.17	42.66	53.01	154.58	458.57	17.33
Minus 215.89 grams manure excreted,	202.18	19.83	26.97	56.17	92.90	6.31
Grams digested,	523.99	22.83	26.04	98.41	365.67	11.02
Minus hay and corn meal digested,	414.44	12.97	21.90	110.60	258.01	10.94
Molasses digested (grams),	109.55	9.86	4.14	–	107.66	–
Per cent. digested,	75.26	23.11	60.44	–	84.90	–

Series XIV., Period XI., Sheep I.

English Hay.

700 grams English hay,	630.35	44.82	48.85	205.74	315.24	15.70
245.46 grams manure excreted,	229.28	25.59	24.42	63.69	107.56	8.02
Grams digested,	401.07	19.23	24.43	142.05	207.68	7.68
Per cent. digested,	63.63	42.91	50.01	69.04	65.88	48.92

Series XIV., Period XI., Sheep II.

English Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
700 grams English hay,	630.35	44.82	48.85	205.74	315.24	15.70
266.16 grams manure excreted,	248.83	26.00	25.31	73.53	116.08	7.91
Grams digested,	381.52	18.82	23.54	132.21	199.16	7.79
Per cent. digested,	60.53	41.99	48.19	64.27	63.18	49.62
Average per cent. for both sheep,	62.08	42.45	49.10	66.66	64.53	49.27

Series XIV., Period III., Sheep I.

Gluten Feed and Hay.

500 grams English hay,	442.10	30.15	33.91	134.21	233.35	10.48
150 grams gluten feed,	136.13	5.61	37.05	10.63	76.97	5.87
Amount consumed,	578.23	35.76	70.96	144.84	310.32	16.35
Minus 172.09 grams manure excreted,	160.27	18.45	21.65	37.90	76.80	5.47
Grams hay and gluten feed digested,	417.96	17.31	49.31	106.94	233.52	10.88
Per cent. hay and gluten feed digested.	72.28	48.41	69.49	73.83	75.25	66.54

Series XIV., Period III., Sheep II.

Gluten Feed and Hay.

Amount consumed as above,	578.23	35.76	70.96	144.84	310.32	16.35
Minus 198.37 grams manure excreted,	184.70	21.17	23.81	46.30	87.08	6.34
Grams hay and gluten feed digested,	393.53	14.59	47.15	98.54	223.24	10.01
Per cent. hay and gluten feed digested.	68.06	40.80	66.45	61.13	71.94	61.22
Average per cent. for both sheep,	70.17	44.61	67.97	67.48	73.60	63.88

Series XIV., Period V., Sheep III.

Gluten Feed and Hay.

500 grams English hay,	447.25	30.50	34.30	135.74	236.11	10.60
150 grams gluten feed,	136.73	5.63	37.22	10.68	77.31	5.89
Amount consumed,	583.98	36.13	71.52	146.42	313.42	16.49
Minus 196.35 grams manure excreted,	184.88	20.13	24.25	46.74	87.25	6.51
Grams hay and gluten feed digested,	399.10	16.00	47.27	99.68	226.17	9.98
Per cent. hay and gluten feed digested.	68.34	44.20	66.09	68.08	72.16	60.52

Series XIV., Period V., Sheep IV.

Gluten Feed and Hay.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	583.98	36.13	71.52	146.42	313.42	16.49
Minus 179.00 grams manure excreted,	163.36	19.36	21.74	39.76	76.27	6.23
Grams hay and gluten feed digested,	420.62	16.77	49.78	106.66	237.15	10.26
Per cent. hay and gluten feed digested.	72.03	46.42	69.60	72.85	75.67	62.22
Average per cent. for both sheep,	70.19	45.31	67.85	70.47	73.92	61.37

Series XIV., Period IV., Sheep III.

Porto Rico Molasses.

500 grams English hay,	446.35	30.44	34.24	135.47	235.62	10.58
150 grams gluten feed,	136.50	5.62	37.16	10.66	77.18	5.88
200 grams molasses,	149.02	12.41	8.60	-	128.01	-
Amount consumed,	731.87	48.47	80.00	146.13	440.81	16.46
238.06 grams manure excreted,	219 92	26.74	30.80	53.22	102.56	6.60
Grams digested,	511.95	21.73	49.20	92.91	338.25	9.86
Minus hay and gluten feed digested,	396.34	15.87	47.12	99.37	225.22	10.04
Molasses digested (grams),	115.61	5.86	2.08	—6.46	113.03	—.18
Per cent. digested,	77.58	47.22	24.19	-	88.30	-

Series XIV., Period IV., Sheep IV.

Porto Rico Molasses.

Amouut consumed as above,	731.87	48.47	80.00	146.13	440.81	16.46
218.07 grams manure excreted,	201.67	25.89	29 93	45 46	94.00	6.39
Grams digested,	530.20	22.58	50.07	100.67	346.81	10.07
Minus hay and gluten feed digested,	419.65	16.59	49 98	106.67	237.73	10.21
Molasses digested (grams),	110.55	5.99	.09	—6.00	109.08	—.14
Per cent. digested,	74.18	48.27	1.05	-	85.21	-
Average per cent. for both sheep,	75.88	47.75	12.62	-	86.76	-

Series XIV., Period VI., Sheep III.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
500 grams English hay, . .	447.25	30.50	34.30	135.74	236.11	10.60
150 grams gluten feed, . . .	137.28	5.65	37.37	10.72	77.62	5.92
50 grams molasses, ...	37.42	3.06	2.23	–	32.13	–
Amount consumed, ...	621.95	39.21	73.90	146.46	345.86	16.52
223.6 grams manure excreted, . .	210.18	24.34	28.63	51.70	98.74	6.77
Grams digested, ...	411.77	14.87	45.27	94.76	247.12	9.75
Minus hay and gluten feed digested,	397.48	15.91	47.30	99.59	225.89	10.08
Molasses digested (grams), . .	14.29	—1.04	—2.03	—4.83	21.23	—.30
Per cent. digested, ...	38.19	–	–	–	66.08	–

Series XIV., Period VI., Sheep IV.

Porto Rico Molasses.

Amount consumed as above, . .	621.95	39.21	73.90	146.46	315.86	16.52
210.03 grams manure excreted, .	197.45	22.96	26.08	46.80	95.07	6.54
Grams digested, ...	424.50	16.25	47.82	99.66	250.79	9.98
Minus hay and gluten feed digested,	420.86	16.63	50.17	106.92	238.43	10.24
Molasses digested (grams), . .	3.64	—.38	—2.35	—7.26	12.36	—.26
Per cent. digested, ...	9.73	–	–	–	38.47	–
Average per cent. for both sheep, .	23.96	–	–	–	52.28	–

Series XIV., Period VII., Sheep III.

Porto Rico Molasses.

500 grams English hay, . . .	448.60	30.59	34.41	136.15	236.82	10.63
150 grams gluten feed, . . .	139.86	5.76	38.07	10.92	79.08	6.03
100 grams molasses, . . .	75.26	6.17	4.51	–	64.58	–
Amount consumed, ...	663.72	42.52	76.99	147.07	380.48	16.66
227.90 grams manure excreted, .	213.63	25.32	30.72	53.79	97.48	6.32
Grams digested, ...	450.09	17.20	46.27	93.28	283.00	10.34
Minus hay and gluten feed digested,	400.15	15.99	47.84	100.01	227.45	10.16
Molasses digested (grams), . .	49.94	1.21	—.57	—6.73	55.55	.18
Per cent. digested, ...	66.37	19.61	–	–	86.02	–

Series XIV., Period VII., Sheep IV.

Porto Rico Molasses.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
Amount consumed as above,	663.72	42.52	76.99	147.07	380.48	16.66
221.48 grams manure excreted,	207.73	23.64	27.57	51.68	98.11	6.73
Grams digested,	455.99	18.88	49.42	95.39	282.37	9.93
Minus hay and gluten feed digested,	423.69	16.72	50.74	107.36	240.08	10.33
Molasses digested (grams),	32.30	2.12	—1.32	—11.97	42.29	—.40
Per cent. digested,	42.92	34.36	–	–	65.48	–
Average per cent. for both sheep,	54.65	26.99	–	–	75.75	–

Series XIV., Period IX., Sheep IV.

Porto Rico Molasses.

500 grams English hay,	451.25	30.77	34.61	136.95	238.23	10.69
150 grams gluten feed,	136.90	5.98	36.14	9.84	79.66	5.28
150 grams molasses,	112.20	9.39	6.68	–	96.13	–
Amount consumed,	700.35	46.14	77.43	146.79	414.02	15.97
228.51 grams manure excreted,	213.34	26.39	32.53	49.47	98.53	6.42
Grams digested,	487.01	19.75	44.90	97.32	315.49	9.55
Minus hay and gluten feed digested,	423.47	16.91	49.53	107.16	241.60	9.90
Molasses digested (grams),	63.54	2.84	—4.63	—9.84	73.89	—.35
Per cent. digested,	56.63	30.24	–	–	76.86	–

STABILITY OF BUTTER-FAT SAMPLES.[1]

BY E. B. HOLLAND, M.SC.

In the examination of butter fat, the question of stability is one of prime importance. Should appreciable changes take place in the samples, results would be vitiated and deductions as to the effect of feed would be of questionable value. That oils and fats are readily acted upon by a number of agents has been long recognized, but whether butter-fat samples as ordinarily treated would be sufficiently changed as to affect analytical results is uncertain, though quite probable from the nature of the substance. To secure definite information on the subject it was necessary to carry out several experiments, of which a description with data follows.

The object of the first experiment was to determine the action of air, light and moisture, respectively, at the same temperature, upon butter fat. Heat as an independent factor could not be studied at that time as it would have increased the work to a point beyond which it could have been handled, but the action of heat was noted more particularly in another experiment. About ten pounds of butter fat were prepared by melting fresh butter and filtering the supernatant fat through paper in a jacketed funnel. Two-ounce bottles, 73 in number, were filled with the melted fat and placed in the north window of the station creamery building in March, 1908. These bottles were divided into seven sets, four of which were closed with a glass stopper and sealed with ceresin to practically eliminate the oxidizing action of the air, and the remainder simply protected by a single thickness of unbleached cotton cloth tied over the top, which readily permitted circulation of the air. One set of

[1] This work was undertaken jointly with Dr. R. D. MacLaurin, but owing to the resignation of Dr. MacLaurin it has been completed and prepared for publication by Mr. Holland.

the sealed bottles was guarded from light [1] and from moisture, and served as a check. Two sets of both closed and open bottles had 1 cubic centimeter of water added, one set of each being exposed to north and east light (not sun) and one set protected from light.[1] Another set of both closed and open bottles was exposed to the light. From these various combinations it was thought deductions might be drawn as to the relative action of air, light and moisture upon butter fat.

The fat was of fair average composition, as shown by the analytical results: —

Saponification number,	232.47
Acid number,	1.48
Reichert-Meissl number,	29.84
Mean molecular weight of volatile acids,	96.90
Insoluble acids (per cent.),	88.21
Mean molecular weight of insoluble acids,	253.08
Iodine number,	28.40
Melting point (Wiley method),	32.95° C.
Refractive index, 40° C.,	1.4525
Valenta test,	28.50° C.

One or two samples were drawn from every series in June and December, 1908, and March and October, 1909, melted, filtered and analyzed. The testing in June, 1908, was more or less unsatisfactory, especially the iodine number, because of the high temperature prevailing, and what deductions may be offered will be based largely upon the remaining data, which represents periods of six, twelve and eighteen months.

Physical Changes.

The original fat, when melted, gave a transparent oil of a pronounced yellow color and a slight but characteristic odor. On standing, the color gradually faded. This, however, was far from uniform, even with members of the same series. The checks were very irregular, varying at the end of the test from yellow to almost white; with moisture the color was less intense, with light similar, and with moisture and light rather better

[1] In providing for the circulation of air, a little diffused light reached the samples.

than the checks. Light, in the absence of air, did not accelerate loss of color.

Air induced the most uniform destruction of color. As the air always carried more or less moisture, it was impossible to differentiate as to the effect of light and added moisture. The most notable change was obtained from the combined action of all three factors.

The sealed samples were porous, and developed a slight odor, unlike that of the original fat. The open samples were more like tallow, both in appearance and odor. Old samples containing added water were turbid on melting, and required considerable time to settle clear.

Chemical Changes.

As decomposition of fats and oil seems to progress along two fairly well-defined lines, that of hydrolysis and that of oxidation, only such determinations were planned as would readily serve to measure these changes; acid and saponification numbers for the former, and iodine number for the latter. Too much must not be expected of these determinations for so complex a reaction, but they are at least indicative. If the decomposition became extensive, other tests would be warranted.

As shown by Table 1, added moisture, in the absence of air, had no appreciable hydrolytic action in excess of the check. Light alone, and with moisture present, preserved the original fat practically unchanged for eighteen months while the check manifested a noticeable breaking down. Moist air increased hydrolysis, both light and added water intensified the reaction. Lewkowitsch states that dry air without light has no action on oils and fats, and his explanation will be presented later.

Aldehydes were produced in both open and closed samples, as shown by the brown color of the saponification test (October, 1909), except in the sealed samples exposed to light.

TABLE 1. — *Saponification Number.*

	March, 1908.	June, 1908.		September, 1908.		March, 1909.		October, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	232.47	233.32	+.75	232.93	+.46	232.81	+.34	234.28	+1.81
Moisture,	–	233.25	+.78	232.60	+.13	232.66	+.19	234.26	+1.79
Light,	–	233.20	+.73	232.33	—.14	232.33	—.14	231.99	—.48
Light and moisture,	–	232.80	+.33	232.53	+.06	232.75	+.28	232.36	—.11
Air and moisture,	–	233.63	+1.16	232.97	+.50	235.19	+2.72	235.63	+3.16
Air and light,	–	234.24	+1.77	233.72	+1.25	235.98	+3.51	237.32	+4.85
Air, light and moisture,	–	234.51	+2.04	234.74	+2.27	238.21	+5.74	239.28	+6.81

Acid Number.

	March, 1908.	June, 1908.		September, 1908.		March, 1909.		October, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	1.46	1.40	—.06	1.51	+.05	1.42	—.04	2.75	+1.29
Moisture,	–	1.44	—.02	1.51	+.05	1.59	+.13	2.80	+1.34
Light,	–	1.40	—.05	1.40	—.06	1.39	—.07	1.60	+.14
Light and moisture,	–	1.41	—.05	1.44	—.02	1.59	+.13	1.93	+.47
Air and moisture,	–	1.43	—.03	1.54	+.08	2.12	+.66	3.39	+1.93
Air and light,	–	1.48	+.02	1.57	+.11	2.29	+.83	4.03	+2.57
Air, light and moisture,	–	1.58	+.12	1.88	+.42	3.29	+1.83	5.90	+4.44

Ether Number.

	March, 1908.	June, 1908.		September, 1908.		March, 1909.		October, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	231.01	231.82	+.81	231.42	+.41	231.39	+.38	231.53	+.52
Moisture,	–	231.81	+.80	231.09	+.08	231.07	+.06	231.46	+.45
Light,	–	231.80	+.79	230.93	—.08	230.94	—.07	230.39	—.62
Light and moisture,	–	231.39	+.38	231.09	+.08	231.16	+.15	230.43	—.58
Air and moisture,	–	232.20	+1.19	231.43	+.42	233.07	+2.06	232.24	+1.23
Air and light,	–	232.76	+1.75	232.15	+1.14	233.69	+2.68	233.29	+2.28
Air, light and moisture,	–	232.93	+1.92	232.86	+1.85	234.92	+3.91	233.38	+2.37

TABLE 2. — *Iodine Number.*

	March, 1908.	June, 1908.		September, 1908.		March, 1909.		October, 1909.	
	Test.	Test.	Difference.	Test.	Difference.	Test.	Difference.	Test.	Difference.
Check,	28.40	29.13	+.73	26.70	—1.70	27.88	—.52	25.88	—2.52
Moisture,	-	28.74	+.34	28.29	—.11	28.13	—.27	25.93	—2.47
Light,	-	28.26	—.14	28.08	—.32	27.38	—1.02	27.43	—.97
Light and moisture,	-	26.86	—1.54	27.83	—.57	27.98	—.42	28.31	—.09
Air and moisture,	-	28.69	+.29	28.02	—.38	26.23	—2.17	25.42	—2.98
Air and light,	-	28.04	—.36	27.79	—.61	25.81	—2.59	24.66	—3.74
Air, light and moisture,	-	27.59	—.81	26.88	—1.52	24.43	—3.97	24.29	—4.11

In the absence of air, added moisture appeared to have no effect as compared with the check on the unsaturated compounds, while light both with and without moisture prevented oxidation to some extent as measured by the iodine number (Table 2). The experiments of Ritsert [1] proved that light, in the absolute exclusion of air, could not produce rancidity, but the preserving action here noted is a peculiar feature worthy of further study.

Moist air increased the oxidation of the fat, with light and added moisture contributing factors. Light in the presence of moist air was destructive, a marked contrast to its action when air was excluded.

The hypothesis of Lewkowitsch,[2] supported by the investigations of Geitel [3] and Duclaux,[4] offers an explanation of the probable changes that take place in the development of rancidity in oils and fats. The initial change he ascribes to the action of moisture in the presence of fat-splitting enzymes. The free fatty acids resulting from the hydrolysis are oxidized by the air in the presence of light. Ritsert[1] asserts that oxygen and light must act simultaneously, neither of the agents alone being able to produce rancidity.

On the basis of the above assumption the hydrolysis of the check samples must have been due to traces of moisture in the fat and in the air between fat and stopper, and the oxidation to the air and a very limited amount of diffused light. This may be possible, as the changes were not, in themselves, excessive, though rather out of proportion to the conditions prevailing. It fails, however, to explain why similar samples in the light gave less rather than equal or greater changes under conditions which naturally should have been more favorable. The changes in the open samples were not wholly in accord with the theory. Light was a factor in oxidation, as was to be expected, but also in hydrolysis, which is difficult to explain. With many points indecisive and others unconsidered, the prime object of the experiment has been attained in showing that filtered butter-fat samples of normal acidity can be satisfactorily preserved in well-stoppered bottles. The action of high temperatures and sunlight

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[1] Untersuchungen über d. Ranzigwerden der Fette. Inaug. Dissert. Berlin, 1890.

[2] Chemical Technology and Analysis of Oils, Fats and Waxes, 3d Edition, Vol. I., pp. 23, 24.

[3] Journ. f. prakt. Chemie, 1897 (55), 448.

[4] Annales de l'Institut Pasteur, 1887; Compt. rend. 102, 1077.

should, of course, be avoided. As to the specific action of air, light and moisture, the experiment should be considered only preliminary, pointing the way for further work under "control" conditions.

Action of Heat.

The object of the second experiment was to ascertain what changes might take place upon heating butter fat several days at 50° C. Fresh samples were prepared. After heating a sample twenty-four hours in a water bath, varying amounts were weighed for saponification, acid and iodine numbers; similar portions were withdrawn at the end of forty-eight hours, and again after seventy-two hours' heating.

The analysis of the check sample and of the heated fat are presented in the following table: —

	Saponification Number.	Acid Number.	Ether Number.	Iodine. Number.
Check, ...	233.07	.84	232.23	28.18
Heated twenty-four hours, . .	233.99	.74	233.25	28.10
Heated forty-eight hours, . .	233.30	.81	232.49	28.17
Heated seventy-two hours, . .	233.62	.83	232.79	28.16

The results indicate a slight difference between the two samples in spite of careful mixing, as shown by the saponification and acid numbers. Heating gave a very slight increase in acid number, otherwise no change is noticeable. It seems evident, therefore, that any reasonable heating of butter fat at a temperature not exceeding 50° C. would have little appreciable effect upon analytical results.

ADDITIONAL NOTES FOR METHODS IN FAT ANALYSIS.[1]

BY E. B. HOLLAND, M.SC.

In the titration of saponification and acid numbers of the fat, and neutralization number of the insoluble acids, 1 cubic centimeter of indicator should be used. This has been our practice for some years, though not so stated in the methods, and gives a more definite end point, especially in the case of acid number. The writer has also noted the rather ambiguous statements relative to desired temperature for the above titrations. A temperature of 40° to 45° C. has proved very satisfactory. It is sufficiently high to maintain the soaps and fatty acids in solution and yet not destroy the sensitiveness of the indicator. Slight saponification may take place in the determination of acid number, but the error is less than the opposite fault of too great chilling.

Sulfuric acid is preferable to hydrochloric for the decomposition of the soap in the determination of insoluble acids; 150 cubic centimeters of water together with 5 cubic centimeters of sulfuric acid (1–4) clears the solution rapidly with little apparent action on the fatty acids.

The variable results in iodine number at a high temperature are evidently due to volatilization of iodine and not to a secondary reaction. Moistening of the cork stopper with potassium iodide solution will reduce the loss, but not prevent it, if the temperature exceeds 10° to 15° C.

[1] Massachusetts Agricultural Experiment Station, twenty-first report (1909), pp. 120–138.

VOLUMETRIC DETERMINATION OF COPPER.[1]

BY E. B. HOLLAND, M.SC.

The co-operation of the laboratory in the experiments conducted by other departments of the station has often rendered necessary quantitative determinations of reducing sugar, sucrose, lactose and starch in a variety of products. The final step in every case is the determination of the cuprous oxide precipitated from Allihn's solution by the reducing action of the sugar. After a considerable study of different methods of filtration, and various ways of determining the amount of precipitate as copper, cuprous and cupric oxides, the following method was adopted, having proved highly satisfactory if reasonable attention is paid to details. It might be said, further, that as such work often has to be done at odd times, it is desirable to maintain a supply of sugar tubes,[2] and only to titrate when there are a number of tests on hand. By exercising a little care the same tubes can be used repeatedly without change of felt.

The process consists of heating an aliquot part of the sugar solution with the mixed Allihn's solution (30 cubic centimeters of "white," 30 cubic centimeters of "blue" and 60 cubic centimeters of water) and filtering by aid of suction through a sugar tube with an asbestos felt supported by glass wool. The cuprous precipitate is transferred to the tube, washed with hot water until free from alkali and then with alcohol. The copper is dissolved in 5 cubic centimeters of concentrated nitric acid, thoroughly washed with hot water, and the filtrate run into an Erlenmeyer flask by means of suction. The solution is evaporated to small volume to expel excess of acid, and afterwards diluted with 60 cubic centimeters of water. Too great concentration should be avoided, as it often results in the precipi-

[1] An adaptation of the Low zinc-acetate method.
[2] Eimer and Amend, No. 3263.

tation of a very insoluble form of copper and the loss of the determination. Twenty-five cubic centimeters of a saturated solution of zinc acetate and 20 cubic centimeters of potassium iodide (165 grams to 1,000 cubic centimeters) are added, and the free iodine titrated with N/10 sodium thiosulfate solution (24.83 grams per liter). The thiosulfate is run in gradually, with constant shaking, until the brownish yellow color (iodine) has been largely destroyed; then 2 cubic centimeters of starch paste (1 gram to 200 cubic centimeters) are added and the titration continued until the blue particles have entirely disappeared. Towards the end of the reaction the flask should be stoppered and shaken thoroughly.

The copper equivalent of the thiosulfate is determined by diluting 25 cubic centimeters of a standard copper solution with water, evaporating and titrating exactly as in the test. The standard solution is prepared by dissolving 10 grams of pure dry metallic copper in 200 cubic centimeters of concentrated nitric acid, and making up to a liter with water at 20° C. The solution should be analyzed gravimetrically, and will keep almost indefinitely. From this data the reducing action of the sugar solution can be readily calculated in terms of copper, and by conversion tables the corresponding amount of sugar. The method has been more recently applied to the determination of copper in Paris green and arsenite of copper, and found equally satisfactory. The copper is precipitated from a hydrochloric acid solution in the presence of sodium acetate with a slight excess of sodium hydrate. The resulting cuprous oxide is transferred to a sugar tube and determined as above. While the first reading of this method might give the impression that it was rather difficult, in reality it is extremely simple, can be carried out rapidly and the titration is very sensitive.

READING THE BABCOCK TEST.

BY P. H. SMITH.

Introduction.

During the summer of 1909 an investigation was undertaken to determine the best method of reading the column of fat in the manipulation of the Babcock test.

Babcock [1] in his first description of the test advocates reading "the divisions which mark the highest and lowest limits of the fat," which would, of course, include the upper and lower meniscus. Subsequent experiments proved that such a practice gave too high results, especially for cream tests in cases where 30 and 50 per cent. 6-inch Connecticut cream bottles were used, and the method of reading to the *bottom* of the upper meniscus became quite prevalent in certain sections of the country. This station has held, however, that until recognized authorities advocated this method, it was better to hold to the original method, in order that results of different chemists and creamery men might be comparative. It was not, therefore, until 1908, when a widely used text-book [2] recommended omitting the upper meniscus from the reading, that it was considered by the Massachusetts experiment station.

An objection to reading tests to the bottom of the upper meniscus is founded upon the fact that the *depth* of the meniscus is influenced by several factors, including diameter of the neck of the bottle, color and clearness of the fat column and different light effects. Different persons conscientiously attempting to read the same test correctly may vary considerably in their results. In order to eliminate this error Eckles [3] recommends the use of

[1] Bulletin 24, Wisconsin Agricultural Experiment Station.
[2] Testing Milk and its Products, Farrington and Woll.
[3] Chicago Dairy Produce, July, 1908.

amyl alcohol, — colored a bright red by fuchsin or any common red dye, — a small quantity of which is dropped on top of the fat column at the completion of the test. Being lighter than butter fat it floats upon the fat, doing away with the meniscus and giving a sharply defined line between alcohol and fat. Farrington,[1] at the suggestion of Babcock, recommends ethyl alcohol saturated with butter fat, which is used in the same manner as the amyl alcohol. "The fat-saturated alcohol is prepared by adding about a teaspoonful of butter fat to 6 ounces of alcohol in a bottle. Warm and shake the bottle until the alcohol has dissolved all the fat possible; some of it will be left undissolved at the bottom of the bottle." Butter fat at the temperature when usually read has a specific gravity of 0.9. It is necessary to have the alcohol reasonably pure, otherwise there is a possibility of its being heavier than the butter fat, in which case it would pass through the fat column instead of floating on top. Ethyl alcohol containing 42 per cent. water has approximately the same specific gravity as butter fat.

Observations at this Station.

Six-inch test bottles having as wide a diversity in size of neck as could be brought together were used. These bottles were carefully cleaned, and before using were washed out with ether to remove all traces of fat. Pure butter fat was then weighed into the bottles on a delicate balance, and enough hot water added to make up to 18 grams. The bottles were then placed in a Babcock tester and whirled three times, five, three and two minutes, respectively, as for the regular test. Readings including and without the upper meniscus were taken immediately; alcohol according to the Farrington method was then added and readings again taken. The theoretical readings were then computed and the results compared. Following is the tabulated data: —

[1] Special circular, Wisconsin Dairy School.

TABLE 1.

Kind of Bottle.	Length of Scale (Millimeters).	Ten Per Cent. on Scale equals (Millimeters).	Each Division represents (Per Cent.).	Grams Fat taken.	Theoretical Reading.	Actual Reading, Top Meniscus.	Error (Per Cent.).	Actual Reading, Bottom Meniscus.	Error (Per Cent.).	Actual Reading, Farrington Method.	Error (Per Cent.).
5 per cent. double neck,	61.0	122.0	.1	.5816	3.23	3.20	—.03	3.15	—.08	3.20	—.03
8 per cent. milk,	73.0	91.2	.1	.9665	5.37	5.50	+.13	5.30	—.07	5.40	+.03
10 per cent. milk,	65.0	65.0	.2	1.0629	5.91	6.20	+.29	5.90	—.01	6.00	+.09
10 per cent. milk,	63.5	63.5	.2	1.1009	6.12	6.40	+.28	6.20	+.08	6.30	+.18
30 per cent. cream,	78.0	26.0	.5	4.0551	22.53	23.25	+.72	22.25	—.28	22.50	—.03
30 per cent. cream,	80.5	26.8	.5	4.0330	22.41	23.50	+1.09	22.50	+.09	22.50	+.09
30 per cent. cream,	77.5	25.8	.5	4.3870	24.37	25.00	+.63	24.25	—.12	24.50	+.13
30 per cent. cream,	71.0	23.7	.5	4.4060	24.48	25.25	+.77	24.75	+.27	-	-
30 per cent. cream,	66.0	22.0	.5	4.3572	24.21	25.50	+1.29	24.75	+.54	-	-
30 per cent. cream,	75.0	25.0	.5	3.2235	17.89	18.75	+.86	18.00	+.11	-	-
30 per cent. cream,	69.0	23.0	.5	3.0236	16.78	17.75	+.97	17.00	+.22	-	-
30 per cent. cream,	66.0	22.0	.5	1.7083	9.49	10.50	+1.01	9.75	+.26	-	-
30 per cent. cream,	74.0	24.7	.5	1.7188	9.55	10.50	+.95	9.75	+.20	-	-
50 per cent. cream,	72.0	14.4	1.0	6.6740	37.08	38.50	+1.42	37.00	—.08	37.50	+.42
50 per cent. cream,	57.0	11.4	1.0	6.6110	36.73	38.50	+1.77	36.50	—.23	37.00	+.27

The results reported were all made with 6-inch bottles, because we were attempting to find the most accurate method for reading tests made under conditions existing at the experiment station laboratory. It would have been quite instructive to have been able to run more tests, using the 9-inch bottles, which require a special machine on account of the longer neck.

Conclusions.

1. With one exception the readings taken to the top of the upper meniscus were too high, the amount of error being in most cases proportional to the diameter of the bottle neck.

2. Where the readings were taken to the bottom of the upper meniscus the results were much more uniform. In several cases, however, there was considerable variation, due very likely to the difficulty of determining accurately the lowest point of the upper meniscus.

3. The alcohol method, where used, showed more concordant results, especially for the 10 and 30 per cent. bottles. The difference between these results and the theoretical test was no greater than might be expected between duplicate tests by the gravimetric method. The tests made in the 50 per cent. bottles varied materially, which might reasonably be attributed to the difficulty of reading these bottles accurately on account of the large diameter of the neck.

It was suggested that the method might give somewhat different results if a mixture of a definite amount of butter fat and skim milk was used in place of butter fat and water, the former mixture more closely resembling milk or cream. In order to test this point butter fat was weighed into several 10 and 30 per cent. thoroughly cleaned bottles, together with sufficient separator skim milk (which had been previously tested) to make the contents of the bottles weigh 18 grams. Sulfuric acid was then added and the test completed as usual. The results are as follows: —

TABLE 2.

KIND OF BOTTLE.	Grams Fat taken.	Theoretical Reading.	Actual Reading, Top Meniscus.	Error (Per Cent.).	Actual Reading, Bottom Meniscus.	Error (Per Cent.).	Actual Reading. Farrington Method.	Error (Per Cent.).
10 per cent. milk, ...	.9740	5.41	5.60	+.19	5.40	—.01	5.50	+.09
10 per cent. milk, ...	.9823	5.46	5.80	+.34	5.55	+.09	5.60	+.14
10 per cent. milk, ...	.9880	5.49	5.80	+.31	5.60	+.11	5.70	+.21
10 per cent. milk, ...	1.0500	5.84	6.10	+.26	5.80	—.04	6.00	+.16
30 per cent. cream, ...	4.1509	23.06	24.25	+1.19	23.75	+.69	23.25	+.19
30 per cent. cream, ...	4.1512	23.06	24.00	+.94	23.50	+.44	23.00	—.06
30 per cent. cream, ...	4.1717	23.18	24.25	+1.07	23.75	+.57	23.25	+.07

As in the former trials, reading to the top of the meniscus gave high results, proportional in most cases to the diameter of the graduated neck; reading to the bottom of the meniscus gave results more nearly corresponding to theory, while the results with the alcohol method were quite uniform and consistent. The high results obtained by attempting to read to the bottom of the meniscus in the case of the three cream bottles was due to the cloudiness of the fat, which made an accurate reading difficult, if not impossible.

Webster and Gray,[1] as a result of experiment, recommend the following procedure, in reading cream tests: "Read from the bottom to the extreme top of fat column, then read the depth of the meniscus and deduct four-fifths of it from previous reading."

Hunziker[2] advocates reading to the bottom of the upper meniscus and adding one-third of meniscus to reading in cream tests.

The introduction of any factor in reading the test tends toward making the method more complicated, and one unacquainted with its scientific aspects may discredit it entirely. With our present knowledge, and pending further investigation, the writer would advocate reading the tests made in 10 per cent. milk bottles from the bottom to the extreme top of the fat column, including the meniscus, as is now generally practiced; while for 30 per cent., 6-inch Connecticut cream bottles the reading should be taken from the extreme bottom of the fat column to the bottom of the upper meniscus, preferably by the use of alcohol, as described either by Eckles or Farrington.

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[1] Bulletin 58, Bureau of Animal Industry, United States Department of Agriculture.

[2] Report read before annual meeting of Official Dairy Instructors and Investigators Association, at Milwaukee, 1909.

THE USE OF THE ZEISS IMMERSION REFRACTOMETER IN THE DETECTION OF WATERED MILK.

BY P. H. SMITH AND J. C. REED.

The campaign before the 1910 session of the Massachusetts Legislature, for a change in the milk standard, brought prominently to the public mind the question as to whether slightly watered milk might be detected and differentiated from normal low-grade milk by methods available to the analytical chemist. In addition to the relative proportion of solids and fat, the index of refraction of the milk serum, as determined by the Zeiss immersion refractometer, has been advocated as a valuable aid in the detection of added water. The details of this method were perfected by Leach and Lythgoe [1] who claim, after careful investigation, that "if a milk serum is found with a refraction lower than 39, it is safe to allege that the sample was fraudulently watered, especially if, in addition to this, the solids not fat stand below 7.3 per cent."

In order to obtain further light on the subject we have made a complete analysis of the milk from three herds, together with the analysis of several samples systematically skimmed and watered. The analytical methods used were those advocated by the Association of Official Agricultural Chemists, while for determining the refractive index the procedure given by Leach [2] was adopted. The results follow in tabular form: —

[1] Thirty-fifth annual report, Massachusetts State Board of Health, 1903, p. 483; Journal American Chemical Society, 1904, 26: 1195.

[2] Food Inspection and Analysis, Leach, p. 765, published by John Wiley & Sons, New York.

Northampton State Hospital (Holsteins).

Number.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Specific Gravity.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.
1, ...	3	26	1.0305	11.74	3.70	8.04	2.98	.70	4.36	41.12
2, ...	5	27	1.0320	12.24	3.50	8.74	3.15	.67	4.92	40.00
3, ...	8	24	1.0315	11.99	3.50	8.49	3.16	.67	4.66	43.00
4, ...	6	27	1.0300	12.33	3.90	8.43	2.97	.75	4.71	–
5, ...	8	26	1.0350	13.39	4.10	9.29	3.91	.76	4.62	–
6, ...	3	23	1.0315	11.72	3.40	8.32	3.08	.66	4.58	42.32
7, ...	4	28	1.0320	11.96	3.60	8.36	2.60	.65	5.11	43.82
8, ...	9	23	1.0310	11.95	3.70	8.25	3.06	.69	4.50	–
9, ...	6	27	1.0330	13.07	4.50	8.57	3.39	.68	4.50	–
10, ...	3	35	1.0300	12.61	4.60	8.01	3.10	.75	4.16	–
11, ...	5	29	1.0330	12.89	4.00	8.89	3.25	.67	4.97	–
12, ...	3	24	1.0325	12.69	3.70	8.99	3.23	.66	5.10	–
13, ...	6	26	1.0300	11.64	3.60	8.04	2.98	.66	4.40	41.26
14, ...	6	30	1.0330	12.17	3.80	8.37	3.11	.72	4.54	–
15, ...	1	34	1.0330	12.70	4.10	8.60	3.22	.75	4.63	–
16, ...	1	65	1.0300	11.63	3.60	8.03	2.78	.68	4.57	41.18
17, ...	9	21	1.0325	13.18	4.10	9.08	3.46	.67	4.95	–
18, ...	6	27	1.0310	12.21	3.70	8.51	3.10	.71	4.70	–
19, ...	6	23	1.0305	11.80	3.60	8.20	3.30	.67	4.23	41.85
20, ...	5	27	1.0335	13.15	4.20	8.95	3.49	.73	4.73	–

Massachusetts Agricultural College Herd.

No.	Breed.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.
1	Jersey, ...	3	24	14.68	5.70	8.98	3.71	.71	4.56	44.30
2	Jersey, ...	12	13	15.28	6.10	9.18	4.00	.77	4.41	44.56
3	Jersey grade, . . .	8	13	14.19	5.70	8.49	3.34	.75	4.40	43.70
4	Guernsey grade, . .	2	26	15.21	6.10	9.11	3.72	.73	4.66	44.39
5	Guernsey grade, . .	4	23	13.14	4.50	8.64	3.18	.75	4.71	44.10
6	Ayrshire, ...	10	5	14.75	5.45	9.35	4.42	.85	4.03	44.45
7	Ayrshire, ...	3	41	12.04	4.20	7.84	2.81	.69	4.34	41.65
8	Ayrshire, ...	10	9	12.75	4.60	8.16	3.72	.69	3.74	41.70
9	Ayrshire, ...	10	13	13.77	4.85	8.92	3.50	.74	4.68	45.15
10	Ayrshire, ...	2	20	13.70	4.90	8.80	3.32	.69	4.79	45.60
11	Ayrshire grade, . . .	1	36	14.11	5.55	8.56	3.60	.72	4.24	43.05
12	Ayrshire grade, . . .	1	38	12.56	4.10	8.46	3.03	.69	4.74	44.27
13	Ayrshire grade, . . .	1	43	12.46	4.00	8.46	3.04	.71	4.71	43.59
14	Ayrshire grade, . . .	2	33	13.39	5.05	8.34	3.03	.71	4.60	44.14
15	Ayrshire grade, . . .	5	23	12.16	4.00	8.16	2.85	.69	4.62	43.26
16	Ayrshire grade, . . .	7	24	13.75	5.10	8.65	3.63	.70	4.32	43.28
17	Ayrshire grade, . . .	–	17	12.37	3.50	8.87	3.27	.69	4.91	44.11
18	Holstein, ...	7	22	13.02	4.35	8.67	3.34	.70	4.63	43.84
19	Holstein, ...	15	5	13.43	4.40	9.03	3.85	.82	4.36	43.88
20	Holstein, ...	1	46	11.58	3.75	7.83	2.97	.74	4.12	42.08
21	Holstein, ...	6	29	13.98	4.80	9.18	3.95	.73	4.50	44.65
22	Holstein, ...	9	9	14.85	5.50	9.35	4.00	.74	4.61	45.15
23	Holstein grade, . . .	–	22	13.62	4.80	8.82	3.63	.72	4.47	44.05
24	Holstein grade, . . .	5	43	12.19	3.80	8.39	3.10	.72	4.57	43.30
25	Shorthorn grade, . .	3	33	12.32	3.90	8.42	3.12	.67	4.63	43.60
26	Mixed herd, ...	–	–	12.77	4.10	8.67	3.17	.72	4.78	43.22

Miscellaneous Analyses.

