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ELEVENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1899.

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

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

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

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 50. The feeding value of salt-marsh hay.
No. 51. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 53. Concentrated feed stuffs.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 56. Concentrated feed stuffs.
No. 57. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

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

New methods and new appliances in the feeding and care of animals and plants have opened up new problems, and the demands made upon the station have taxed it to its uttermost. Briefly summarizing the work of the year, we find it distributed as follows: in the division of foods and feeding a new feature has been added, viz., regulating the sale of concentrated feed stuffs. There have been 663 analyses of these materials made, 292 of fodder and 420 of dairy products. In an investigation of Cleveland flax meal *v.* old-process linseed meal for feeding early lambs, it was found that no injurious results followed from the use of flax meal, and that there was the same average daily growth of the lambs on either ration; in an experiment of corn meal *v.* hominy meal and corn meal *v.* cerealine feed for growing pigs, it was found that the corn meal was five to ten per cent. more valuable than cerealine feed used in connection with skim-milk, while hominy meal was quite as valuable as corn meal in connection with skim-milk.

In the entomological division, besides the special work in connection with the gypsy moth, attention has been paid to combining the arsenate of lead and the Bordeaux mixture, with favorable results. The life histories and habits of two pernicious insects have been worked out, — the grass thrips, particularly destructive in this State, and the small clover-leaf beetle (*Phytonomus nigrirostris*). The pernicious scale insects (*Chionaspis*) have also been carefully studied, and the results will soon be published.

The horticultural division has continued its work of testing varieties of fruits, domestic and foreign, suitable for this State, and its investigation of hydrocyanic acid as an insecticide.

The division of fertilizers has made five hundred and fifty-two analyses; has conducted experiments on the use of concentrated chemical manures to supply plant food in greenhouses, combinations of high-grade fertilizers for garden, greenhouse and pot cultivation; and has made observations with dried blood and two kinds of leather refuse as a source of nitrogen for growing rye in presence of acid and alkaline phosphates.

The agricultural division, in addition to its soil tests with corn, onions, oats, etc., has undertaken the testing of seeds of the same variety of potatoes raised in different localities, finding a variation of fifty per cent. in Early Rose and Beauty of Hebron. In experiments with poultry the following results were obtained with reference to egg production: (*a*) that condition powders had no effect; (*b*) that animal meal was of more value than cut bone; (*c*) that the influence of the cock was *nil;* (*d*) that a wide ration was preferable to a narrow ration.

The botanical division has issued an illustrated bulletin (No. 55) on the nematode worm, in which its life history is traced, and a simple remedy, steaming the soil, given for its repression. Work has been done in the drop and top burn of lettuce, asparagus and chrysanthemum rust, and in sub-irrigation and the mechanical condition of soil as affecting the growth of lettuce.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

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

For the Year ending June 30, 1898.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,443 00	
for labor,	3,605 36	
for publications,	2,885 54	
for postage and stationery,	235 56	
for freight and express,	355 49	
for heat, light and water,	130 17	
for seeds, plants and sundry supplies,	448 72	
for fertilizers,	285 86	
for feeding stuffs,	141 17	
for library,	244 78	
for tools, implements and machinery,	250 00	
for furniture and fixtures,	105 19	
for scientific apparatus,	228 36	
for live stock,	901 00	
for traveling expenses,	220 00	
for contingent expenses,	80 65	
for building and repairs.	439 15	
		$15,000 00

Cash on hand July 1, 1897,	$19 73	
Received from State treasurer,	11,200 00	
from fertilizer fees,	3,278 75	
from farm products,	1,763 86	
from miscellaneous sources,	1,663 45	
		$17,925 79
Cash paid for salaries,	$8,901 77	
for labor,	3,167 18	
for publications,	708 27	
for postage and stationery,	236 16	
for freight and express,	154 97	
Amount carried forward,	$13,168 35	

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Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

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

For the Year ending June 30, 1898.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,443 00	
for labor,	3,605 36	
for publications,	2,885 54	
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for postage and stationery,	236 16	
for freight and express,	154 97	
Amount carried forward,	$13,168 35	

Amount brought forward, . . .	$13,168 35	
Cash paid for heat, light and water, . . .	549 44	
for chemical supplies, ...	958 54	
for seeds, plants and sundry supplies, .	368 02	
for feeding stuffs, ...	592 46	
for library, ...	191 10	
for tools, implements and machinery, .	34 49	
for furniture and fixtures, . . .	40 23	
for scientific apparatus, . . .	187 11	
for live stock, ...	313 50	
for traveling expenses, . . .	356 73	
for contingent expenses, . . .	163 96	
for building and repairs, . . .	1,001 86	
		$17,925 79

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1898; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $32,925.79, and the corresponding disbursements $32,925.79. All the proper vouchers are on file, and have been by me examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1898.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 31, 1898.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the meteorological division has been principally engaged in the observations of the various weather elements and phenomena, and the compilation of the records in permanent form. The more important results, together with summaries of most of the others, have been published, as heretofore, in bulletin form each month. The usual summary of the weather for the year will be issued when the records are completed.

The records of the division were begun with the year 1889; accordingly, this year completes the first decennial period. A tabulation of the results for the whole period is under way, for use in determining the means of the several weather elements at this station. These results should give normal conditions differing but little from those that may afterward be deduced from observations covering a much longer time, and will be found valuable for the purpose of determining departures from mean conditions in the future. The tables are being arranged in a suitable form for publication, so that they may be issued in bulletin form, if it is thought desirable.

While the self-recording instruments in the tower give generally good results, the records of the sun thermometer are lacking in precision. Cold-air currents and variable wind velocities give at times records which cannot be distinguished from those due to cloudiness. The desirability of having a photographic or an electrical sunshine recorder, for use in conjunction with the Draper instrument, is suggested.