No.	Milk from —	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.	Proteids N x 6.25 (Per Cent.).	Ash (Per Cent.).	Sugar by Difference (Per Cent.).	Refractive Index.	Specific Gravity.
1	College herd, .	–	–	12.77	4.10	8.67	3.17	.72	4.78	43.22	–
2	College herd, .	–	–	11.76	3.70	8.06	2.99	.69	4.38	41.62	–
3	College herd, .	–	–	11.49	3.69	7.80	2.85	.65	4.30	40.08	–
4	College herd, .	–	–	10.22	3.28	6.94	2.54	.58	3.82	37.35	–
5	College herd, .	–	–	11.06	3.30	7.76	2.88	.63	4.25	40.10	–
6	Holstein grade, .	5	43	12.04	3.60	8.44	3.11	.71	4.62	42.90	–
7	Holstein grade, .	–	–	10.84	3.24	7.60	2.80	.64	4.16	39.80	–
8	Holstein grade, .	–	–	9.63	2.88	6.75	2.49	.57	3.69	37.15	–
9	Ayrshire grade, .	–	17	12.97	4.40	8.57	3.07	.69	4.81	43.52	–
10	Ayrshire grade, .	–	–	10.38	3.52	6.86	2.46	.55	3.85	37.52	–
11	Holstein, . .	1	110	9.87	2.30	7.57	2.69	.71	4.17	39.97	1.0300
12	Jersey-Holstein, .	7	19	15.51	6.50	9.01	3.87	.77	4.37	44.20	1.0340
13	Jersey-Holstein, .	–	–	13.41	5.00	8.41	3.56	.70	4.15	42.05	1.0315

NOTES.

No. 2. Same as No. 1, with 5 per cent. water and 5 per cent. skim milk added.
No. 3. Same as No. 1, with 10 per cent. water added.
No. 4. Same as No. 1, with 20 per cent. water added.
No. 5. Same as No. 1, with 10 per cent. water and 10 per cent. skim milk added.
No. 7. Same as No. 6, with 10 per cent. water added.
No. 8. Same as No. 6, with 20 per cent. water added.
No. 10. Same as No. 9, with 20 per cent. water added.
No. 11. Pure-bred cow on forced test.
No. 13. One liter of No. 12 allowed to stand in cylinder over night, 20 per cent. of the cream (by volume) removed and 10 per cent. of water added.

Massachusetts Agricultural Experiment Station Herd.

No.	Breed.	Number of Months in Milk.	Approximate Daily Production at Time of Sampling (Pounds).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proteids N x 6.25 (Per Cent.).	Refractive Index.
1	Jersey,	5	18	14.61	5.40	9.21	3.94	45.32
2	Jersey,	5	19	14.65	6.20	8.45	3.06	44.04
3	Jersey,	3	23	14.03	5.30	8.73	—	44 18
4	Jersey high grade,	4	19	14.82	5.85	8.97	3.88	44.20
5	Jersey high grade,	5	17	15.58	6.40	9.18	4.00	44.60
6	Jersey high grade,	4	20	13.91	5.55	8.36	3.31	42.75
7	Jersey-Ayrshire,	5	17	13.80	4.85	8.95	3.63	44.25
8	Jersey-Holstein,	7	19	15.58	6.55	9.03	3.81	44.25
9	Holstein grade,	6	15	12.84	4.30	8.54	3.44	43.55
10	Holstein grade,	6	20	13.81	5.05	8.76	3.44	44.11
11	Holstein grade,	6	20	13.31	4.45	8.86	3.50	44.25

The results secured and tabulated above justify the following tentative conclusions: —

1. The serum of a milk of known purity is not likely to have a refractive index below 40.

2. It seems probable that the refractive index depends, to an extent, upon the stage of lactation of the cow, being highest in the advanced stages, when the animal is giving but little milk. More data are needed, however, to confirm this statement.

3. Rich milk, containing 4 per cent. or more of fat, has a tendency to give a higher index of refraction than thin milk (less than 4 per cent. fat). This rule, however, does not always hold true.

4. Many milks, especially those produced by Jerseys and Guernseys and their grades, can be adulterated with 10 per cent. of water, or 5 per cent. of water and 5 per cent. of skim milk, and escape detection by means of the index of refraction. In case of very rich milk, *i.e.;* pure milk containing 6 per cent. of fat, it may be possible to add 20 per cent. of water, or 10 per

cent. of water and 10 per cent. of skim milk, without positively detecting its presence by the aid of the refractometer.

5. It is believed that the Zeiss refractometer will prove very helpful in the detection of added water in milk. The evidence furnished, however, must be considered in connection with that secured by direct chemical analysis.

It is believed that the percentage of ash in milk is likely to prove fully as helpful in many cases as the index of refraction in detecting the presence of added water. Mixed milk falling substantially below .70 per cent. of ash must be regarded with suspicion, and that testing below .65 per cent. of ash as watered.

The impression held by some milk inspectors and producers, that the immersion refractometer will detect very small amounts of added water, is erroneous. Such an impression, firmly fixed in the minds of unscrupulous producers and dealers might have a salutary effect, but it is not justified by results in actual practice.

MALNUTRITION.

BY G. E. STONE.

Malnutrition is a term referring to certain pathological conditions in a plant which result from the improper use of plant foods. It may occur from a lack of plant foods of any kind, or starvation; or it may result from an excess of some particular plant food.

An increasing number of troubles has been called to our attention the past five or six years which have been found to be typical cases of malnutrition, induced by an excess of some particular substance in the soil. By far the larger number occur in greenhouses, being found chiefly in the houses of growers of limited skill and experience in handling greenhouse crops. These troubles all originate from an injudicious use of commercial fertilizers, or from applying certain manures to crops in excess of what they can stand.

The symptoms of malnutrition, as might be expected, are more or less specific, the nature of the response depending not only on the crop but also on the nature and amount of plant food used. Identical stimuli may produce different effects upon different individuals, or plants remotely related to one another may react similarly. The reaction of the plant to stimuli is dependent more upon its individuality than upon the nature of the stimulus which might give rise to any series of responses; in other words, the principal factor determining the nature of the reaction is more a property of the individual than one associated with the stimulus.

In some cases an excess of fertilizers causes burning of the roots, which results in the death of the plant, but these are not necessarily cases of malnutrition, since by the rapid and more or less complete destruction of the root system little or none of the substances is absorbed. Burning and collapse of the root system also have been observed where an excessive amount of muriate or carbonate of potash had been applied, and an excess of tannin, such as is found in the sawdust from certain trees, will cause the roots of plants to turn yellow and eventually die.

The effects of chemical substances on roots are not always the same, although ultimate death may follow their use. Certain chemical substances, on coming into contact with the roots, may merely cause plasmolysis of the cells. The immediate result here may not be death of the cells, but if the cells remain in a state of plasmolysis for any length of time, the collapse of the plant follows.

Any substance in the soil which affects the osmotic tension or turgidity of the cell would naturally prevent root absorption, and if the plant was transpiring very freely it would sooner or later wilt and collapse. On the other hand, a large number of chemical substances act as direct poisons to the protoplasm, killing it the moment of contact.

By far the largest number of cases of malnutrition which have been brought to our notice are found in greenhouse plants, although outdoor crops are by no means wholly free from it. Conditions in a greenhouse are entirely different from those out-of-doors. The frequent rainfalls, together with the action of frosts in winter, naturally hasten the process of leaching, and soil in the field which might become abnormal from injudicious fertilizing is kept in a normal condition. In the greenhouse the leaching is not so thorough, since the water and plant food are usually confined to the surface in a concentrated form. Moreover, in the greenhouse new supplies of plant food are being constantly added, and in the end do harm. When the soil is treated with hot water or steam, as is often the case, additional soluble food becomes available, which, in a soil already rich, is likely to produce ideal conditions for malnutrition. It would appear from the results of our experiments and observations that by far the greater amount of trouble from malnutrition comes from excess of nitrates in the soil.

Some years ago a potted specimen of a Johnsonian lily which had a number of eruptions or blisters on its leaves was called to our attention. These reddish blisters, on careful examination, showed no evidence of the presence of fungi or insects. The cells in the vicinity of the blisters, however, indicated that they had been greatly stimulated. This had resulted in excessive cell division, causing rupturing and a ragged, wounded appearance of the tissue. An experiment with perfectly healthy lilies was made, in which the plants were liberally fertilized with Chili saltpeter, and in a short time we obtained practically the same characteristics, that is, the blisters or eruptions. Blisters developed on a cyclamen were also observed, and were shown to be due to an excessive use of nitrate of soda.

Many cases of injury from overwatering and forcing have come to our attention in connection with such plants as carnations, tomatoes, etc.

The effects of nitrates on plants have long been known, and instances are mentioned by Czapek. Cases have been brought to our attention several times where tomato plants have been affected by the excessive use of fertilizers, and tests of the foliage for nitrates revealed an excess in the leaves. The tomato leaves in such cases had a curled and crinkled appearance, caused by the contorted vascular bundles or veins. A somewhat similar contortion of the foliage has been observed by us in soy beans when grown under certain conditions. These symptoms have been occasionally found in the field as well as in plants growing in pots in the greenhouse, and analyses have revealed an excess of nitrates in the foliage.

Greenhouse cucumbers are more susceptible to injury from manures and fertilizers than any crop known to us, and produce more cases of malnutrition than any of the others grown under glass. The condition of the soil which will destroy a crop of cucumbers will not, however, affect lettuce or tomato plants, while a rose or carnation plant might appear underfed in such a soil.

From a long experience in growing cucumbers under glass, as well as years of experimenting with this crop, and annual observations on a large number of commercial houses in the State, we are convinced that it is not safe for the ordinary grower to apply commercial fertilizers to a crop of this kind. Commercial fertilizers undoubtedly could be used on cucumbers, but would have to be used very sparingly, and only with the advice of the expert.

The best soil for cucumbers is composed of loam, decomposed sod and horse manure. No other manure of any kind is necessary, and should not be applied except sparingly, and as for commercial fertilizers, none should be used except ground bone and wood ashes, and it is questionable whether these are of any value. Cucumbers require a porous soil, and this is furnished by the sod and horse manure. When growing in solid beds the crop can be treated with horse manure if necessary to furnish underground heat, but trenching of the horse manure should be at least eight inches or one foot below the surface.

Malnutrition in cucumbers is characterized by a rolling of the foliage, producing a convexity of the upper surface of the leaf. The edges or margins of the leaf may or may not be slightly burned or dead, but this symptom is often associated with malnutrition. This latter condition may also be caused by a lack of root absorption and excessive transpiration. In extreme cases, besides the more or less severe curling of the leaves, the vascular bundles or veins become badly contorted, the leaves arrested in growth and the apex of the stem curled up into a mass; and plants once in this condition may remain so for weeks. There is, however, a certain amount of plasticity in cucumber plants, as in all others, and they sometimes succeed in adapting themselves to extreme conditions, and showing some attempt to recover or outgrow these symptoms. In very severe cases, such as were found to be associated with a rich soil to which had been added an excessive amount of pulverized sheep manure, and which had received the hot-water treatment, the fruit becomes mottled and irregular in shape, the surface often presenting excrescences or tubercular growths.

We have had occasion to observe a large number of cases of malnutrition in greenhouses in this as well as in other States, and a few of the conditions which produce it may be mentioned here. It should be pointed out that practically all greenhouse growers of cucumbers start with a well-manured soil composed of sod, loam and horse manure. A soil prepared in this way is suitable, without the addition of anything else for the normal production of cucumbers, and even if well supplied with horse manure it is not likely to produce cases of malnutrition. There is, to be sure, much difference in horse manure, some being much more concentrated than others, but we have grown cucumbers in boxes in soil to which 75 per cent. of horse manure had been added without producing any abnormal symptoms. Excessive use of horse manure, especially if it is too strong, may cause symptoms of malnutrition, but no trouble should be caused by a careful use of this manure each year. Constant watering of cucumber plants with liquid fertilizer or manure of any kind will cause malnutrition, and the addition of pig or cow manure to the horse manure, or the use of either alone, is very likely to produce it. We have frequently observed trouble from the use of pig manure mixed with horse manure, and Professor Whetzel of Cornell University has called our attention to the injury caused by this combination in New York State. In one particular case the plants, in addition to being treated with horse manure containing considerable amounts of pig manure, were watered frequently with a strong decoction of these manures.

Some of the most severe cases of malnutrition we have observed resulted from the use of hen manure worked into soil already provided with an abundance of plant food, such as would be obtained from a constant use of horse manure. In practically all the instances which have come to our notice where hen manure had been applied rather freely, symptoms of malnutrition have followed.

A more recent tendency among cucumber growers is to make use of dried, pulverized sheep manure, either alone or in combination with cow manure. Two cases of malnutrition in cucumber houses have recently been brought to our attention, one extremely severe and the other more or less so. These were caused by the use of pulverized sheep manure and various fertilizers. One grower, having some 2,800 feet in length of houses, applied 3 tons of pulverized sheep and cow manure, with the result that the whole crop died. This house had been used for some years without changing the soil, and had received every year probably from 30 to 60 tons per acre of horse manure. The soil was naturally in good condition, and had plenty of plant food without the addition of the sheep manure. The malnutrition symptoms were so marked on this crop that even the young seedlings were affected. In addition to this the hot-water treatment was used, which only served to aggravate the trouble.

We have recently seen another case in which the plants in a range of houses about 1,800 feet in length were more or less affected. Besides the application of horse manure for a number of years, the houses had been treated with cow manure, various kinds of phosphates, nitrate of soda, lime, hen manure and pulverized sheep manure, as well as hot water. Different types of greenhouses were represented in this establishment, and the houses were also of different ages. The older houses, which had been manured and fertilized the most heavily, were decidedly the worst. The new houses, where less manure and fertilizer had been applied, were least affected. In the older houses it had become almost impossible to grow good crops of cucumbers, but fairly goods crops were growing in the new houses. These houses had been used occasionally for growing other crops, like tomatoes and radishes, which were not affected in any way. This practice of rotation is beneficial, and has a tendency to make the soil more suitable for cucumber growing.

The extensive use of nitrate of soda is responsible for many cases of malnutrition. We have demonstrated by experiments that potted plants of cucumbers watered with potassium or sodium nitrate will wilt in the sunshine more quickly than those treated with water alone. Nitrate of soda, when used in greenhouses, often acts by preventing root absorption. As a consequence of this reduction of the root absorptive capacity of the plant, particularly when the house is warm and dry and transpiration very active, the leaf edges of the cucumber wilt and die, which causes a rolling of the leaf or convexity of the upper surface.

Wetting down the soil with hot water, or steaming it, as already pointed out, is favorable to malnutrition, for the reason that a considerable amount of plant food already in the soil is by this practice made more available. This is shown by the greatly increased growth of plants in such soil, and the increased number of bacteria present.

In the growing of greenhouse crops of all kinds, manure is extensively used. For example, lettuce has been grown for forty years in soil which has been repeatedly manured with horse manure and straw, and no indications of malnutrition caused by this extensive manuring have ever been noticed. It is generally considered that the older a lettuce soil, the better it is for this crop, but if commercial fertilizers are employed indiscriminately in a lettuce house already well supplied with plant food, the chances are that a case of malnutrition will result.

Roses, carnations and violets require a rich soil, and a considerable amount of manure is used by floriculturists in their soil. Cases of malnutrition are prevented here by never growing these crops in the same soil more than one year, the benches being refilled with fresh soil each year. A typical rose soil is composed of one-third loam, one-third pulverized sod and one-third cow manure. In addition to this, the plants are watered once a week with a strong liquid manure. Cases of malnutrition with this treatment seldom if ever occur with roses.

A few years ago an experiment was conducted in one of our houses devoted exclusively to the growing of American Beauty roses. The soil was prepared as described above, and liquid manure was applied freely once a week or oftener. The first year the roses did well, and for the purpose of experiment we attempted to grow a new crop of roses in the same soil which had been used the previous year. The soil was partially renovated by the addition of new sod and some cow manure, and besides this it received its customary application of liquid cow manure. The plants had not been in the soil many weeks, however, before they commenced to die, and it was not unusual for a number to die in a single week. The results of this experiment were only what was expected, but a careful examination of the plants was made which showed them to be free from pathogenic organisms. The roots, however, were in a bad state, their condition showing plainly what was the matter. Since it was thought that this experiment had then proceeded far enough, we decided to flood the beds with water, and make analyses of the percolate which came through the bottom of the beds. The beds were flooded for two hours each, and the water that came through first was, as might naturally be expected, highly colored, while that which came through later was clearer. The last percolate, after two hours' drenching, was remarkably clear. Samples of this water were collected at intervals of every fifteen minutes, and chemical tests for acids and other substances were made. The results of the analyses were quite surprising, and it was difficult to conceive of any plant living under such conditions. After the soil had been drenched and the injurious substances washed out, not a single death occurred among the plants.

The question was put to a number of florists, through a leading florists' journal, why they changed their soil in growing roses, carnations and other plants. None of the growers gave a satisfactory reply; they simply knew from experience that it was not practicable to attempt to grow these crops in the same soil two consecutive seasons. An analysis of the percolated water showed such large amounts of soluble compounds that it is not surprising that the plants failed to grow.

One occasionally finds instances of what appear to be typical cases of malnutrition in the suckers on stumps of trees on cut-off woodland. Different species of trees develop different symptoms in their leaves when growing from the stumps. In some cases the leaves are abnormally large, and in others they are highly colored and more or less contorted or malformed. Here we have an instance of a small amount of foliage being supplied with food from a root system which formerly supported a large tree, and this excess of food supply causes, as it were, congestion. Chemical analyses of these abnormal leaves, made by Mr. G. H. Chapman in our laboratory, show them to be unusually rich in nitrates. A feature often observed by us in connection with these growths, but which may possibly be of no significance whatsoever, is their greater susceptibility to attacks of aphids. It is not improbable, however, that their abnormal chemical condition would affect their natural immunity to attacks from aphids and other insects.

From the nature of the conditions causing malnutrition, a remedy is not difficult to find. It is first essential, of course, to be careful in the use of manures and fertilizers. If the soil in a house has become unfit for use from the injudicious application of manures and fertilizers, subsoiling may be done to good advantage. Washing out the soil thoroughly, as previously described in our experiments with roses, would also prove helpful in some cases, but it should be pointed out that there is more danger in a soggy soil to cucumber roots than those of roses. If leaching out has to be done when the plants are in the soil, it should be done only in sunshiny weather, when the soil will dry out quickly, so that its original porosity can be regained by cultivating. It is always best to use any such treatment as this, if possible, when there are no plants in the soil.

Another succesful treatment consists in covering the surface of the soil with two or three inches of loam. We have frequently seen this done with the best results. New roots have quickly formed in the loam, and these have supplied the plant with food proper to its development.

CALICO OR MOSAIC DISEASE OF CUCUMBER AND MELON.

BY G. E. STONE.

For a number of years our attention has been called to mottled cucumber leaves occasionally found in greenhouses. This trouble has the same characteristics as the so-called "calico" on tobacco, or "mosaic disease," as it is often termed. It also occasionally occurs on other plants.

A case of calico was noticed on melon plants grown under glass in the department's conservatory the past summer. Only four plants were affected, and there was no evidence of contagion or infection. This disease, so far as is known, is not associated with pathogenic organisms, and little is known concerning it.

The trouble is characterized by a mottled or spotted appearance of the foliage, and the whole plant appears abnormal. The plants were growing in soil well enriched with horse manure, and in all cases the laterals were kept pruned, and the affected plants topped. A similar spotting and mottling occurred on pruned tomato plants, and was more abundant when the plants were topped than when the laterals were pruned.

A study of this peculiar and little known trouble is now being made by Mr. G. H. Chapman of this department.

NOTES ON THE OCCURRENCE OF FUNGOUS SPORES ON ONION SEED.

BY GEORGE H. CHAPMAN.

It has been found in the seed separation and germination work in this department that spores of various fungi are often found on market seeds. This has been especially noticed in the germination work, for in many cases, no matter how carefully the germinating dishes were sterilized and the tests carried on, some of the samples would mold much worse than others. It was also thought that in the case of onion seed the spores of onion smut might be carried from one locality to another, and thus spread the disease in that way.

Under the direction of the head of this department several samples of onion seed were examined during the past year and the different kinds of spores present noted. The method of examination was as follows: —

A representative sample of the lot was taken, and then of this sample about 15 grams were shaken up with warm, distilled water for ten minutes. The supernatant liquid was then drawn off in a pipette and drops placed on a slide for examination. Several examinations of each sample were made and the different kinds of spores found were noted. This method of detaching the spores may be open to objections, but it is thought that enough of the spores are detached to give an idea of the different kinds present.

In all, ten different samples of seed were examined, and in two, onion smut spores were found in small quantity. It has been the generally accepted opinion that the smut spores do not occur on the seed, but this idea is probably due to the fact that only in very few cases do these spores appear to be present. From our results we are forced to conclude that onion smut spores may be found on seed and may thus be transferred from one locality to another. They were also found last season by Dr. G. E. Stone of this department.

As stated above, in ten samples of seed, two were found to contain spores of onion smut, and in addition nearly all contained mold spores, such as *Penicillium* (blue mold), *Mucor* (bread mold), etc. These mold spores may to a certain extent be on the seed before it is gathered, but the probabilities are that the seed becomes contaminated after gathering, during the cleaning and drying processes, and results from improper drying and cleaning or dampness in the storehouse. Other spores and pollen grains were found which were in no way associated directly with onion diseases. These are perfectly harmless and come from various sources. Among these may be mentioned various conidia and rust spores which do not have the onion for a host.

Among the spores found which cause diseases of the onion were *Urocystis cepulæ* (Frost) (onion smut), *Macrosporium Porri* (Ellis) (brown mold) and *Peronospora Schleidenina* (D By) (downy mildew). The spores of these fungi do not, of course, inhibit the germination of the seed.

The presence of smut spores and others is objectionable in the seed since the ones just mentioned are capable of causing infection to the crop, and the molds cause the molding of the seed, thus lessening the vitality of the seed and sometimes killing it during a germination test.

Macrosporium Porri, the so-called brown or black mold, affects seed onions. *Peronospora* (downy mildew) spores were found in many cases, and this disease has occasionally caused some trouble in Connecticut and elsewhere. This disease, like the preceding one, is confined to seed onions, the fungus penetrating the tissue in all directions, causing a yellow, sickly looking growth, eventually killing the plant. The summer spores, or conidia, are very short lived, however, and do not retain their vitality for any length of time, but the oöspores or resting spores are capable of propagating the disease from year to year.

The kinds of spores found in each sample are shown in the following table.

Showing Spores found on Onion Seed.

Sample Number.	Spores Noxious to Onion.			Non-noxious Spores.	
	Onion Smut (Urocystis cepulæ).	Brown Mold (Macrosporium).	Downy Mildew (Peronospora).	Molds.	Other Spores.
1,	Very few,	Present,	Absent,	Penicillium, Eurotium,	Pollen.
2,	Absent,	Present,	Present,	Penicillium, Mucor,	Various conidia, Teleutospores.
3,	Absent,	Absent,	Present,	Absent,	Pollen.
4,	Absent,	Present,	Absent,	Penicillium,	Rust spores, pollen.
5,	Absent,	Absent,	Absent,	Penicillium, Eurotium, abundant,	Conidia, pollen.
6,	Absent,	Present, abundant,	Present, abundant,	Penicillium, scarce,	Pollen, conidia.
7,	Absent,	Present,	Absent,	Eurotium, Penicillium, Mucor,	Rust spores, pollen.
8,	Few,	Present,	Present,	Penicillium, Eurotium,	Rust spores, conidia, pollen.
9,	Absent,	Absent,	Absent,	Eurotium, Mucor,	Conidia.
10,	Absent,	Present,	Absent,	Absent,	Rust spores.

No attempt has been made to specifically identify many of these spores as that is not within the scope of this experiment.

By disinfecting and sterilizing the seed used for germination tests, and also for planting, it is believed that much of this excessive molding may be prevented. Work of this character is being carried on in this laboratory. Some favorable results have been obtained, but these have not been verified sufficiently to warrant publication at present.

PLANT BREEDING STUDIES IN PEAS.

BY F. A. WAUGH AND J. K. SHAW.

The department of horticulture has had various plant-breeding investigations under way for several years. These have included studies in variation, correlation and heredity in peas. Two reports on this general subject have already been made.[1] The year 1909 has enabled us to collect a large amount of additional data, the most interesting of which are here presented.

Character of Variation in Peas.

At the beginning of these experiments, a commercial strain of Nott's Excelsior was made the basis of study. The same strain has been maintained till the present time, so that we may now discover whether or not the range and character of variation have changed. In looking over the figures, it must be remembered that absolute figures have been greatly affected by the nature of the growing season. Thus, in 1908, with severe drought on naturally dry land, the size of plants and all other measurements fell very low. With this in mind we may profitably study the following table, giving statistics of variation for three years: —

[1] Massachusetts experiment station report, 20, p. 171 (1908), and Massachusetts experiment station report, 21, p. 167 (1909).

Variation in Peas — Nott's Excelsior. Series I.

	1907.	1908.	1909.
Number of vines measured,	179	225	1,770
Length of vine (centimeters): —			
Minimum,	20.00	19.00	6.00
Maximum,	88.00	61.00	83.00
Range,	68.00	42.00	77.00
Average,	54.70	38.22	45.90
Number of pods per vine: —			
Minimum,	1.00	1.00	1.00
Maximum,	13.00	12.00	37.00
Range,	12.00	11.00	36.00
Average,	4.68	3.91	6.74
Number of peas per pod: —			
Minimum,	–	–	–
Maximum,	9.00	8.00	9.00
Range,	9.00	8.00	9.00
Average,	3.46	3.44	–
Length of pod (centimeters): —			
Minimum,	2.00	2.00	–
Maximum,	9.50	8.00	–
Range,	7.50	6.00	–
Average,	6.88	6.10	–

Differences in Variability.

As was shown in our last report, there are great differences in variability to be seen in different strains, even within the same variety. The progeny of nine different parents, all belonging to the same variety, was compared in this respect. These same strains may now be compared again, bringing into comparison the progeny grown in another year's crop. In the following table CV stands for "coefficient of variability," which is simply a mathematical function showing the relative variability of the various strains. It is secured by dividing the standard deviation by the mean. The larger the figure the greater the variability indicated.

Comparison of Variability — Nott's Excelsior.

	CV.		Rank.	
	1908.	1909.	1908.	1909.
Vine length: —				
Strain A,	12.1	22.4	4	4
Strain B,	14.1	25.4	5	8
Strain C,	11.8	16.5	3	1
Strain D,	15.8	23.9	8	7
Strain E,	20.2	27.8	9	9
Strain G,	14.7	21.4	6	3
Strain H,	15.1	22.8	7	5
Strain J,	10.1	23.1	2	6
Strain K,	8.8	19.9	1	2
Pods per vine: —				
Strain A,	25.3	43.7	8	3
Strain B,	10.1	45.7	6	6
Strain C,	52.1	50.2	9	7
Strain D,	8.1	45.1	4	5
Strain E,	9.1	50.8	5	8
Strain G,	16.7	38.1	7	1
Strain H,	8.0	44.6	3	4
Strain J,	6.3	41.4	1	2
Strain K,	7.4	57.5	2	9
Total peas per plant: —				
Strain A,	40.6	49.3	6	5
Strain B,	23.7	54.1	1	8
Strain C,	49.0	51.6	9	6
Strain D,	41.7	41.1	7	1
Strain E,	46.2	52.1	8	7
Strain G,	31.3	45.9	4	3
Strain H,	40.2	46.5	5	4
Strain J,	23.9	45.6	2	2
Strain K,	27.7	57.8	3	9

Three interesting facts appear from this table: —

1. The plants were markedly more variable in 1909 than in 1908. This appears in all characters, and there is hardly a single exception to the rule. On the surface, it would seem that the dry season and unfavorable conditions of 1908 decreased the amount of variation, while the comparatively strong growth of 1909 increased the amount of variation.

2. The amount of variation is less and the fluctuations less in the case of vine length than in pods per vine or peas per vine. In other words, the vegetative characters seem to be more stable than reproductive characters.

3. There is a manifest (though not very strong) tendency to transmit the quality of variability (or stability). In a number of instances the strains which were most variable in 1908 were the most variable in 1909, and those which were most stable one year were most stable the next. Out of the 27 comparisons made in the foregoing table, 11 show a decided correspondence, while

only 6 show decided shift. Counting the disagreements in rank by units, the results are as follows: —

In vine lengths, ...	16
In pods per vine, ...	26
In peas per plant, ...	26

These figures indicate once more the relative stability of the vegetative character — vine length — as discussed in paragraph 2 above.

Correlation of Characters.

In former reports, some figures have been given on correlation of character, particularly between the average number of peas per pod and the number of pods per vine. It might be supposed that the vines bearing the largest number of pods would have the smallest pods with fewest peas. The general fact seems to be the contrary, — a fact which is of considerable practical importance in the development of prolific strains and varieties.

This year we have fresh figures at hand for three separate groups. Series I. consists of a number of strains of Nott's Excelsior, all having the same origin. They are, in fact, the same plants spoken of as Strain A, Strain B, etc., in the experiments reported herewith, p. 170, — the whole series being combined for the purposes of this computation. Series II. is the group of Nott's Excelsior from which the progenitors of Series I. were selected in 1907. Series III. is a strain of Earliest of All which we have had under study for two years.

Taking this material, therefore, and computing the correlation coefficients (in which complete correlation equals + 1 and no correlation equals 0), we get the following results: —

	Correlation Coefficient.[1]
Series I. (Nott's Excelsior), ...	— .0081 ± .0012
Series II. (Nott's Excelsior), ...	+ .1300 ± .0095
Series III. (Earliest of All), ...	+ .3200 ± .0120

[1] It is probable that the coefficient of Series III. most nearly represents the true correlation, and the lower coefficient for Series I. and possibly Series II. is due to rather strict selection that has been practiced, Series I. being the second generation from 10 selected plants. See Pearson, Phil. Transactions A, Vol. 193, p. 278; also Rietz, Biometrika, Vol. VII., p. 106.

In Series I. no relation between number of pods and peas per pod is shown. In Series II. there is exhibited a distinct tendency toward the production of the largest and fullest pods on those plants which produce at the same time the largest number of pods; and this tendency becomes fairly emphatic in Series III.

Heredity in Peas.

One of the prime objects in this series of experiments has been the study of heredity. We have wanted to know in what degree the various characters were transmitted in peas. Some figures in this field were published last year.[1] The figures this year are still more interesting, especially when compared with last year's results.

The reader may know that heredity is now commonly calculated by a mathematical formula which gives results theoretically varying between + 1 and — 1 (practically between + 1 and 0). Ordinary inheritance, in which parental characters are transmitted in the usual degree, will show a coefficient of +.25 to +.40. Larger coefficients are rare; lower coefficients are surprisingly frequent. Taking our peas in Series I. (omitting Strain C on account of its abnormal character), we secure the following heredity coefficients from the crop of 1909: —

Coefficients of Heredity.

Vine length,	$+.2483 \pm .0164$
Pods per vine,	$+.0792 \pm .0017$
Total peas per vine,	$+.0544 \pm .0018$

Here it will be seen that vine length is transmitted much more fully than either of the other characters. This fact is apparently closely related to the one mentioned above (p. 170). The vegetative character is more stable and is more perfectly transmitted than the reproductive characters.

Prepotency.

In all old-time discussions of heredity, much was made of prepotency. Though this word and the idea have to a large extent been submerged in recent discussions of plant breeding,

[1] Massachusetts Experiment Station Report, 21, p. 171 (1909).

the idea is still sound and the word still holds. Moreover, the facts are of great practical importance to the actual breeder.

The question is, Does one individual transmit its characters more perfectly and surely than another? In order to answer this question, it was found necessary to adopt a new method of calculating coefficients of heredity, explained in the article referred to.[1] The study of the material which we then had in hand seemed to give a positive answer to the main question. Apparently, certain individuals did show decided superiority over others in their ability to transmit their characters to their offspring. This conclusion seems to be confirmed with all the other material which we have been able to study, and it would be very interesting to see the same method — or some improvement of it — applied to other plants and animals. For the present, the most interesting feature of our experiment lies in a comparison of the prepotency of parent and offspring, — in an attempt to answer the question whether prepotency is inherited or not.

In the following tables we will present first the figures showing the inheritance of vine length, then those dealing with pods per vine, and finally those dealing with total peas per vine. In each case we present first the coefficients of heredity (computed as shown in the footnote), followed by figures denoting the rank of the several strains in each comparison. The designations f_1, f_2 and f_3 will be understood at once by students of thremmatology. They refer to the three generations of peas compared: f_3 represents the crop of 1909, f_2 represents their parents (crop of 1908), while f_1 represents the grandparents, with which this experiment began.

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[1] *Ibid.*, p. 172. The formula is $C = \frac{1}{\sigma D}$.

C = coefficient of heredity.

σ = standard deviation.

D = difference between the numerical value of the parent character and the mean of the same character in the progeny.

This we have been calling "Waugh's formula," for the sake of a distinctive name.

Coefficients of Heredity — (Prepotency).

Vine Length.

	Coefficients.			Rank.		
	$f_1 : f_2$	$f_2 : f_3$	$f_1 : f_3$	$f_1 : f_2$	$f_2 : f_3$	$f_1 : f_3$
Strain A,	.0068	.0383	.0028	7	3	9
Strain B,	.0085	.0183	.0065	5	6	4
Strain C,	.0106	.0079	.0244	2	9	1
Strain D,	.0086	.0090	.0093	4	8	3
Strain E,	.0042	.0265	.0031	9	4	8
Strain G,	.0061	.0260	.0045	8	5	6
Strain H,	.0071	.0158	.0054	6	7	5
Strain J,	.0095	.0596	.0042	3	2	7
Strain K,	.0250	.0707	.0126	1	1	2

Pods per Vine.

Strain A,	.145	.193	.076	7	5	7
Strain B,	.011	.210	.222	9	4	4
Strain C,	.104	.023	.047	8	9	9
Strain D,	.512	.093	1.562	4	8	1
Strain E,	3.003	.144	.387	3	6	3
Strain G,	.327	.350	.145	6	1	5
Strain H,	.490	.279	.075	5	2	8
Strain J,	5.555	.262	.532	2	3	2
Strain K,	14.285	.121	.135	1	7	6

Total Peas per Vine.

Strain A,	.007	.010	.006	8	4	6
Strain B,	.027	.012	.221	3	2	2
Strain C,	.006	.001	.002	9	9	9
Strain D,	.013	.006	.068	5	6	3
Strain E,	.016	.006	1.000	4	8	1
Strain G,	.008	.009	.005	6	7	7
Strain H,	.007	.012	.004	7	3	8
Strain J,	.027	.012	.021	2	1	4
Strain K,	.068	.008	.013	1	5	5

It can hardly be claimed that these figures show any fixed lines in prepotency. Certain individuals are plainly relatively prepotent with respect to certain characters, though not always with respect to other characters. While the figures do not show any striking inheritance or prepotency, there are a few instances wherein such inheritance may be strongly suspected. Certain points will bear statement at least.

1. In the transmission of vine length, Strain K is notably prepotent, while Strain E is notably deficient.

2. In the transmission of pods per vine and total peas per vine (reproductive characters representing fecundity), Strain C is remarkably defective. This is curious from the fact that Strain C is notably the most prolific one in the experiment.

3. In the transmission of pods per vine, Strain J leads by a good margin; while in the transmission of total peas per vine, Strains B and J stand equal.

4. Strain K, which in last year's comparison stood first in every column, now, in the whole comparison, ranks first in the transmission of vine length, seventh in pods per vine and third in total peas.

It seems fair to conclude, in general terms, that a careful study of prepotency will sometimes reveal tendencies sufficiently strong and trustworthy to be useful to the practical plant breeder.

THE BEN DAVIS GROUP OF APPLES.[1]

BY J. K. SHAW.

It is generally agreed by pomologists that the most feasible and satisfactory method of classifying varieties of fruits is by segregating them in groups typified by more or less well-known sorts, each differing in considerable degree from the type of the neighboring groups. Many writers speak of the Ben Davis group, but so far as is known to the present writer the only real attempt to single out the members of this group is that given by Hedrick, Bul. 275 of the New York State Experiment Station.

Starting with the group as given here as a foundation, a somewhat thorough examination of all available literature and suggestions from several men, authorities in systematic pomology, gave a list of forty varieties which were considered as candidates for this group. In order to decide, with some feeling of certainty, just which of these properly belong here would require much longer time and more material than has been available. The personal study of material was necessarily limited to the fruit with nearly every variety, and with many of the varieties it was impossible to obtain specimens, making it necessary to rely upon printed descriptions and the opinions of others, and everything of this kind available has been carefully considered.

As a result of this study the following varieties are believed to belong here, and are separately considered and described in this paper: —

[1] This article is a condensation of a part of a thesis presented to the faculty and trustees of the Massachusetts Agricultural College for the degree of M.S. The work was done under the direction of Prof. F. C. Sears, and special thanks are due him and to Prof. F. A. Waugh for advice and encouragement in the work; also to many horticulturists, fruit growers and others who have supplied information regarding the different varieties.

Arkansas Beauty.
Arkansas Belle.
Ben Davis.
Ben Hur.
Black Ben Davis.
Coffelt.
Cole Davis.
Eicke.
Etris.
Extra.
Flat Ben Davis.
Gano.
Improved Ben Davis.
Nordhaussan.
Ostrakavis.
Paris.
Shackleford.
Shirley.
Sweet Ben Davis.
White Ben Davis.

Many of these are of minor importance, and doubtless some are not propagated and will soon disappear from cultivation. Almost without exception they are of southern origin and best adapted to growing under southern conditions. When grown north of the southern Missouri and Ohio valleys they are inferior in quality, though fairly hardy and bearing good crops.

The fruit is generally roundish conic in form, nearly regular, with regular cavity and basin, the latter generally more or less abrupt. In color, greenish yellow, usually overspread with bright red, more or less striped. The flesh is generally white and firm, of medium or coarse texture. They are of only moderately good quality but long keepers and good shippers. With one exception they are more or less acid in flavor, generally a mild subacid. A notable characteristic common to all varieties examined was the presence of a pistil point or the persistent base of the pistil, a character rarely found in apples not belonging to this group.

Description of Varieties.

Arkansas Beauty.

I have not seen this apple and have been able to learn little about it. Stinson gives the following description and notes concerning it: —

Size, medium to large; form, roundish, slightly inclined to conical; stem, very long and rather slender; cavity, small, smooth; basin, small; core, open, with a peculiar marking of a white growth or downy substance in seed cavities; color, skin yellow, striped with two shades of red, rather dull in color, giving it a brownish-red appearance; flesh, yellow, fine grained, subacid and very good, juicy. It is grown to some extent in a few sections of the State; it is probably more grown in Johnson County than elsewhere. It has not proved valuable.

Arkansas Belle.

This variety very closely resembles the Gano, and it has been claimed that the two are identical. A letter from Mr. D. Branchcomb of Rhea, Ark., states that he planted the seed from which grew the original tree. It does not seem to have been much planted and probably will not be, as it does not appear that it is in any way superior to the Gano.

Ben Davis.

The place of origin of this variety has always been in doubt. Downing, in "Fruits and Fruit Trees of America," edition of 1857, says it is supposed to have come from Todd County, Ky., but in the edition of 1872 he says that the origin is unknown. It has been attributed to Virginia, North Carolina, New York, Missouri, Kentucky and Tennessee. The statements giving New York and Missouri origins are without doubt erroneous. Those attributing it to North Carolina and Virginia are to the effect that the trees or scions were taken from one or the other of these States to Kentucky, from whence it was disseminated. So far as the writer is aware, there is no record of its occurrence in either of these States except as introduced from outside nurseries. It is extremely probable that the apple originated or at least was first propagated from scions in either Kentucky or Tennessee. The late Wm. M. Howsley of Kansas gives the following account of its origin: —

> In the year 1789, Wm. Davis and John D. Hill emigrated to Kentucky and settled in that part of Logan County now called Butler County. They located near Capt. Ben Davis, the brother of Wm. Davis and the brother-in-law of Hill. A few years afterward, Hill returned to Virginia on business, and when he returned to Kentucky he brought some apple grafts with him. Hill and Wm. Davis raised fruit from these grafts. Capt. Ben Davis, finding the apple a desirable one, grafted the same for himself, as well as raised a young nursery of it. These were sold throughout the country. For want of knowing any other name, the people called it the Ben Davis apple. The Davis family, however, called it the Virginia Pippin.[1]

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[1] Watts, Bulletin Tennessee Experiment Station, IX., 1, p. 7.

Mr. J. C. Hodges of Morristown, Tenn., thinks it is a Tennessee apple, and gives the following story of its origin: —

> During most of the first half of the present century, and up to 1860 or thereabouts, there lived on Nolichucky River, within this (Hamblin) county, a wealthy farmer whose name was Ben Davis. His son, R. A. Davis, resides now at White Pine, Jefferson County, Tenn. On the farm owned by Ben Davis originated the apple in question. From the original tree others were propagated, and for many years before the death of Ben Davis he raised and harvested large quantities of these apples. The house of Ben Davis was on the great stock route from Kentucky to the Carolinas. Many drovers made it a point to stop with him in going and returning to the south. It was his custom to supply their saddle bags with these apples, especially on their return trips. There was no name of the apple known to them, so they called it the Ben Davis. Grafts or scions were taken to Kentucky, and the apple was propagated and disseminated there before it was in Tennessee. I have obtained these facts on personal inquiry from the sons of Ben Davis, above mentioned. And besides, these facts are well known in the neighborhood among the older people.[1]

The writer has made considerable effort to follow up both of these accounts and to ascertain if either one is the true history of the variety.

Concerning the Kentucky account, Mr. Ben McKenney of Maquon, Ill., states that the Ben Davis mentioned, who was his grandfather, lived at Berry's Lick, Butler County, Ky., and that it was from a neighbor of his, Nat Porter by name, that Dr. Housely obtained the account above given. Ben Davis was a nurseryman as well as a farmer and introduced several other varieties.

Concerning the Tennessee account, a letter from Mr. Hodges expresses the conviction that this is the true origin of the variety. It is stated by a daughter of this Ben Davis, who is not connected with the Kentuckian of the same name, that the original tree, which was well known to her, was destroyed in 1860, and that it was eighteen years old at the time. This would seem to indicate that this was not the original Ben Davis tree, as the variety was well known over Kentucky, southern Indiana and Illinois at about this time. Mr. Hodges, however, expresses the belief that this particular tree was a sprout from the original,

[1] Watts, Bulletin Tennessee Experiment Station, IX., 1, p. 7.

which would seem reasonable, for Ben Davis died in 1852 at the age of fifty-six, or soon after the earliest date at which this tree could have borne, and in this case he could not have been concerned with the growth and distribution of the fruit, as it seems beyond question that he was. The writer has attempted to learn the facts about this, but thus far without success.

It would seem possible that the apple originated in Tennessee, as related by Mr. Hodges, and that the fruit, carried by the drovers into Kentucky, came to the notice of the Kentucky Ben Davis, who lived on the route which would be traveled, and, being a nurseryman, he was attracted by the fruit and took steps to secure scions, by which he propagated and disseminated the variety. If this is true, however, it is hard to explain why the apple was called the Virginia Pippin.

Another possible explanation is that the apple may have "originated" twice, or, to put it in another way, two varieties appeared, one in Kentucky and the other in Tennessee, and both were called the Ben Davis and resembled each other so closely as to be confused; or it is even possible that the two were distinct, and that one of them was not the Ben Davis we now know at all. A third possibility is that it first appeared in Kentucky, and that the Tennessee tree was a graft derived from it.

That both the accounts are true in the main, at least, is not doubted by the writer, and the Tennessee story is vouched for by several people of prominence and reliability residing in that neighborhood. It is likewise evident that the whole truth is not set forth.

Wherever the place of origin may have been, the variety was first brought to public notice from Kentucky. The first published notice of it seems to have been in the "Horticulturist" for 1856, and Downing describes it in the "Fruits and Fruit Trees of America," edition of 1857, as received from Mr. J. S. Downer of Elkton, Ky. From this time on the mention of it in pomological publications is frequent. At the time when Downing described it it was spread over Kentucky, southern Indiana and Illinois, and was known in Missouri. It is stated by Ezekiel Honsinger of Burnt Prairie, Ill., that his father grafted the Ben Davis in White County, Ill., about 1825, obtaining the scions from a neighbor, Mr. Funkhouser, and he

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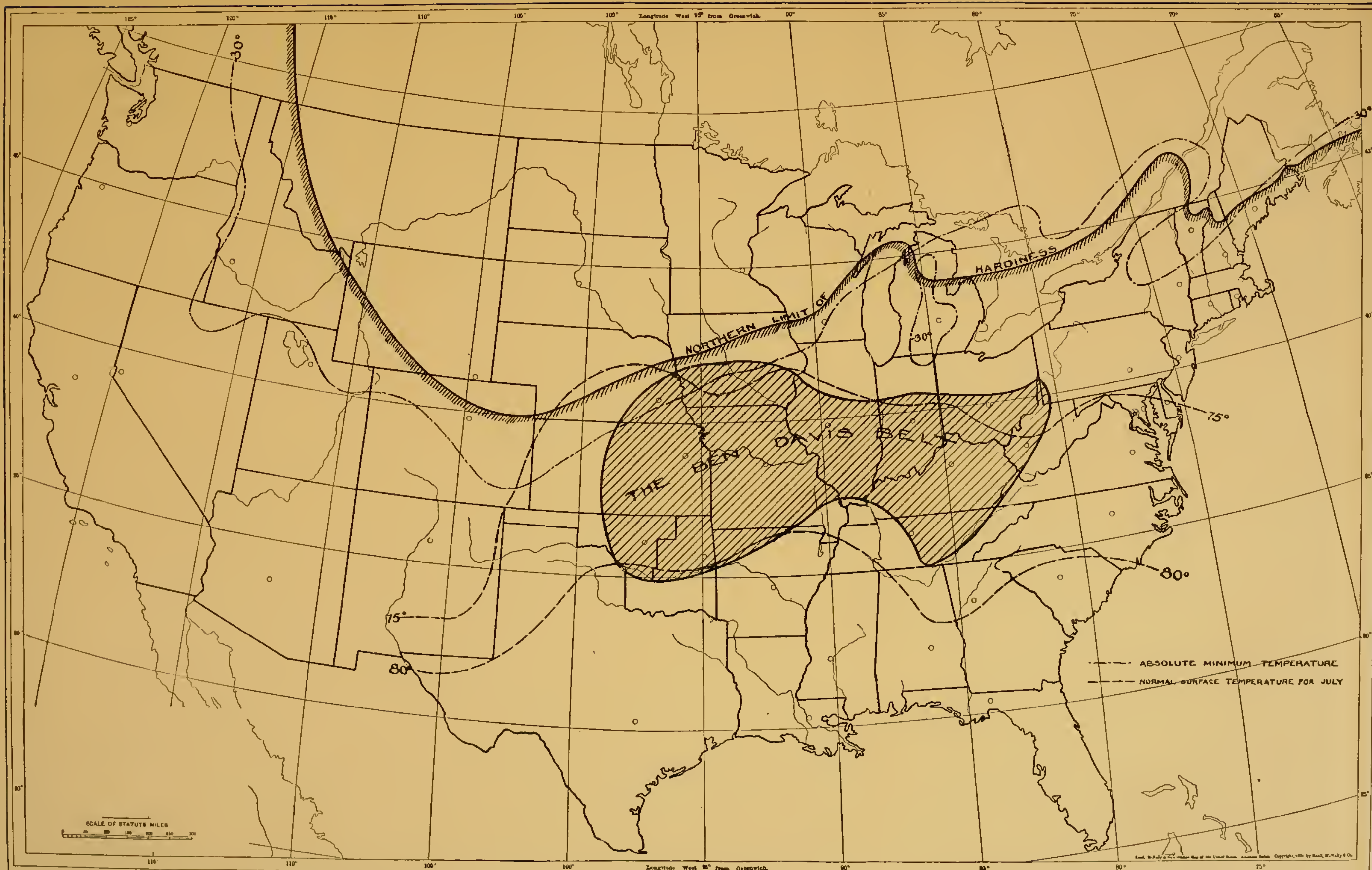

DISTRIBUTION OF THE BEN DAVIS.

from Mr. Newman, who brought them from Kentucky before 1820. Here is explained how the variety obtained the names Funkhouser and Newman. A nursery was established in this neighborhood in 1839, and was instrumental in disseminating the variety far and wide.

With the rise of commercial orcharding in this region, after the civil war, the variety attained widespread favor, and it may justly claim the first place among commercial varieties, taking the country as a whole. No other commercial variety is so widely planted, and none succeeds so well under such widely varying conditions. It is a sure, abundant bearer, the tree is vigorous, reasonably healthy, a good grower in the nursery, and comes into bearing early, and the fine appearance and excellent shipping and keeping qualities of the fruit are well known. That it is of excellent quality as a dessert fruit no one will contend, but much of its evil reputation in this way comes through its being grown in localities where it should never have been planted. When well grown, near the region of its origin, it is not of poor quality; when grown in the colder north, it does not have time to fully develop, and is most decidedly an inferior apple.

An attempt was made by means of library research and by correspondence to learn something of the limits of culture of the Ben Davis. The map shown herewith shows approximately the northern limit of the variety, and also what may be spoken of as the Ben Davis belt, where this is easily the leading commercial sort. It will be noted that the limit of hardiness is a little north of the isotherm of an absolute minimum temperature of — 30° F., indicating that a temperature of between 30° and 35° below zero is likely to kill the trees. In the Rocky Mountains the limit of hardiness is indicated only in a general way, as it here depends largely on altitude, and would be difficult to accurately define.

It is interesting to note the coincidence of the limits of the Ben Davis belt with the normal surface temperature for July of 75° on the north, and, more especially, for 80° on the south. In as much as the line showing the limits of the belt is intended to show where it is actually grown, and not where it is possible to grow it well, it is probable that it would succeed equally well farther to the southeast in the mountains of northern Georgia and Alabama, and thus its southern limit of successful growth conform more closely to this isotherm than is indicated.

Ever since the Ben Davis became known, fifty or more years ago, there has been much unfavorable comment on its quality, and many have predicted its speedy disappearance from the orchard and market. All the while the Ben Davis trees have borne full crops and have filled the owner's pocket in years when other sorts were delinquent in these most important qualities of a commercial apple. During the past season (1908–09) reply postcards were sent to over 225 nurserymen in the United States and Canada asking the following questions: —

How do your sales of Ben Davis compare with those of other varieties?

In what States are your sales of Ben Davis increasing, and how rapidly?

In what States are they decreasing, and how rapidly?

In what States are they practically stationary?

Is it being replaced by other varieties, and if so, what ones?

One hundred and thirty-one of these cards were returned. A few gave no definite replies, owing to various reasons, but from the great majority the following facts are gleaned: —

Number reporting increased sales,	8
Number reporting decreased sales,	59
Number reporting no change,	27

From the replies to the question as to what varieties are replacing the Ben Davis the following summary is made: —

	Number of Times mentioned.		Number of Times mentioned.
Jonathan,	26	Baldwin,	5
Gano,	19	Esopus Spitzenburg,	5
Winesap,	17	McIntosh,	4
Arkansas (*Mam. Blk. Twig*),	15	Newtown Pippin,	4
Grimes Golden,	12	Delicious,	3
York Imperial,	12	Wagner,	3
Rome Beauty,	9	Missouri Pippin,	2
Stayman Winesap,	7	Oldenburg,	2
Northern Spy,	6	Paragon,	2
Stark,	6	Wealthy,	2
Arkansas Black,	5		

And the following, once each; Aiken, Black Ben Davis, Blenheim, Belleflower, Cox Orange, Fameuse, Gates. Ingram, Janet, Kinnaird, Maiden Blush, Oliver, Red Russett, Salome, Transparent and Winter Banana.

It is evident that, on the whole, the sales of nursery trees of this variety are decreasing, and with some nurserymen with considerable rapidity. One firm reports a falling off of one-half in three years, another of 90 per cent. in five years and another of 50 per cent. decrease this year. One says, "We formerly grew as many as of all others; now 5 per cent." A few say they have ceased to propagate it. None report any marked increase in sales. The firms reporting an increase are largely in New York, and a few in Canada and some parts of the south. Among the large nurserymen in the Ben Davis belt, the report is almost unanimous that there is a falling off, and often a large one. West of the great plains it is planted hardly at all. In some parts of Maine and in southern Ontario and the Georgian Bay district it seems to be slightly on the increase. In the northwest prairie States it has not proved hardy and has been discarded.

The variety mentioned the most times as replacing the Ben Davis is Jonathan, which is of much better quality, and of the others that are taking its place in the Ben Davis belt, York, Winesap and Grimes Golden are notably better. In the northeast Stark is coming in and the McIntosh is gaining in popularity. In the northwest the Northwestern Greening is increasing, and in New York and Ontario the Spy is frequently mentioned. In the Pacific northwest it is scarcely planted at all, and many of the bearing trees are being worked over to other sorts, such as Jonathan, Gano, Rome Beauty, Newtown Pippin and Esopus.

On the strength of this inquiry the writer ventures to predict that the long-looked-for decadence of the Ben Davis is at hand, and that twenty-five years hence it will have become a variety of minor importance.

Description of Fruit.[1] — Size, below medium to large, fairly uniform; form, roundish to roundish conic or oblong, base broad and flattened

[1] Descriptions are original where not otherwise noted. This description is intended to include all forms of the variety as grown in the United States and Canada.

to narrow and rounded, apex rounded to sharp conic, fairly regular, slightly compressed, fairly equal sides, fairly uniform in any given locality; color, clear greenish yellow, covered with dull pinkish red to bright or deep red, 50 per cent. to 90 per cent. mottled, splashed and striped, deepening almost to blush on sunny side; bloom, medium, greasy or waxy; skin, medium thick, rather tough, smooth and shining; dots, inconspicuous, few to medium, small to medium, roundish, whitish to yellowish or russet, scattered, slightly raised; cavity, shallow to very deep, medium to very wide, flaring to abrupt, acute to acuminate, fairly regular, filled with russet; stem, short to very long, medium to slender, curved, brownish red, smooth; basin, very shallow to very deep, medium to very wide, generally abrupt, round obtuse, almost always very regular; calyx, closed to partly open, medium size, pubescent; segments, medium size, long, pointed, reflexed; tube, very short to very long, medium width, conic or funnel form, median stamens, pistil point present; core, axile to very abaxile, medium or below, central, turbinate to oval, with clasping core lines; cells, closed to open, medium in size, symmetrical to asymmetrical; carpels, roundish to obovate, emarginate, usually slightly slit, medium concave; seeds, few to medium, fairly plump, medium in size, brownish red, oval, pointed; axis, straight, rather short to very long; flesh, white, sometimes slightly tinged with yellowish, rather coarse, generally very firm, medium juicy to dry; flavor, mild subacid, often slightly aromatic, sometimes rather flat, sometimes slightly astringent; quality, poor to good.

Ben Hur.

This a comparatively new sort, offered by Stark Brothers of Louisiana, Mo., who state that it originated in Perry County, Ind., and that it is a cross of the Ben Davis and Rome Beauty. Prof. J. C. Whitten writes me, "From the characters of both fruit and tree, I should unhesitatingly put Ben Hur in the Ben Davis type." Stark Brothers describe it as follows: —

Tree, a strong, thrifty grower, young bearer, productive; fruit, fully as large or larger than Ben Davis, brilliantly striped and splashed with red; flesh, tender, fine grained, juicy, highly flavored, excellent.

Black Ben Davis.

This variety is said to have originated near Fayetteville, Ark., about the year 1880. An earnest controversy has arisen as to whether it is identical with the Gano. A number of samples of apples were received under these two names and examined with some care. It was easy to distinguish two types of apples, but they were connected by intermediate forms in such a way as to render it difficult to say whether two distinct varieties were represented or not. The most striking difference was in color, this varying from a distinctly striped apple to those with a clear blush, with no sign of stripes, a rather remarkable variation to appear in a single variety, but which exists in the McIntosh. It was evident that if the varieties were really distinct the names were confused, for the apples that were the most typical of the Black Ben Davis were called Gano; and of another sample, consisting of two apples, one would be called Gano and the other Black Ben Davis. In addition to examining these apples, the writer has consulted all the available literature on this point, and after considering everything with care, is, on the whole, inclined to the opinion that these are two distinct varieties, and describes them accordingly.

Description of Fruit. — Size, below medium to above, not uniform; form, round conic, almost regular, slightly compressed, generally with unequal sides, rounded base and round conic apex; color, bright greenish yellow, covered with rich, dark red, 20 per cent. to 95 per cent., blushed and mottled, sometimes showing slight tendency to striping; bloom, medium to heavy, waxy; skin, medium thick, rather tough, smooth and shining; dots, inconspicuous, medium in number, small, round, gray, scattering, scarcely raised; cavity, medium in depth and breadth, sloping, acute, nearly regular, slightly compressed, partly filled with greenish russet; stem, long, very slender, curved, brownish red, smooth; basin, rather shallow, medium, generally abrupt, nearly regular, slightly compressed; calyx, closed or partly open, medium, pubescent; segments, medium, reflexed; tube, short, medium width, conic, medium stamens, pistil point present; core, axile, large, central, turbinate, core lines meeting or clasping; cells, closed, medium; carpels, broad oval, emarginate, smooth, medium concavity; seeds, few to medium, plump, medium size, medium brown, oval, medium pointed; axis, medium to rather long, straight; flesh, white, firm, medium coarse, rather dry; flavor, subacid; quality, good. Described from six specimens received from the New York Experiment Station.

Coffelt.

This apple originated with Wyatt Coffelt of Bentonville, Ark., and is said by Henthorn to be a seedling of the Red Limbertwig, though Beach says that some nursery catalogues state that it is a seedling of the Ben Davis. As received from the New York

Experiment Station, it strongly resembles the Ben Davis. It has been planted to a limited extent in Arkansas, but it does not appear that it is superior to others of this group.

Description of Fruit. — Size, small, uniform; form, roundish oblate, nearly regular, slightly unequal sides, rounded base and roundish, slightly conic apex, uniform; color, yellowish green, covered with rather dull deep red, 65 per cent. to 95 per cent., mottled, more or less obscurely splashed, deepening almost to blush on sunny side; bloom, medium, waxy; skin, rather thick, medium texture, fairly smooth and bright; dots, more or less conspicuous, few to many, medium size, angular, russet, slightly raised; cavity, rather shallow, wide, flaring, broad acute, nearly regular, sometimes partly filled with russet; stem, long, slender, inclined, brownish red, smooth; basin, shallow, broad, flaring, flat obtuse, pentangular; calyx, open, medium size, slightly pubescent; segments, medium size, long, pointed, reflexed, separate at base; tube, medium in length and breadth, funnel form, medium stamens, pistil point present; core, axile, small, central, oval, clasping core lines; cells, closed, small, symmetrical; carpels, obvate, emarginate, smooth, concavity medium; seeds, few, plump, medium size, medium brown, oval; axis, medium, straight; flesh, white, slightly yellowish, a little tinged with green, fine, medium firm, moderately juicy; flavor, mild subacid, almost sweetish; quality, good. Described from specimens received from the New York Experiment Station.

Cole Davis.

This variety originated with S. T. Cole of Lincoln, Ark., about a dozen years ago, the original tree appearing in an orchard of Ben Davis. According to Mr. Cole the apple was of higher color than the Ben Davis, but otherwise much the same. It was propagated for a time by the Stark Brothers, but so far as known is not now offered for sale.

Eicke.

Concerning this variety the writer has been able to learn but little. Specimens received from the New York Experiment Station resemble the Ben Davis, and Hedrick groups it here. Ragan gives its origin as Nebraska.

Description of Fruit. — Size, small, uniform; form, roundish, regular, slightly compressed, nearly equal sides, rounded base and apex, uniform; color, bright greenish yellow covered with bright, rather deep red, 50 per cent. to 85 per cent., striped, splashed and mottled, deepening almost to blush on sunny side; bloom, heavy, waxy; skin, rather thin, medium texture, smooth and bright; dots, inconspicuous, few to medium, rather small, roundish, light gray, general, very slightly raised; cavity, rather shallow, medium width, sloping, acute approaching obtuse, nearly regular, partly filled with russet; stem, long, slender, inclined or curved, brownish red, smooth; basin, shallow, medium width, abrupt, somewhat ribbed and plaited; calyx, closed or partly open, medium size, pubescent; segments, medium size, medium long, pointed, reflexed; tube, rather short, medium, conic, medium stamens, pistil point present; core, abaxile, medium size, central or distant, broad oval, slightly clasping core lines; cells, open, medium size, asymmetrical; carpels, obovate, emarginate, slightly slit, concavity medium; seeds, medium in number, plump, medium size or above, dark brown, oval, more or less straight on one side; axis, rather short, straight; flesh, whitish, slightly tinged with yellowish green, fine, medium firm, medium juicy; flavor, subacid to slightly acid; quality good. Appears to resemble Coffelt. Described from specimens received from the New York Experiment Station.

Etris.

According to Professor Stinson, this variety was first fruited near Bentonville, in the orchard of A. K. Etris, the trees coming from the nursery of John Breathwait, about fifteen years ago. It is not generally disseminated, but is considerably grown in the county of its origin. It is quite possible that it is identical with Gano.

Extra.

An apple was offered by Stark Brothers under this name about ten years ago, described as being larger and higher colored than Ben Davis. It is not now sold. It may have been a distinct or a special strain of Ben Davis.

Flat Ben Davis.

A distinct strain of the Ben Davis was observed by the writer in 1909 growing in an orchard in Monmouth, Me. It differed from the usual type in being larger and decidedly more oblate in form. The striping seemed to be coarser and more distinct than on neighboring trees of the common type. The tree also differed in being more open and apparently of rather less vigorous growth. There were several trees in this and a neighboring orchard. It appears to be in no way markedly superior to the ordinary Ben Davis.

Gano.

The exact origin of this variety is not perfectly clear. It is said to have been grown by Mr. Ely Jacks, in Howard County, Mo., in 1840, and to have been somewhat disseminated in that vicinity. It was first brought to general notice in 1884, when it was exhibited before the Missouri Horticultural Society, and about this time it was named Gano, for Mr. W. G. Gano who was concerned with its introduction. Mr. Gano states that the original tree came from a lot of Ben Davis, and was planted in the orchard under the supposition that it was of that variety, but on fruiting it proved to be different. Prof. S. A. Beach advances the theory that it is a bud sport of the Ben Davis.[1] He thinks that it is improbable that a seedling stock should prove to be so like the Ben Davis, the variety supposedly worked on the stock. If, however the Gano originated as a bud sport in the same way that Red Gravenstein has originated from Gravenstein, and Collamer Twenty Ounce from the original Twenty Ounce, then the fact that the Gano appeared under propagation in a lot of Ben Davis apple trees is easily and naturally accounted for.

As compared with the Ben Davis, it is a little smaller, not quite as prolific a bearer, considerably higher colored, perhaps slightly better in quality, and sells for a little more per barrel. It takes second place in importance in this group, and is being planted in the southwest in place of the Ben Davis to a considerable extent, but has been planted but little in a commercial way elsewhere.

Description of Fruit. — Size, medium, uniform; form, roundish, more or less conic, nearly regular, slightly compressed, nearly equal sides, rounded base, apex round or conic, not very uniform; color, clear greenish yellow covered with deep rich red, 15 per cent. to 70 per cent., mottled, blushed and striped, always blushed on sunny side, slightly russet; bloom, rather light, waxy; skin, rather thick, medium tough, smooth and shining; dots, inconspicuous, few, medium size, roundish, gray, scattering, slightly raised; cavity, medium in depth and breadth, sloping, acute, fairly regular, filled with greenish russet; stem, long, slender, straight, brownish red, smooth; basin, shallow, medium width, steep to abrupt, ribbed and plaited; calyx, closed or partly open, medium or above, pubescent; segments, medium to large, long, pointed,

[1] Personal letter from S. A. Beach.

reflexed; tube, short to medium, medium breadth, conic basal stamens, pistil point present; core, axile, medium size, central, turbinate, core lines meeting; cells, nearly closed, medium or above, asymmetrical; carpels, slightly obovate, strongly emarginate, nearly smooth, concavity variable; seeds, medium in number, plump, medium size, oval or angular, rather short; axis, medium, straight; flesh, white, slightly tinged with greenish yellow, firm, medium texture, medium juicy; flavor, mild subacid, very slightly astringent; quality, good. Described from specimens received from the New York Experiment Station.

Improved Ben Davis.

It is stated in the report of the Illinois Horticultural Society for 1899, p. 89, that on several occasions an Improved Ben Davis has been brought to the attention of the society. It is rather probable that these were simply superior strains of the Ben Davis and not a distinct variety. So far as known, no variety of this name is being propagated.

Nordhaussan.

Scions of this sort were sent to the Division of Pomology at Washington by Mr. John Gabler of Springfield, Mo., in 1896, and by them distributed to various State experiment stations, including that of Massachusetts. Professor Waugh informs me that in both tree and fruit it resembled the Ben Davis. This tree was destroyed some few years ago, and I have not been able to secure either specimens or any further information concerning it. So far as known it is not offered for sale at the present time.

Ostrakavis.

A cross of the Ostrakoff and Ben Davis, originated at the Iowa Experiment Station. Distributed only for trial and not considered to be of value.

Description of Fruit.[1] — Fruit medium or below, conical, regular, surface oily; color, yellow, with faint bronze blush; cavity, regular, deep, obtuse, with faint trace of russet; basin, wide, very shallow, minutely wrinkled; core, wide open, meeting; cells, large, roomy, ovate, slit; tube funnel shaped; stamens, median; seeds, twelve, large, plump; flesh, white, sweet. Season probably late fall or early winter. Interesting as showing that a cross of two sour apples may produce a sweet apple.

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[1] From S. D. Bulletin, 76, p. 80.

Paris.

Reported by Mr. L. A. Goodman as a new apple of the Ben Davis family, sent by Mr. Ambrose of Paris, Mo., to the meeting of the Missouri Horticultural Society.

Shackleford.

This variety is first mentioned in the report of the Illinois Horticultural Society for 1883, at which time it appears to have been known in southern Illinois and adjacent parts of Missouri. Beach says that it originated near Athens, Mo. It has been planted considerably in the southwest, but has not attained great favor as a commercial sort. It is generally of rather poor color and is said to be a straggling grower. It does not appear to be in any way superior to the Ben Davis and in some qualities it is inferior.

Description of Fruit. — Size, medium, uniform; form, roundish oblate, slightly conic, nearly regular, slightly compressed, sides generally nearly equal, base rounded, apex round conic, uniform; color, clear waxy greenish yellow covered with bright red, 10 per cent. to 50 per cent., splashed mottled and short striped, deeper on sunny side of some specimens; bloom, light, waxy; skin, rather thick, medium texture, smooth, and fairly bright; dots, very inconspicuous, few to medium, very small, round, gray russet or greenish, scattering, even or submerged; cavity, rather shallow, medium width, sloping to flaring, nearly obtuse, nearly regular, markings none; stem, medium long, slender, straight or inclined, brownish red, smooth; basin, medium in depth and breadth, abrupt, truncate conic, fairly regular, sometimes slightly ribbed and plaited; calyx, closed, medium size, pubescent; segments, large, broad, pointed, reflexed; tube, short, medium width, conic, stamens median, pistil point present; core, abaxile, small, central, broad oval, core lines meeting; cells, partly open, medium size, symmetrical; carpels, oblong, emarginate, slit, concavity medium; seeds, medium in number and size, plump, medium brown, oval, medium long, pointed; axis, medium in length, straight; flesh, greenish white, medium firm, rather coarse, fairly juicy; flavor, brisk subacid; quality, good. Described from specimens received from the Ontario Agricultural College.

Shirley.

Mr. T. V. Munson of Dennison, Tex., gives the following history of this variety.

This apple was found growing in two old orchards, namely the A. Alkire orchard, some four miles west of Dennison, Tex., and the Alex. Shirley orchard, some five miles southeast of Dennison. The writer saw these trees in said orchards about the year 1880, and made diligent inquiry as to their origin, but neither Mr. Alkire nor Mr. Shirley (both now deceased some years) knew from whence they came. I presume they came from some local Texas or Louisiana nursery that passed out of existence soon and left no history of the variety. The orchards were planted before railroads were built into Texas. There was a small nursery at Paris, Tex., and another at Clarksville, farther east, and one at Shreveport, La., the latter conducted by G. W. Storer, the others by a Mr. Walker at Clarksville and his son, J. Q. A. Walker, at Paris, Tex. These nurseries were the first in Texas and sold trees all through north Texas. They handled only southern varieties. The elder Walker came to Texas from Tennessee about the year 1838.

In 1880 or 1881 I sent samples of the apples to Charles Downing, with whom I corresponded often for a number of years. Mr. Downing could not identify it. As the apple was a sure and prolific bearer, a large, handsome, salable fruit of fine keeping qualities, I began propagating and advertising it over twenty-five years ago. Mr. Shirley sold the apple in Dennison and Sherman markets, where it acquired the name Shirley apple or sometimes Shirley Keeper. I described it in my catalogue as Shirley, which name it has retained ever since.

In tree and fruit it resembles York Imperial more than any other variety. It was the first to point out before the public this similarity; but the two are distinct. The Shirley is better in tree and fruit, somewhat larger and brighter, and in quality a little better.[1]

As grown in Texas this apple resembles the York Imperial, but the specimens received from the New York Experiment Station are clearly of the Ben Davis type. The trees were received from Mr. Munson and the apples were identified by Mr. Munson as the Shirley.

Description of Fruit. — Size, small, uniform; form, roundish oblate, nearly regular, often slightly compressed, nearly equal sides, base rounded, apex rounded or slightly conic, quite uniform; color, clear greenish yellow covered with bright medium red, 40 per cent. to 80 per cent., mottled, splashed and striped, deepening almost to blush on sunny side; bloom, scant, waxy; skin, medium thick, rather tough, smooth and bright; dots, inconspicuous, medium in number, small, roundish, light gray, generally slightly raised; cavity, medium in depth, rather wide, flaring, broad acute, nearly regular, generally without markings; stem, long, slender, straight or inclined, brownish red, smooth;

[1] Personal letter from Mr. T. V. Munson.

basin, medium in depth and width, abrupt, truncate conic, smooth and nearly regular; calyx, closed or partly open, rather small, pubescent; segments, medium, short, pointed, reflexed; tube, long, medium in breadth, funnel form, stamens median or basal, pistil point present; core, abaxile, medium to small, central, oval turbinate, core lines clasping; cells, closed, rather small, symmetrical; carpels, roundish to obovate, emarginate, smooth, concavity medium; seeds, medium to many, plump medium brown, irregular or oval, obtuse; axis, medium straight; flesh, white, slightly tinged with yellowish green, firm, moderately coarse, medium juicy; flavor, brisk subacid; quality, good. Described from nine specimens received from the New York Experiment Station.

Sweet Ben Davis.

Concerning this variety, Heiges makes the following statement in the report of the pomologist for 1895. The apples were from Prof. John T. Stinson of Fayetteville, Ark., who presumably furnished the facts of origin, etc.

Originated about 1870 on farm of Garret Williams in Madison county, Ark. The tree resembles Ben Davis in shape, wood and leaf, and is nearly as good a bearer. The fruit ripens about two weeks earlier than Ben Davis. Roundish, truncated, slightly oblique, slightly unequal; large, smooth, except for a few russet knobs; greenish yellow, washed with pale red, striped and splashed with crimson; dots, numerous brown; cavity, large, regular, deep, abrupt furrowed and russet netted; calyx segments, short, wide, converging or slightly reflexed; eye, large, partially open; skin, thick, tough; core, large, roundish, clasping, nearly closed; seeds, numerous, large, angular, brown; flesh, whitish satiny, juicy; sweet; good; season, winter.

White Ben Davis.

Professor Stinson says that this apple has been found in several orchards in Missouri. I do not know that it has been much disseminated or that it is now offered for sale.

It has been said that a list of forty varieties was under consideration. Only twenty are given as belonging to this group. Of the remaining ones the following varieties, that have by various writers been more or less clearly and definitely assigned to this group, are considered to properly belong elsewhere: —

Beach.
Dickenson.
Gill (Gill Beauty).
Loy.
Rutledge.
Wallace Howard.

Regarding the following the writer is in some doubt, owing to lack of opportunity for sufficient study, but considers it probable that they do not belong to this group: —

Breckinridge.
Chicago.
Collins (Champion).
Florence.
Givens.
Hastings Red.
Highfill.
King David.
Marion Red.

The remainder of the forty are accounted for as synonyms.

In deciding whether or not any variety should be admitted to a place in the Ben Davis group as here given, the intention has been to be conservative. The study of varieties of fruits by groups has only recently begun and the writer feels that in constituting these groups it is best to include in any group under consideration only such varieties as seem beyond doubt to belong there, even if there are strays left that do not seem to belong anywhere. If any of these odd varieties are of great importance they will in time become the central types of new groups, while if only of minor account they may as well be left by themselves.

It is to be understood that the foregoing is not final, but of the nature of a report of progress. In order to be conclusive the study of the fruit in some cases and of the tree characters in many cases is necessary. It is hoped, however, that it may prove a contribution of some value on this subject and a basis for further study.

VARIATION IN APPLES.[1]

BY J. K. SHAW.

It is safe to assume that the Ben Davis is the most widely cultivated of any commercial variety of apples in America. It is known in almost every apple-growing section. It is therefore grown under a great variety of conditions of climate, from the short hot summers and long cold winters of Quebec to opposite conditions in Arkansas and Texas. It also flourishes in a great variety of soil conditions. Moreover, it seems to be in itself more variable than other sorts, and responds in a greater degree to varying environment than do most other varieties.

These considerations led to its selection as a variety for the study of variation in apples, and the results of two years' investigation are here reported. The matter is presented under two headings, (1) the variation in size and form as grown in the Clark orchard of the Massachusetts Agricultural College, and (2) the variation in form, quality and other characters when grown under widely varying conditions of climate and soil in the United States and Canada.

Variation in the College Orchard.

In the fall of 1908 the product of four trees in the college orchard was picked separately and divided each into four lots, comprising the product of the upper south, lower south, upper north and lower north quarters of the trees. These were studied with reference to size and form. This arrangement gave opportunity for two comparisons: (*a*) from different trees, (*b*) from different parts of the trees.

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[1] Work on this subject was begun by the writer in 1907 as a part of the requirements for the degree of M.S. by the Massachusetts Agricultural College, and was continued and extended in 1908. It was done under the direction of Prof. F. C. Sears, to whom the thanks of the writer are extended for encouragement and suggestions, and also to Prof. F. A. Waugh, who has aided in many ways. Assistance and suggestions have also been received from many horticulturists and fruit growers from various parts of the country. It is impossible to name them here, but the debt to all is gratefully acknowledged.

(a) *From Different Trees.*

Table 1 shows the means,[1] standard deviations and coefficents of variability, with their probable errors, in the size and form of the apples from each of the four trees. It is evident that there are differences in both size and form.

TABLE 1.

	Size.[2]			Form.			
	Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.	Number of Apples.
Tree 2, . .	71.02±.14	6.16±.10	8.67±.14	1.1422±.0014	.0576±.0009	3.04±.88	864
Tree 3, . .	68.80±.15	5.31±.10	7.72±.16	1.1399±.0016	.0543±.0011	4.73±.09	567
Tree 5, . .	68.35±.13	5.55±.08	8.12±.13	1.1666±.0019	.0626±.0013	3.76±.08	469
Tree 7, . .	72.80±.18	6.45±.13	8.86±.17	1.1716±.0019	.0578±.0013	3.37±.07	423
	70.23±.08	5.95±.06	8.47±.08	1.1515±.0008	.0589±.0006	5.29±.05	2,321

There seems to be little or no relation between the size of the apples and the yield. Trees 2 and 7 produced the larger apples,

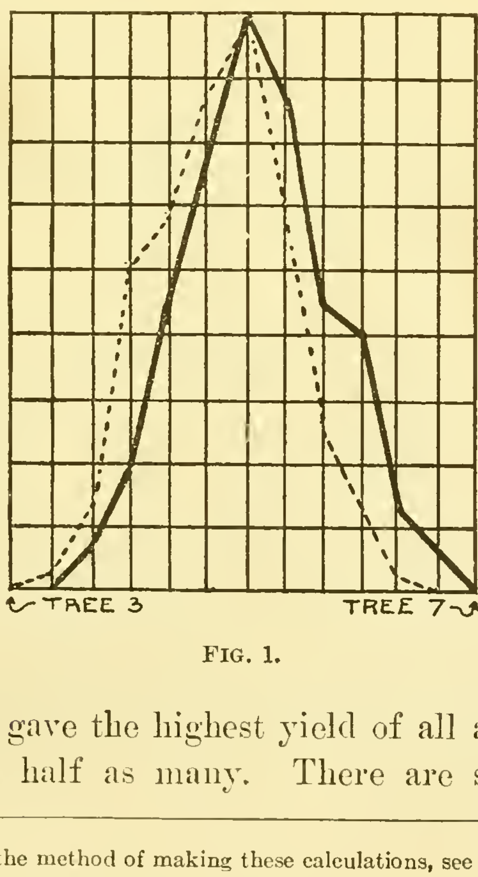

FIG. 1.

and one of these gave the highest yield of all and the other the lowest, less than half as many. There are seen to be slight

[1] For the method of making these calculations, see p. 198.
[2] All measurements are in millimeters.

differences in the variability in size of apples from the different trees.