The local forecasts of the weather have been received daily, except Sunday, from the Boston office of the United

States Weather Bureau, and the signals displayed on the top of the tower. At the request of Mr. J. W. Smith, director of the New England section of the United States Weather Bureau, this division has arranged to furnish his office the weekly snow reports, as has been done the past few years. The record of the number of days of sleighing, begun by Professor Metcalf, is being continued.

During the year attempts were made to secure some records of atmospheric electricity by using the quadrant electrometer in the tower, but without success. The extreme sensitiveness of the instrument seems to preclude its working at any such height from the ground, where it is necessarily subjected to the vibrations of the building. Unless a suitable location and mounting can be provided elsewhere, the records it was intended to secure cannot be obtained with any degree of success.

During the year the division purchased one of the resistance boxes made after the design of Prof. Milton Whitney, of the Division of Soils, United States Department of Agriculture, for the purpose of continuing the examination of soil moisture by the electrical method. The electrodes could not be obtained from the manufacturer until early in June, and then a number proved defective. Others were loaned us later by the Department at Washington for continuing the work. The results obtained have been even less satisfactory than those of last year. An examination of the electrodes in the soil showed in some cases short circuits to have been produced by the growth of roots across the face; in other cases no cause could be found for unusual changes in the resistance. A continuation of the experiment another year may perhaps furnish more satisfactory results, or reveal the causes of some abnormal fluctuations.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The work of this division during the past year has been carried on in about the same lines as for the year of 1897.

Of the experiments conducted, variety testing of fruits, vegetables, flowers, etc., has occupied considerable attention. This work has been undertaken largely in response to the constant calls from the people to know the value of widely advertised new varieties put upon the market with extravagant claims of merit and at exorbitant prices, nine-tenths or perhaps ninety-nine-hundredths of which prove of less value than the old established sorts.

Fruit Investigations.

The Apple.

With each succeeding year the fact is more and more clear that old varieties, from the many conditions of cultivation, from increased injury by insects and fungous pests, grow more feeble and are more and more subject to the continued action of the above agencies; and that new varieties must be found, that can be more easily and cheaply grown, or that will meet the demand for fruit of better quality. The Baldwin apple, for so long a time the most profitable and satisfactory variety for market, has in many places in the last two or three years shown so great a tendency to the dry-rot spots under the skin, long before its normal time for the breaking down of its tissues in the process of ripening, that much of its fruit put on the market has had the effect of decreasing the demand and lowering the price; while the Ben Davis, not nearly as good in quality, but firm, fresh and solid from skin to core, has been sold in our local markets to the exclusion of the home product.

The varieties of apples tested here and in many other sections, that stand out prominently as possessing those qualities that will enable them to successfully compete with the winter varieties shipped to our markets from other States, are the Sutton Beauty, Palmer, MacIntosh Red, Wealthy and Gano.

Sutton Beauty. — Much superior in quality to the Baldwin; is of similar color, perhaps not quite as large unless thinned, and has not shown the dry-rot spots so common in the latter variety. The tree is vigorous and compact in growth, generally with strong, healthy foliage, and so prolific as to require thinning. For local trade it is one of the best.

Palmer. — An apple of medium to large size, of a golden-yellow color when grown on trees in the full exposure of sunlight, but of a green color if grown on closely planted trees. It is of the best quality, tender, crisp and rich. Being an apple of light color and tender flesh, it should be handled very carefully when gathered, and sold in bushel boxes, in which it will not be subjected to much pressure or jolting.

MacIntosh Red. — This is one of the most beautiful of late fall and early winter apples, and, as far as it has been tested in Massachusetts, has done well, and promises to secure much of the trade for fancy apples that demands such varieties as the Fameuse, or Snow apple, which is not successfully grown in this State.

Wealthy. — Generally this variety has proved very satisfactory, but has only been grown on young trees. Its season of ripening is when there is an abundance of fall apples, but it often keeps into early winter. It colors up early, and its beauty, together with its fine quality and somewhat elastic texture, not easily bruised, makes it a good market variety, and should make it valuable as an early shipping apple with which to open the fall trade in European markets, which in the past has been greatly injured by shipping half-ripe and poorly colored Baldwins, and other varieties not as well colored or matured as the latter variety. It has thus far proved prolific, an early bearer and free from disease, but will be greatly improved by thinning.

Ben Davis. — It has been stated on good authority that more of this variety were sold in the Boston markets and on fruit stands during the winter of 1897 than of any other kind, almost the entire amount of which were imported from the western States. In quality and beauty this apple is far below any of the varieties above mentioned; yet its perfect form, uniform size, good keeping qualities, and its very firm, but somewhat elastic flesh, render it less affected by handling and shipping than almost any variety in cultivation. It is very productive, but, as grown in New England, unless thinned, will be of medium or small size. From its behavior thus far it would seem that, if a variety of so poor quality is to be demanded by our markets, it may be grown quite as successfully in many sections of the State as in any other section of the country. This, however, is not necessary; for, if the previously named varieties are well grown, there will be no difficulty in securing the local markets for them, if they are properly sorted and delivered.

Gano. — This variety was introduced as an improved Ben Davis, and, as far as tested, has proved superior to that variety in color, and perhaps to a very slight degree in quality. As yet it has only been produced on young trees, so that its real value cannot be determined without many years' further trial.

Pears.

With the large number of kinds of choice fruit that is now competing with the fruit grown in New England, the pear seems to be less in demand than formerly. Fewer varieties also are found profitable than a few years ago. Of those that stand at the head of the list, the Bartlett, Bosc, Sheldon, Seckle and Hovey are the most generally grown and bring the highest prices.

Peaches.