More striking are the differences in mean index of form, though the variability of form is less than that of size. The difference in form of the apples from Trees 3 and 7 is shown graphically in Fig. 1. These differences in form were perceptible to the eye, and there were also differences in color, apples from Tree 5 being higher colored than the others.

These differences may be attributed to bud variation or to the influence of the stock, for the trees were near each other, and, so far as could be seen, on exactly similar soils. In passing it may be suggested that this method offers means of throwing light on these two disputed questions, namely, bud variation and the mutual influence of stock and scion.

(*b*) *From Different Parts of the Trees.*

The results of computations of the apples from different parts of the tree are shown in Table 2. It appears from this that apples from the top of the tree are a little larger than those from the lower branches and also slightly more variable. In form the differences in both mean and standard deviation are slight, those from the lower branches being a little longer than those from the top of the tree. The most important thing about this table is that it serves to bring out the greater differences in the products of the individual trees.

TABLE 2.

	Size.			Form.			Number of Apples.
	Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.	
Upper south, .	70.93±.18	6.40±.13	9.02±.19	1.1643±.0017	.0593±.0012	3.61±.07	518
Lower south, .	69.24±.14	5.68±.10	8.20±.14	1.1512±.0015	.0619±.0011	4.19±.07	714
Upper north, .	71.27±.20	6.14±.15	8.47±.19	1.1553±.0020	.0607±.0014	3.91±.08	414
Lower north, .	69.79±.12	4.96±.08	7.11±.12	1.1406±.0016	.0644±.0011	4.58±.07	676

Climatic Variations.

The variations in the college orchard are comparatively slight when compared with those observed when apples from widely separated localities are compared. This variation has been often observed and noted, but so far as the writer knows there has been no attempt to study systematically and record it. The work here reported is a beginning. The study is based on a careful examination and measurement of twenty lots of apples of the crop of 1907 and of twenty-five of the crop of 1908, received from growers in different localities in the United States and Canada. These lots were generally about a bushel each. The numbers are given in Table 3. An attempt was made to secure apples from the same orchards both years, but on account of crop failures and other reasons this was unsuccessful in a few cases. In addition to these, several smaller samples have been received from other localities which, while not large enough for the same sort of study, serve to indicate the gradual variation of the variety when passing from one region to another. In the following pages the variation of form, size, quality and other characters are separately taken up and considered.

Discussion of the Variation.

Form.

The most important character studied was that of form, and the variation of this was nothing short of remarkable. One familiar with the variety in a certain locality would hardly recognize it as grown perhaps not more than one or two hundred miles away. Much time was given to the study of this, and careful measurements of more than 9,000 apples from the different localities were made and calculated by statistical methods.

The different lots may be grouped in four classes as regards the general form, as follows: —

1. The oblong conic, more or less ribbed form from the Maine seacoast and Nova Scotia and Prince Edward Island.

2. The round conic type from the north central and northeastern United States and southern Canada, from as far south

as Pennsylvania and possibly farther in the mountain regions, and from the Pacific coast.

3. The oblate or oblate conic type from the Delaware peninsula and the valley of the Ohio and its tributaries.

4. The roundish oblate form from the Ozarks and from Colorado.

The outlines of specimens representing these four types are shown in Fig. 2. Each of these types seems to be pretty constant in the localities given, and they gradually shade into each other in passing from one region to the next. These differences in form are closely related with certain other characters which are discussed later.

Coming now to the mathematical expression of the form of the apples, the method was as follows. Each apple was carefully measured, ascertaining in millimeters its greatest transverse and longitudinal diameters, and the figures recorded. Then the transverse diameter of each apple was divided by its greatest longitudinal diameter. The number resulting from this calculation was taken as representing the form of the apple, and is called the index or coefficient of form. If the index is 1 the diameters are equal; if it is less than 1 the apple is longer than broad, and if more than 1 it is broader than long. The calculation of this index for a large number of apples gives an array of numbers representing the forms of the apples measured which may be dealt with by statistical methods.[1]

Calculating the means of the several arrays representing the different lots of apples measured gives the interesting and significant figures shown in Table 3. Translated into simple language these figures mean that in Port Williams, N. S., for example, the average Ben Davis apple of the crop of 1907 was about 1.0196 larger in transverse diameter than in longitudinal diameter, and, as shown by the probable error, the chances are even that this figure is not over .0035 of the transverse diameter away from the truth. This average apple is nearly as long as broad, and to one familiar with this sort of measurement indicates an apple that may be correctly described as oblong.

[1] For these methods see C. B. Davenport, "Statistical Methods," or "Principles of Breeding," by E. Davenport.

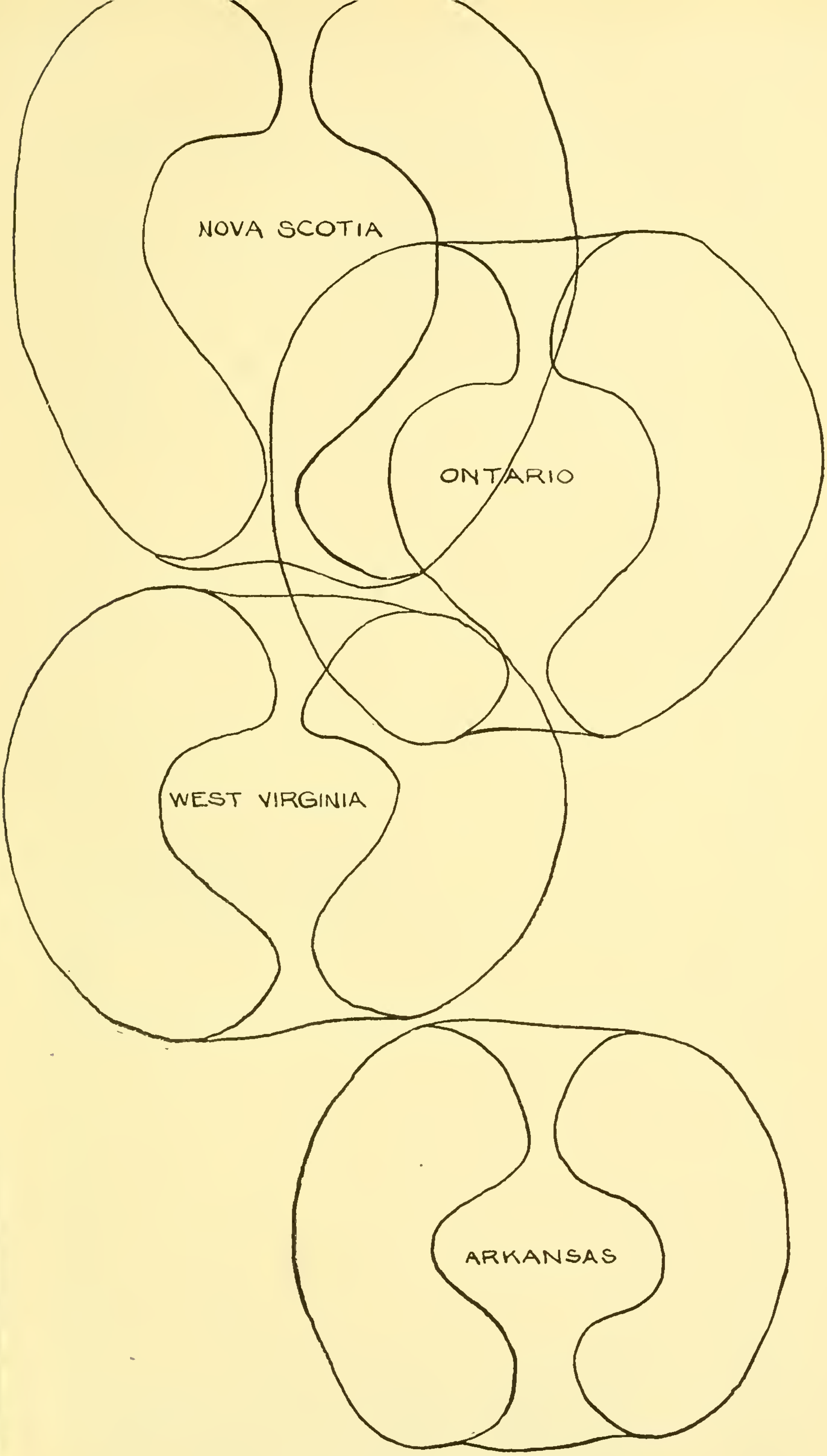

FIG. 2.—Typical Forms of the Ben Davis.

Nova Scotia, the oblong form. Ontario, the round conic form. West Virginia, the oblate form. Arkansas, the roundish form.

Table 3. — *Form.*

Apples from —	1907. Number of Apples.	1907. Mean Index of Form.	1907. Standard Deviation.	1907. Coefficient of Variability.	1908. Number of Apples.	1908. Mean Index of Form.	1908. Standard Deviation.	1908. Coefficient of Variability.
Charlottetown, P. E. I.,	74	1.0511 ± .0049	.0619 ± .0034	5.88 ± .31	122	1.1250 ± .0052	.0858 ± .0037	7.63 ± .33
Port Williams, N. S.,	135	1.0196 ± .0035	.0656 ± .0026	6.37 ± .26	102	1.1183 ± .0044	.0672 ± .0031	5.68 ± .26
Lower Gagetown, N. B.,	–	–	–	–	226	1.0948 ± .0031	.0465 ± .0022	4.25 ± .20
East Sangerville, Me.,	–	–	–	–	197	1.2013 ± .0028	.0587 ± .0020	4.88 ± .17
Skowhegan, Me.,	–	–	–	–	130	1.1041 ± .0027	.0474 ± .0020	4.27 ± .18
Farmington, Me.,	–	–	–	–	149	1.1108 ± .0031	.0565 ± .0022	5.10 ± .19
Livermore Falls, Me.,	–	–	–	–	128	1.1262 ± .0030	.0519 ± .0021	4.19 ± .18
West Paris, Me.,	–	–	–	–	116	1.0934 ± .0045	.0461 ± .0031	4.22 ± .29
Monmouth, Me.,	–	–	–	–	173	1.1128 ± .0024	.0483 ± .0017	4.34 ± .16
Turner, Me.,	237	1.0451 ± .0025	.0571 ± .0018	5.71 ± .18	–	–	–	–
New Gloucester, Me.,	–	–	–	–	97	1.0978 ± .0031	.0451 ± .0022	4.11 ± .19
Marblehead, Mass.,	–	–	–	–	192	1.1021 ± .0029	.0598 ± .0021	5.42 ± .18
Barnstable, Mass.,	–	–	–	–	162	1.1281 ± .0021	.0407 ± .0015	3.67 ± .14
Amherst, Mass.,	284	1.1656 ± .0023	.0581 ± .0017	4.98 ± .14	2,321	1.1515 ± .0008	.0589 ± .0006	5.29 ± .05
Storrs, Conn.,	147	1.1557 ± .0030	.0534 ± .0021	4.62 ± .18	131	1.1423 ± .0041	.0689 ± .0029	6.03 ± .21
Abbotsford, Quebec,	151	1.1788 ± .0039	.0735 ± .0028	6.23 ± .24	129	1.1739 ± .0041	.0683 ± .0029	5.82 ± .23
Isle la Motte, Vt.,	203	1.1547 ± .0024	.0735 ± .0024	6.28 ± .27	170	1.1406 ± .0027	.0526 ± .0020	3.74 ± .15
Guelph, Ont.,	147	1.1309 ± .0030	.0524 ± .0020	4.72 ± .18	–	–	–	–
Belleville, Ont.,	124	1.0829 ± .0026	.0442 ± .0019	4.08 ± .18	135	1.1111 ± .0025	.0436 ± .0018	3.92 ± .16
State College, Pa.,	209	1.1556 ± .0026	.0568 ± .0020	4.91 ± .14	–	–	–	–
New Brunswick, N. J.,	–	–	–	–	36	1.1525 ± .0051	.0460 ± .0036	3.99 ± .32
Middletown, Del.,	87	1.2010 ± .0060	.0831 ± .0042	6.92 ± .35	–	–	–	–
Martinsburg, W. Va.,	157	1.2272 ± .0035	.0603 ± .0020	4.91 ± .18	101	1.1537 ± .0036	.0563 ± .0027	4.78 ± .23
Tiptop, Ky.,	481	1.1914 ± .0018	.0592 ± .0013	4.97 ± .11	–	–	–	–
Mitchell, Ind.,	111	1.1928 ± .0038	.0599 ± .0027	5.02 ± .23	174	1.1758 ± .0033	.0560 ± .0020	4.76 ± .17
Bentonville, Ark.,	183	1.1588 ± .0024	.0492 ± .0017	4.24 ± .15	–	–	–	–
Lincoln, Ark.,	116	1.1536 ± .0042	.0677 ± .0015	5.87 ± .26	–	–	–	–
Manhattan, Kan.,	–	–	–	–	77	1.1629 ± .0059	.0520 ± .0042	4.47 ± .36
Stillwater, Okla.,	107	1.1550 ± .0035	.0541 ± .0025	4.68 ± .22	129	1.1861 ± .0035	.0584 ± .0024	4.92 ± .21
Grand Junct., Col.,	87	1.1409 ± .0039	.0544 ± .0028	4.77 ± .24	132	1.1465 ± .0036	.0617 ± .0025	5.38 ± .22
Redlands, Cal.,	79	1.1086 ± .0042	.0567 ± .0030	5.11 ± .27	87	1.1418 ± .0052	.0718 ± .0033	6.29 ± .37
Kaslo, B. C.,	108	1.0630 ± .0043	.0671 ± .0031	6.31 ± .29	73	1.1045 ± .0054	.0706 ± .0039	6.39 ± .35

At the other extreme stands the lot from West Virginia, with an index of 1.2272 ± .0035. The average apple grown under exactly those conditions under which these apples grew has a cross diameter about 1.2272 times larger than the longitudinal diameter, and we know that the chances are even that this figure is not more than .0035 of the transverse diameter out of the way. Stating this last in another way, it means that the chances are even that the true index of form is not less than 1.2257 nor more than 1.2307.

The third column of Table 3 gives the standard deviation with its probable error, which gives a measure of variability for each lot. This is affected by the selection or want of selection, as the case might be, of the person sending the apples, some growers sending the apples just as they came from the trees and some selecting them more or less, and doubtless throwing out many specimens which were off type, thus reducing the amount of variation in that lot. Several tests showed that the amount of variability among the larger apples and smaller apples of a given lot was about the same, and this was also true of the mean index of form. It is believed, however, that this selection has not greatly modified the figures, and that the mean indexes of form are scarcely affected at all.

The fourth column gives the coefficient of variability and its probable error. This is an abstract number giving, in percentages of the means, the variability of each lot of apples, and enables one to compare the variability in form with that of any other character of the apples, or any character which can be measured and expressed by this method.

The variation in form is shown graphically in the diagrams in plates I. to V. These are based on the same measurements as the mathematical calculations, each lot being reduced to the basis of 200 apples for the sake of uniformity. Many of them are somewhat irregular, owing to the small numbers of specimens measured. The ordinate representing the index of form of 1.1300 is in each case made heavier in order to furnish a standard for comparison, this ordinate being near the average of all apples measured. The shape and relative position of these diagrams show strikingly the differences in variability and in mean index of form of the various lots of apples.

Considering the diagrams and the figures given in the table, we find that in the extreme northeast the Ben Davis is much elongated, and as we go south and west it becomes less elongated and more flattened, till we reach West Virginia and Kentucky, where it becomes a decidedly oblate apple. In the Ozarks it is a little longer, and in southern California still longer, and in British Columbia it is almost as much elongated as in Nova Scotia and neighboring regions. This noticeable elongation of the apples from Belleville, Ont., as compared with those from Guelph, is significant, as Belleville is located not far from the north shore of Lake Erie, while Guelph is some miles inland. The same influence is perhaps shown in the Vermont lot, though the figures for those of Quebec and Massachusetts, which serve to bring this out, are themselves in some degree exceptions to the general rule that the apples are longer as one goes north. Nevertheless, it seems reasonable to conclude that, beginning in the southern Allegheny mountains and in southern California, and going north, the apples become more elongated, and that this elongation is much more pronounced in the vicinity of large bodies of water, either salt or fresh.

The comparison of apples from the same orchard both years shows reasonably close agreement in most cases. Several, however, are quite different. It will be noted that these are among the extremes of form. The maritime provinces and the Pacific coast, that furnished extremely long apples in 1907, gave shorter ones in 1908, and the extremely flattened ones from West Virginia were longer. On the other hand, those near the average form show very slight differences. Professor Sears states that in Nova Scotia there are two types of Ben Davis that differ much in both tree and fruit. The fruit of one generally approaches an oblong form, while the other is more conic. Most of the Nova Scotia apples of 1907 were of the former type, while those of 1908 were more like the latter. The same would apply in some degree to those from Prince Edward Island. Both lots were the run of the orchard, no selection whatever being made. It is possible that the difference in the forms of these apples in the two years may be due to their representing these different types.

The apples from Quebec are flatter than those from farther

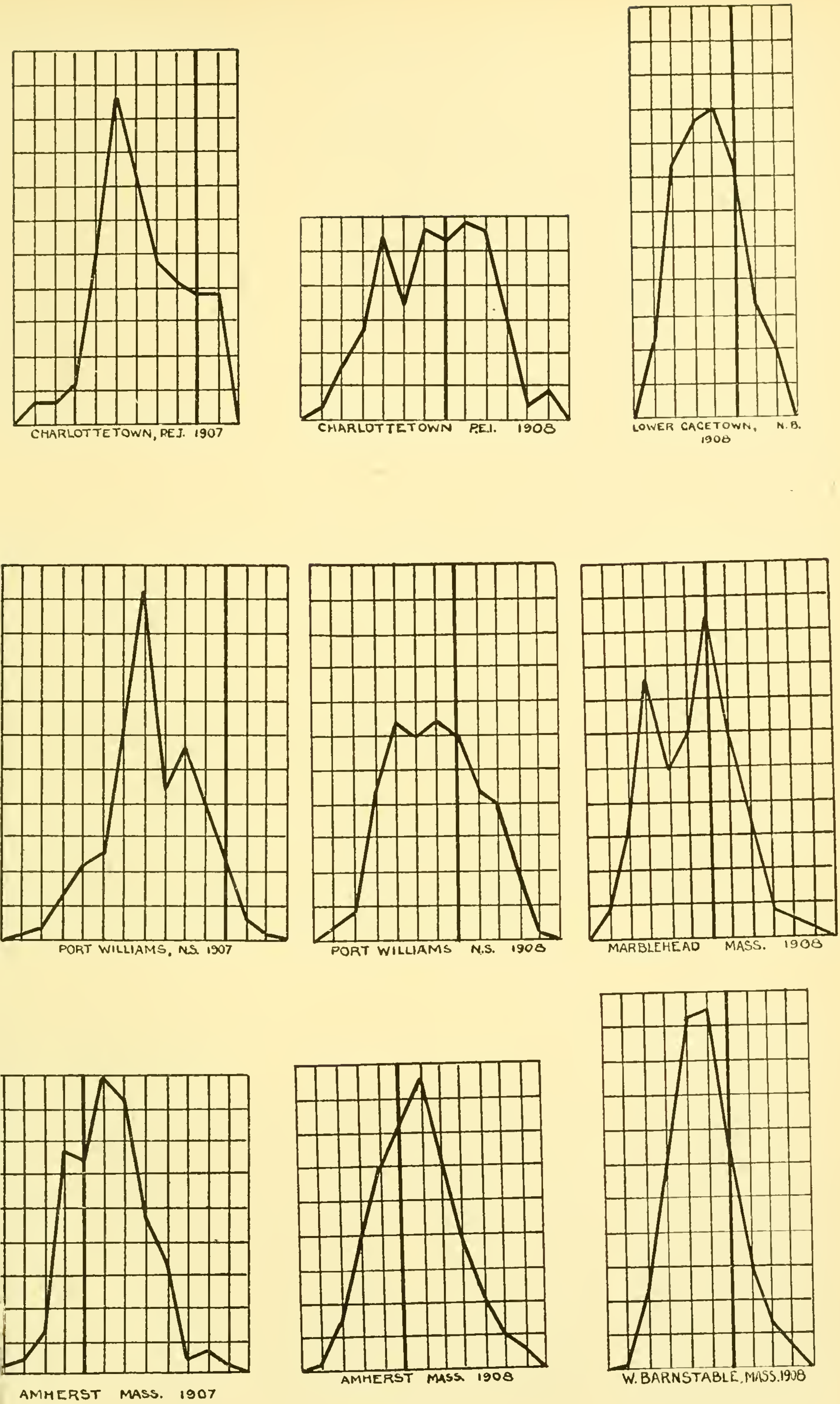
CHARLOTTETOWN, P.E.I. 1907
CHARLOTTETOWN P.E.I. 1908
LOWER GAGETOWN, N.B. 1908
PORT WILLIAMS, N.S. 1907
PORT WILLIAMS N.S. 1908
MARBLEHEAD MASS. 1908
AMHERST MASS. 1907
AMHERST MASS. 1908
W. BARNSTABLE, MASS. 1908

PLATE I.

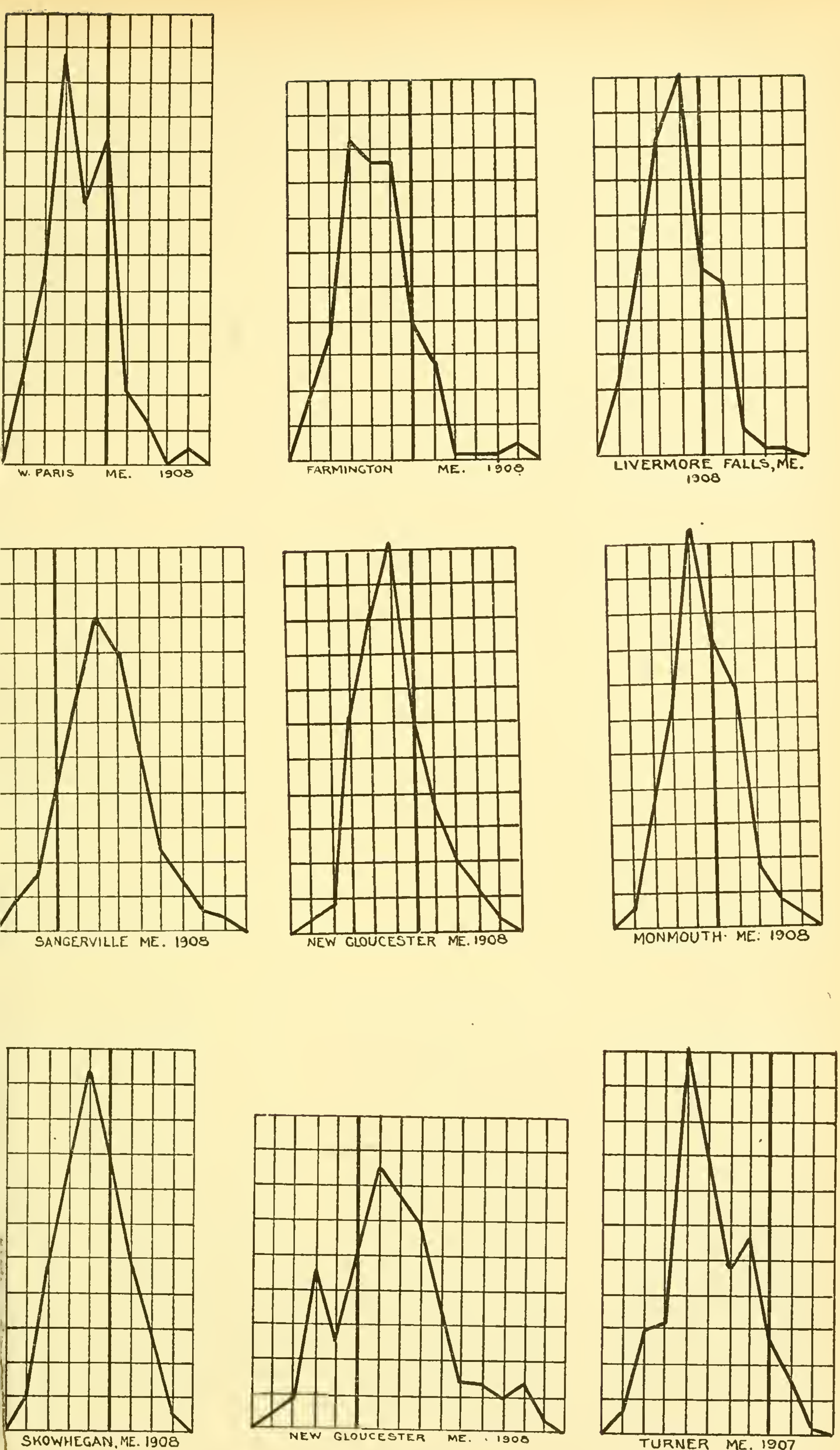
W. PARIS ME. 1908
FARMINGTON ME. 1908
LIVERMORE FALLS, ME. 1908
SANGERVILLE ME. 1908
NEW GLOUCESTER ME. 1908
MONMOUTH ME. 1908
SKOWHEGAN, ME. 1908
NEW GLOUCESTER ME. 1908
TURNER ME. 1907

PLATE II.

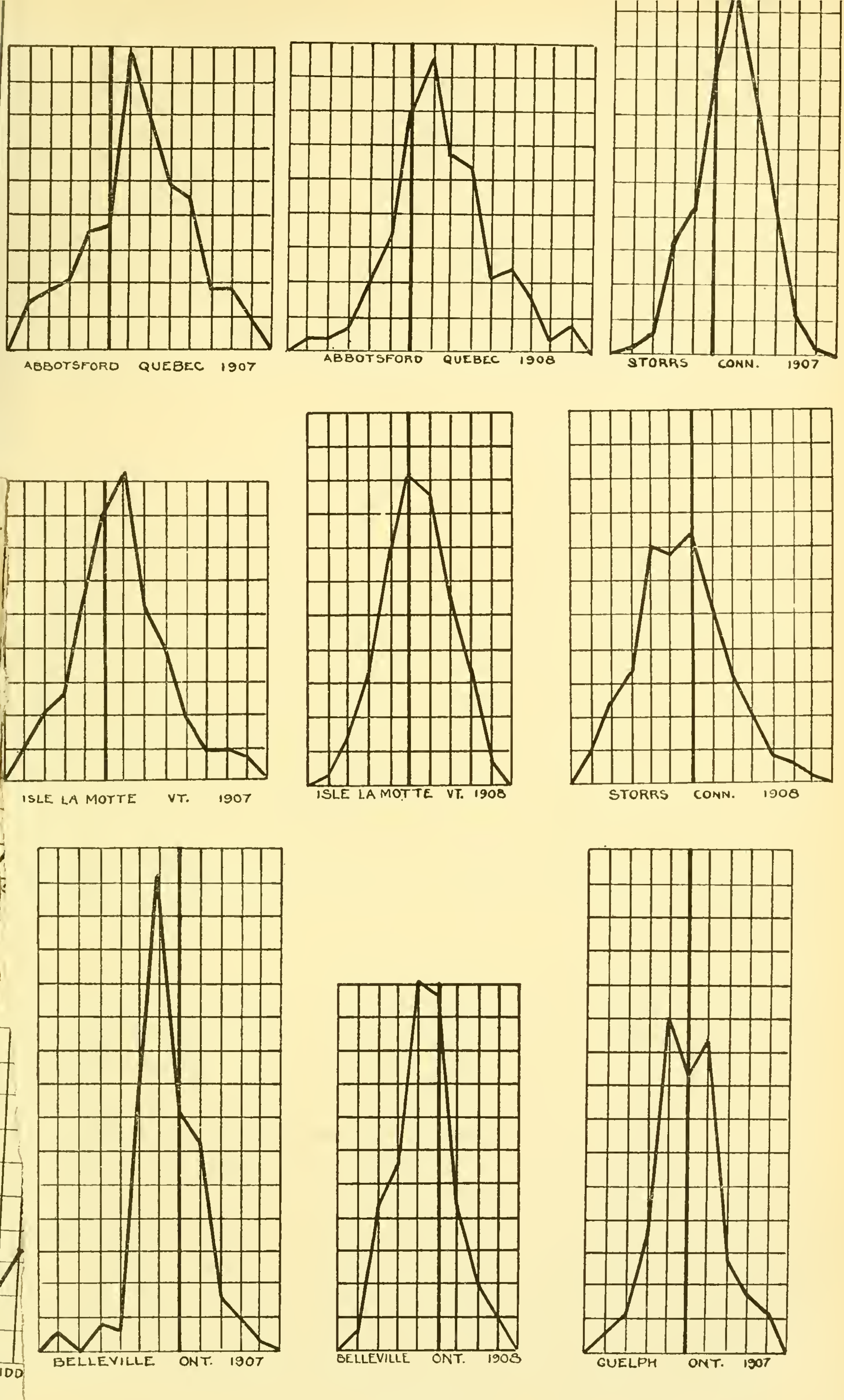
ABBOTSFORD QUEBEC 1907
ABBOTSFORD QUEBEC 1908
STORRS CONN. 1907
ISLE LA MOTTE VT. 1907
ISLE LA MOTTE VT. 1908
STORRS CONN. 1908
BELLEVILLE ONT. 1907
BELLEVILLE ONT. 1908
GUELPH ONT. 1907

PLATE III.

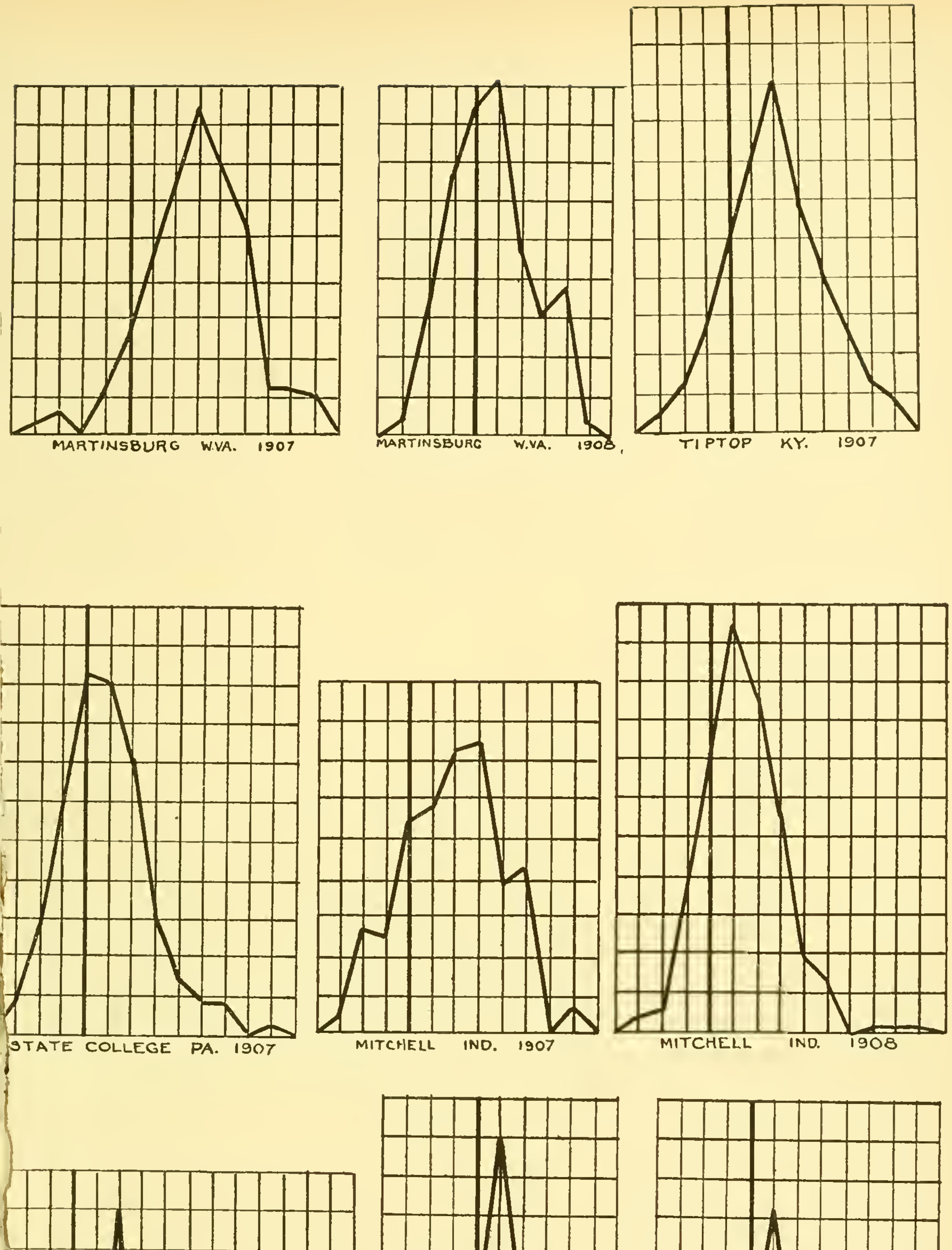
MARTINSBURG W.VA. 1907
MARTINSBURG W.VA. 1908
TIPTOP KY. 1907
STATE COLLEGE PA. 1907
MITCHELL IND. 1907
MITCHELL IND. 1908
MIDDLETOWN DEL. 1907
BENTONVILLE ARK. 1907
LINCOLN ARK. 1907

PLATE IV.

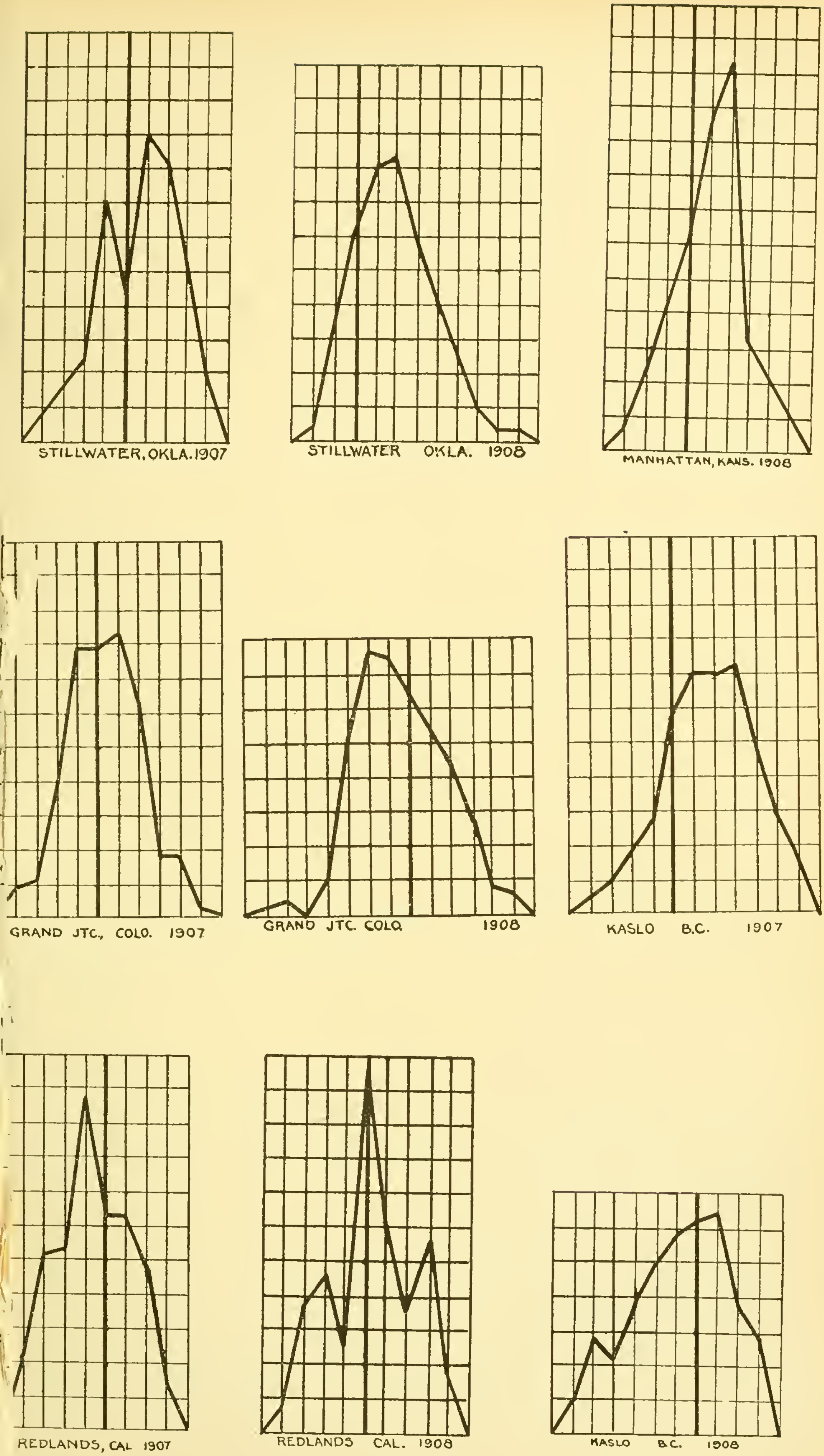
STILLWATER, OKLA. 1907
STILLWATER OKLA. 1908
MANHATTAN, KANS. 1908
GRAND JTC., COLO. 1907
GRAND JTC. COLO. 1908
KASLO B.C. 1907
REDLANDS, CAL 1907
REDLANDS CAL. 1908
KASLO B.C. 1908

PLATE V.

south, and those from Arkansas longer than those from farther north. This suggests the possibility that near the northern and southern extremes of distribution the general rule of elongation, as one goes north, is reversed, and that in the extreme north they are a little flatter than they are a little farther south, and at the extreme south they become slightly elongated. More data are needed to decide this question.

With a feeling that much could be learned by a more detailed study of the apples along the coast and adjacent region of New England and the maritime provinces, a special effort was made in the past season to secure apples from this section. These show the elongation towards the seacoast and northward, but among those from Maine the figures are not as harmonious as might be wished. Sangerville is farthest inland and New Gloucester nearest the coast, and they give the flattest and second longest apples, respectively; but the localities between do not show the gradual change in form that might be expected. These differences, however, are not large, and selection of the sample and local influences may account for it. More information is needed to clear this up.

Variability of the Different Lots.

An examination of the measures of variability of the different lots, bearing in mind the selection or want of selection of the shippers, indicates a somewhat greater variability in northern localities. This is shown both years, but is more pronounced in 1908.

Size.

The size of the apples was in many cases dependent largely on the selection practiced by the grower in making up the lots for shipment. Some were carefully selected and others were the run of the orchard. Any figures on size are, therefore, likely to be of little value. It is doubtless true that the apple attains a larger size in the south than in the extreme north. The season of 1907 was cold in the north and dry in the southwest, and may account for the inferior size of the apples from these regions. The season of 1908 was warmer in the north, and it appears that the apples were larger. Table 4 shows the results

TABLE 4. — *Size.*

APPLES FROM —	1907.				1908.			
	Mean.	Standard Deviation.	Coefficient of Variability.	Temperature (Degrees).	Mean.	Standard Deviation.	Coefficient of Variability.	Temperature (Degrees).
Charlottetown, P. E. I.,	61.36± .30	3.82± .22	6.20± .36	48.9	68.11± .53	8.75± .35	12.80± .52	51.3
Port Williams, N. S.,	63.63± .37	6.51± .26	10.23± .42	50.4	71.29± .42	6.37± .30	8.92± .42	51.2
Amherst, Mass.,	66.80± .20	5.53± .15	8.27± .23	55.9	70.23± .08	5.95± .06	8.47± .08	58.8
Storrs, Conn.,	70.83± .27	4.82± .20	6.80± .27	55.3	70.24± .24	4.32± .17	6.15± .24	58.8
Abbotsford, Quebec,	59.40± .24	4.32± .17	7.27± .28	49.9	66.89± .30	4.81± .21	7.19± .32	52.4
Isle la Motte, Vt.,	59.48± .23	4.85± .16	8.15± .27	53.0	64.40± .29	5.57± .20	8.65± .31	55.6
Belleville, Ont.,	65.45± .36	6.06± .26	9.25± .39	52.4	64.54± .16	2.84± .11	4.40± .18	54.8
Martinsburg, W. Va.,	73.30± .31	5.79± .22	7.89± .30	60.4	75.86± .13	1.99± .08	2.62± .11	63.9
Mitchell, Ind.,	73.89± .37	5.74± .26	7.76± .35	63.2	–	–	–	66.6
Stillwater, Okla.,	71.92± .24	3.61± .17	5.15± .32	68.9	74.49± .25	4.18± .18	5.61± .24	68.9
Redlands, Cal.,	73.21± .34	4.49± .24	6.13± .32	65.9	77.93± .33	4.64± .23	5.95± .31	68.5
Kaslo, B. C.,	71.10± .23	3.61± .17	5.07± .30	49.5	83.88± .30	3.77± .21	4.49± .24	50.9

of measuring a few lots from the same orchard both seasons, where it appears, from correspondence with the growers, safe to make comparisons. For comparison the average monthly mean temperatures for the growing season March to September, inclusive, for the different towns or some near-by station are given. It appears safe to infer that in any given orchard the size of the apple is governed largely by the temperature, but this by no means holds in different localities.

Flesh.

The whiteness of flesh which is characteristic of the variety was always maintained in considerable degree; those from Colorado were notably white of flesh. The less mature specimens had a greenish tinge, which, as the fruit ripened, gave way to a slight yellowish.

The firmness of the flesh likewise gradually gave way with ripening. The Colorado and in less degree the California lots were less firm and more of a spongy texture. Those from California carried well, but those from Colorado were soft enough to bruise quite badly, though this appeared to not seriously injure their keeping qualities, as the bruises showed a tendency to dry out rather than to decay.

The juiciness and quality were found to be variable. The apples were generally more juicy in the south, and of notably better quality. Northern-grown fruit was dry, flat, hard, and in some cases noticeably astringent, and these undesirable qualities did not entirely disappear with ripening.

In an attempt to learn something of the real nature of this, and of the general quality of the flesh, some chemical work was done.[1] Owing to a lack of time this was not as complete as might be wished, but the results, as far as they go, are interesting.

The methods used in this work may be briefly described as follows. One or two small slices, reaching to the core, were cut from three or more carefully selected apples, and dried in a water bath at 90° to 98° C. for about thirty-six hours. The weight of the residue gave the amount of dry matter. This dry residue, after cooling, was ground in a mortar until it

[1] For the opportunity to do this and for many suggestions as to methods, etc., the writer is indebted to the chemical department of the college.

would pass through a very fine sieve, and this fine powder used for the other work. The "insoluble matter" was determined by digesting 1 gram with about 200 cubic centimeters distilled water at room temperature, filtering through a tared filter paper and drying. The filtrate was titrated with n/5 alkali, using phenolphthalein as an indicator, and calculated as malic acid. For crude fiber the methods of the Association of Official Agricultural Chemists were followed, except that the sample was not previously extracted with ether.

The results of this work are shown in Table 5. From this table it appears that there is slight variation in the water content of these apples, those from Arkansas and Oklahoma having a little lower water content that those from the north. There is nothing in this column to account for the observed differences in juiciness and quality.

TABLE 5.—*Chemical Determinations (Per Cent.).*

Apples from —	In Original Subsistence.						In Dry Matter.	
	Water.	Dry Matter.	Soluble Matter.	Insoluble Matter.	Crude Fiber.	Acid, as Malic.	Insoluble Matter.	Crude Fiber.
Prince Edward Island,	84.9	15.1	11.13	3.97	1.07	1.03	26.3	7.15
Nova Scotia, . .	85.4	14.6	11.11	3.39	1.13	-	23.9	7.75
Maine, ...	84.6	15.4	-	-	-	.70	-	-
Quebec, ...	84.2	15.8	11.80	4.00	-	-	25.3	-
Vermont, ...	84.0	16.0	-	-	-	.76	-	-
Guelph, Ont., . .	83.6	16.4	13.52	2.89	-	-	17.5	-
Belleville, Ont., . .	83.6	16.4	-	-	-	-	-	-
Pennsylvania, . .	85.8	14.2	-	-	-	.70	-	-
Massachusetts, . .	85.2	14.8	11.52	3.26	.99	.73	22.0	6.68
Connecticut, . .	84.2	15.8	-	-	-	-	-	-
Delaware, . . .	84.3	15.7	-	-	-	.79	-	-
West Virginia, . .	84.8	15.2	12.00	3.21	.80	.79	21.1	5.28
Kentucky, . . .	84.7	15.3	12.58	2.74	-	-	17.9	-
Indiana, ...	83.2	16.8	-	-	-	.76	-	-
Bentonville, Ark., .	82.4	17.6	-	-	.93	-	-	5.29
Fayetteville, Ark., .	81.2	18.8	-	-	1.03	.65	-	5.52
Oklahoma, . . .	82.6	17.4	14.30	3.04	-	.66	17.6	-
Colorado, ...	84.8	15.2	12.82	2.39	1.00	-	15.7	-
California, . . .	83.2	16.8	13.88	2.94	-	.63	17.5	-
British Columbia, .	84.5	15.5	-	-	-	-	-	-

The constituents of apples, soluble in water, include the sugars, acids and doubtless some others of minor importance. These are lowest in Nova Scotia and highest in Oklahoma, and samples from intermediate points are generally between these figures in so far at least as determined.

The percentage of insoluble matter, which consists of pectin, cellulose and possibly starch and allied substances, are in general inversely proportional to those of soluble matter, being highest in the north and lower in the more southern part of the range of the variety.

Color.

The body color was, as a rule, closely correlated with the degree of ripeness of the fruit, the riper the apple the more yellowish in color. Aside from this, no variation was noted. The depth of overcolor was closely correlated with latitude, the farther north the deeper the color, and the variation was from a pale pinkish red in Arkansas to a deep crimson in the extreme north. The amount of overcolor did not seem to be dependent on latitude but was probably controlled largely by local conditions. The overcolor was especially good on the Pacific coast apples and on those from Colorado, Pennsylvania and Indiana, though in case of the last it was rather dull. The disposition of the color showed no striking variation. The mottling ran together into a blush on highly colored specimens, and there were always more or less stripes and splashes present. Probably all the russet that appeared was caused by Bordeaux mixture.

Bloom.

The amount of bloom seemed to be rather less in the north than in the south and on the Pacific coast. The nature of the bloom, whether waxy or greasy, seemed to depend largely on the maturity of the fruit.

Skin.

The skin was generally thicker in the south and west than in the northern localities. The texture did not vary greatly. The surface of the fruit varied much, but this seemed to be brought about by local conditions, and most of the roughness was due to Bordeaux mixture. The specially dull rough surface of the Massachusetts specimens was probably due to a heavy application of nitrate of soda the previous year.

Dots.

The size and color of the dots was variable, but the number and form were quite constant, and they were always very slightly raised above the surface of the apple. They are generally very small in the extreme north and become quite constantly larger as one goes south, being largest in the southwest and in Colorado. Almost all specimens showed some dots with russet and some without. Aside from this they are generally lighter in the north and more gray or yellowish toward the south.

Cavity.

The variation in the size of the cavity was marked. It was small and very shallow in the extreme northeast, of medium depth in the central and south central States and very deep in the Ozarks and in Colorado and California. It was very narrow in the Ozarks and generally wide in other localities. In cross-section there was little significant variation except that the cavity was generally more smooth and regular in southern-grown specimens.

Stem.

The stem presented little of interest. It was extremely variable in length and size, but the variation was nearly as great between specimens of almost any one lot as between those of different lots. The variability was perhaps greater in northern-grown apples than in those grown farther south.

Basin.

The remarks concerning the variation of the cavity will apply almost as well to the basin. A noticeable variation was the tendency towards a five-crowned fruit in Nova Scotia and to a less degree in neighboring regions. This was also seen in some degree in specimens from British Columbia, but was less pronounced. This tendency towards a pentagonal form extends more or less to the whole apple, giving somewhat of a pentagonal outline to the fruit as a whole. In the more southern localities, and particularly in the Ozarks and neighboring regions, the basin is remarkably smooth and regular and the sides abrupt, which make the basin one of the surest means of identifying specimens of this variety that may chance to be off type.

Calyx.

The calyx was generally more or less distorted by handling, and it was difficult to make very much out of it. The most striking thing about it was that in the small, poorly developed specimens it was nearly always closed, while in large, well-grown specimens it was at least partly open and sometimes a little separate at the base.

Calyx Tube.

The calyx tube was extremely variable, being sometimes very short, not more than one-fourth as long as wide, as in some of the Quebec specimens, and sometimes extremely long, extending almost to the cells, as in some of those from Arkansas and Colorado. This variability lay mostly in what may be called the stem of the funnel, this being very long in some apples and varying all the way to complete suppression, leaving a conical tube, in others. As a rule it was longer in the fully developed specimens and short in the poorly developed apples from northern regions.

Core.

The variation of the core closely followed that of the general form of the apple. In the elongated specimens it approached an oval form, and in the roundish and oblate apples it was turbinate. Likewise, in the elongated specimens it was usually abaxile, often strongly so, and in the more oblate ones it became axile or nearly so. The size as compared with that of the whole fruit varied but little, being possibly a little larger in the ill-developed apples, and it was always central and the core lines generally clasping.

Cells.

The variation of the cells very closely followed that of other parts of the core, being wide open and asymmetrical in the northern-grown apples and closed and symmetrical in those from the south. It was most open and asymmetrical in the larger apples. The carpels were never tufted but often were a little slit, especially in those from the north; they varied considerably in form, following pretty closely the general form of the apple. The concavity of the carpels was chiefly dependent on the development of the seeds.

Seeds.

The seeds showed little variation worthy of note. The number was somewhat variable; they were usually plump and of medium size. The color varied with the degree of maturity of the fruit, being generally lighter in poorly developed, northern-grown specimens.

Causes of the Variation.

The most interesting and significant variation is found (1) in the form of the apple and its parts, both external and internal; (2) in size, and (3) in the quality of the flesh. The variation in color is that usually found, being darker in the higher latitudes.

Form.

It appears beyond question that, speaking generally, and possibly excluding the extremes of distribution, Ben Davis apples become gradually more elongated as one goes from its Southern range northward, and this elongation is much more pronounced near large bodies of water. This is probably somewhat affected by local influences, but in general it appears to hold. That these differences are caused by climate, and not by different soils, sites, fertilizers or methods of cultivation, the writer has no doubt. Just what factor or factors of climate bring this change about is not so clear. It would seem probable that humidity has something to do with it, but the writer has been unable thus far to secure conclusive evidence on this point. The available records of humidity have been unsatisfactory, and more exact knowledge of this at the stations where the apples are grown and more data on their variation are needed. It is also possible that temperature may have an influence, either direct or through its influence on humidity.

It is entirely possible that other factors enter in, but a careful consideration of latitude, altitude, amount and intensity of sunlight, rainfall and other considerations fail to show anything that can be demonstrated as having any constant effect. To determine just what the cause is will require much patient investigation.

Size.

The size of the apples appears to be largely governed in any locality by the summer temperature. This is shown by the larger apples in the warmer season of 1908. In only two cases has a higher temperature failed to produce larger apples, and in one case the apples are larger while the temperature remains the same. The other eight comparisons in Table 4 show a higher temperature and larger apples. It may also be noted that a comparatively low temperature in the north produces as large or larger apples than a much higher temperature farther south. It is of course to be understood that methods of cultivation have an effect on size sometimes greater than temperature, and this fact, together with some possible selection on the part of the shipper, probably accounts for the above exception to the general rule.

Flesh.

During the winter of 1907 careful notes were kept on the quality of the apples from the different localities. In the judgment of the writer the various lots would rank in quality about in the following order with a notable difference between 9 and 10: —

	Degrees F.		Degrees F.
1. Colorado,	63.0	11. Connecticut,	55.3
2. Indiana,	63.2	12. Pennsylvania,	56.9
3. Bentonville, Ark.,	–	13. Massachusetts,	55.9
4. Oklahoma,	68.9	14. Guelph, Ont.,	–
5. Lincoln, Ark.,	69.0	15. Nova Scotia,	50.4
6. California,	65.9	16. British Columbia,	49.5
7. Kentucky,	66.3	17. Maine,	53.8
8. West Virginia,	60.4	18. Prince Edward Island,	48.9
9. Delaware,	61.8	19. Vermont,	53.0
10. Belleville, Ont.,	52.4	20. Quebec,	49.9

Accompanying the list is given the average monthly mean temperatures for the growing season of 1907, March to September, inclusive, as compiled from the records of the United States Weather Bureau and Canadian Meteorological Service.

It appears from this that an average monthly mean temperature for the growing season of at least 60° is required for the satisfactory development of the Ben Davis apple, and if grown where a lower temperature prevails the product is likely to be inferior.

That the poor quality of these northern-grown apples, as shown by their acidity, and dry, tasteless flesh, is due to lack of sufficient heat to fully develop the fruit is indicated by the results of certain work of the Bureau of Chemistry of the United States Department of Agriculture on the development of the Ben Davis,[1] where is shown the constant increase of sugars and decrease of acids with the development of the apples. It is also shown that the tannin which is present in the partially developed apples gradually disappears, and it is doubtless this substance that gives the apples their astringent taste.

Summary.

1. Apples vary greatly in response to the widely varying conditions of soil, and, more especially, climate, in the apple regions of North America. The Ben Davis variety seems to be especially variable.

2. This variability may be accurately measured and studied by means of statistical methods.

3. The most striking variation is in the external form of the apples, and this is accompanied by corresponding changes of the internal structure.

4. The cause of this variation is some factor or factors of climate, which are closely related to latitude and the proximity of large bodies of water. It is probable that humidity or temperature, or both, may be the controlling factors.

5. The differences in warmth of different growing seasons definitely affect the size of the apples for that season.

6. The most favorable temperature for development in size

[1] Bureau of Chemistry, Bulletin 94, p. 44.

varies with the locality. It is lower in the north than in the south.

7. The cause of the variation in quality is chiefly the varying amount of heat prevalent during the growing season.

8. In order to develop satisfactorily in quality the Ben Davis should have an average monthly mean temperature of not less than 60° F. for the growing season, March to September, inclusive.

FUMIGATION DOSAGE.

I. TOMATOES.

BY W. V. TOWER, B.S.

INTRODUCTION.

BY H. T. FERNALD.

Tomatoes are extensively grown in Massachusetts in greenhouses. Unfortunately, they are subject to the attacks of several kinds of insects which under glass seem to be more than ordinarily destructive. The most important of these enemies are the greenhouse white fly (*Aleyrodes vaporariorum* West.) and thrips, and as these are most successfully controlled by fumigation with hydrocyanic acid gas, this treatment should be familiar to tomato growers. Unfortunately, however, this is not the case, many growers seeming to be afraid to use it for fear that when the gas is generated in sufficient quantity to destroy the insects it will also injure the plants.

The amount of hydrocyanic acid gas to which tomato plants can be exposed without injury, under varying conditions of light, temperature, humidity, age, variety, etc., has never been investigated, so that there has hitherto been some reason for this fear. To determine, therefore, just what tomato plants could withstand in the way of treatment, under all conditions likely to be met with in commercial work, the experiments which follow were planned by the writer and were carried out in the greenhouse of the department of entomology of the Massachusetts Agricultural Experiment Station during the winter of 1905–06, by Mr. W. V. Tower, then a graduate student in entomology at the Massachusetts Agricultural College. The experiments had just been completed when Mr. Tower accepted an appointment in Puerto Rico and was obliged to leave before the results were ready for publication. It is therefore desirable, for the sake of placing responsibility, to state that the experiments were planned largely by the writer, assisted to some extent by Mr. Tower; that the entire care of the plants, the fumigations and the observation of the results were the work of Mr. Tower; while most of the conclusions and the duty of editing the work for publication have fallen upon the writer. In fact, the original work herein contained should be regarded as Mr. Tower's, while for the planning of the experiments and the editorial work the writer should be held responsible.

Three varieties of tomato — Livingston, Lorillard and Freedom — were selected, these being the ones most generally raised under glass in Massachusetts. Two plants of each variety were used in each test. In the tabulations which follow, factors common to the entire set are given before the tabulation itself. The abbreviations indicating the results are as follows: —

B, burned.	N, normal (uninjured).
BB, badly burned.	SB, slightly burned.
BC, burned and leaves curling.	SI, slightly injured.
BI, badly injured.	TI, temporarily injured.
C, leaves curling.	TK, top killed.
I, injured.	VBI, very badly injured.
K, killed.	

Wilted leaves are the first indication of injury. If this is not too severe they gradually become normal again. Curled leaves indicate more serious effects, but plants thus affected frequently become normal later.

The fumigation in all cases was with 98 per cent. to 99 per cent. potassic cyanide, the proportions of the cyanide, acid and water used being 1, 2, 4. The column marked "Time of exposure" gives the time at which the treatment began. Temperatures are given by the Fahrenheit scale.

The first two sets of experiments were carried on in direct sunlight. In the first set periods of ten, twenty, thirty, forty-five minutes' and one hour's exposure quickly showed that it was not necessary to make any long exposures with the greater strength of cyanide, and, accordingly, exposures of ten, twenty and thirty minutes only were made, even the shortest of these being too severe a treatment for the plants.

Experiment I.

Day Exposures with Direct Sunlight.

First four sets treated March 14; fifth set treated December 14.

Fumigation with .005 gram KCN per cubic foot; plants six weeks old; humidity for first four sets, 65°; for fifth set, 60°; amount of sunlight (March 14) for first four sets, four hours; for fifth set (December 14), five hours; plants of first four sets, watered the morning of the test; of the fifth the day before; all sets dry when treated; conclusions drawn five days after treatment with the first three sets, eight days afterward with the fourth set and about three weeks afterward with the fifth set. The sunlight was not as strong for the fifth set as for the others, it being December, while the other tests were in March.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	2.28	3.00	3.30	4.10	8.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	68	65	63½	65	67
Livingston,	B	BB	BB	BB	VBI
Lorillard,	N	B	SB	BC	VBI
Freedom,	B	B	BB	BC	VBI

Experiment II.

Day Exposures with Direct Sunlight.

First two sets treated December 14; third set March 14.

Fumigation with .01 gram KCN per cubic foot; plants six weeks old; humidity, 79°; amount of sunlight for first two sets five hours; for third set four hours; all plants watered at 8.30 A.M. the day of the test, but dry when treated; one plant of each variety placed under a bench in the house for fourteen to nineteen hours before treatment; conclusions drawn after three weeks for the first and second sets and after one week for the third set.

	Set Numbers.		
	1	2	3
Time of exposure,	11.20	12.00	1.45
Length of exposure,	10 m.	20 m.	30 m.
Temperature of house (degrees),	70	70	71
Livingston normal,	K	K	BI
Livingston under bench,	I	K	K
Lorillard normal,	K	K	BI
Lorillard under bench,	K	K	BI
Freedom normal,	K	K	BI
Freedom under bench,	K	K	BI

This experiment would seem to indicate that the plants placed under the benches before treatment were not benefited in this way.

Experiment III.

Cloudy Day Exposures, December 19.

Fumigation with .02 gram KCN per cubic foot; plants six weeks old; humidity not taken till 8 P.M., when it was 81°; good sunlight for four days before the test and for two hours in the morning that day; all plants watered at 8.30 A.M. the day of the test, but dry when treated; half the plants of each variety were sprinkled just before the test; conclusions drawn after seventeen days' observation. It was dusk when the fourth set was fumigated.

	Set Numbers.			
	1	2	3	4
Time of exposure,	2.45	3.15	4.00	5.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature of house (degrees),	68	67	65	65
Livingston normal,	TI	TI	TI	TI
Livingston sprinkled,	TI	TI	TI	TI
Lorillard normal,	TI	I	TI	I
Lorillard sprinkled,	SI	I	TI	
Freedom normal,	TI	I	TI	
Freedom sprinkled,	I	I		

In addition to the effects noted, the sprinkled plants developed white spots where the drops of water stood, and in general were in worse condition than the others.

Experiment IV.

Day Exposures during Rain, Snowstorm and Cloudy Weather, January 12 and 13.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; set 1 treated during a rainstorm; sets 2 and 3 during a snowstorm and set 4 during cloudy weather; no direct sunlight either day; plants of set 1 watered the day before the test; the others, the morning of the test, but dry when treated; conclusions drawn after three days for the first set; after six days for the second and after nine days for the third and fourth sets.

	Set Numbers.			
	1	2	3	4
Time of exposure,	10.30	9.00	11.00	1.15
Length of exposure,	1.30 m.	1.30 m.	1 h.	1 h.
Temperature of house (degrees),	65	65	55	68
Humidity before (degrees),	62	55	65	57
Humidity after (degrees),	80	84	82	80
Livingston,	K	BI	BI	I
Lorillard,	K	BI	BI	I
Freedom,	K	BI	BI	I

Experiment V.

Night Exposures, December 13.

Fumigation with .005 gram KCN per cubic foot; plants si[x] weeks old; house humidity, 60°; six hours of sunlight the day o[f] treatment, but cloudy the previous week; weather cloudy durin[g] the treatment of the first three sets; moonlight during the othe[r] two; treatment began on set 1 as soon as it was really dark wee. watered at 9 A.M., dry when treated; half the plants of third set had been placed under benches for thirty hours ...nt; conclusions drawn three weeks after treat...

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	5.25	7.10	8.00	9.00	10.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	66	66	66	65	65
Livingston normal,	N	N	N	Sl	Sl
Livingston under bench,	N	N	N	N	Sl
Lorillard normal,	N	N	N	Sl	Sl
Lorillard under bench,	N	N	N	Sl	N
Freedom normal,	N	N	Sl	Sl	Sl
Freedom under bench,	N	N	N	N	N

In this experiment it would seem that plants which had been shaded for a time before the treatment, by being placed under the benches, were at a slight advantage.

Experiment VI.

Night Exposures, December 14.

Fumigation with .01 gram KCN per cubic foot; plants six weeks old; house humidity, 79°; five hours of sunlight the day of treatment; dark during treatment of first two sets, moonlight during the last three; treatment began on set 1 as soon as it was really dark; plants watered at 8.30 A.M., dry when treated; half the plants of each variety had been placed under the bench for twenty-four hours before treatment; conclusions lrawn three weeks after the treatment.

	Set Numbers.				
	1	2	3	4	5
ime of exposure,	5.20	7.20	8.30	9.30	10.45
ength of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
emperature of house (degrees),	55	58	62	60	58
ivingston normal,	C	Tl	C	C	
ivingston under bench,	N	N	N	C	
orillard normal,	N	C	C	C	
orillard under bench,	N	N	N		
reedom normal,	N	C	C		
reedom under bench,	N	N			

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Experiment VII.

Night Exposures, December 15 and March 15.

Fumigation with .015 gram KCN per cubic foot; plants six weeks old; house humidity, 83°; dusk during treatment of first set, cloudy during second and third sets, starlight during the last three sets; plants watered at 8 A.M.; half of each variety sprinkled before treatment, the others dry; conclusions drawn one week after treatment for set 5, three weeks after treatment for the others.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	4.45	5.45	7.20	8.30	7.30	9.55
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature of house (degrees),	65	65	64	65	58	65
Livingston normal,	SI	N	SI	C	C	K
Livingston sprinkled,	N	SI	SI	C	C	K
Lorillard normal,	SI	SI	SI	C	C	K
Lorillard sprinkled,	N	SI	SI	C	C	K
Freedom normal,	N	SI	SI	C	C	K
Freedom sprinkled,	N	SI	SI	C	C	K

The sprinkled plants showed spots on the leaves where the drops of water stood, as a result of the treatment; otherwise little difference in the two lots was noticeable.

Experiment VIII.

Night Exposures, January 8.

Fumigation with .015 gram KCN per cubic foot; plants eight weeks old; house humidity, 84°; amount of sunlight the day, four hours; plants watered at 10 A.M., dry when eactwo; th night cloudy during the treatment; conclusions drawn nindants e week.
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	Set Numbers.	
	1	2
Time of exposure,	8.30	9.30
Length of exposure,	30 m.	45 m.
Temperature of house (degrees),	58	65
Livingston,	SI	SI
Lorillard,	SI	SI
Freedom,	SI	SI

Experiment IX.

Night Exposures, January 9.

Fumigation with .015 gram KCN per cubic foot; plants eight weeks old; house humidity, 49°; amount of sunlight that day, six hours; plants watered at 8 A.M., dry when treated; treatment during moonlight; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	5.15	7.00	8.30
Length of exposure,	30 m.	45 m.	1 h.
Temperature of house (degrees),	58	68	65
Livingston,	SI	SI	C
Lorillard,	SI	SI	C
Freedom,	SI	SI	C

Experiment X.

Night Exposures, January 31.

Fumigation with .015 gram KCN per cubic foot; plants eleven weeks old, rather weak, tall and spindling; amount sunlight that day, one hour; plants watered at 8.30 A. when treated; moonlight during the treatment; c drawn after four days.

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	Set numbers.	
	1	2
Time of exposure,	5.30	7.30
Length of exposure,	1½ h.	2 h.
Temperature of house (degrees),	62	62
Humidity before (degrees),	58	62
Humidity after (degrees),	76	76
Livingston,	C	I
Lorillard,	C	I
Freedom,	C	I

Experiment XI.

Night Exposures, December 16.

Fumigation with .02 gram KCN per cubic foot; plants six weeks old; house humidity, 63°; amount of sunlight that day, four hours; plants watered at 9.30 A.M., dry when treated, except that half of the plants of each variety were sprinkled just before the treatment; first set treated at dusk, other sets treated in starlight; conclusions drawn after three weeks

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	4.30	5.40	7.05	8.20	9.50
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	68	60	65	66	64
Livingston normal,	N	N	C	BI	BI
Livingston sprinkled,	Sl	N	C	BI	BI
Lorillard normal,	N	N	C	BI	K
Lorillard sprinkled,	N	N	C	K	K
Freedom normal,	Sl	N	C	K	K
Freedom sprinkled,	Sl	N	C	K	K

the ... each two; ... sprinkled plants developed spots on the leaves where nineteen ... weeks ... water stood during the treatment.
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Experiment XII.

Night Exposures, January 10.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; house humidity, 61°; amount of sunlight that day, four hours; plants watered at 8 A.M., dry when treated; sets treated in moonlight; conclusions drawn after five days.

	Set Numbers.			
	1	2	3	4
Time of exposure,	7.15	8.15	9.15	5.05
Length of exposure,	20 m.	30 m.	45 m.	1 h.
Temperature of house (degrees),	65	67	67	65
Livingston,	N	SI	C	C
Lorillard,	SI	SI	C	I
Freedom,	SI	SI	I	I

Experiment XIII.

Night Exposures, January 12 and 13.

Fumigation with .02 gram KCN per cubic foot; plants nine weeks old; weather cloudy the day of treatment of first two sets, clear the day of treatment of the third set; plants watered at 8.30 to 9 A.M., dry when treated; first set treated at dusk, the other two in starlight; conclusions drawn after five days.

	Set Numbers.		
	1	2	3
me of exposure,	5.30	7.30	7.25
ength of exposure,	1½ h.	2 h.	2 h.
mperature of house (degrees),	60	62	65
umidity before (degrees),	65	65	[illegible]
umidity after (degrees),	80	80	[illegible]
ivingston,	SI	[illegible]	[illegible]
orillard,	SI	[illegible]	[illegible]
reedom,	TI	[illegible]	[illegible]

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Experiment XIV.

Night Exposures, December 18.

Fumigation with .04 gram KCN per cubic foot; plants si weeks old; house humidity, 82°; eight hours of sunlight th day of treatment; plants watered at 8.15 A.M., dry whe treated; clear, starlight night during the treatment; set fumigated twenty-five minutes, aired and then treated te minutes longer; conclusions drawn after two and a half week

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.00	9.00	10.00	5.
Length of exposure,	10 m.	15 m.	20 m.	35
Temperature of house (degrees),	68	70	68	68
Livingston,	N	C	C	C
Lorillard,	TI	SI	C	C
Freedom,	TI	C	K	K

The Freedom plants in sets 3 and 4 were weak and not good condition.

Experiment XV.

Night Exposures, January 11.

Fumigation with .04 gram KCN per cubic foot; plants 1 weeks old; house humidity, 73° six hours of sunlight the of treatment; plants watered at 8 A.M., dry when treated; three sets treated in dim moonlight, set 4 at dusk; conclus drawn after four days.

	Set Numbers.		
	1	2	3
[illegible]xposure,	7.05	8.00	9.30
[illegible]ure,	20 m.	30 m.	45 m.
[illegible]se (degrees),	65	65	65
[illegible]	SI	SI	SI
[illegible]	SI	SI	SI
[illegible]	SI	SI	SI

Experiment XVI.

Night Exposures for Temperature and Humidity, February 26, 27, 28, March 5, 6.

Fumigation with .01 gram KCN per cubic foot; plants about seven weeks old; first two sets treated in starlight, third and fourth on a cloudy night, fifth and sixth in starlight, seventh and eighth in moonlight, ninth and tenth in a darkened box at night; plants watered at 8.30 A.M., dry when treated; all the plants vigorous; conclusions drawn after nine days.

	Set Numbers.									
	1	2	3	4	5	6	7	8	9	10
Time of exposure,	7.15	8.15	7.00	8.15	7.00	8.20	7.15	10.00	7.00	9.30
Length of exposure,	45 m.	45 m.	45 m.	1 h.	1 h.	2 h.	2 h.	2 h.	2 h.	2 h.
High temperature (degrees),	68	64	-	-	-	-	-	67	-	63
Low temperature (degrees),	-	-	58	55	58	56	57	-	52½	-
Humidity before (degrees),	45	58	50	55	50	51	52	70	45	60
Humidity after (degrees),	65	75	64	67	74	63	59	80	65	77
Livingston,	SI	SI	SI	SI	C	C	C	C	C	C
Lorillard,	SI	SI	SI	TK	I	C	I	C	I	C
Freedom,	SI	SI	SI	I	TI	C	C	C	I	C

Comments and Conclusions.

BY H. T. FERNALD.

The experiments were planned so that only one factor should vary at a time. It quickly became evident, however, that many of the factors were beyond control, and therefore entire certainty as to the cause of differences in results could not always be obtained. Thus, the treatment itself had the effect of increasing the humidity of the fumigator, and sometimes this change was quite considerable.

Morrill's experiments on the white fly (Technical Bulletin No. 1, Hatch Experiment Station, Massachusetts, p. 50, 1903) indicated that fumigation with from .007 gram to .01 gram KCN per cubic foot for three hours should control most stages of this insect, and that three such treatments at intervals of about twelve days would probably clear an infested house. Hinds's experiments on Thrips (Bulletin No. 67, Hatch Experiment Station, Massachusetts, p. 11, 1900), though less complete, indicate that these insects would probably be also controlled by this treatment.

An examination of the first two experiments given in this paper shows at once that under the conditions stated serious injury or the destruction of the plants would result long before the above-named insects were killed, and a comparison of the data in Experiments II., V. and VI. indicates that daylight treatment was, at least in part, responsible for this. Fumigation in cloudy weather, as shown in Experiment III., sustains this view, the injury being less than with plants treated in sunlight. Experiment IV. gives the results of treatment during rain and snowstorms with longer exposure, showing that even in bad weather daylight treatment is unsafe.

Comparison of the experiments carried on at night is also suggestive. Those treatments which were made on moonlight nights were always more injurious than those made in starlight, while slightly better results were obtained on cloudy nights. From the data at hand it would seem probable that the safest treatment for the plants would be on a cloudy night following a dark day; and the night experiments with plants which had been kept under the benches for a day or so before treatment, thus giving them partial shade, sustain this view.

The results of variation in temperature of the house during fumigation were by no means as noticeable as had been anticipated; indeed, as a result of these tests it would seem to make little difference whether treatment should be given in a warm or a cool house. Much the same can be said of humidity, though here it would appear probable that with high humidity — 75 degrees or over — there is more chance of injury than would be the case where the humidity is rather low.

It may be stated as a general conclusion that prolonged exposures to weak strengths of the gas are more liable to cause injury to the plants than are shorter exposures to greater strengths. As this does not entirely meet Morrill's directions for the control of the white fly, which would come under the head of prolonged exposure to a rather weak strength of gas, it would seem desirable to determine whether short exposures to greater strengths would be effective against the insects. Until this is determined it is probable that the best treatment for the white fly on tomato plants is to fumigate them with a strength of .015 gram of KCN per cubic foot for a period of from forty-five minutes to one hour, on a dark — moonlight, or perfectly cloudy — night, in a house where the humidity is below 70 degrees at the beginning of the treatment. Fumigation in this way will probably slightly injure the plants and may cause curling of the leaves; but the injury will be less than would be that caused by the insects if there were no treatment given, and three such treatments at intervals of twelve days should not prove serious to the plants, while they should reduce the white fly to a negligible quantity for quite a period, — probably until after the crop has been gathered from the plants concerned.

II. CUCUMBERS.

BY CHARLES W. HOOKER, PH.D.

Introduction.

BY H. T. FERNALD.

The experiments on cucumbers which follow were made during the year 1907 by Dr. Charles W. Hooker as a portion of his graduate work at the Massachusetts Agricultural College. More time being available for the purpose than was the case with the tomato tests, it was possible to make the tests more exhaustive, but the general ideas were the same for both series of experiments.

The two most common varieties of cucumber grown under glass in Massachusetts were used, viz., Rawson's Hothouse and White Spine. The latter variety seemed, on the whole, to produce the better plants. Two plants of each variety were used for each test.

The supervision of this work fell upon the writer of this introduction, but the work itself, the daily care and observations were made by Dr. Hooker, and the conclusions drawn are mainly his. For some editorial work on all the parts the writer is responsible. Abbreviations indicating the results are the same as those used for the tomato, which are explained on page 215. All the plants used were watered the day of the experiment, but their leaves were dry in all cases unless otherwise noted.

Experiment I.

Day Exposures with Direct Sunlight, April 4.

Fumigation with .01 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment, ten hours; conclusions drawn after three days.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	9.00	9.25	10.00	10.50	12.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	94	94	108	107	115
Humidity (degrees),	47	40	41	45	47
White Spine,	N	BB	B	B	BB
Hothouse,	N	BB	VBI	BB	BB

It is evident that, under these conditions, treatment long enough to be of any value against insects would seriously injure the plants.

Experiment II.

Cloudy Day Exposures, May 6, 7.

Fumigation with .01 gram KCN per cubic foot; plants of sets 1 to 5, ten days old; of set 6, seventeen days old; no sunlight the day of treatment; conclusions drawn after one week.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	9.40	10.05	10.40	1.25	2.25	2.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	59	59	60	62	69	67
Humidity (degrees),	70	84	90	85	81	98
White Spine,	N	N	N	N	N	N
Hothouse,	N	N	N	N	N	N

A comparison of the last two experiments shows how much less sensitive cucumbers are in cloudy weather.

Experiment III.

Cloudy Day Exposures with Older Plants, April 26, 29, May 8, 16.

Fumigation with .01 gram KCN per cubic foot; sunlight a portion of each day, but not during treatment; plants watered the day before the treatment; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Age of plants (days),	45	45	48	48	48	31	41
Date of treatment,	April 26	April 26	April 29	April 29	April 29	May 8	May 16
Time of exposure,	8.30	8.55	8.05	8.45	9.45	9.00	9.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.	2½ h.
Temperature (degrees),	70	75	73	73	72	74	61
Humidity (degrees),	73	76	74	79	79	94	98
White Spine,	N	N	N	N	N	N	K
Hothouse,	N	N	N	N	N	N	K

Experiment IV.

Cloudy Day Exposures with Stronger Fumigation, May 23, 27.

Fumigation with .015 gram KCN per cubic foot; plants of first two sets sixteen days old, fumigated May 23; of the other sets twenty days old, fumigated May 27; amount of sunlight the day of fumigating first two sets, seven hours; on day of fumigating the other three sets, none; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.40	9.15	8.25	9.30	2.30
Length of exposure,	20 m.	30 m.	45 m.	1 h.	1½ h.
Temperature (degrees),	56	71	60	61	60
Humidity (degrees),	86	78	95	92	89
White Spine,	N	N	N	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment V.