The interest in peach growing in this State seems on the increase, and the growers are coming to see that it is useless to plant the peach for profit except on high land, where a moderately vigorous growth can be maintained, and where the temperature is such that the fruit buds mature more fully and are not so liable to be destroyed by extreme cold. The varieties that are popular in the market and that are most profitably and successfully grown are Crawford's Early, Crawford's Late, Old Mixon, Elberta and Crosby. All of these varieties except the Elberta have long been grown in Massachusetts. The latter is an oval peach of large size and of a light-yellow color, with more or less color on the exposed side. It is generally hardy and productive, but the past season, in a great many sections of this and other States, was so seriously injured by the "leaf curl" as to endanger its vitality. Should it continue to be attacked by this disease, it will not long remain a profitable variety.

Plums.

Many growers of this fruit in the State have become discouraged from the lack of profit in the domestic plum, on account of the black knot, plum curculio, leaf blight and brown rot. The results obtained in the station orchards give no reason for such discouragement. Trees of all ages, from thirty years old to those of one or two years' growth, may be found, and almost every variety of any value is represented. Upon these trees will be found hardly a knot to the tree. No leaf blight appeared on the majority of the trees, and many varieties matured their fruit with little or no injury from the brown rot, while a few others were seriously injured. In the average season the use of the Bordeaux mixture, as recommended in the spraying calendar in Bulletin 52, has been found to prevent even the serious injury of the fruit by the brown rot; and the past season, had one or two applications of the copper sulphate solution (one-fourth pound to fifty gallons of water) been made the last of July or in early August, this loss might have been greatly reduced. The black knot has almost wholly succumbed to the treatment outlined in the bulletin mentioned, and the most healthy and vigorous foliage is to be found upon all the trees. The varieties that show the greatest tendency to rot are Lombard, Washington, Gueii, Smith's Orleans and Victoria. Those that show the least are Bradshaw, Prince Englebert, Kingston, Grand Duke, Reine Claude and Fellemberg. The amount of rotting of many varieties, however, is largely dependent upon the weather at the time of their approaching maturity, and only prompt and frequent spraying at this time will save the crop.

Of the newer varieties, those that show the most promise are the Kingston, Lincoln and Fellemberg.

Kingston. — Fruit very large, oval in form, slightly pointed at both ends, of the brightest blue color, firm in texture and very acid in quality; ripens late in the season and hangs a considerable time on the tree; very productive and valuable for canning, though it is rather large for this purpose.

Lincoln. — Early, dark purple, of large size and very fine quality; fruited but two years in the station orchards, but it seems very promising.

Fellemberg. — This seems identical with a variety that we have had growing for nearly thirty years under the name of the German prune. It is a regular biennial bearer, but never produces large crops. The fruit is of medium to large size, tapering at both ends. It is of deep purple color, a perfect freestone and of very good quality. Its great value lies in its long keeping and its fine canning qualities.

The Japanese plums, from their rapid growth, great productiveness, early bearing and attractiveness, are being quite largely planted in nearly all sections of the country, and promise to be of considerable value to our fruit growers who do not succeed in growing the domestic varieties. The trees seem to be a little less subject to the black knot and the brown rot, but more subject to the shot-hole fungus, and are often seriously injured by the use of the copper solution and the arsenites. The fruit is attractive, and meets a ready sale; but whether the demand will be large enough to keep up with the increased planting that is going on, time only can determine. All of the varieties of reported value have been planted in the station orchard, forty-eight in all, many of which will fruit next summer for the first time, unless the fruit buds are destroyed by the cold winter weather. In some cases these varieties are attacked by some disease similar to the peach yellows. Of the varieties that have been tested for several years in various sections of the country, the Abundance, Burbank, Red June and Satsuma have proved satisfactory. Of the newer varieties that are of very fine quality the Wickson, Hale and October Purple may be mentioned.

The Satsuma has not ripened here so as to be of much value for table use, but from the deep-red color of its flesh it is especially valuable for canning. It seems to be weak in self-fertilizing qualities, and needs to be planted among other varieties for the best results in pollination.

Cherries.

The crop of cherries in the station orchard would have been unusually large but for the extremely hot and moist weather at the time of ripening, which caused the fruit to rot badly. The trees had been regularly sprayed with Bordeaux up to the time when it would disfigure the fruit, but there was not a sufficient quantity of the copper from this to spread over the rapidly growing leaves and fruit. From results obtained here and from reports received from other stations, it is probable that spraying thoroughly *immediately* after each rain, as the fruit begins to color, with the copper solution (four ounces of copper sulphate to fifty gallons of water), would largely prevent this loss. It is urged that the coming season those engaged in growing cherries should try this treatment. It must be borne in mind that the application should be made very soon after the rain ceases, as the spores of the brown rot germinate very quickly when placed in moisture, and it is to prevent this germination that the application is made. Heavy rains, especially if soon followed by dry weather, need be little feared, as they tend to wash the spores off the plants, though some may gain a lodgement in the axils of the leaves or in the calyx of the fruit or other places. The varieties most satisfactory were Governor Wood, Napoleon, Black Tartarian and Early Richmond.

Grapes.

Perhaps upon no fruit crop grown in New England is the certainty of protection by spraying so great as with the grape crop, when properly done, and upon which insecticides and fungicides are so easily and cheaply applied. Campbell's Early, the only new variety fruiting that stands out as decidedly promising, produced fruit on several young vines. The growth of vine was satisfactory, the foliage free from disease, the fruit beautiful in appearance and of good quality. The compactness of bunch and firmness of berry will make it a good shipping grape, and, if it does not develop a tendency to disease, it will be a valuable addition to the few varieties that can be profitably grown in New England. It ripens as early or perhaps a little before Moore's Early, and is much superior in quality. The varieties recommended for this section are Winchell or Green Mountain, Worden and Delaware.