Cloudy Day Exposures with Older Plants, April 30, May 3, 6.

Fumigation with .015 gram KCN per cubic foot; amount of sunlight April 30, six hours; May 3, seven hours; May 6, none; plants of sets 2 and 5 watered the day before treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Age of plants (days),	38	41	41	41	44
Date of treatment,	April 30	May 3	May 3	May 3	May 6
Time of exposure,	9.30	8.00	8.35	10.00	8.15
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	73	65	72	57	59
Humidity (degrees),	80	97	97	93	90
White Spine,	N	N	SB	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment VI.

Cloudy Day Exposures with Stronger Fumigation, May 16.

Fumigation with .02 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment, four hours; plants watered the day before treatment; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.30	8.55	9.30	10.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature (degrees),	69	67	67	76
Humidity (degrees),	91	81	81	83
White Spine,	N	N	SB	K
Hothouse,	N	N	SB	K

Experiment VII.

Cloudy Day Exposures with Older Plants, May 8.

Fumigation with .02 gram KCN per cubic foot; plants forty-seven days old; amount of sunlight the day of treatment, eight hours; plants watered the day before treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.25	8.35	9.15	10.00	11.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	63	64	66	63	63
Humidity (degrees),	90	84	88	91	87
White Spine,	N	N	N	SB	SB
Hothouse,	N	N	N	SB	SB

Experiment VIII.

Moonlight Night Exposures, March 20.

Fumigation with .01 gram KCN per cubic foot; plants eight days old; amount of sunlight the day of treatment, nine and a half hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	62	59	58	60	65
Humidity (degrees),	58	52	44	43	51
White Spine,	N	N	N	N	Sl
Hothouse,	N	N	N	N	N

Experiment IX.

Moonlight Night Exposures with Stronger Fumigation, March 20, 21.

Fumigation with .015 gram KCN per cubic foot; plants eight days old; amount of sunlight the day of treatment of the first three sets, nine and a half hours; of the last two sets, eleven hours; slightly hazy the evening the first three sets were treated; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	11.00	11.25	12.00	6.35	7.35
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	76	75	73	63	70
Humidity (degrees)	36	40	44	55	61
White Spine,	N	N	N	Sl	SB
Hothouse,	N	N	N	Sl	SB

Experiment X.

Moonlight Night Exposures with Stronger Fumigation, March 21, 22.

Fumigation with .02 gram KCN per cubic foot; plants nine days old; amount of sunlight the day of treatment of first four sets, eleven hours; of fifth set, five and a half hours; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	8.30	9.15	9.50	10.35	6.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	69	68	66	64	64
Humidity (degrees),	51	54	59	54	64
White Spine,	N	N	SB	SB	B
Hothouse,	N	N	N	SB	B

A comparison of the last three experiments would indicate that, under these conditions, an increase of .005 gram KCN was about equivalent to fifteen minutes' exposure.

Experiment XI.

Starlight Night Exposures, April 3.

Fumigation with .01 gram KCN per cubic foot; plants eleven days old; amount of sunlight the day of treatment, twelve hours; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.25	8.10	9.10
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	64	62	62
Humidity (degrees),	58	65	66
White Spine,	N	N	N
Hothouse,	N	N	N

Experiment XII.

Starlight Night Exposures with Older Plants, May 21, 23, 24, 1907; May 4, 14, 1908.

Fumigation with .01 gram KCN per cubic foot; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Date of treatment,	May 21	May 21	May 23	May 24	May 4	May 4	May 14
Age of plants (days),	14	14	16	18	13	20	25
Time of exposure,	7.35	9.00	8.00	7.30	9.20	7.15	7.15
Length of exposure,	1¼ h.	1½ h.	1¾ h.	2 h.	1½ h.	2 h.	2 h.
Temperature (degrees),	56	56	55	57	61	65	69
Humidity (degrees),	90	81	80	76	100	96	94
White Spine,	N	N	N	N	SB	SB	N
Hothouse,	N	N	N	N	N	SB	N

Experiment XIII.

Starlight Night Exposures with Still Older Plants, April 15, October 7, November 4.

Fumigation with .01 gram KCN per cubic foot; plants of first five sets, five weeks old; of the sixth and seventh sets, four weeks; of the eighth and ninth sets, thirty-two days; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Time of exposure,	7.10	7.35	8.10	8.55	9.55	6.30	8.15	6.30	8.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	2½ h.
Temperature (degrees),	63	63	59	60	62	61	66	56	53
Humidity (degrees),	70	71	76	70	76	50	80	79	84
White Spine,	N	N	N	N	N	N	N	N	N
Hothouse,	N	N	N	N	N	N	N	N	N

Experiment XIV.

Starlight Night Exposures with Old Plants, May 20, 23, 31, June 7, 17.

Fumigation with .01 gram KCN per cubic foot; entire greenhouse full of plants used in each exposure; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Age of plants (days),	69	72	80	87	97
Time of exposure,	8.10	8.15	8.20	8.00	8.00
Length of exposure,	1 h.	1½ h.	1¾ h.	3 h.	3 h.
Temperature (degrees),	63	63	62	62	-
Amount of sunlight for day,	10 h.	3.8 h.	2.7 h.	6.8 h.	12 h.
White spine,	N	SB	SB	SB	SB
Hothouse,	N	SB	SB	SB	SB

Experiment XV.

Starlight Night Exposures with Stronger Fumigation, April 11.

Fumigation with .015 gram KCN per cubic foot; plants nineteen days old; amount of sunlight the day of treatment, eleven and a half hours; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.00	7.45	8.45
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	70	69	69
Humidity (degrees),	59	63	63
White spine,	N	N	N
Hothouse,	N	N	N

Experiment XVI.

Starlight Night Exposures with Older Plants or Longer Exposures.

Fumigation with .015 gram KCN per cubic foot; amount of sunlight May 13, nearly twelve hours; not taken on the other days; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Age of plants (days),	24	24	24	24	24	21	21	16	16
Date of treatment, .	May 13	May 13	May 13	May 13	May 13	Nov.11	Nov.11	Nov.12	Nov.12
Time of exposure, .	7.25	7.50	8.25	9.05	10.00	6.30	8.15	6.30	8.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	1½ h.
Temperature (degrees), . . .	70	65	62	61	58	63	63	60	60
Humidity (degrees),	75	73	73	75	72	79	81	71	73
White Spine, . .	N	N	N	N	N	N	N	SB	SB
Hothouse, . . .	N	N	N	N	N	N	N	SB	SB

Experiment XVII.

Starlight Night Exposures with Still Older Plants, May 1.

Fumigation with .015 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 8.7 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure, ...	7.00	7.25	8.00	4.45	9.45
Length of exposure, ...	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees), ...	60	56	56	54	53
Humidity (degrees), ...	90	87	90	82	87
White Spine, ...	N	N	N	N	N
Hothouse, ...	N	N	N	N	N

Experiment XVIII.

Starlight Night Exposures with Old Plants, May 14.

Fumigation with .015 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 11.5 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.15	7.35	8.10	8.55	9.55
Length of exposure,	10 m.	20 m.	30 m.	45 m	1 h.
Temperature (degrees),	68	65	60	59	59
Humidity (degrees),	78	71	83	84	84
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	N

Experiment XIX.

Starlight Night Exposures with Stronger Fumigation, May 17.

Fumigation with .02 gram KCN per cubic foot; plants ten days old; amount of sunlight the day of treatment, 2.3 hours; night slightly hazy, with the moon in the first quarter; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.20	7.40	8.10	8.55	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	58	58	58	60	60
Humidity (degrees),	71	71	88	86	86
White Spine,	N	N	N	BB	BB
Hothouse,	N	N	N	BB	BB

Experiment XX.

Starlight Night Exposures with Older Plants, April 18.

Fumigation with .02 gram KCN per cubic foot; plants thirty-seven days old; amount of sunlight the day of treatment, twelve hours; slightly cloudy just at the beginning of the experiment; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	7.00	8.25	9.10	10.10
Length of exposure,	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	65	63	63	65
Humidity (degrees),	71	71	80	76
White Spine,	N	N	N	SB
Hothouse,	SB	SB	SB	N

Experiment XXI.

Starlight Night Exposures with Stronger Fumigation, May 20, June 4.

Fumigation with .03 gram KCN per cubic foot; plants of first three sets, three weeks old, treated May 20; of last two sets, twenty-six days old, treated June 4; amount of sunlight May 20, 10 hours; June 4, 6.6 hours; small amount of moonlight during sets 1 and 4; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.35	8.55	9.50	8.00	9.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	56	54	52	65	62
Humidity (degrees),	75	88	82	83	80
White Spine,	SB	SB	B	BB	B
Hothouse,	SB	SB	B	B	B

Experiment XXII.

Starlight Night Exposures with Older Plants, May 28.

Fumigation with .03 gram KCN per cubic foot; plants thirty-two days old; amount of sunlight the day of treatment, 3.8 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.30	7.55	8.30	9.10	10.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	54	50	52	54	55
Humidity (degrees),	90	95	85	89	83
White Spine,	N	SB	SB	BB	BB
Hothouse,	N	SB	SB	BB	BB

Experiment XXIII.

Starlight Night Exposures with Strong Fumigation, April 22.

Fumigation with .04 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 11.5 hours; small amount of moonlight during the first three sets; moon and stars nearly obscured during the last two sets; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	81	68	67	65	65
Humidity (degrees),	63	72	78	78	72
White Spine,	N	N	BB	BB	BB
Hothouse,	SB	B	BB	BB	BB

Experiment XXIV.

Cloudy Night Exposures, April 8.

Fumigation with .01 gram KCN per cubic foot; plants two weeks old; amount of sunlight the day of treatment one-half hour; conclusions drawn after one week.

	Set Numbers.		
	1	2	3
Time of exposure,	7.05	7.50	8.50
Length of exposure,	30 m.	45 m.	1 h.
Temperature (degrees),	69	66	65
Humidity (degrees),	63	70	60
White Spine,	N	N	N
Hothouse,	N	N	N

Experiment XXV.

Cloudy Night Exposures with Plants of Various Ages, May 6, Nov. 19, 1907; April 27, 1908.

Fumigation with .01 gram KCN per cubic foot; no sunlight any of the days when treatment was given; conclusions drawn after one week.

	Set Numbers.						
	1	2	3	4	5	6	7
Age of plant (days),	10	10	10	10	10	33	16
Time of exposure,	7.00	7.25	8.00	8.45	9.45	9.10	7.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	2 h.
Temperature (degrees),	57	56	54	56	57	69	75
Humidity (degrees),	91	89	91	88	88	72	91
White Spine,	N	N	N	N	N	N	BB
Hothouse,	N	N	N	N	N	N	BB

Experiment XXVI.

Cloudy Night Exposures with Stronger Fumigation, May 10, 1907; April 27, 1908.

Fumigation with .015 gram KCN per cubic foot; plants of first five sets, two weeks old; of sixth set, sixteen days old; amount of sunlight the day of treatment of the first five sets, 7.4 hours; not taken for the sixth set; conclusions drawn after one week.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	7.10	7.40	8.15	9.00	10.00	9.10
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	65	61	57	57	55	72
Humidity (degrees),	79	77	83	78	84	93
White Spine,	N	N	N	N	SI	BB
Hothouse,	N	N	N	N	SI	BB

Experiment XXVII.

Cloudy Night Exposures with Older Plants, April 16.

Fumigation with .015 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, 11.5 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	71	71	72	74	76
Humidity (degrees),	55	60	63	68	68
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	SB

Experiment XXVIII.

Cloudy Night Exposures with Plants of Various Ages, April 25, May 13, 28.

Fumigation with .015 gram KCN per cubic foot; dim moonlight during treatment of the first three sets; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Date of treatment, ...	April 25	April 25	April 25	May 28	May 13
Time of exposure, ...	8.00	8.45	9.45	8.00	7.20
Length of exposure, ...	30 m.	45 m.	1 h.	1½ h.	2 h.
Temperature (degrees), ...	81	81	78	68	69
Humidity (degrees), ...	62	66	68	93	92
White Spine, ...	N	N	SB	SB	BB
Hothouse, ...	N	B	SB	SB	BB

Experiment XXIX.

Cloudy Night Exposures with Stronger Fumigation, May 15, Nov. 12, 1907; May 13, 1908.

Fumigation with .02 gram KCN per cubic foot; conclusions drawn after one week.

	Set Numbers.								
	1	2	3	4	5	6	7	8	9
Date of treatment, . .	May 16	May 16	May 16	May 16	Nov. 13	Nov. 13	Nov. 13	May 13	Nov. 19
Age of plants (days), .	9	9	9	9	17	17	17	20	23
Time of exposure, . .	7.45	8.10	8.50	9.40	6.30	7.45	9.30	9.30	6.30
Length of exposure, .	10 m.	20 m.	30 m.	45 m.	1 h.	1½ h.	1¾ h.	2 h.	2½ h.
Temperature (degrees), . .	66	63	63	61	58	58	56	66	71
Humidity (degrees), .	90	90	91	95	74	56	76	95	73
White Spine, . . .	N	N	N	N	N	N	N	K	BB
Hothouse, . . .	N	N	N	N	N	N	N	K	BB

Experiment XXX.

Cloudy Night Exposures with Older Plants, April 26.

Fumigation with .02 gram KCN per cubic foot; plants five weeks old; amount of sunlight the day of treatment, five hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	64	62	63	68	74
Humidity (degrees),	75	73	80	72	72
White Spine,	N	N	N	N	N
Hothouse,	N	N	N	N	N

Experiment XXXI.

Cloudy Night Exposures with Still Older Plants, May 9, 13.

Fumigation with .02 gram KCN per cubic foot; plants of the first five sets, fifty-one days old; of sixth set, thirty-eight days old; conclusions drawn after one week.

	Set Numbers.					
	1	2	3	4	5	6
Time of exposure,	7.00	7.25	8.15	8.55	9.55	9.30
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.	2 h.
Temperature (degrees),	61	58	55	54	53	66
Humidity (degrees),	81	88	91	91	92	95
White Spine,	N	N	SI	SB	B	K
Hothouse,	N	N	SI	SB	B	K

Experiment XXXII.

Cloudy Night Exposures with Stronger Fumigation, May 27.

Fumigation with .03 gram KCN per cubic foot; plants twenty days old; no sunlight the day of treatment; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.15	7.40	8.15	9.00	10.00
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees)	60	60	59	62	58
Humidity (degrees),	95	95	94	85	88
White Spine,	N	SB	SB	SB	SB
Hothouse,	N	SB	SB	SB	SB

Experiment XXXIII.

Cloudy Night Exposures with Older Plants, April 19.

Fumigation with .03 gram KCN per cubic foot; plants thirty-eight days old; amount of sunlight the day of treatment, four hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	64	64	66	68	68
Humidity (degrees),	74	74	73	73	72
White Spine,	SB	N	N	N	N
Hothouse,	N	N	N	SB	N

Experiment XXXIV.

Cloudy Night Exposures with Strong Fumigation, March 23.

Fumigation with .04 gram KCN per cubic foot; plants eleven days old; amount of sunlight the day of treatment, ten hours; conclusions drawn after two weeks.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	6.55	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	73	68	65	66	67
Humidity (degrees),	60	62	60	59	61
White Spine,	N	SI	SB	BB	VBI
Hothouse,	N	SI	SB	BB	VBI

Experiment XXXV.

Cloudy Night Exposures with Electric Light, April 29.

Conditions in this series of experiments were about like those of the preceding set, except that a 16 candle-power incandescent bulb hanging near the fumigating box was left turned on during the exposures.

Fumigation with .01 gram KCN per cubic foot; plants thirty-seven days old; amount of sunlight the day of treatment, 4.6 hours; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure,	7.00	7.25	8.00	8.45	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees),	72	70	72	68	67
Humidity (degrees),	55	58	78	82	82
White Spine,	N	N	SB	BB	BB
Hothouse,	SB	N	N	BB	BB

Experiment XXXVI.

Cloudy Night Exposures with Electric Light, Stronger Fumigation, May 2.

Fumigation with .015 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 8.2 hours; conclusions drawn after one week.

	Set Numbers.			
	1	2	3	4
Time of exposure,	8.00	8.25	9.00	9.45
Length of exposure,	10 m.	20 m.	30 m.	45 m.
Temperature (degrees),	65	60	59	59
Humidity (degrees),	85	72	85	83
White Spine,	N	N	SB	SB
Hothouse,	N	SB	SB	SB

Experiment XXXVII.

Cloudy Night Exposures with Electric Light, Still Stronger Fumigation, May 7.

Fumigation with .02 gram KCN per cubic foot; plants seven weeks old; amount of sunlight the day of treatment, 3.1 hours; rather cloudy and with a heavy mist during the treatment of the first three sets; cloudy during the last two treatments; conclusions drawn after one week.

	Set Numbers.				
	1	2	3	4	5
Time of exposure, ...	7.00	7.25	8.00	8.45	9.45
Length of exposure, ...	10 m.	20 m.	30 m.	45 m.	1 h.
Temperature (degrees), ...	65	63	63	63	62
Humidity (degrees), ...	72	84	84	86	86
White Spine, ...	N	SI	SB	BB	BB
Hothouse, ...	N	SI	SB	BB	BB

From the last three experiments it is evident that even an electric light near the plants which are being fumigated has an effect upon them.

Comments and General Conclusions.

BY C. W. HOOKER.

1. Day fumigation in direct sunlight is unquestionably unsafe, as the plants are badly injured or killed.

2. Fumigation on a cloudy day is unsafe at best, the plants being generally more or less injured.

3. Fumigation on a bright moonlight night is also unsafe, often causing much burning of the foliage.

4. The best results are obtained by fumigating on clear starlight nights, with little or no moonlight, and on dry, cloudy nights.

5. A clear, dry evening without moonlight, with a temperature in the house of from 55 degrees to 65 degrees, or a cloudy evening with the same temperature, offer the best conditions for fumigation. This should be followed by a thorough ventilation for at least fifteen minutes, and the temperature should be kept rather low for twenty-four hours thereafter.

6. A general survey of the experiments seems to indicate that a small amount of KCN with a longer exposure is preferable, to a large amount for a shorter exposure.

7. Individual results obtained here and there in the course of these experiments which seem to contradict the others may, in general, be accounted for by the condition of the plants,

which frequently, at least, in such cases were not as vigorous as the others, though this was avoided whenever possible.

8. Comparison of the results of these experiments on cucumbers with those of Mr. W. V. Tower on tomatoes shows that the former are much the hardier, successfully resisting more cyanide and longer exposures.

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MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.

GENERAL REPORT OF THE EXPERIMENT STATION.

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PART II.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-SECOND ANNUAL REPORT.

PART II.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

The papers presented in this part of the report treat a wide variety of subjects. These will be found in the table of contents. Many of the articles are of such a character that it is impossible briefly to summarize them. The articles themselves are concise, and those interested in the subjects should refer to them. Some of the more important of the conclusions may be stated as follows: —

1. A combination of fine-ground bone and low-grade sulfate of potash appears to constitute a satisfactory fertilizer for apple trees. The low-grade sulfate is much superior as a source of potash to the muriate, and basic slag meal seems likely to prove well adapted for use in the apple orchard as a source of lime and phosphoric acid.

2. Dried beet pulp at prevailing prices is not an economical food. The farmer should make it a rule to produce starchy or carbohydrate feeds, rather than to purchase them.

3. Dried molasses beet pulp is a very palatable food for dairy stock. It seems to be nearly equal to corn meal in its value for such stock.

4. Beet residues should be moistened before being fed; but while their use may occasionally be necessary, it should be the rule to buy foods rich in protein whenever it is necessary to supplement home-grown supplies.

5. Beet leaves may be fed to dairy stock with fairly satisfactory results, and may be used either fresh or in the form of silage; but they should not be largely used as food for cows producing milk for infants.

6. The factors which enter into the cost of milk are stated, and estimates based upon them show that the cost may be expected to vary (according to the quantity of milk yielded by the cows) from 3.86 to 5.18 cents per quart. The food cost of milk produced at the station during two years has been from 3 to 3.3 cents per quart. If other items of cost are added, it is believed that the total cost has amounted to a little more than 5 cents per quart, and that the cost of producing milk satisfactory in sanitary quality, and containing from 4 to 5 per cent. of butter fat, will usually be found to amount to from 4 to 5 cents per quart.

7. The extravagant claims made for the condimental and medicinal stock and poultry foods are not justified by the facts. They possess neither the food nor medicinal value claimed for them. It is pointed out that the healthy animal does not need medicine, and that medicines should rarely be used without the advice of a competent veterinarian.

8. Figures showing the composition of peat are presented, and its value for composts, as an absorbent and for direct application to light soils is pointed out.

9. Among the principal causes of injury from spraying the following are the most important: improper preparation of the spraying fluid and the meteorological conditions. Injury is more likely when spraying is carried on in damp, cloudy weather than in bright, sunny weather.

10. Very many of the more serious greenhouse diseases appear to be caused by faulty environment. The most skillful growers avoid most diseases by suitable attention to the composi-

tion of the soil, temperature, light, ventilation, etc. Spraying is seldom necessary.

11. Calcium benzoate proves ineffective as a spray for the prevention of rot in plums.

12. Examination of a large number of commercial seeds shows that the percentage of impurities and weed seeds is relatively large. There appears to be danger that Massachusetts will become the dumping ground for inferior seeds, since most of the neighboring States have enacted seed laws.

13. Further experiments confirm the favorable estimate earlier formed as to the beneficial effects of separation of seed for the removal of impurities and light and imperfect seeds on the germination, size and vigor of the young plants.

14. Among the leading causes of sun scorch of the foliage of the white pine, frost injury to the feeding rootlets in winter, hot, dry weather and drying winds appear to be the most important; although burning of the foliage is occasionally due to the action of a fungus. The diseases affecting the pine do not appear to be as serious as has been often represented.

15. Among the insects which were most prominent during the season of 1909 may be mentioned the elm-leaf beetle, San José scale and various kinds of plant lice. The article on "Insects of the Year" calls attention to the introduction of the leopard moth, which promises to be a serious pest, and to the continued spread of the brown-tail moth. It calls attention further to the discovery of an egg parasite of the asparagus beetle, which it is hoped will prove of great assistance in checking the ravages of that insect.

WM. P. BROOKS,
Director.

MANURING AN APPLE ORCHARD.

BY WM. P. BROOKS, DIRECTOR.

This article is based upon the results of experiments on the station grounds originally planned by Dr. C. A. Goessmann, when director of the old State Experiment Station. They have been in progress for twenty years. The leading results and conclusions only will be presented; but in order that readers may have a basis for judgment as to their significance and value, a brief statement of the conditions and plan of the experiment must be given.

Location and Soil.

The orchard is located on a moderate and fairly uniform slope, lying just to the west of a forest composed chiefly of chestnut and hemlock which covers the northerly part of College Hill. The soil is a strong and retentive gravelly loam, with fairly compact subsoil. It was originally somewhat overmoist in some places. In preparation for the orchard tile drains were put in to carry off the excess of water. In preparing the area for the trees a catch-water was placed at the head of the slope, so that the orchard is protected from surface wash from higher land. There can be no doubt that the moisture conditions are exceptionally favorable, for the water absorbed by the forest soil on higher levels to the east must constantly work through the soil downwards towards lower levels, thus furnishing a constant supply of moisture to the roots of the trees.

The soil is of a character naturally well suited for apples, except that, in common with all the soils of this part of the State, it is naturally deficient in lime. It is, however, the type of soil commonly selected in almost all parts of the State as naturally well suited for fruit.

Plan of the Experiment.

The area originally included in the experiment was considerably larger than that now occupied by the apple trees. Pears, plums and peaches as well as apples were planted, but neither of the first three fruits did well. A considerable number of the trees died, and after a few years all were removed.

The area devoted to apples is divided into five plots, all equal in area (about one-third acre). The plots were laid out and manures and fertilizers applied in accordance with the plan adopted one year before the trees were set, in 1889, during which year a hoed crop was cultivated. Each plot contains twelve trees, three each of Gravenstein, Baldwin, Roxbury Russet and Rhode Island Greening. The trees were ordinary nursery stock, two years old, when set in the spring of 1890.

Fertilization.

Each plot has been continuously fertilized in the same way each year since the date (1889) above mentioned. The annual rates per acre are as follows: —

Plot.	Fertilizer.	Pounds.
1	Barnyard manure,	20,000[1]
2	Wood ashes,	2,000
3	Nothing,	-
4	Bone meal,	600
	Muriate of potash,	200
5	Bone meal,	600
	Low-grade sulfate or potash (sulfate of potash magnesia),	400

All manures and fertilizers have invariably been applied broadcast in early spring. They were mixed with the soil so long as the orchard continued under cultivation, but since it has been in grass they have necessarily been left upon the surface.

[1] About 3⅓ cords.

Care of the Trees.

The entire orchard was carefully cultivated for the first five years after the trees were set, the area between the trees being occupied by hoed crops. Since 1895 the orchard has been kept continuously in mixed sod, grasses and clovers, except that during the first few years after it was seeded small circles immediately about the trunks of the trees were kept free from grass by hand culture. The product was cut, usually twice each season, made into hay and removed every year until 1902, when the trees first bore a large crop of fruit.

In 1902 the first crop was made into hay and removed, but the second crop was cut and left upon the ground. This practice has been followed annually since 1902. In seasons when rainfall is normal we cut over the orchard twice with the mowing machine; but during the past two seasons, which have been exceptionally dry, a single cutting has appeared to be sufficient. The orchard has been well cared for as regards pruning and spraying. The San José scale, however, obtained a foothold in it in 1901. It was discovered before serious damage had been done, and annual thorough spraying in spring with the lime and sulphur mixture has been sufficient to protect it from any serious injury from this pest.

Condition and Size of the Trees.

The trees have maintained for the most part a thoroughly healthy and normal growth. They have broad, low heads, well adapted for modern orchard methods. One tree has been lost in each of two plots, — a Gravenstein in plot 1 and a Russet in plot 4. These trees were promptly replaced, but the young trees have not yet come into bearing. The trees of all varieties exhibit considerable individual variations in size within each of the plots. To what these differences are due it is impossible to say. Possibly it may be attributed to differing individual characteristics in the trees themselves, for, as has been stated, they were ordinary nursery stock, and not known to have come in the case of any of the varieties from scions from the same parent tree. Variations in the amount of fruit produced would undoubtedly affect the growth of the trees, while it is of course possible that variations in the soil are responsible for the differences in growth. In spite of the fact of these individual variations, the trees of any particular variety in a given plot exhibit a fair degree of uniformity, and the averages presented below afford a good indication of the relative effects of the different systems of fertilization followed.

Average Circumference of the Trees.

Autumn, 1909.

	Inches.
Plot 1,	38.25
Plot 2,	33.23
Plot 3,	27.98
Plot 4,	32.27
Plot 5,	37.02

Yields of Fruit.

As has been previously indicated, the first fairly full crop of fruit was produced in 1902. Since that date the amount of fruit in different years has varied quite widely. The Baldwins have usually exhibited a strong tendency to produce fruit only in alternate years, the other varieties producing more moderate crops, as a rule annually. The following tables exhibit the nature of the results: —

Total Yield of All Trees to Date, including 1909.

Plot.	Pounds of Fruit.	Equal to Barrels per Acre.
1	24,934	556.3
2	12,841	286.6
3	3,940	87.9
4	14,453	322.6
5	21,863	488.0

Total Yield to Date for Each Variety.

PLOT.	Gravensteins.		Baldwins.		Russets.		Greenings.	
	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.
1	3,644.25	325.4	7,060.0	630.4	6,190.00	552.8	8,185.0	730.8
2	1,905.00	170.1	3,197.0	285.4	3,827.00	341.7	3,893.5	347.6
3	999.25	89.2	564.5	50.4	1,281.00	114.4	1,086.0	96.9
4	3,578.25	319.5	1,962.5	175.2	5,272.75	470.8	3,674.5	328.1
5	2,996.50	267.5	9,174.0	819.1	6,341.25	566.2	3,822.0	341.3

Yields of Each Variety in 1909.

PLOT.	Gravensteins.		Baldwins.		Russets.		Greenings.	
	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.	Pounds per Plot.	Barrels per Acre.
1	1,179.75	105.3	2,590.0	231.3	1,719.00	153.5	2,157.0	192.6
2	284.00	25.4	695.0	62.1	547.00	48.8	1,165.0	102.2
3	223.75	19.9	132.0	11.8	90.00	8.0	140.0	12.5
4	1,217.50	108.7	682.0	60.9	991.00	88.5	604.0	53.8
5	1,189.50	106.2	2,443.0	218.1	1,172.00	104.6	1,087.0	97.1

Attention is called to the fact that while the total yield of fruit upon plot 5 is materially greater than on plot 4, the yield of Gravensteins on plot 5 is inferior to that on plot 4. This may be in part accounted for by the fact that the Gravenstein row in plot 5 stood on the southern edge of the plot and within a comparatively short distance of a well-grown forest. It is believed that these trees were somewhat injuriously affected for a few years; but in 1908 this forest was cut back to a sufficient distance from plot 5 so that it is believed that this influence can no longer prove harmful. It will be noticed that in 1909 the yield of Gravensteins on plots 4 and 5 was practically equal.

The Quality of the Fruit.

In color and general attractiveness of appearance the fruit of the several plots has usually ranked in the following order: plots 2, 5, 4, 1 and 3. In the early years of the experiment the rank of the fruit in size was in the order: plots 5, 4, 1, 2 and 3. At the present time the apples on plot 1 take a higher relative rank, and in all cases where the quantity of fruit is not excessive the apples on plot 1 are usually larger than on any of the other plots.

A number of tests of keeping quality have been made, and in this respect the fruit has usually ranked in about the following order: plots 5, 4, 1, 2 and 3. The relatively low rank of the fruit from plot 2 in keeping quality appears to be connected with the fact that this fruit comes to maturity earlier than that on the other manured or fertilized plots. It will be noted that the fruit from plot 2 ranks highest in appearance. This is due to its superiority in coloring. This in turn is undoubtedly connected with the fact that the fruit is somewhat more mature. Such fruit might undoubtedly be kept if promptly put into cold storage; but in ordinary storage it is considerably inferior to the somewhat less thoroughly ripened fruit on the other manured plots.

The fruit from plot 5 has almost invariably been much superior in appearance to that produced on plots 1 or 4. Here again there have been individual variations in the product of the different trees of the same variety on all of the different plots. There has, however, been no doubt as to the fact that on the whole the product of plot 5 has been considerably superior in color and general attractiveness as well as in firmness of flesh to the product from plot 4; while the product from plot 1, which receives barnyard manure, ranks below either of the others in the qualities just mentioned. In general, the fruit produced on plot 5 shows a considerably brighter and clearer color than that on either plots 4 or 1. There can be no doubt that it would sell at a higher price in the general market than either of the others, although the difference between plots 4 and 5 is considerably less than between plots 1 and 5. The product of the unmanured plot, 3, shows good color and in some cases is of fair size, but in general is too small to command the best prices.

The Results discussed.

The most significant result of the experiment is the superiority of plot 5 as compared with plot 4. Reference to the tables will show that the trees are much larger and that they produce a much greater amount of fruit. It will be noted that both have annually received equal amounts of bone meal, and, since muriate of potash contains practically double the amount of actual potash contained in the low-grade sulfate, and is applied in one-half the quantity of the latter, it will be seen that both have received annually practically equal amounts of actual potash (at the rate of 100 pounds per acre). These two plots, therefore, have received annually applications supplying equal amounts of the three most essential elements of plant food, — nitrogen, phosphoric acid and potash. There is, however, one important difference in the applications made to the two plots. The low-grade sulfate of potash contains a large amount of magnesia; muriate does not supply this element. Whether the superior growth and fruitfulness of the trees on plot 5 is due to the magnesia supplied we cannot, unfortunately, feel certain. We know, indeed, that magnesia is an essential element of plant food. It is, however, an element which ordinarily appears to be supplied in sufficient quantities from natural sources. It is of course possible that there may be a natural difference in the soil of the two plots, although this is not believed to have been the case; or that the sulphuric acid combination with potash (sulfate) is better suited to the trees than the hydrocholoric acid of the muriate.

Experiments upon a larger scale to test the questions raised by the result of this experiment are now in progress.

This experiment shows most decisively that apple trees must be fed to grow well and bear well. The inferior results obtained on plot 3, which has been unmanured throughout the entire period of the experiments, strikingly establishes this point.

The manure used in this experiment is undoubtedly furnishing too large a proportion of nitrogen. The growth of the trees is rank; the foliage is heavy; the fruit is overgrown, coarse and inferior in color. In this particular experiment the combination of bone meal with low-grade sulfate of potash has produced results which, on the whole, must be regarded as the most satisfactory.

Cost of the Fertilizers.

The prices of the different materials used in this experiment have been subject to some variation from year to year. On the average the total cost has been at the rate of about $12 per acre for the materials applied to plots 2, 4 and 5. Barnyard manure, which is a home product, may be variously estimated. If purchased, the quantity applied would have cost somewhat more than either of the combinations of fertilizers employed. It may be that the cost of the fertilizers used in this experiment is excessive. For the twenty years it would, of course, amount to a large sum per acre; but in this connection it should be kept in mind that the crops produced (hoed crops and hay) up to the year 1902 were probably sufficient to cover the cost of the materials applied. The weights of hay were not at first taken; but from 1897 to 1901 the total product of the five plots, 1⅔ acres, amounts to about 27 tons, which must have had a value, when standing, of at least $6 per ton, or a total value of $162. During these five years the value of the manure and fertilizers applied to the four plots amounted to about $28 annually, or $140 for the five years. On this basis the fertilizer cost appears to have been lower than the value of the hay crops. Certainly it will not be the opinion of those qualified to judge that the fertilizer cost is excessive for a bearing orchard. The product of single trees this year on each of the manured plots was worth more than the entire cost of the fertilizers applied per plot.

How an Orchard should be fertilized.

No one familiar with such matters will for a moment believe that any one selection of materials can always be best. Certainly the writer is not disposed to claim that he knows what is the best selection of materials. The combination of bone meal with low-grade sulfate of potash in this experiment has produced satisfactory results. It seems likely that in many cases similar results would be obtained. It is the writer's belief, however, supported not alone by his own work, but by results obtained by some well-known private growers, that on soils naturally deficient in lime, basic slag meal might wisely be used in place of the whole or a part of the bone. It should be remembered, however, that the bone furnishes some nitrogen as well as phosphate of lime, while basic slag meal contains no nitrogen. It does, however, supply lime in a considerably larger proportion than the bone, and this is likely to prove valuable on the class of soils under consideration. In some cases it might be advisable, in connection with basic slag meal and low-grade sulfate of potash, to give an occasional very light dressing of manure, to furnish nitrogen; although it is probable that by the introduction of a legume as a cover crop the necessary nitrogen may be obtained from the air.

Practical Suggestions.

For orchard top-dressing the following fertilizer formulas are recommended. In each case the amounts given are intended for an acre.

Formula.	Fertilizer.	Pounds.
No. 1,	Bone meal,	600-800
	Low-grade sulfate of potash,	350-400
No. 2,	Basic slag meal,	800-1,000
	Low-grade sulfate of potash,	350-400
No. 3,	Basic slag meal,	600-800
	Low-grade sulfate of potash,	300-350

The materials recommended should be mixed and applied in early spring. In the case of trees ten or more years of age the mixture should be applied broadcast, covering the entire surface, with the exception of circles about the trunks of the trees equal in diameter to one-third to one-half of the spread of the branches. There will be few feeding roots within such circles. The practice of piling manure or spreading fertilizers close to the trunks of trees is not to be recommended. Manure in contact with the base of the trunk increases the probability of injury from insects or vermin, and neither manure nor fertilizer so placed is in position to exert its fullest influence in feeding the trees.

Formula No. 1 is likely to prove most valuable on the lighter orchard soils. It supplies a little nitrogen, in which such soils are often deficient and which they have little capacity to hold. If these soils are deficient also in lime, as is likely to be the case, an application at the rate of 1,500 to 2,000 pounds per acre before the trees are set, and a further application at the rate of 600 to 800 pounds per acre once in five or six years, will prove useful.

Under this system clover will become abundant in the orchard kept in sod, while such cover crops as soy beans, vetches or clovers will thrive if tillage is practiced. Under either the sod or tillage system, therefore, a sufficient supply of nitrogen will be brought within the reach of the trees.

Formula No. 2 will prove well suited for use on the medium or heavy soils. It supplies no nitrogen, but creates soil conditions peculiarly favorable for the coming in of clovers in the sod, or nitrogen-gathering cover crops in tilled orchards. Under these conditions it seems likely that sufficient nitrogen will be brought within reach of the trees. If, however, the growth of the trees is not satisfactory, a small amount of nitrate of soda, 100 to 125 pounds, may be added.

Formula No. 3 differs from No. 2 only in supplying the slag and low-grade potash in smaller amounts. This formula is suggested for use in those cases where it is convenient and regarded as desirable to employ some manure in the orchard. It is not the writer's belief that it will usually pay to purchase manure for such use, but in so far as it is available as a home product its use in moderate quantities may be advisable. Manure, however, supplies nitrogen in relative excess for fruit trees. It seems wise, therefore, to supplement it with materials like slag meal and low-grade sulfate of potash, which will supply additional phosphoric acid, lime and potash. It is not the writer's belief that it will usually be best to use manure in top-dressing orchards in annual amounts in excess of about 1½ cords per acre.

Sod or Tillage.

The fact that the orchard in which the experiments upon which this article is based have been tried has been kept in sod since 1895 should not be regarded as indicating that the sod system is held to be always superior to the tillage system. Both systems have their advocates. The question whether sod or tillage is better cannot be regarded as settled; indeed, as an abstract question it never will be settled. Each has earnest advocates; but the fact undoubtedly is that neither system is always best. The best must vary with conditions. Neither system possesses all the advantages.

It is not proposed to enter upon a full discussion of the subject here, but simply to present such statements as seem necessary to guard against misunderstanding.

The experiments here reported do not directly bear upon the question. No comparison of the two systems has been made. It will be admitted that the trees in this orchard have made good growth and produced a fair amount of fruit. In estimating the significance of these facts the character of the soil must be kept in mind. It will be remembered that it is strong and retentive, and that the moisture conditions are good. Under such conditions, trees as well as grass find their need of water abundantly supplied.

Whether or not the trees will be abundantly supplied with moisture must, in the writer's judgment, determine in any particular case whether an orchard should be kept in sod. On the lighter or gravelly soils there is always danger that the grasses will rob the trees of needed water. It is an easy matter to supply plant food both for grass and trees, but not so with water. On soils inclining to be dry the moisture must be carefully conserved for the trees, and such tillage as will maintain a dust mulch during the spring and early summer (Hale's horse leg irrigation) is necessary for good results.

It is of course true that allowing the grass and clovers to remain on the ground when cut, as has been the practice in our experiments, will provide a partial mulch which will help retain moisture in the orchard soil; but, even if this course be followed, there is danger of water shortage at critical times in orchards upon light or gravelly soils with subsoils of open texture, provided they are kept in sod. This danger is much reduced if the grass produced in the orchard is gathered and spread under the trees, thus providing a heavy mulch; but, while this fact is everywhere admitted, a large proportion of the most progressive orchardists practice tillage in spring and early summer, sowing a cover crop in late summer to furnish organic matter and nitrogen, and in many cases to protect from injurious soil washing during the late fall, winter and early spring rains.

BEET RESIDUES FOR FARM STOCK.

BY J. B. LINDSEY.

1. Dried Beet Pulp.

Dried beet pulp represents the residue in the manufacture of sugar from sugar beets. It is first run through presses to reduce its water content as much as possible, and then put into kilns where it is thoroughly dried by direct heat.

Composition of the Product.

The prepared product is very dry, coarse and of a grayish color. It contains substantially 9 to 12 per cent. of water, about 4 per cent. of ash, 8 per cent. of protein, 18 to 20 per cent. of fiber, 60 per cent. of extract matter and less than 1 per cent. of fat. The fiber is quite soft, being free from incrusting substance and hence quite digestible.

Digestibility of the Dried Pulp.

No digestion experiments made in this country are recorded. German experiments show it to have a digestibility of 77 per cent.; corn silage made from mature dent varieties shows an average digestibility of 66 per cent.; and corn meal 88 per cent.

Dried Pulp as a Substitute for Corn Silage.

Wing[1] compared the wet pulp with corn silage, feeding 50 to 100 pounds daily, together with 8 pounds of grain and 6 to 12 pounds of hay, and concluded that the dry matter in the pulp was of equal value, pound for pound, with the dry matter found in the silage. The milk-producing value of wet beet pulp as it

[1] Bulletin, No. 183, Cornell Experiment Station.

comes from the factory [1] is, pound for pound, about one-half that of corn silage.

Billings [2] compared the dry pulp with corn silage, and concluded that the pulp ration gave 10.2 per cent. more milk than did the silage ration; but, because of the cost of the dried pulp, it was more economical to feed silage. In his trial the cows receiving the pulp ration lost in flesh.

The fact must not be overlooked that the dried pulp is a carbohydrate, similar in chemical composition to corn silage and corn meal. It is believed that 5 tons of silage is substantially equivalent in feeding value to 1 ton of the dried pulp. Putting the value of the 5 tons of silage at $20, the ton of pulp should be bought for the same money, whereas its present cost is some $26. It is believed, under present conditions, not to be good economy for farmers to buy pulp to be used in place of home-grown corn silage, the farm being the place for the production of carbohydrate food stuffs.

Beet Pulp as a Substitute for Corn Meal.

On the basis of digestible dry matter in dried pulp and corn meal, the former is worth 90 per cent. of the latter. According to Kellner the dried pulp has substantially 80 per cent. as much value as corn meal.

2. Dried Molasses Beet Pulp.

Beet pulp, after it has been pressed to remove the excess of water, is mixed with residuum beet molasses and the mixture put into driers where it is thoroughly dried by direct heat. This product, similar to the plain pulp, is quite dry, coarse, and resembles in its appearance ordinary black tea.

Composition and Digestibility.

The molasses beet pulp does not vary much in the percentages of the several fodder groups from ordinary pulp. It usually tests slightly higher in protein and ash and a little lower in fat.

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[1] Only those living in the immediate vicinity of the factory can afford to use the wet pulp. It is worth not over $2 a ton on the farm.

[2] Bulletin, No. 189, New Jersey Experiment Station.

The average of three analyses of molasses beet pulp made at this station is as follows: —

Composition.	Molasses Beet Pulp (Per Cent.).	Corn Meal for Comparison (Per Cent.).
Water,	8.00	14.00
Ash,	5.40	1.30
Protein,	9.50	9.80
Fiber,	15.40	1.90
Extract matter,	61.30	69.20
Fat,	.40	3.80

The pulp differs from corn meal in having rather more of its protein in the form of amids, in containing more ash and less fat. Its carbohydrates are in the form of fiber, gums and sugar, while the carbohydrate of corn meal is practically all starch.

Our own experiment [1] on the digestibility of the molasses beet pulp carried out with two sheep is the only one on record. It shows it to be 85 per cent. digestible, as against 77 per cent. for the plain pulp. These results, however, are hardly comparable, as the latter figure represents the average of German experiments. In any case the molasses pulp has a high relative digestibility, and is not very much inferior in this respect to corn meal.

Molasses Pulp for Dairy Stock.

Billings [2] compared the dried molasses beet pulp with the plain dried pulp, and secured a trifle more milk with the former. He likewise compared it with hominy meal, and secured some 4 per cent. more milk as a result of its use.

Our own experiment, made in 1903,[1] comparing it with corn meal, resulted in an increase of 5 per cent. of milk when the corn meal was used. It is believed, however, to be a satisfactory carbohydrate food, slightly superior in its nutritive effect, as well as in palatability, to the plain dried pulp.

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[1] Bulletin 99, Hatch Experiment Station.

[2] Already cited.

3. How Beet Residues should be fed.

Dried beet pulp absorbs a great deal of water, and in case it is fed dry, this absorption will take place in the mouth and stomach, and is likely to cause choking, indigestion and stomach irritation. It should be first moistened with two to three times its weight of water, and the dry grain mixed with it.

Daily Grain Rations containing Dried Beet Residues.

(*a*) *Dairy Cows.*

I.	II.
3 pounds distillers' grains. 4 pounds dried plain or molasses pulp.	1.5 pounds gluten feed. 1.5 pounds cotton-seed meal. 4.0 pounds dried beet pulp.
III.	**IV.**
2 pounds gluten feed. 2 pounds flour middlings. 3 pounds dried beet pulp.	2 pounds wheat bran. 2 pounds cotton-seed meal. 4.05 pounds dried beet pulp.

(*b*) *To supplement Pasturage.* — By weight one-half of dried beet pulp and one-half gluten feed; or one-third dried beet pulp, one-third gluten feed and one-third wheat bran; or two-thirds beet pulp and one-third distillers' grains would prove desirable combinations (feed from 3 to 7 pounds daily depending upon requirements).

(*c*) *For fattening Stock.* — It should prove satisfactory for fattening beef animals, in the proportion, by weight, of two-thirds beet pulp and one-third cotton-seed meal. The material is hardly to be recommended for swine and horses.

The Place of Dried Beet Residues in the Farm Economy.

Farmers who are in position to produce their own feed cannot afford, as a rule, to purchase starchy feed stuffs; they should be produced upon the farm, in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cotton-seed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feed stuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-half) of the daily ration.

4. Beet Leaves.

Every autumn the station is in receipt of inquiries concerning the value of beet leaves for feeding purposes. In order to answer these inquiries the following information is submitted: —

Composition and Digestibility.

The leaves have the following average composition:[1] —

	Per Cent.
Water,	89.30
Ash,	1.80
Protein,	2.30
Fiber,	1.50
Extract matter,	4.70
Fat,	.40

From the above analysis it is evident that the leaves contain a great deal of water and on the basis of dry matter are relatively rich in protein and ash and poor in fiber. The leaves contain 20 to 37.7 per cent. of their nitrogen in the form of amids. The ash contains a large amount of oxalic acid (3.5 per cent. of the dry matter), and in the extract matter varying amounts of dextrose and lævulose have been recognized.

According to F. Lehmann,[2] sheep digest 61 per cent. of the crude protein, 52 per cent. of the fat and 75 per cent. of the extract matter.

How to feed the Leaves.

Beet leaves are best suited for dairy cows and for fattening cows and steers. They are less suited for young stock, swine, horses and sheep. Fed in too liberal quantities they have a decidedly laxative effect, and likewise cause indigestion. This is due to the oxalic acid and inorganic ash constituents. The same bacteria which in the paunch of the bovine produces lactic

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[1] E. Pott, Handbuch der Thier. Ernährung, etc. Zweite Auflage, II. Bd. S. 201.

[2] See E. Pott, already cited, p. 202.

acid act to an extent upon the oxalic acid and partially decompose it. It is advisable to feed not over 50 pounds daily of the green leaves to dairy cows, together with dry hay and grain. In case of cows that are near to calving one-half of this amount is preferable. It is stated that dry cows and thin steers will take larger amounts without bad effect.

German observers have found it helpful, in order to guard against the unfavorable action of the oxalic acid, to feed 1 ounce of precipitated chalk to every 50 pounds of leaves. It is not advisable to feed the leaves when the milk is intended for young children. Before feeding, the leaves should be made as free from soil as possible. This can in a measure be accomplished by shaking off the dirt with the aid of a fork, or by placing them in slatted drums or on sieves made of slats. It is not economical to wash them, as too much of the water-soluble nutrients is lost.

Beet leaves may be ensiled, and thus treated have been found to be less laxative in their effect. The oxalic acid is also partly decomposed. The leaves should be allowed to wilt, freed from excessive earth or sand, and then placed in pits in the earth or in ordinary wooden silos and thoroughly tramped. Excess of moisture is to be avoided. In case of necessity the leaves may be placed in small piles, and will keep very well for from one to two weeks. The ensiled material contains approximately 76 per cent. of water, and E. Wildt[1] has shown it to have the following percentages digestible: —

	Per Cent.
Protein,	65
Fat,	60
Extract matter,	54

It is not advisable to feed to cows over 25 pounds daily of the ensilage, together with hay, straw and grain. Larger amounts frequently act unfavorably on the animal, and are likely to produce a strong taste in the milk. German authorities are inclined to prefer the ensiled to the fresh leaves, especially if the latter are at all frosted or decayed.

[1] *Loco citato*, p. 207.

THE COST OF PRODUCING MARKET MILK.

BY J. B. LINDSEY.

It is impossible to determine just how much it costs to produce a definite amount of milk, as so many factors enter into the problem. Among such factors may be mentioned fertility of the farm, skill in management, kind of buildings and utensils employed, quality and care of dairy stock and care of the resulting product. It is the belief of the writer that in the past a great deal of milk has been made and sold for less than the cost of production. In making an attempt to gain a temporary livelihood from dairying, many have sacrificed the fertility of their farms, employed the most primitive methods of housing and caring for the dairy stock, and the family has cared for the milk and for the dairy utensils without credit. Now that the health authorities are demanding better dairy methods, the dairyman is indeed confronted with a serious problem, namely, how can he conform to these requirements, and produce milk at a reasonable profit? The writer sees no way out of the dilemma other than to teach the public to appreciate the highly nutritious character of milk, and to educate it to pay a price commensurate with the increased cost of producing a reasonably sanitary article. An attempt has been made, in the figures which follow, to estimate the cost of producing a definite amount of milk containing 4 per cent. of butter fat, which will meet the ordinary requirements of the city boards of health. The figures per quart mean the wholesale price at the farm, and do not include profit to the producer, other than the fact that he sells all of his roughage and whatever grain he may produce upon his farm at market rates. If he cares for his own cattle, he is allowed a reasonable compensation. It would probably be no more than fair to add to the cost per quart 10 per cent. for actual profit. In order to determine the retail price to the consumer, the cost of delivery to wholesale centers as well as the cost of retail distribution should be added.

Estimated Cost of Milk Production per Cow.

Basis 20 Cows.

1. Building for housing cow and feed (per cow),	$75 00	
Interest, taxes, depreciation, repairs and insurance, 10 per cent.,	–	$7 50
2. Value of cow,	75 00	
Interest and taxes, 6 per cent.,	–	4 50
Depreciation, 20 per cent.,	–	15 00
3. Value of carpenter's tools (per cow),	80	
Interest and depreciation, 15 per cent.,	–	12
4. Value of barn tools (per cow, — farm scale, shovels, forks, trucks for grain, manure, etc.),	2 28	
Interest and depreciation, 15 per cent.,	–	34
5. Value of dairy implements (per cow, — milk pails, scale, Babcock tester, strainers, hot water heater, cleaning brushes, etc.),	3 35	
Interest and depreciation, 15 per cent.,	–	50
6. Value of perishable tools and supplies (per cow, cards, brushes, record sheets, soap, salt, ice, bedding, bull service, veterinary, etc.),	–	11 86
7. Value of food consumed for one year: —		
40 pounds of silage daily for 224 days (7½ months), at $3.75 a ton,	16 80	
12 pounds of hay daily for 224 days (7½ months), at $17 a ton,	22 85	
8 pounds of grain daily for 224 days (7½ months), at $32 a ton,	28 67	
20 weeks' pasturage, at 30 cents per week,	6 00	
One-third cost of food (basis of winter feeding) while at pasture,	14 93	
		89 25
8. Care of cow and milk for one year,		30 00
		$159 07

Credits.

5 cords manure,	$20 00	
1 calf each year,	2 00	
		22 00
Net cost of one cow for one year,		$137 07

Cost of Milk per Quart.

$137.07 ÷ 2,660	quarts	(6,000 pounds)	= 5.15	cents per quart.
137.07 ÷ 2,930	quarts	(6,500 pounds)	= 4.68	cents per quart.
137.07 ÷ 3,100	quarts	(7,000 pounds)	= 4.42	cents per quart.
137.07 ÷ 3,330	quarts	(7,500 pounds)	= 4.12	cents per quart.
137.07 ÷ 3,550	quarts	(8,000 pounds)	= 3.86	cents per quart.

It must be remembered that the above figures are intended only as an estimate. The value of the barn for housing 20 cows is estimated at $1,500; some may consider this a low estimate, others a high one. The cost of food for one year is intended for cows weighing from 1,000 to 1,200 pounds and producing at least 7,000 pounds of milk yearly. The food cost for smaller cows, weighing 750 to 900 pounds and producing 6,000 pounds of milk, would be $6 to $8 less.

The care of the cow and the milk for one year has been estimated by different individuals at from $18 to $45. It is believed that $30 represents a fair average.

It will be noted that the food is by far the largest cost item. Thus, the food is estimated at $89.25 and the other expenses at $47.82, after an allowance of $22 for manure and calf. Otherwise expressed, the housing and care of the animal and its products represents substantially 50 per cent. over the cost of food. The figures show that the cost of producing a quart of average milk varies from substantially 4 to 5.15 cents.

Food Cost of Milk produced by Station Herd.

The station keeps from ten to twelve cows, mostly pure-bred or grade Jerseys, for the purpose of carrying out a variety of experiments in studying the value of different foods for milk production, and for noting the effect of foods upon the composition of milk and butter fat. An exact record of the cost of the milk produced by this herd has been kept since 1895. In this connection a résumé of the record is presented for the years 1907 and 1908. At this writing the 1909 cost has not been tabulated.

1907.

No. of Cows.	Total Yield (Pounds).	Per Cent. Fat.	Per Cent. Solids.	Cost of Food consumed.	Cost of 100 Pounds of Milk.	Cost of 1 Quart Milk (Cents).
12	56,492.0	5.37	14.85	$766 01	$1 44	3.2
7[1]	41,120.9	-	-	547 35	-	3.0

1908.

No. of Cows.	Total Yield (Pounds).	Per Cent. Fat.	Per Cent. Solids.	Cost of Food consumed.	Cost of 100 Pounds of Milk.	Cost of 1 Quart Milk (Cents).
12	64,238.6	5.00	13.98	$932 74	$1 45	3.30
9[1]	50,755.6	4.98	13.91	739 85	1 46	3.30

During each year twelve cows were kept, but only seven and nine respectively remained during the entire year. The average yield per cow for the seven cows in 1907 was 5,874.4 pounds, the food cost per cow was $78.19 and the cost of a quart of milk 3 and 3.2 cents. In 1908 the yield per cow in case of nine cows was 5,639.5 pounds (2,564 quarts), the food cost per cow $82.21 and the food cost per quart of milk 3.3 cents. It will be remembered that these were grade and pure-bred Jerseys, producing 5 per cent. milk. Seven of the cows were pastured about two months each, *i.e.,* during the time they were dry. The remainder of the summer they, in common with the others which did not go to pasture, were fed hay, soiling crops and grain. It was obviously not possible for us to keep an exact record of the cost of care of cow and milk, for the reason that these animals were not kept for producing market milk, but for experimental purposes.

If to the yearly cost of food ($82.21) is added $47.82, representing the estimated cost of housing and caring for the animal and her product,[2] we have $130.03, which, divided by the number of quarts of milk produced (2,564), gives 5.07 cents as the cost of one quart of 5 per cent. milk. Another way of getting at substantially the same result is to add 50 per cent. (representing the cost of housing and care) to 3.3 cents, the food cost of a quart, which makes 4.95 cents, or, in round numbers, 5 cents. The general statement may be made that it is

[1] Kept during the entire year.
[2] $39.82 + $30 = $69.82 — $22 = $47.82. (See previous page.)

likely to cost the average producer from 4 to 5 cents a quart to produce milk of satisfactory sanitary quality, testing from 4 to 5 per cent. of butter fat.

Milk produced under more than average sanitary conditions, or certified milk, will naturally cost considerably more than the figures presented in these estimates.

CONDIMENTAL AND MEDICINAL STOCK AND POULTRY FOODS.

BY J. B. LINDSEY.

Several years ago the station made quite an exhaustive study of the composition of this class of feeds, and published its results in Bulletin No. 106, the edition of which has long since been exhausted. It is intended in what follows to give a résumé of the most important points made in the bulletin, in order to answer the frequent inquiries which come to the station concerning them.

It is not thought advisable to publish in this connection the detailed composition of each brand as it was given in the bulletin, as it may have been modified to some extent since the examination was made. It is believed, however, that the following statements will prove sufficient to enable every one to form a correct opinion concerning their general character, commercial value and utility.

Basic or Food Ingredients.

The chemist and microscopist have found these foods to consist principally of ordinary grains and concentrates, such as wheat by-products (bran and middlings) and corn meal. In some cases a few hundred pounds to the ton of linseed, cottonseed and occasionally meat and bone meal have been added, obviously to increase the amount of protein; such mixtures contained from 10 to 20 per cent. of that nutrient. Occasionally the presence of considerable quantities of mustard hulls, cocoa shells and weed seeds are noted, used evidently as a filler.

The poultry foods more frequently reveal the presence of from 10 to 50 per cent. of ground oyster shells or noticeable quantities of ground bone, which accounts for the exceptionally high ash percentage.

Nutritive and Commercial Values of the Food Ingredients.

It having been shown that the bulk of these foods is made up of ordinary ground grains and by-products, it must be evident to all that they cannot have a greater nutritive value than is to be found in the materials of which they are composed. The extravagant claims made by the manufacturers concerning their wonderful nutritive properties is in no way substantiated by the analytical results. It also must be clear that their commercial value from a nutritive standpoint cannot exceed 1 to 1½ cents a pound. Certainly no one would entertain the idea of purchasing these mixtures, at the prices asked, because of any particular nutritive value they may possess.

Character of Medicinal Ingredients.

In addition to the various cereals and by-products, these foods contain small quantities of a variety of substances, most of which possess simple medicinal qualities, to which it is understood is attributed the wonderful nutritive and curative properties claimed for them. The *condition powders,* so called, generally contain larger quantities of these medicines than the stock and poultry mixtures. The medicinal substances are described as follows: —

Fenugreek and *fennel* are the ground seeds of plants grown in southern Europe, known botanically as *Trigonella Fœnum Græcum* and *Fœniculum vulgare.* They are aromatic substances, used to excite the action of the stomach, thereby relieving indigestion and gas, and also to impart an agreeable flavor. It was formerly believed that fenugreek increased the quantity and improved the quality of milk, but such ideas are now largely exploded. The quantity used is comparatively small.

Anise or Aniseed (*Pimpenella Anisum*) is the seed of a plant cultivated in Spain and Malta. It has a pleasant warm taste and an agreeable odor, and is used for much the same purpose as fenugreek.

Gentian, occasionally recognized, is the dried root of the plant known as *Gentiana lutia,* and is grown in central and southern Europe. It is very bitter, and is used as a stomach tonic, promoting an increased secretion of the gastric juice.

Ginger is the powdered underground stem of *Zingiber officinale,* grown principally in India and the West Indies. It stimulates the various membranes with which it comes in contact, and is used as an appetizer and to reduce the griping effects of purgatives.

Pepper, the common black form, is obtained from the brown berries of an East India climbing plant, *Piper nigrum.* Cayenne pepper consists of the dried ripe fruit of *Capsicum fastigiatum* and *annum.* Both kinds are used as a stomachic and to increase the activity of the reproductive organs.

Salt, of which many of the mixtures contained from 2 to 20 per cent., was used as an appetizer.

Sulfates of magnesia and soda, in the form of Epsom and Glaubers salts, are purgatives, and are frequently spoken of as "salts."

Saltpeter, nitrate of potash or niter, is used in medicine to excite the action of the kidneys and to reduce fever.

Sodium bicarbonate is employed to neutralize an undue acidity of the stomach.

Sulphur is used as a laxative, alterative, and as a stimulant of mucous surfaces.

Iron found as the oxide — Venetian red or Princess metallic[1] is not used medicinally, but is employed to color or disguise the real character of the food. Sulfate of iron used as a restorative and tonic was seldom identified.

Charcoal. Its medicinal value consists in its ability to check fermentative changes, and to absorb undesirable gases. In most cases it appears to have been ground fine and mixed with the other ingredients to conceal their identity.

Tumeric, the powdered root of an East Indian plant, the *Curcuma longa,* is a stomachic, but is used principally as coloring matter.

Quantity of Medicinal Ingredients.

No attempt was made to determine the exact quantity of each of the several drugs employed. Most of the foods contained from 5 to 40 per cent. of ash. Ordinary grains and by-products rarely contain more than 5 per cent. of ash; the excess in the

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[1] Dry paints.

present cases was made up of such mineral substances as oyster shells, bone, sand, common salt (2 to 20 per cent.), Epsom or Glaubers salts (about 5 per cent.), niter (1 or more per cent.) and Venetian red. The vegetable drugs — fenugreek, fennel, anise, gentian, ginger and pepper — were employed in sufficient quantities to produce an agreeable odor and smart taste, probably in quantities varying from 5 to 10 per cent. of the whole mixture. In some cases the total quantity of mineral and vegetable drugs constituted from one-sixth to one-third of the mixture, while in other cases the amount of such substances was very much less.

Cost and Selling Price compared.

None of the mineral drugs, excepting niter, cost much over 1 cent a pound; the vegetable drugs vary in price from 3 to 12 cents a pound. Judging from all the data at hand, the cost of the entire mixtures — grains and drugs — could rarely have exceeded 3 to 4 cents a pound. In many cases it could not have been more than 2 cents a pound.

The initial cost of the condition powders is probably somewhat greater than the ordinary stock foods. The retail prices of the latter vary from 6 to 25 cents a pound, depending on the brand and quantity purchased. Condition powders are much higher priced, varying from 30 cents to $1 a pound. Is it not strange that many are willing to pay extravagant prices for materials possessing such ordinary feeding and medicinal values? It is hoped that poultrymen have sufficient common sense to purchase bran, corn meal, salt, oyster shells, charcoal and meat scraps separately, rather than pay from 10 to 20 cents a pound for such mixtures put up in attractive packages, for which the manufacturers make the most astounding and unreasonable claims.

Utility of these Foods.

Their food value cannot be greater than the ordinary grains, of which they are largely composed. Their medicinal value depends largely upon the aromatic seeds and roots used as a tonic for the stomach, on charcoal as an absorbent and on the purgative effect of the Epsom or Glaubers salts. The quantity recommended to be fed daily is usually so small (1 ounce or less) that very little if any effect can be expected unless the material is fed for a considerable length of time. While it is probably true that some of these stock foods may prove beneficial under certain conditions, it is also true that most of them are heterogeneous mixtures, and evidently put together by parties quite ignorant of the principles of animal physiology, pathology and veterinary medicine.

Claims made by Manufacturers.

The following are the principal claims made by one of the largest manufacturers of stock and poultry foods: —

Horses. — Gives greater speed endurance. Imparts new life and strength. Makes colts grow very rapidly and keeps brood mares and colts healthy. Guaranteed to save corn and oats. Makes horses fat, gives glossy coat and fine appearance.

Cattle. — Increases the milk yield 15 to 25 per cent. and increases the richness of the milk. Removes taint from milk, cream and butter, and makes milk more healthful for human use. Such milk will convey some of the beautiful elements of the vegetable ingredients we use into the systems of your children, and they will be stronger to ward off disease. Makes calves grow as fast as new milk. Saves thirty days' time in fattening cattle, and 15 to 25 per cent. of the grain usually required.

Hogs. — Cures and prevents hog cholera, and is the quickest hog grower ever discovered. Makes juicy and tender meat.

Poultry. — It prevents disease and cures chicken cholera. It greatly increases egg production and makes chickens grow very rapidly.

The amount advised to be fed daily to horses and cattle to accomplish these marvelous results is two-thirds of an ounce! The material costs 14 cents a pound in 25-pound lots.

The Connecticut, Pennsylvania, Rhode Island, Virginia, Iowa, South Dakota and Massachusetts stations have found this stock food to consist principally of wheat (bran and middlings), to which has been added fine charcoal, a bitter substance resembling gentian, cayenne and common salt. Another large manufacturer makes essentially the same claims as above, and the material sells at 6 cents a pound in 25-pound lots. The same experiment stations found it to be composed largely of corn meal, with small quantities of fenugreek, gentian, charcoal and salt.

Farmers, dairymen and poultrymen: What would be your opinion of any experiment station worker who would make such statements concerning the nutritive, medicinal or commercial value of corn meal, wheat bran, charcoal, gentian and salt? Do you think there is any humbug in the claims made by the manufacturers of such goods? *The question is left for you to decide. You may be the judge.*

Do Healthy Animals need Medicine?

Dr. Paige, the veterinarian at this college, very pointedly expresses the most advanced views of the profession when he says, "Animals in a state of health do not need condition powders or tonic foods. There is in the body of a healthy animal a *condition of equilibrium of all body functions.* The processes of digestion and assimilation are at their best. All that is required to maintain this condition of balance is that the animal be kept under sanitary conditions, and receive a sufficient supply of healthful, nutritive food and pure water. While tonics may improve the appetite so that the animal will temporarily consume and digest more food, should this increased quantity of nutrients consumed not be appropriated by the tissues of the body, harm may result from thus overloading the lymphatic system, or from an increased action of the excreting organs."

Treatment of Sick Animals.

The writer believes it unwise to give drugs to animals when it can possibly be avoided. Even such simple substances as "salts," ginger, gentian and the like should be used as sparingly as possible. If an animal is out of condition, and it is believed a tonic will be helpful, try the following, suggested by Bartlett of the Maine station: "pulverized gentian, 1 pound; pulverized ginger, ¼ pound; pulverized saltpeter, ¼ pound; pulverized iron sulfate, ½ pound. Mix and give one tablespoonful in the feed once a day for ten days, omit for three days, then give ten days more. Cost of the above, 20 cents a pound."

In exceptional cases, when skilled medical treatment appears absolutely necessary, it is far wiser to employ a reliable veterinarian than to attempt home doctoring by the indiscriminate use of patent medicines or powders recommended to cure everything.[1]

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[1] This bulletin does not decry the various veterinary medicines put up by pharmacists and veterinary surgeons for the use of stockmen. The claims made for them are, as a rule, quite reasonable, and they unquestionably have their proper sphere of usefulness.

THE UTILIZATION OF PEAT IN AGRICULTURE.

BY H. D. HASKINS.

Peat is composed largely of partially decomposed vegetable matter. In its natural condition, when found in the swamp, it is very dark or nearly black in color and contains about 80 to 90 per cent. of water. The limited use of peat dates back many years, before the introduction of the commercial fertilizer, but in the early history of its use little was known regarding its chemical composition. It was used as a supplement to farmyard manure and to improve the mechanical condition of light, sandy and gravelly soils. If we should measure the value of peat for agricultural purposes from the standard of a chemical analysis, the standard by which the worth of all commercial manurial substances is established, we would find that its greatest value lies in its organic nitrogen-containing constituents, which means the organic combinations commonly known as humus.

During the past fifteen years there have been many analyses of peat made at this laboratory. These analyses, 55 in number, and representing products from every county in the State, have been averaged, and will serve to illustrate fairly well the chemical composition of the peats found in Massachusetts. A discrimination has been made between peat and muck samples; those containing a relatively high percentage of insoluble matter or ash, and which are commonly known as muck deposits, have been excluded from the average.

Average Chemical Composition of 55 Samples of Peat made at the Massachusetts Experiment Station Laboratory.

Moisture,	60.85
Dry matter,	39.15
	100.00

100 parts of dry matter contain: —

	Parts.
Organic matter,	58.00
Nitrogen,	2.19
Ash,	28.12

100 parts of peat ashes contain, on the average: —

	Parts.
Potassium oxide,	.44
Phosphoric acid,	.99
Calcium oxide,	2.53
Silicious material soluble in dilute hydrochloric acid,	88.12

There can be only a very small agricultural commercial value to the mineral constituents found in peat, as may be seen by the small amount of potash, phosphoric acid and lime given in the average analyses. The greater part of the ashes of peat is composed of insoluble silicious material possessing little or no value as plant food. The commercial value of the potash, phosphoric acid and lime in 1 ton of peat ashes, provided they were all in a highly available form, which is probably not the case, would be less than $2. It might be mentioned in this connection that it would take 7,115 pounds of peat of the above composition to make 1 ton of ashes. If peat has any pronounced value as a fertilizer, therefore, it must lie in the organic portion, — that portion which contains the humus and nitrogen.

In selecting the most valuable peat for fertilizing purposes we would, therefore, choose the product which contains the smallest amount of mineral matter; in other words, that portion that appears to be purely organic vegetable matter. In this connection a question suggests itself to the mind: is there any difference in the availability of the nitrogen contained in peat taken from various depths? Upon first thought one would expect that the lower layers of peat would be in a more advanced state of decomposition, and its nitrogen would, therefore, be more available. Several years ago the writer was able to make an interesting experiment regarding the availability of the nitrogen in peat taken at various depths. The samples were procured from a deposit averaging about 5 feet deep. One sample was taken from the first 18 inches of the surface layer, the intermediate layer was sampled between 18 inches and 3 feet below the surface, and the lower layer was sampled at a depth of 3 feet. A fourth sample was procured from the same locality, but was taken from a pile of air-dried peat which had been excavated several months previous and had been allowed to lie exposed to the oxidizing agencies incidental to the weathering process.

The table of analyses has been prepared on the basis of 100 parts of dry matter, the method used for the determination of the availability of the nitrogen being the alkaline permanganate method.

Peat.	Total Nitrogen.	Per Cent. of Nitrogen Available.
Weathered peat,	1.72	28.4
Top layer (first 18 inches),	2.29	28.3
Intermediate layer (18 inches to 3 feet),	1.83	26.2
Lower layer (below 3 feet),	1.25	23.2

In case of the samples examined it will be seen that the lower layers contained less nitrogen, which was probably rather less available than that in the upper layers. It may be seen, further, that the weathered peat, although showing a smaller nitrogen content than even the intermediate layer, apparently has a slightly higher availability. These results seem to me very significant. The weathered sample was a mixture of the peat taken from the same locality to a depth of from 4 to 5 feet, and yet we find that it leads in the availability of its nitrogen. This indicates the possible beneficial effect of the weathering or oxidizing process.

It should not be understood that the above figures represent the actual amount of nitrogen in the peat that is immediately available as plant food. There is no certainty that laboratory methods accurately indicate availability. They are as yet arbitrary, and much work needs to be done along the lines of vegetation experiments before we can definitely say just how much of the nitrogen in any organic substance is available as plant food. The results, however, are comparative.

Peat is found in such immense quantities and is so widely distributed throughout the country that it may not be out of place to give it a careful study from an economical standpoint.

We should realize that it is not the nitrogen alone that gives peat or any other organic manurial substance its superior value as a fertilizer. We depend upon these substances to furnish valuable organic matter and humus, without which it is impossible to successfully grow a crop, even with the most concentrated mineral fertilizers. We depend upon these substances further to improve the mechanical condition of soils, to make the heavy compact clay soils more open and porous, and to make the light sandy soils more retentive of moisture, and to furnish conditions whereby the soluble plant food may be retained near the surface of the ground, within easy reach of the rootlets of growing vegetation. We acknowledge the value of barnyard manure as a fertilizer, and yet a glance at its chemical analysis reveals only a small amount of nitrogen, potash and phosphoric acid. The average of 38 analyses of barnyard manure made at the Massachusetts experiment station shows only .42 per cent. of nitrogen, .53 per cent. of potash and .31 per cent of phosphoric acid. The calculated commercial value of the plant food contained in 1 ton of the average barnyard manure would be about $2. The agriculturist recognizes the value of the organic matter furnishing humus, and expects and is willing to allow a reasonable amount for the same. It is well known that peat carries a relatively high percentage of humus, and this fact, in no small degree, enhances the value of this material as a fertilizer. Aside from the consideration of the humus in peat it is of interest to study the value of peat as based upon its content of nitrogen and the availability of this most expensive element of plant food.

But little work has been done by the scientific agriculturist to establish the relative value of peat as a fertilizer. A few analyses have been made in various experiment stations, by the alkaline and neutral permanganate methods, which show the better grades of peat to have a nitrogen availability of 21.4 per cent. as compared with blood and fish having a nitrogen availability of 65 per cent. or over, but this is only comparative. These figures do not actually show the true amount of nitrogen which is available; this can only be accomplished by vegetation experiments. The Massachusetts experiment station has for several years been carrying on such experiments by growing millet in pots under conditions which can be absolutely controlled in every detail. The experiments in question were not instituted for the sole purpose of studying the availability of nitrogen in peat, but rather to make a detailed investigation regarding the availability of nitrogen from every well-known source, whether of a mineral or organic nature. The duplicate investigations were conducted in galvanized iron pots holding 38.75 pounds of soil. Each pot was fertilized with an abundance of potash and phosphoric acid, and the same amount of nitrogen was applied in each instance (5.4 grams) a few days before planting the millet seed. Five millet plants were allowed to grow and reach maturity in each pot. Care and watering were so regulated as to maintain uniform conditions. The results for the year 1908 show that sulfate of ammonia leads, with a percentage increase over the nothing pots of 74.17 per cent. of seed and 91.03 per cent. of straw. The peat ranks low, giving an increase of only 5.44 per cent. seed and 10.53 per cent. straw. These results are, of course, not conclusive, as they show only one year's investigation.

It is claimed that garbage tankage of our large cities can be economically made into a fertilizer, commonly known to manufacturers as base goods, by treating the tankage with sulphuric acid, the resulting product showing a high degree of availability of its nitrogen. The writer has successfully made a fertilizer from wool waste, the resulting product of which showed nearly 100 per cent. of nitrogen availability. Some such process may be applied to peat, and it is not improbable that the time will come when the nitrogen in peat will be utilized as a source of plant food by treatment with strong mineral acids as in the manufacture of base goods. It is questionable, however, if it would be at present on account of the large variety of other more concentrated and easily accessible ammoniates, both animal and vegetable that may be used in this process.

The use of commercial fertilizers is increasing enormously, and in a comparatively few years every source of plant food will be taxed to supply the demand for available ammoniates. As our western States become obliged to use more and more fertilizer each year, attention must sooner or later be turned towards our immense peat deposits.

The present seems to be a period of investigation and discovery. The manufacture of cyanamid compounds from the nitrogen in the atmosphere has furnished a most valuable economical source of nitrogen. This fact may retard somewhat the development of our peat industry from an agricultural standpoint, although the fact that peat furnishes valuable humus directly, while the mineral forms of plant food can only furnish it indirectly by growing a green crop to be subsequently ploughed under, will always be an incentive to its use in the natural or modified condition. The manufacturers of commercial fertilizers have recognized the value of peat as a drier, an absorbent and a source of humus in which many chemical formulas are deficient, and some are already using peat as a drier, and to improve the mechanical condition of fertilizer mixtures. How far this can be done legally and still comply with the fertilizer laws of our various States is an open question. If the manufacturer does not count the nitrogen which the peat carries in his guaranteed composition, but simply uses the material to improve the physical condition of his goods, it would not be undesirable, but the practice would offer a chance to the unscrupulous manufacturer to load his fertilizer with low-grade ammoniates.

There can be no question but what the nitrogen in dried peat has a much lower availability than the nitrogen in the high-grade animal and vegetable ammoniates, and for this reason its use as a *source of nitrogen* in mixed fertilizers must be excluded in order to comply with many State laws.

It is, of course, desirable to utilize peat as a fertilizer on as large a commercial scale as is possible, and the introduction of some process whereby this material may be made available for extensive use will be welcomed. In the mean time, however, there is no reason why peat should not be utilized to improve the chemical and physical condition of soils. It is a well-known fact that dry peat is a most wonderful absorbent. Experience teaches us, however, that it is rather slowly decomposed. If we can compost peat, therefore, with something that is teeming with bacteria and is easily decomposed there is a gain in two ways. For instance, if air-dried peat is composted with manure from the horse stable, the manure aids in disintegrating the peat, while the peat retards the too rapid decomposition of the manure, at the same time absorbing any plant food in form of ammonia compounds or other soluble plant food elements that may be made available. This is a very practical and economical manner of utilizing peat, and it will be found that the resulting compost will prove a very valuable manure. It may be necessary to make a frequent application of lime to soils on which such a mixture is constantly used, and it may be found necessary, in some cases, to use lime in making the compost.

The application of air-dried peat to light sandy or gravelly soils often results in their material improvement. Such applications can best be made by a manure spreader, and the peat may be applied to a depth of 2 inches. Freshly slaked lime should be used at the rate of 5 or 6 bushels to each cord of peat. The whole should be thoroughly harrowed into the soil and subsequently ploughed to a depth of from 4 to 5 inches. As an absorbent and deodorizer in the stable, dry peat has few equals.

Many of our peat lands make our most productive soils when properly drained and reclaimed, and especially is this true when the crops selected are particularly adapted to that class of soils. *Natural peat soils are deficient in available mineral plant food which has become washed out through successive years of leaching. Such soils, therefore, need an abundant application of potash, phosphoric acid and lime before they become productive.*

SPRAYING INJURIES.

BY G. E. STONE.

In recent years injury from spraying has become more common; at least, it appears to be more noticeable than formerly. This injury is more prevalent some seasons than others, and it is known that certain crops can be treated at one time without being injured and at other times precisely the same treatment may be given with bad results.