Currants.

There is scarcely another fruit the merits of whose new varieties it is so difficult to decide as the currant, because of its great variation in size and productiveness under different conditions. All the new varieties of any prominence have been planted in the station plots, and those that stand out prominently as possessing merit are the Pomona, Wilder and the Red Cross; and, after three years fruiting, their value seems to be in the order given. The Pomona may be mentioned as of especial value, because of its superior quality. We have no records, however, to show that any of the above varieties will be more valuable for general cultivation than Fay's Prolific or the Cherry.

Blackberries.

All of the prominent new varieties have been added to the list under trial, but none have thus far shown themselves to be more valuable than the best older sorts, — the Agawam, Snyder and Taylor's Prolific. On heavy soils, where the growth is large and furnishes an abundant soil cover, thus keeping the ground cool, the first-named variety proves very satisfactory: but when grown on light land it is of much less value.

The Eldorado continues to do well, and compares favorably with the above-mentioned varieties; but whether it will prove more valuable than any other, can only be determined in large plantation.

Raspberries.

With the red raspberry there has been little or no progress made in improved varieties. The Loudon, which, from its stocky growth, hardiness and fruit of good size, color and quality, seemed very promising, has the past season shown a tendency to mildew of the leaves and young growing canes. If this becomes general, it will greatly reduce its value. The seedlings produced from the seeds of the Shaffer, and referred to in a previous bulletin, have again fruited, and many of them show decided merit, some producing fruit of a bright scarlet color upon plants that propagate only from the tip of the cane, as does the Shaffer; while others produce fruit of the Shaffer type that propagate from suckers, like the common red raspberry.

Strawberries.

The past season was favorable for a large crop of fruit, but the extremely wet weather at the time of ripening caused much loss by rotting. The named varieties were planted in plots of twenty-five plants each, while the most promising of these are planted each season in rows under field culture. Of the varieties in plots (soil medium heavy loam), the Brandywine, Gandy Bell, Glen Mary, Sample and Howard's No. 14 gave the best results. Of those grown under field culture, on light land, the Clyde, Cumberland, Glen Mary, Howard's Nos. 36 and 41 gave the best results.

New Fruits.

Several new species of raspberries, the strawberry-raspberry, Logan-berry, Salmon-berry, May-berry, etc., have been planted, some of which have fruited, but only two seem to possess any merit for this climate. The strawberry-raspberry is an herbaceous perennial, the top of which dies to the ground in the winter, but is followed by numerous shoots in the spring from underground stems, that bear most beautiful wine-colored fruit in abundance. This fruit is of a peculiar, insipid, though not unpleasant flavor, and may be the origin of new varieties with a more decidedly pleasant taste. Should such varieties be produced, and a system of cultivation be worked out by which a reasonably certain crop can be secured, it may prove a valuable addition to our list of hardy fruits.

The Logan berry resembles the common dewberry or running blackberry in habit of growth and form of fruit; but the latter is rather larger, and of a dark-red or mahogany color. It possesses a pleasant flavor, but the same obstacle to its general cultivation is met as with the dewberry, — that it is difficult to devise a method of cultivation and training that will give a large crop of fruit every year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, P. H. Smith, Jr.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The laboratory work connected with this department has been much increased during the past year. We have received for examination 159 samples of water, 228 samples of milk, 17 samples of butter, 4 samples of oleomargarine and 81 samples of feed stuffs. The work in connection with this and other divisions of the Station has consisted of the analysis of 394 samples of milk, 26 samples of butter, 292 samples of fodders and 11 miscellaneous samples. In addition to the above, we have collected 754 samples of feed stuffs under the provisions of the feed law, of which 663 samples have been examined. This makes a total of 1,875 substances analyzed, as against 1,147 in 1897. There have also been carried on for the Association of Official Agricultural Chemists, investigations relative to the best methods for the determination of potash, and of the different ingredients in cattle foods, as well as a study of the most desirable methods to be employed in the estimation of sugar. It is hardly possible to express numerically the extent of this work.

Character of Chemical Work.

Water. — We have followed the same general line of investigation as in former years, in the examination of waters sent by farmers and others.

Whenever possible printed instructions are sent for sampling and sending the water. In making a report to the party, a printed form is used. Upon the form there is explained the meaning of the terms used, so that every one will have at least a general idea of what the analytical results are meant to convey.

Those sending the samples have been advised promptly whether in our judgment the water was suitable for drinking and general domestic purposes. Whenever necessary, suggestions have been offered with the hope of improving the family supply. We again caution everyone who depends upon wells and springs for their drinking water to have all sink drains, etc., remote from the well, and to keep the ground in the vicinity free from objectionable matter. Lead pipes should never be used in drawing water from wells.

Milk. — Some of the milk sent to the station has been from farmers who ship their milk to the Boston market, and having been notified by the contractors that their article was below the legal standard, wished to ascertain if such was the fact, and if so, what could be done for its improvement. To such we have given the same advice as appeared in our last annual report, to which interested parties are referred.

Many farmers are now sending occasional samples of milk, cream and skim-milk to the station, to ascertain the amount of butter fat contained in them. These producers sell their milk to creameries, and they are desirous of knowing its quality for butter production. This is a very encouraging sign, for it shows that the farmer really wishes to know the butter-producing capacity of his cows, and the efficiency of his separator, or Cooley creamer, in removing the fat from his milk. To all who desire, printed information is given, stating how to ascertain the yearly butter capacity of dairy cows.

Much of the milk and butter analyzed in connection with our own experiments has been studied with a great deal of care. We have estimated the water, solids, fat, casein, milk sugar, and ash in a large number of samples. We have also made a very thorough examination of 26 samples of butter fat produced by cows employed in connection with our feeding experiments. There have been determined in duplicates or triplicates, volatile acids, specific gravity, melting point, and the iodine number.