The causes underlying injury from spraying are complex and require attention from the best-equipped investigator. Already enough is known in some special cases concerning the nature of the injury to explain its occurrence at one time and not another. It is also well known that some plants are more susceptible to injury from spraying or fumigation than others, a wide range of susceptibility existing in plants.

Investigations have shown that meteorological conditions have an important bearing on the problem, but the data which have been collected are not sufficient, either in kind or quantity, for practical use.

Spraying injury to fruit and foliage has been noticeable the past season, especially on apple foliage. The fruit has also been injured to quite an extent by Bordeaux mixture, which causes the so-called "russeting" of the fruit.

Some cases have come to our notice during the past year of burning of foliage by arsenate of lead, and our attention was called in one case to the heavy loss of foliage on plum trees, due to spraying with this poison. It is well known that when spraying mixtures are not carefully prepared they are likely to cause burning, and in some of the cases observed by us it is not unlikely that the chemical nature of the arsenate of lead may have been responsible for the burning. A number of firms are now putting this on the market, and it is presumable that their products vary considerably as regards chemical composition. It is imperative for manufacturers of spraying mixtures or other remedial substances used on plants to demonstrate that their products are thoroughly trustworthy before putting them on the market. It is true that a spraying mixture can be used on one crop safely and not on another. It is also known, as previously mentioned, that meteorological conditions play an important role in this connection. It is safer to spray when the sun shines than during cloudy weather, for severe injury has often been noticed from spraying with various fungicides and insecticides in cloudy periods when no injury would have occurred had the sun been shining.

It is therefore important in spraying that attention should be given to the weather conditions, since if the spray is allowed to remain on the foliage in a moist condition for too long a time burning is likely to result. On the other hand, if the sun is bright and the spray mixture dries on the foliage very quickly, no such injury is likely to occur.

Burning of maple tree foliage has also been noticed as resulting from spraying with arsenate of lead, at the rate of 13 pounds to 100 gallons of water, and our attention has been called to a number of cases of severe burning of beech trees sprayed with this after standard formulas.

CONTROL OF CERTAIN GREENHOUSE DISEASES.

BY G. E. STONE.

One occasionally finds growers of greenhouse crops spraying for mildews and other diseases, and even contributors to the florists' journals sometimes recommend such treatment, perhaps because they know of no other. One at least of the objections to the practice of extensive spraying is that it is too likely to be considered a universal remedy or panacea for all the diseases plants are heir to. Any one attempting to control the diseases of greenhouse crops by spraying is wasting his time, and has much to learn concerning the fundamental principles of pathology. The most skilled florists and market gardeners discovered the true cause of disease many years ago, not from any particular experiments, but from intelligent reasoning out of the problem.

No one can long grow crops under glass before realizing that environment is a factor very largely under his control. He also discovers that many, if not all, of the blights with which he has to contend are caused by conditions of environment, and that if these conditions are modified properly the blights are checked. Considerable skill is required to manage the greenhouse in such a way that blights may be controlled, but it has been accomplished very successfully in many cases. In others, they are controlled to such an extent that only a minimum amount of damage occurs.

The important factors to which the grower of greenhouse crops must pay attention are heat, light, moisture, circulation of the air, and the chemical and mechanical conditions of the soil, and a knowledge of their effects upon plant development enables him to grow healthy plants. The influence of moisture in the air is alone an important, perhaps the most important, factor in controlling disease, and is very plain in the case of outdoor diseases also. In wet seasons certain diseases are common which may be entirely absent in dry seasons. The presence of dew, even in dry periods, may bring about infection by furnishing favorable conditions for spore germination. If the moisture conditions out of doors could be controlled as easily as they are inside, a very large percentage of so-called blights could be eliminated.

Cucumbers and Melons.

Experiments made with melons and cucumbers, covering a period of many years, have demonstrated that by proper regulation of the moisture in well-ventilated houses *Anthracnose* (*Colletotrichum*), downy mildew (*Plasmopara*), *Alternaria* and powdery mildew (*Erysiphe*) can be held absolutely in check.

At the time some of our experiments were being carried on, melons which were growing out of doors, within a few feet of our greenhouse, were infected with all of the above diseases except powdery mildew, but not a trace of infection could be found from any of these diseases inside. During the many years we have grown cucumbers and melons under glass we have never had any infection from the above diseases except the powdery mildew, which was introduced into our house at one time and encouraged to spread for a special purpose. All of these diseases are more or less common each year in cucumber houses, and cause much injury.

Downy mildew affects cucumbers during July and August, and *Anthracnose* in the spring. Most greenhouses growing cucumbers are kept too moist and are often poorly ventilated. There is no reason whatsoever why these crops cannot be grown without infection from the above-mentioned diseases. Experience has shown us that in order to control blights it is necessary that the air moisture should be held down, and if syringing of the foliage becomes necessary, it should be done only on bright, sunshiny mornings, when the foliage will dry off quickly, thus preventing the spores from germinating and affecting the crop.

Tomatoes.

There are a large number of troubles associated with tomatoes under glass which arise from improper handling of the crop.

The tomato leaf blight, caused by *Cladosporium*, often termed scab, can be perfectly controlled by paying attention to the air moisture and to details of syringing the foliage. The same attention to syringing, ventilation, etc., should be paid in the case of tomatoes as with melons and cucumbers.

When tomato plants are crowded, and there is an insufficient amount of light and circulation of the air, the lower leaves are frequently attacked by a leaf blight, known as *Cylindrosporium*, but this will give no trouble if the conditions are kept normal. This leaf blight occasionally occurs in commercial houses, although we have never had a trace of it in our many years' experience in growing tomatoes under glass, both summer and winter. It is more common in winter, when the light is poor, than in the spring and summer.

The blossom end rot of tomatoes is often a very troublesome disease and furnishes a good illustration of a trouble brought about by neglect of certain details necessary for the normal development of the crop. This disease is caused by bacteria, one or more fungous growths (*Fusarium, Cladosporium*, etc.) occasionally accompanying the bacteria. Lack of water in the soil when the fruit is maturing, especially if the atmosphere of the house is more or less dry, will cause the rot, and a liberal supply of moisture, preferably supplied by irrigation, will prevent it. Moisture plays an important role here because a too dry atmosphere causes the fruit to crack at the blossom end and become imperfectly developed, and infection follows. This rot is more common near steam pipes, where the air is drier, and in the spring, when the sunlight is more intense and prolonged, than during the late fall or winter. In the spring transpiration is more active, hence the necessity for more soil moisture and more attention to wetting down the house. Sunshine and transpiration are important factors in causing the rot, and our experiments have shown that slight shading in the spring months is of great value in holding back the trouble. In our experiments in the greenhouse we obtained over 30 per cent. more blossom end rot on plants which were watered on the surface than on those subirrigated, and a very material decrease in the amount of rot occurred from the shading afforded by the plants.

Lettuce.

Many years ago lettuce growers were troubled with a disease known as top-burn, and amateur growers have it to contend with at the present time. The disease is characterized by the margins of the young leaves becoming wilted and dying from a collapsing of the tissue. The older and more skilled lettuce growers early learned that the trouble was not associated with fungi, and it could be easily controlled by the adjustment of the day and night temperature to the conditions of the weather. It has been found that if the night temperatures are kept too high, — 50° or more in cloudy weather, — top-burn will follow, if the following day is clear and the day temperature reaches as high as 70° or 80°. By carefully maintaining low night temperatures, 40° or 45°, during cloudy periods, and holding the day temperature down, top-burn can be prevented. On the other hand, in bright, sunshiny weather, higher day as well as night temperatures may be maintained without running the risk of getting top-burn.

Lettuce as well as other indoor crops must be grown according to the weather, and as no two seasons are alike it follows that no two crops can be grown precisely alike. Every successful greenhouse grower realizes this and handles his crop accordingly.

Chrysanthemums.

The chrysanthemum is affected with three diseases, which can be controlled if attention is given to proper methods of culture.

Leaf blight (*Cylindrosporium*), similar to that on the tomato, occasionally affects more or less badly the lower leaves of chrysanthemum plants when grown to a single stem close together. This leaf spot, like the one on tomatoes, is caused by too close planting, which shuts out the light and prevents the circulation of air. More open planting, or anything which would allow more light or freer access of air, will prevent it.

The chrysanthemum rust, which once caused considerable alarm, can be prevented by paying attention to watering. Some greenhouse growers are often troubled with this rust, while others have never had the least indication of it. Even if two growers buy their stock from the same concern, and it is identical as regards freedom from rust, one is likely to have it very severely and the other not at all, which proves that the method of handling the plant has everything to do with the occurrence of the rust. When plants are grown outside, as they occasionally are in summer, and are exposed to rains and dews, they are very likely to become infected, but when grown inside, and especial care given to watering the foliage, little rust is present.

Powdery mildew (*Erysiphe*), although occasionally seen on chrysanthemum foliage, has never been considered a serious trouble, and is seldom, if ever, severe enough to require treatment. Stem rot, occasionally caused by *Fusarium,* which is more likely to affect the weak stems on closely planted crops, is sometimes destructive, but the chrysanthemum is, as a rule, quite immune to stem rots.

Carnations.

The principal troubles peculiar to the carnation are the stem rots, termed the wet and dry rot, and the rust. There are other troubles which are not serious, however, such as leaf spot (*Septoria*), purple joint, stigminose, etc., the latter being caused by insects. The breeding and selection of new varieties of carnations has had a more important influence on the elimination of carnation diseases than anything else. Carnation rust, which a few years ago gave much uneasiness among the growers, is now fairly well handled by expert carnation men. Careful attention given to syringing the plants has been of great value in preventing the rust, as has also subirrigation, or applying the water below the surface.

The stem rots are more recent troubles and are more difficult to handle. Wet rot, caused by a sterile fungus (*Rhizoctonia*) can be easily controlled by sterilizing the soil with steam, and formalin is also good, being applied to the soil at the rate of 2 pints to 50 gallons of water. It can be applied with any sprinkling device. It is generally recommended that formalin be applied at intervals of a few hours, until the whole amount has been taken up by the soil, and frequent stirring of the soil is necessary. Since formalin is extremely poisonous to plants it is necessary to get it all out of the soil before planting, and the house must remain idle some days. One gallon of the solution of the strength given above to each square foot has been recommended.

The dry rot, caused by *Fusarium,* is more difficult to handle, and the methods employed for the control of the wet rot appear to be of little use for this disease. *Fusarium* rots in general have increased during the last decade. In the case of carnations this is due possibly to the more extensive forcing common in recent years. Too extensive forcing, too close planting and shading have a tendency to weaken the stem, and undoubtedly render it more susceptible to attacks from fungi. On the other hand, low temperatures and exposure to the light harden the plant tissue, rendering it less susceptible to disease. There are authentic cases known where certain plants subject to stem rots, when transplanted and raised out of the ground slightly, become hardened and perfectly immune.

Damping-off Fungi.

There are two serious damping-off fungi which cause trouble to the greenhouse grower by affecting seedlings and cuttings. The damping fungus *Botrytis* is the most common, and affects plants in a low state of vitality. The *Botrytis* propagates freely by spores, and therefore does not yield to treatment by sterilization. The most healthy plants will become affected with the damping-off fungus if they remain in an abnormal condition for brief periods, and if cuttings are kept too moist or too warm, or lack sufficient light, they are likely to damp off. By paying close attention to cultural and sanitary conditions, damping-off can almost always be prevented.

Another damping-off fungus, known as *Pythium deBaryanum,* often gives considerable trouble to cucumber, tobacco and other seedlings when the conditions are not normal for their best development. Even sudden changes in the condition of the plant will cause the trouble. For example, when plants are taken from hotbeds where they have been forced too freely, and placed out of doors in damp, cold weather, they will damp off, and too much heat will cause the same thing in cucumber seedlings. Attacks of this fungus are confined almost entirely to the seedlings, and when the plant grows out of the seedling stage it generally becomes immune. *Pythium* can be easily eliminated from a soil by sterilizing with steam.[1] The formalin method of treatment, previously described, is beneficial.

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[1] Ohio Circular No. 57, Ohio Agricultural Experiment Station.

SPRAYING EXPERIMENTS WITH CALCIUM BENZOATE.

BY G. E. STONE.

Calcium benzoate has been recommended by manufacturers and dealers for a few years past as being a fungicide of some value, and samples of this substance have frequently been sent to us for trial by the manufacturers, with directions as to its proper use. We have previously tested sodium benzoate, an allied compound, on potatoes, and the results are reported elsewhere.[1]

It was desired that a test be made of this substance for the control of plum rot (*Monilia*), the claim having been made that it would completely control the rot. If true, the calcium benzoate would prove of inestimable value to the fruit grower, and would find a ready market.

In testing the material we selected half a dozen plum trees, leaving checks for comparison. The trees, which were laden with fruit and had always been susceptible to the rot, were given a very thorough spraying with the calcium benzoate, at the rate of 2 pounds to 50 gallons of water. The spray covered the foliage and fruit very thoroughly, and was applied at a favorable time to control any rot which might subsequently appear. As the season was very dry, and no rains occurred during the period of experiment, none of the substance was washed off.

Later in the season considerable rot was observed on both the sprayed and unsprayed trees, and a thorough examination showed absolutely no difference in the sprayed and unsprayed fruit as regards infection. We regard the experiment, therefore, as being purely negative in its results.

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[1] Annual Report Hatch Experiment Station, 1908, p. 128.

Monilia rot of the plum and peach is a very difficult thing to control by spraying, and none of the spraying solutions or mixtures seems to have more than a partial effect. The best methods of handling the rot, in the absence of any suitable spraying mixture, particularly where it appears late in the season, on ripened fruit, consists in gathering the fruit just before it is mature and not allowing any overripe fruit to remain on the tree to become affected. When the rot occurs early in the season, as is sometimes the case, this method would be of little use, and spraying, even if only partially effective, might be resorted to tentatively.

SEED PURITY WORK, 1909.

BY G. H. CHAPMAN.

The testing of seeds for purity was not taken up at this station to any extent before 1908. In 1908 only about 12 samples of seed were sent in to this department for examination as to purity, but owing to other States having taken the matter up in a very decided manner, and some of them passing seed laws for the regulation of the sale of commercial seeds, the seedsmen and farmers of Massachusetts began to take interest in the matter.

The seeds found in the Massachusetts market are in general of very good quality, when purchased from well-known, reliable dealers, but since laws have been passed in other States suppressing the sale of impure seeds in those States, it has become customary with certain seedsmen to ship poor quality seeds out of the State, and place them for sale in States which have no such seed law. This has been brought to our attention more forcibly this year than ever in the past, and the farmers of this State are beginning to pay more attention to the matter, as is evidenced by the increased number of samples sent in for purity tests. In all, 100 samples have been examined this year, and it has been deemed advisable to make a report of the work done at this time.

Most of the seeds examined were offered for sale by reliable dealers in this and other States, and such can be bought with reasonable assurance, as these dealers are, in the main, careful to offer only a good grade of seed, and usually advise the purchase of their best grades. This is not because it brings them in a larger profit, but because the best grade of seed is usually purer than other grades of the same seed offered by them at a lower price. It is to their advantage to offer a good article, as well as to the farmer's advantage to buy a good article; but, as in any other business, if a man is not willing to pay the price of a first-class article he can be accommodated with something inferior.

One great mistake which the farmer makes is the buying of seed from the small country stores, as it has been found in many cases during the past year that these seeds were improperly cleaned, or not cleaned at all. We therefore strongly advise purchasing seed from a reliable dealer rather than buying them haphazard anywhere.

The table gives briefly the results of the seed purity tests carried on this year. This table is practically self-explanatory, and gives briefly the different kinds of seed examined, with the maximum, minimum and average percentage of purity, as well as the kinds of weed seeds found and the number of samples in which these were found. The most common impurities in the different kinds of seed examined were plantain, ribgrass, sheep sorrel and dock. Dodder might be mentioned as being among the most noxious of seeds found in the clovers and alfalfa, but it was present in only a small percentage of the samples submitted for examination.

In this table no mention has been made of the chaff, bits of stem and dirt which were found in the samples, as these were usually present only in small amounts.

It is believed that it would be advisable for Massachusetts to draw up a seed law governing the sale of commercial seeds, but this should not be done without great deliberation and the utmost care, as it appears to us that many of the laws drawn up by other States are either harmful, or unjust to the seed dealer, or to the purchaser of commercial seed. At the present time nothing can be done about this, but it is hoped that in the near future the seed dealers and farmers will take up the matter, and that some law may be passed which will protect both the farmer and the dealer. Justice should be done to both parties, and we do not believe that it will be a difficult matter to draw up a law which will not only protect the buyer from purchasing impure seeds offered for sale in this State which are grown outside of the State, and shipped in for sale, but would also protect the Massachusetts seed dealer as well.

According to some of the laws in our neighboring States, Massachusetts might easily become the dumping ground for impure seeds which could not be sold by dealers in other States. This is inimical to the Massachusetts seed dealer as well as to the buyer, and it is evident that something must be done to safeguard the interests of the farmer and the seed grower and dealer.

Showing Results of Seed Purity Tests, 1909.

Seed.	Number of Tests.	Per Cent. Purity.			Kinds of Weed Seeds found, and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Timothy,	14	100.0	96.0	98.9	Yellow daisy (1). Plantain (7). Dock (2). Five-finger (2). Sheep sorrel (3). Pepper grass (2). Hawkweed (1). Ox-eye daisy (1). Switch grass (1). Lamb's-quarters (2). Wild parsnip (1).	Red clover (4). Alsike clover (4). Redtop (6).
Red clover,	24	100.0	82.7	97.6	Sheep sorrel (2). Plantain (11). Rib grass (10). Curled dock (5). Sorrel (5). Dodder (5). Daisy (2). Lamb's-quarters (2). Foxtail (6). Wild turnip (1), Switch grass (2). Medicago sp.? (3). Parsnip (5). Wild carrot (2). Tumble weed (2). Mallow (1). Self-heal (1). Canada thistle (2). Dock (2). Lady's-thumb (4). Smartweed (1). Witch grass (1). Pepper grass (1). Melilotus sp.? (1).	Timothy (13). Alsike clover (7). White clover (6). Orchard grass (1). Redtop (4). Alfalfa (2). Fescue (1). Medic (1).
Redtop,	12	100.0	92.0	96.8	Daisy (3). Sorrel (2). Plantain (4). Five-finger (3). Smartweed (1). Chickweed (1).	Timothy (6). Red clover (2).
Oats,	1	98.6	98.6	98.6	-	Wheat (1). Barley (1).
Alfalfa,	7	99.0	98.0	98.4	Medic (1). Bitter dock (1). Dodder (3). Sweet clover (1). Gum plant (1). Medicago sp.? (1). Plantain (1). Bur clover (1). Switch grass (1). Rib grass (2). Mustard (1). Lamb's-quarters (2).	Red clover (4). Timothy (1). Old seed (1).

Showing Results of Seed Purity Tests, 1909 — Con.

Seed.	Number of Tests.	Per Cent. Purity.			Kinds of Weed Seeds found, and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Alsike clover.	14	99.5	91.0	97.4	Sorrel (7). Dock (2). Plantain (4). Switch grass (2). Shepherd's purse (1). Dodder (3). Daisy (2). Pepper grass (2). Field sorrel (1). Medicago sp.? (1). Chickweed (1). Five-finger (1). Rib grass (1). Crab grass (1). Corn-cockle (1).	Timothy (14). Red clover (6). Redtop (3). White clover (2).
White clover.	6	99.0	84.0	96.2	Plantain (2). Sheep sorrel (4).	Timothy (1). Alsike clover (2). Henbane (1). Red clover (1).
Orchard grass.	2	94.0	91.0	92.5	Dock (2). Plantain (2). Corn-cockle (1). Ox-eye daisy (1). Sheep sorrel (1). Quack grass (1). Rib grass (1).	Timothy (1). Red clover (1). Redtop (1). Buttercup (1).
Agrostis,	2	99.8	-	49.9	- -	Timothy (1). Old seed (1). Orchard grass (1).
Kentucky blue grass.	2	97.0	92.0	94.5	Shepherd's purse (2). Pepper grass (2). Plantain (1). Chickweed (1). Lamb's-quarters.	Clover (1). Timothy (1).
Meadow fescue.	10	100.0	97.0	98.7	Dock (4). Lady's-thumb (1). Foxtail (1). Mustard (3). Medicago sp.? (1).	Paspalum sp.? (1). Clover (1).
Alfalfa clover.	2	99.0	98.0	98.5	Dock (1). Bull thistle (1). Foxtail (1). Lamb's-quarters (1).	
Millet, . .	2	96.0	74.0	85.0	Ragweed (1). Yellow foxtail (1). Lady's-thumb (1). Tumble weed (1). Lamb's-quarters (1). Plantain (1). Barnyard grass (1).	
Italian rye grass.	1	99.0	-	-	Curled dock. Tall buttercup.	
Yellow oat grass.	1	99.8	-	-	Curled dock (trace). Tall buttercup (trace).	

SEED GERMINATION AND SEPARATION.

BY G. E. STONE.

The routine work in seed germination and separation has been carried on as in the past. Several methods were tried for the separation of mixtures of seeds, especially of grass seed, but work along these lines is not far enough advanced to warrant a report.

The number of samples of seed sent in for germination far exceeded those of the preceding year (see Table I.), 273 samples of different seeds being received, 92 of which were onion. Onion seed for 1909 seemed better than that of the preceding year, and the average germination of all the seed samples seemed to be a little higher than for 1908. The tobacco seed, especially, gave a higher germination percentage than ever before. Large seeds produce large plants, and if this characteristic is inherited it might be supposed that selection and separation would ultimately result in a better strain of seed and better crops.

TABLE I. — *Records of Seed Germination, 1909.*

Kind of Seed.	No. of Samples.	Average Per Cent.	Per Cent. of Germination.	
			Highest.	Lowest.
Onion,	92	82.2	97	25
Tobacco,	8	93.6	97	85
Corn,	4	78.0	97	50
Lettuce,	15	60.8	100	-
Pansy,	43	46.4	88	3
Celery,	8	69.0	85	25
Miscellaneous,	108	69.0	100	-
Total,	273	-	-	-

The work in seed separation also increased during the season of 1909 (see Table II.), the principal seeds separated being onion, tobacco and celery. This season about 1,440 pounds of onion seed were separated, against 720 in 1908, and 60 pounds of tobacco seed, against 56 pounds during 1908. In all, about 1,500 pounds of seed have been separated for the growers during the past year, and indications point to a still larger increase in the amount of seed separated next season.

Table II. — *Records of Seed Separation, 1909.*

Kind of Seed.	No. of Samples.	Weight (Pounds).	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	48	1,439.34	88.9	11.1
Tobacco,	88	59.08	89.9	10.1
Celery,	7	3.27	89.4	10.6
Total,	143	1,501.69	-	-

The per cent. of onion seed discarded was only 11.1 for all the samples, showing that the seed offered in 1909 was on the whole of slightly better quality than that offered in 1908. The average per cent. of seed discarded for tobacco was also less than in the past, only 10.1 per cent. being taken out, against 14 per cent. in 1908. Of course, in a great many samples a much larger percentage was taken out than was absolutely necessary, as some of the growers specifically requested that a certain percentage of the seed be blown. One grower, especially, asked that one-third of the seed be blown in order to insure practically perfect seed for planting.

We are occasionally requested to test the germination of seed both before and after separation, and the results of a few such tests have been published at different times in our annual report. Table III. shows the results of tests made the past year. Two hundred seed were used in each test. The average amount discarded was 7.09 per cent., and the average germination of the seed before being separated was 74.7 per cent. and after separation 83.6 per cent., showing a gain of 8.9 per cent. as a result of separation.

TABLE III. — *Showing Increase in Germination of Seeds by Separation.*

KIND OF SEED.	PER CENT. OF GERMINATION.		Per Cent. discarded.
	Before Separation.	After Separation.	
Onion, ...	83.0	92.0	9.10
Onion, ...	85.0	85.0	7.60
Onion, ...	25.0	30.0	13.00
Onion, ...	82.0	87.0	9.00
Onion, ...	80.0	94.0	5.00
Onion, ...	82.0	96.0	3.30
Onion, ...	70.0	89.0	4.00
Onion, ...	91.0	93.0	9.00
Onion, ...	75.0	87.0	3.80
Average, ...	74.7	83.6	7.09

In some previous separations with onion seed, in which 7 samples of seed were used and an average of 14 per cent. blown out, we obtained an increase of 9 per cent. in the germination.

In Table IV. are shown the results of seed germination before separating, also the germination of the heavy and light seed. The average amount of seed discarded here was 8 per cent. The heavy seed showed an average increase of 5 per cent. in the germination, while the light or discarded seed gave an average of only 57 per cent., or 28 per cent. less than the heavy seed.

TABLE IV. — *Showing Increase in Germination of Seeds by Separation.*

KIND OF SEED.	No. of Experiment.	PER CENT. OF GERMINATION.			Per Cent. discarded.
		Before separating.	AFTER SEPARATING.		
			Heavy.	Light.	
Onion, ...	1	85.0	88.0	56.5	8.58
Onion, ...	2	76.0	83.0	59.0	7.60
Average, . .	-	80.5	85.5	57.7	8.09

In Table V. the per cent. of germination and the weight of celery seedlings are shown, the results being an average of two experiments. The amount discarded in this experiment was 15 per cent., and the difference in the percentage of germination between the heavy and discarded seed was 32 per cent., while there was a gain of 68 per cent. in the germination of the heavy over the light.

Table V. — *Showing Effects of Seed Separation on Germination.*

	Per Cent. of Germination.	Weight (Grams).	Per Cent. discarded.
Heavy, . .	43.5	.44	15
Light, . . .	11.5	.14	-

It is becoming a recognized fact that under present conditions governing the sale of seed in Massachusetts and elsewhere separation is necessary in order to produce the best results, being particularly valuable in the case of such seed as tobacco, onion, celery, radish, lettuce, etc., as often a great deal of light or old seed, which is absolutely worthless and only a "makeweight," is mixed with the seed offered for sale. The grower, however, is beginning to realize that he is sometimes imposed upon, so is more careful about the quality of seed which he buys, and is consulting the station more and more frequently about the problems connected with the seed question and the growing of crops.

The station is always glad to receive seed for separation or germination from people residing in the State, and will do all in its power to assist them in any way possible. From the gratifying increase in the number of samples sent in for both germination and separation it is believed that people in the State are realizing more and more the benefits resulting from the gratuitous work done for the people at this station.

All samples of seed to be germinated or separated should be addressed to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the express or freight on these seeds should be prepaid by the parties sending the seed.

SUN SCORCH OF THE PINE.

BY G. E. STONE.

Much interest, accompanied by an unusual amount of alarm, has been felt since 1905 in the so-called "pine blight," and, as is customary where more or less conspicuous injury to trees occurs, exaggerated reports have been made concerning it. This blighting of the pine is not new to Massachusetts as we have noticed it for at least twenty-five years. About twelve years ago it was quite prevalent in the eastern part of the State, being noticed by us and reported by others. Prof. B. M. Watson of the Bussey Institute and others have recently called our attention to a similar burning which occurred apparently at the same time.

Sun scorch of conifers in general is of common occurrence. Pines growing in very dry situations are often sun scorched, and frequently show yellow, inferior foliage; the needles are sometimes burned, and it is not unusual for fungi to attack the dead needles, but these fungi are never the primary cause of the trouble. This condition of the pines may be found here and there almost any season, but is more noticeable some seasons than others.

The present pine blight dates back to the winter of 1902-03, when the conditions were such as to cause much injury to vegetation in general. The following winter, that of 1903-04, was even more severe in its effects on vegetation, and caused extensive root killing of many trees and shrubs. The pine, as well as other trees, in many cases was killed outright, but the injury to the pine was largely confined to the smaller roots, or those less than 3/16 of an inch in diameter. It was not, however, until the very dry summer of 1905 that extensive burning was noticed, and this was very general throughout the State. The season of 1905 was the first to attract attention to this burning although in our annual report[1] we had already mentioned the condition of the pine roots, and stated that we anticipated trouble if this condition continued.

The blight was characterized by a burning of the needles, which was so severe in some cases as to cause the death of the tree; in others, burning was not so severe, affecting only parts of the tree, and in a large number of cases the trees recovered the following year (1906). In some cases the tips of the needles only were burned, while in others the whole leaf was involved. The branches bearing such leaves, and sometimes the whole tree would die. The trees which recovered in 1906, of which there were a large number, were not perfectly healthy as regards color or leaf development, but they were free from burning. Extensive burning occurred again during the summer of 1907, appearing simultaneously all over the State the latter part of July. It was much more noticeable than formerly, and occurred at a very dry period, when high winds were common, although the effects on the trees were not so disastrous. An examination of the root system in 1907 showed that about 90 per cent. of the small feeding roots had collapsed, and the micorhiza on the roots appeared to suffer the same fate as the roots themselves. The soil during part of the season was so dry that it was like powder. Many of the trees improved during the fall of 1907, and in 1908 they appeared much better.

The principal burning during 1908 occurred on the young tips of the needles, before they had expanded, and was much less severe than in the preceding year. Many trees which burned previously appeared perfectly green in 1908, and an examination of the root system showed that new feeding roots were forming.

In all the burning of the foliage we have never discovered any indication of fungi on the needles at first, although after the leaves had been dead a few weeks different fungi were found, being purely secondary. In the summer of 1908 considerable *Septoria* occurred on the dead leaves, but there has been no indication of infection at any time since the blight's appearance. Hundreds of instances may be noted where trees have remained

[1] Annual Report, Hatch Experiment Station, 1905, p. 9.

perfectly healthy whose branches interlaced with those of blighted trees.

The number of pine trees affected with the so-called blight or sun scorch in Massachusetts is probably less than 1 per cent., and the number which have died is so insignificant that it is hardly worthy of mention. Most of the affected trees have periods of burning and periods of recovery. When new leaves form, the old, blighted leaves drop off; consequently, when a new crop of foliage appears the tree no longer shows the effects of blight. Trees which have blighted once have almost invariably been affected again; in other words, blighting has been confined each year to certain trees.

During the past five or six years the writer and his assistants have examined a great many hundreds of pine roots from different parts of the State, and have made many observations and notes on the affected trees. Sun scorch of the pine has been found to be associated with a very dry condition of the soil, aided by severe winds. The side of the tree corresponding with the direction of these winds is most severely affected, and many instances may be found to prove this assertion. Moreover, that part of a forest which is exposed to severe winds has shown the greatest amount of blight. There has been more blight of trees on the margins of forests than in the interior, and trees growing in the open under exceptional conditions seldom if ever blight. Small pines growing in the shade of older trees in the forest have proved to be more or less susceptible, but they have not been affected to such an extent by burning as by winter-killing of the roots. Pines growing under such conditions are not able to attain their best development in any season, and are more likely to die from any cause that would tend to weaken them than those growing in the open.

For the past five or six years the white pine has been looking badly. It has been unusually susceptible to attacks of insects of one kind or another, the pine borer killing the leaders in many cases, and a black, scurfy-like growth on the foliage, known as *Scorias,* has been more common than usual. Many trees which have shown no inclination to burn possess a poor root system which causes a yellow and sickly appearance of the foliage. These trees are also noticeable for their short needles and stunted growth.

Besides the typical burning of the pine, troubles of a different nature have occasionally been observed. In the season of 1906–07 there was considerable burning, caused by the fungus *Phoma*. This fungus attacked the young stems and branches, causing the death of the leaves. In this case the leaves die but remain on the branch. There was also a burning of pine foliage in the early spring months similar to that which occurs on arbor vitæs and various conifers, generally known as sun scald. This has been more or less common the last year or two, and is confined to certain branches. The effects of burning from contact with drifting snow have also been noticed from time to time in certain localities, and serious burning has been noted on the foliage of the pitch pine, which, according to Mr. T. H. Jones, a graduate student who specialized in entomology, is due in part if not wholly to the work of insects.

Occasional dying of the white and Scotch pines has been observed, and the Norway and other spruces have been dying to a greater extent than usual.

It should be pointed out that reports of the so-called pine blight have been exaggerated even by those who should have known better. Fortunately this exaggeration has had slight effect on owners of woodland, and the planting of young pine is still going on in this State, owing to the excellent work of State Forester F. William Rane.

Of all the trees peculiarly adapted to this region, the white pine stands at the head of the list, and it has been and is to-day one of the most valuable assets of our soil. So well adapted is this tree to our region, and so rapidly does it fill up old pastures and woodlands, that if Massachusetts should become deserted now, in one hundred and fifty years it would be densely covered with a magnificent growth of white pine. In the primeval forests of the State, pine and hemlock constitute the principal trees, but the hemlock has disappeared to such an extent, owing to the modification of soil conditions, that it would take several centuries for it to regain its former pre-eminence. On the other hand, the white pine is such a cosmopolitan tree in this region, adapting itself to such a variety of conditions, that if left to itself to propagate it would form from 50 per cent. to 75 per cent. of the entire tree growth in this State in a comparatively short time.

As to the treatment of the pine blight, in some cases spraying has been resorted to, with supposed beneficial results, but if such results followed spraying, it is very likely due, as Dr. G. P. Clinton of the New Haven station has pointed out, to the clogging of the stomata, which prevents excessive transpiration at a critical period. In the case of lawn pines, which are greatly prized, we have recommended as treatment for the blight mulching the soil with horse manure well diluted with straw, and applying to the tree fertilizers, such as wood ashes, ground bone, pulverized sheep manure, etc.

INSECTS OF THE YEAR.

BY H. T. FERNALD.

During the year 1909 insects were abundant, but no serious outbreak of any one species was noted. Average losses were the rule, and in some cases there was less destruction than usual.

For several years the elm-leaf beetle (*Galerucella luteola* Mull.) has been increasing in abundance and attracting more attention. During 1909 its work was evident over quite a large part of the State, and this has led to attempts to control it by legislation. Under these circumstances an outline of its history in the State may not be out of place.

Just when this insect reached Massachusetts is unknown, but as it came from the south, and was found in Amherst in 1895, it is probable that it entered the State by the Connecticut valley a year or two earlier. At first it was not abundant enough to attract much attention, but by 1899 it had begun to be noticeable on the elms there, had also reached the eastern part of the State and was working northward. Two years later it had become injuriously abundant in eastern Massachusetts, and in 1902 it was becoming a pest in the northeastern part of the State, though elsewhere its injuries seemed to be less, on the whole, than they had been the year before.

The beetles appeared abundantly the spring of 1903 and laid many eggs. About the first of May, however, a prolonged drought began, lasting nearly eight weeks. During this period many of the egg masses failed to hatch, and some, at least, appeared to dry up, while in many cases where the eggs hatched the tiny grubs could be seen biting at the leaves hardened by the drought, but failing to make any impression on them. The mortality of these insects under the circumstances was enormous, and the amount of injury comparatively small. The following winter — that of 1903–04 — was exceptionally cold, and in the spring of 1904 almost no elm-leaf beetles could be found.

How far the unusually cold winter was responsible for this destruction it is impossible to say, but it seems certain that the spring drought, causing the failure of eggs to hatch, and the starvation of the newly hatched young, were important factors in the destruction of this pest.

Many towns and cities sprayed their trees for the elm-leaf beetle in 1903, and it seems to have been too generally supposed that this was the reason so few of these insects were found the following year.

Since 1904 the elm-leaf beetle has been gradually increasing in abundance again, and in 1908 it had become so plenty as to cause considerable injury. In 1909 this was also the case, and a repetition of this may be expected each year hereafter, until some combination of natural or climatic conditions unfavorable to the insect shall appear.

The question of controlling the elm-leaf beetle is important under these circumstances, and two lines of action seem possible. Cities and towns may spray their trees if they see fit to do so, holding the insect in check in this way. There are many parts of the State, particularly on the west and north, as far east as Ashby, perhaps, where it is not probable that this insect will ever do serious injury, unless it acquires greater resistance to cold than it now has. For this reason local treatment would seem particularly desirable. The difficulty would be that trees not on town streets, but on private grounds, and those in the fields and woods would not be reached in this way, and each year these would restock the street trees. The other method would be by State law requiring all elms to be sprayed. This would be impracticable of enforcement, however, for there are not enough people in the business to spray one one-hundredth of the trees, and it is impossible to spray elms without power sprayers, with any degree of success, during the period when spraying must be done. If the State should take up the work, it would mean the expenditure of about half a million of dollars annually, for the entire State, except the western and northwestern portions, would need to be treated during a period of five weeks for it to be of any value, and this would require at least fifty gangs of men and power pumps. Then, too, it must be remembered that the boundaries of Massachusetts are not impassible to these insects, and the work would have to be done every year. In other words, State treatment would mean an annual tax of about half a million dollars for this purpose, or else work of no lasting value and a waste of money.

The oyster-shell scale (*Lepidosaphes ulmi* L.) and several others of our common scale insects have been the cause of some correspondence, but nothing new has developed about them. The San José scale (*Aspidiotus perniciosus Coms.*) is becoming more abundant in orchards and on ornamental shrubs and trees, and in some cases may be found in wooded areas. The desire for legislation has included this pest also, but there is little chance of any law being passed which will accomplish much against it. In the end, those persons who will treat their trees will save them, while those who do not will lose them, and the burden will fall where it should, upon those who neglect their property.

The past spring was unusually favorable for the rapid increase of plant lice, and many kinds of them were extremely abundant. On the other hand, the cranberry fruit worm was very markedly less abundant than usual, losses by the attacks of this insect being much smaller than for several years.

The leopard moth (*Zeuzera pyrina* L.) has increased in the region around Boston and is another menace to our shade trees. The gypsy moth (*Porthetria dispar* L.) has also increased, and, in spite of a disease which attacked the caterpillars in many places, killing large numbers of them, there is no question that the general condition of eastern Massachusetts as regards this insect is worse than ever before.

The brown-tail moth (*Euproctis chrysorrhœa* L.) is spreading in the State, and nests have now been found as far west as Brookfield and Belchertown. It is only a question of a few years when the whole northeastern United States will be infested by this insect, in spite of all the laws and repressive measures which have been adopted against it.

The twelve-spotted asparagus beetle (*Crioceris 12-punctata* L.) has now been taken in Massachusetts. It was found fairly abundant at Concord and at Roslindale last summer, but has not yet been reported in the Connecticut valley. This pest passes its early stages in the asparagus berry.

On the 2d of June, 1909, a Chalcid parasite was captured at Amherst, laying its eggs in the eggs of the common asparagus beetle (*Crioceris asparagi* L.). The parasite was quite abundant, and was later discovered at Concord. It proved to be a new species, and was described by Mr. J. C. Crawford of the United States National Museum as *Tetrastichus asparagi*. This insect has two and probably three broods a year, corresponding to those of the asparagus beetle, and, to judge from its work last summer, it promises to be quite effective in controlling its host.

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