Cattle Feeds. — Our feed law has now been in operation about one and one-half years. We have made frequent inspections covering the entire State, and have published two especially prepared bulletins giving the results of our investigations. We have endeavored to make these bulletins as practical as possible, and judging from the way in which the bulletins are received, it is believed that we have in a measure succeeded. During the spring of 1898 a considerable quantity of adulterated cotton-seed meal was found in various sections of the State. Printed slips of warning were immediately sent to 100 newspapers in the State, and a concise circular was also mailed to every grain dealer, cautioning against its purchase. While meal of this character generally has a darker appearance than the prime article, samples of inferior meal have recently been found having quite a bright yellow color. A number of reputable manufacturers now print a guaranty upon every package, and purchasers are strongly advised to buy only the guaranteed article. The effect of the feed law has been to call the attention of all manufacturers to the necessity of branding their products, and having them run as even as possible in composition. Many of the more reputable manufacturers are now placing a guaranty upon their feeds, and it is hoped others will soon follow.

Many new feeds are constantly being offered for sale in our markets. A number have appeared during the year 1898. Our object is to secure samples of these materials promptly, and ascertain their feeding and comparative commercial values. For detailed information the reader is referred to Bulletins 53 and 56.

Other Chemical Work. — The analyses of feed stuffs and manures in connection with the numerous digestion experiments carried on by this division, involves a considerable amount of time and effort, but because of this work we are enabled to state with a reasonable degree of accuracy the feeding and commercial values of the concentrated feeds sold upon the market, and of the coarse feeds produced upon our farms.

It is the object of this division to assist the Association of Official Agricultural Chemists as much as possible in perfecting methods of chemical analyses, and in finding out methods for the estimation of the quantity and nutritive value of several of the newer carbohydrates. We spend whatever time can be had during each year in working along these lines, believing it will be productive of much good in the future. During the past year we have given attention to the estimation of pentosans, starch and sugar in agricultural plants.

The chemical work received from the agricultural division has very much increased during the past year. This work consists of the determination of dry matter in a large number of plants, the estimation of starch in potatoes, the analyses of feed stuffs used in poultry experiments, and in general fodder analyses. This increased work is now severely taxing the resources of our chemical force.

Part II.

A. Cleveland Flax Meal *v.* Old-process Linseed Meal for Early Lambs.

Object of the Experiment.

It has recently been claimed, by parties who grow early lambs for market, that the so-called new-process linseed meal (Cleveland flax meal) exerted an injurious effect upon the young lamb. Some claim that this meal did not favor growth, and others that it was the cause of frequent sudden deaths. On the other hand, it was stated that the old-process meal did not have these injurious effects, but favored rapid growth and fattening. The station was asked to throw some light on the subject, and conducted the following experiment in the winter and early spring of 1898.

The Experiment.

Six grade Southdown ewes were brought to the station barn the first week in February, and each placed in a separate pen six feet wide by fifteen feet long. The pens were separated by stout wire netting, thus enabling the animals to see each other. The ewes were all in fair condition, and in about two weeks' time began to drop their lambs. Each lamb was weighed five days after being dropped.

Daily Feed for the Ewes after Lambing. — Two pounds corn ensilage, rowen *ad libitum*, 1 pound grain mixture. The grain mixture* was gradually increased until each ewe received 2½ pounds daily. This grain feed was kept up as long as the ewes would take it, and was then gradually reduced. The grain mixture, as will be noticed, contained about one-third of one of the two kinds of linseed meal.

Daily Feed for the Lambs. — The pens were so arranged that the lambs gained access to a separate compartment, containing a mixture of grains. They soon learned to go in as soon as the feed was placed in the troughs. It was our aim

* The grain mixture consisted of 7.5 pounds of old-process linseed or flax meal, 7.5 pounds of bran, 5 pounds corn meal and 5 pounds gluten feed.

to feed them what they would eat daily: grain mixture No. 1, 7.5 pounds flax meal or old-process linseed meal, 7.5 pounds bran, 10 pounds corn meal.

After feeding this mixture for about two weeks, a second was fed, as follows: 10 pounds flax meal or old-process linseed meal, 5 pounds bran, 5 pounds corn meal.

When the lambs each reached 40 pounds in weight, the mixture was again changed to: one-third flax meal or old-process linseed meal, one-third bran, one-third corn meal.

It was our object to give the lambs as much of each of the two linseed meals as they would stand, and keep in a healthy, growing condition.

Care of the Lambs. — The lambs were kept in the pens with the ewes. As the season advanced, they were allowed the run of a large yard in the warmer part of sunny days.

Record of Growth.

Flax Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 8, . .	March 3,	May 5,	62	15.25	67.00	51.75	.83
Lamb No. 6, . .	March 1,	May 18,	78	10.25	57.50	47.25	.62
Lamb No. 7, . .	March 1,	May 25,	85	10.50	53.00	42.50	.50
Lamb No. 1, . .	February 25,	May 18,	82	9.50	47.50	38.00	.46
Lamb No. 2, . .	February 25,	May 25,	89	9.25	41.00	31.75	.36
Average, . .	-	-	79	10.95	53.20	42.25	.54

Old-process Linseed Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 5, . .	February 25,	April 29,	63	11.75	52.25	40.50	.64
Lamb No. 3, . .	February 25,	May 18,	82	11.00	50.00	39.00	.48
Lamb No. 4, . .	February 25,	May 25,	89	8.75	44.50	35.75	.40
Lamb No. 9, . .	March 19,	June 1,	74	10.25	52.25	42.00	.57
Lamb No. 10, . .	March 19,	June 1,	74	9.00	51.00	42.00	.57
Average, . .	-	-	76	10.15	50.00	39.85	.53

Note. — Lambs 6 and 7, 1 and 2, 3 and 4, 9 and 10, were twins.

The lambs were shipped to Ira C. Lowe of Greenfield, Mass., who slaughtered them, and reported on their condition. He had no knowledge as to which lambs were fed the flax meal and which lambs were fed the old-process linseed meal ration. Lamb No. 8 was reported to be of extra quality, Lamb No. 5 next in quality to No. 8, and the others of fair quality only. Looking at the average figures in the above tables, it will be seen that each lot of five lambs showed the *same daily gain*. Mr. Lowe noticed no particular advantage in favor of either lot.

Results of the Experiment.

As a result of our observations, we conclude: —

That the flax meal had no injurious effect either upon the growth or dressed appearance of the lambs, and that both sets of lambs produced the same average daily growth, and were both in the same average condition when slaughtered.

Remarks and Suggestions.

It is well known to all growers of early lambs, that in order to secure a rapid growth of the lamb, the ewe should be thrifty, and a good milker. A liberal feeding will aid in keeping up a continuous flow of milk. The early growth of the lamb will depend very much on the constitution it inherits, and upon its success in obtaining a large supply of milk. Easily digested nitrogenous feed stuffs will unquestionably assist in producing quick growth, but they are secondary to the milk supply. This is quite forcibly illustrated in case of our experiments as described above. Lamb No. 8 was single, and its mother was an excellent milker. The lamb was above the average in size and vigor when dropped. He grew rapidly, showing .83 of a pound gain per day. It was noticed that this lamb did not consume very large amounts of grain, although he had a constant opportunity. He derived the larger part of the food necessary for his growth from his mother. Lamb No. 5 was also a single lamb. He made a very good growth, but the ewe was not as good a milker as the previous one. This lamb took more grain than did No. 8, but was not able to make as rapid growth. The other lambs were twins. They did not grow as rapidly as did the single lambs, because of the lack of milk, although they ate quite freely of the grain mixtures. Lambs Nos. 6 and 7 came from a good milker, and they were also quite vigorous and hearty eaters.

In addition to inherited constitution and plenty of milk, it is very essential, in order to secure rapidity of growth, that early lambs should be housed in a warm, dry barn, and have a maximum amount of sunlight from a southern exposure.

B. Corn Meal *v.* Hominy Meal, and Corn Meal *v.* Cerealine Feed for Growing Pigs.

Experiment I. — Corn meal *v.* hominy meal.
Experiment II. — Corn meal *v.* cerealine feed.
Experiment III. — Corn meal *v.* cerealine feed.

Objects of the Experiments.

Skim-milk is a very valuable feed for growing pigs. It is a digestible, nitrogenous feed stuff. Of itself it is not a complete food, being deficient in solid matter as well as in carbohydrates (starchy material). In order to make a complete food, carbohydrate feeds are necessary to properly balance the daily ration. A combination of skim-milk and corn meal (1 quart milk and from 3 to 6 ounces of meal) has been found to make a most excellent feed for rapid growth. The object of the above-mentioned experiments was to get at the feeding values of hominy meal and cerealine feed, when compared with corn meal, for this purpose.

What Hominy Meal is. — Hominy meal consists of the hulls, germ and some of the starch and gluten of the corn, ground together. This separation is said to be brought about solely by the aid of machinery. The hard, flinty part of the corn is the hominy, which is used as a human food.

What Cerealine Feed is. — This feed consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than does the hominy meal. It is the by-product resulting from the preparation of the breakfast preparation known as cerealine flakes. It is very coarse looking, and appears much like unground corn hulls.

Results of Experiments.

1. Hominy meal produced 5 to 7 per cent. more growth, when fed to pigs in connection with skim-milk, than did corn meal. This difference was probably due to the dryer condition of the hominy meal, and nearly disappears when the meals are compared on a basis of dry matter they contained.

2. In view of the fact that Pig IV. was thrown out of the experiment, we should hesitate to say that the hominy meal had proved itself in any degree superior to the corn meal. This experiment would seem to indicate, however, that pound for pound, as found in the market, the hominy meal is at least fully as valuable as the corn meal.

3. In the two experiments with cerealine feed and corn meal, the corn meal produced 5 per cent. more growth than did the cerealine feed. Corn meal constituted but 62 per cent. of the dry matter of the ration; and, if 62 per cent. of dry matter of the ration in the form of corn meal produced a gain of 5 per cent., 100 per cent. of corn meal — *e. g.*, its full effect — would show an 8 per cent. gain.

4. We think we are justified in saying that corn meal is from 5 to possibly 10 per cent. more valuable than cerealine feed for use in connection with skim-milk for growing pigs.

5. Cerealine feed might prove equal to corn meal as a feed for milch cows, as digestion experiments with sheep have shown it to contain as much digestible matter as corn meal. It is very probable that pigs are not able to digest the hulls of the corn as well as other animals.

6. Because of the important part played by the individuality of the animal, we are frank to confess that a larger number of pigs would be desirable in conducting experiments of this kind. We feel confident, however, that these experiments give a fairly accurate representation of the comparative values of the several feed stuffs.

Experiment I. — Corn Meal v. Hominy Meal.

Nov. 23, 1896, to March 1, 1897 (98 Days). — Eight grade Chester White pigs, all of the same litter, were purchased in October. They were first fed skim-milk alone, and finally divided into two lots, and corn or hominy meal added to the skim-milk diet. Pigs Nos. I. and II. were together in one pen, and so were pigs Nos. VII. and VIII.; the others were in separate pens. Pig IV. was taken sick during the experiment, and his record is not considered. Each pig was allowed from 7 to 10 quarts of skim-milk daily, and from 3 to 6 ounces of grain for each quart of milk, the quantity depending on the appetite and stage of growth of the animals. As the pigs advanced in age and growth, the quantity of grain was increased, thus furnishing an increased food supply and an increasing amount of carbohydrates.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. V.,	884.00	1,927.12	183.08	255.44	223.25
Pig No. VI.,	883.00	1,924.94	182.87	255.44	223.25
Pigs Nos. VII. and VIII.,	1,766.00	3,849.88	365.74	510.88	446.50
Totals,	3,533.00	7,701.94	731.69	1,021.76	893.00
Averages,	883.25	1,925.49	182.92	255.44	223.25

Hominy Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Hominy Meal (Pounds).	Dry Matter (Pounds).
Pigs Nos. I. and II.,	1,768.00	3,854.24	366.15	255.06	470.23
Pig No. III.,	883.00	1,924.94	182.87	255.44	235.46
Totals,	2,651.00	5,779.18	549.02	765.56	705.69
Averages,	883.67	1,926.39	183.01	255.19	235.23

The above tables show that each lot of pigs consumed identical amounts of skim-milk, and very nearly equal amounts of grain. The hominy meal lot ate about 12 pounds more of dry grain per pig, than did the corn meal lot.

TOTAL GAIN IN LIVE WEIGHT.

Corn Meal Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pouuds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. V., ...	54.50	184.25	129.75	1.32
Pig No. VI., ...	58.25	167.00	130.25	1.33
Pigs Nos. VII. and VIII., . .	109.25	188.50 185.25	243.00	2.48
Totals, ...	222.00	725.00	503.00	5.13
Averages, ...	55.50	181.25	125.75	1.28

Hominy Meal Lot.

Pigs Nos. I. and II., ...	115.50	387.25	271.75	2.77
Pig No. III., ...	57.75	196.00	138.25	1.41
Totals, ...	173.25	583.25	410.00	4.18
Averages, ...	57.75	194.42	136.66	1.39

One notes a very slight difference in favor of the hominy fed lot, this being caused perhaps by the slightly increased amount of actual dry matter found in the hominy meal.

By referring to the table, it will be noticed that each pig received 223.25 pounds of perfectly dry corn meal and 235.23 pounds of perfectly dry hominy meal.

Total Gain in Dressed Weight.

Corn Meal Lot.

Number of Pig.	Dressed Weight at End of Experiment (Pounds).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Total Gain in Dressed Weight (Pounds).	Loss in Weight in Dressing (Pounds).
Pig No. V.,	150.50	44.52	105.98	18.31
Pig No. VI.,	154.25	47.67	106.58	18.17
Pigs Nos. VII. and VIII.,	287.25	89.09	198.16	18.45
Totals,	592.00	181.28	410.72	54.83
Averages,	148.00	45.32	102.68	18.28

Hominy Meal Lot.

Pigs Nos. I. and II.,	306.00	91.25	214.75	20.89
Pig No. III.,	152.00	44.79	107.21	22.45
Totals,	458.00	136.04	321.96	43.34
Averages,	152.66	45.35	107.32	21.67

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. V.,	3.13	3.84
Pig No. VI.,	3.12	3.81
Pigs Nos. VII. and VIII.,	3.34	4.09
Averages,	3.20	3.91

Hominy Meal Lot.

Pigs Nos. I. and II.,	3.08	3.89
Pig No. III.,	3.03	3.90
Averages,	3.06	3.89

The very slight difference between the gains in the two lots is within the limit of error.

Experiment II. — Corn Meal v. Cerealine Feed.

April 12 to July 26, 1897 (106 Days). — The six pigs used in this experiment were grade Chester Whites, about five weeks old when purchased, March 2. They were brought into separate pens April 1, and the experiment began April 12. Each pig was fed 6 to 9 quarts of skim-milk daily, together with 3 ounces of grain for each quart of milk. The amount of grain was gradually increased as the animal demanded it, until some 4 pounds daily were fed. The milk never exceeded 9 quarts per day.

At the beginning of the experiment the animals were receiving 1 part protein to 3 parts carbohydrates. The ration was gradually widened, until towards the close of the experiment the nutritive ratio was as 1 to 7. The corn meal heated during the latter part of the experiment, and became somewhat musty.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. I.,	738.00	1,608.84	152.84	243.63	204.98
Pig No. II.,	738.00	1,608.84	152.84	243.63	204.98
Pig No. III,	738.00	1,608.84	152.84	243.63	204.98
Totals,	2,214.00	4,826.52	458.52	730.89	614.94
Averages,	738.00	1,608.84	152.84	243.63	204.98

Cerealine Feed Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. IV.,	738.00	1,608.84	152.84	243.63	214.39
Pig No. V.,	738.00	1,608.84	152.84	243.63	214.39
Pig No. VI.,	738.00	1,608.84	152.84	243.63	214.39
Totals,	2,214.00	4,826.52	458.52	730.89	643.17
Averages,	738.00	1,608.84	152.84	243.63	214.39

Some 10 pounds more dry cerealine feed were consumed per pig than corn meal during the experiment, due to the dryer condition of the cerealine feed when fed.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	51.25	188.00	136.74	1.29
Pig No. II.,	48.50	184.00	135.50	1.28
Pig No. III.,	43.25	184.25	141.00	1.33
Totals,	143.00	556.25	413.25	3.90
Averages,	47.67	185.42	137.75	1.30

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	44.00	175.50	131.50	1.24
Pig No. V.,	41.00	170.50	129.50	1.22
Pig No. VI.,	49.25	186.00	136.75	1.29
Totals,	134.25	532.00	397.75	3.75
Averages,	44.75	177.33	132.58	1.25

A slight gain in favor of the corn meal lot is noted.

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	2.62	3.28
Pig No. II.,	2.64	3.30
Pig No. III.,	2.54	3.17
Averages,	2.60	3.25

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.79	3.49
Pig No. V.,	2.84	3.54
Pig No. VI.,	2.69	3.37
Averages,	2.77	3.46

The above figures show a slight difference in favor of the corn meal, rather less dry matter in corn meal being required to make a pound of growth than in cerealine feed.

Experiment III. — Corn Meal v. Cerealine Feed.

Oct. 25 to Jan. 10, 1898 (78 Days). — The six pigs employed in this experiment were a cross between the Poland-China and the Chester White. They were received early in September, when five weeks old, and allowed the run of a large pen out of doors until October 20, when they were placed in separate pens in the feeding barn, and divided as equally as possible into two lots. They were in a very vigorous condition. In this experiment the cerealine feed heated towards the close of the experiment. It was shovelled over and dried at once when this condition was observed, and the experiment continued. The pigs ate it with seeming relish at all times.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. IV.,	468.00	1,020.24	96.92	226.50	197.06
Pig No. V.,	468.00	1,020.24	96.92	226.50	197.06
Pig No. VI.,	468.00	1,020.24	96.92	226.50	197.06
Totals,	1,404.00	3,060.72	290.76	679.50	591.18
Averages,	468.00	1,020.24	96.92	226.50	197.06

Cerealine Feed Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. I.,	468.00	1,020.24	96.92	226.50	201.59
Pig No. II.,	468.00	1,020.24	96.92	222.50	198.03
Pig No. III.,	468.00	1,020.24	96.92	226.50	201.59
Averages,	468.00	1,020.24	96.92	225.20	200.40

The amount of feed consumed by the two lots is practically identical.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	68.50	172.50	104.00	1.33
Pig No. V.,	67.75	172.00	104.25	1.34
Pig No. VI.,	66.75	173.00	106.25	1.36
Totals,	203.00	517.50	314.50	4.03
Averages,	67.67	172.50	104.83	1.34

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	73.75	169.00	95.25	1.22
Pig No. II.,	57.25	150.00	92.75	1.19
Pig No. III.,	68.75	174.00	105.25	1.35
Totals,	199.75	593.00	293.25	3.76
Averages,	66.58	164.33	97.75	1.25

Each pig in the corn meal lot shows an average gain of 7 pounds over the cerealine feed pigs. This might partly be accounted for by reason of the poor condition of the cerealine feed, already mentioned.

Dry Matter required to produce One Pound Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.83	3.53
Pig No. V.,	2.82	3.52
Pig No. VI.,	2.77	3.42
Averages,	2.81	3.49

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	3.13	3.91
Pig No. II.,	3.18	3.98
Pig No. III.,	2.84	3.55
Averages,	3.05	3.81

The dry matter required to produce a pound of gain confirms the results given in the tables under gain in live weight, and shows that in this experiment a pound of live weight was produced by ¼ of a pound less of absolutely dry corn meal than of dry cerealine feed. The conclusions from these three experiments have already been given on page 28.

Composition of Feeds (used in Three Feeding Experiments).

Separate Ingredients of Feeds.	Average Skim-milk, All Experiments (per Cent.).	Experiment I.		Experiment II.			Experiment III.	
		Corn Meal (per Cent.).	Hominy Meal (per Cent.).	Corn Meal, I. (per Cent.).	Corn Meal, II. (per Cent.).	Cerealine Feed (per Cent.).	Corn Meal (per Cent.).	Cerealine Feed (per Cent.).
Water,	90.50	12.63	7.82	20.00	14.00	12.00	13.00	11.00
Protein,	-	8.78	10.59	8.86	9.03	9.55	9.64	10.96
Fat,	-	4.08	8.50	2.18	2.15	6.60	3.59	6.30
Extract matter,	-	71.73	65.46	65.80	71.68	65.23	70.80	64.55
Fibre,	-	1.42	4.11	1.82	1.81	4.40	1.70	4.36
Ash,	-	1.36	3.52	1.34	1.33	2.22	1.27	2.83
Totals,	-	100.00	100.00	100.00	100.00	100.00	100.00	100.00

C. The Cost of Pork Production.

In a section of our State the cream from the milk produced upon the farm is sold to the creamery, and the skim-milk is either fed to pigs or calves. A large number of experiments have been made at this station with growing pigs. The pigs averaged from 37 pounds in weight at the beginning of the experiments to 183 pounds when slaughtered. The daily rations have been essentially as follows: —

I. From 5 to 7 quarts of milk per day; and, beginning with 3 ounces of corn meal to each quart of milk, the grain has been gradually increased to satisfy the appetite of the animal.

II. About the same quantity of milk, and, instead of the corn meal, other carbohydrate foods, such as ground rye, wheat, hominy meal, cerealine feed and oat feed, to satisfy appetites.

III. About the same quantity of milk, together with 3 to 6 ounces of corn meal to each quart of milk, and a mixture of one-third wheat bran, one-third gluten meal and one-third corn meal, to satisfy appetites.

More exact statements of rations will be found farther on. We rarely had more than from 5 to 7 quarts of milk daily for each pig. The animals did well with this amount of milk; if they did not secure this quantity, their growth was noticeably slower.

Explanation of Tables.

As a result of these various experiments, we have endeavored to ascertain: —

1. The price that skim-milk has returned per quart.
2. The cost of feed required to produce *a pound* of *live* or *dressed weight*, taking the various grains at a reasonable range of market prices, and allowing either $\frac{1}{4}$ or $\frac{1}{2}$ cent per quart for the milk.

In tables I., II. and III. will be found the results where milk and corn meal have been fed.

Tables IV., V. and VI. will show the results where milk and other starchy (carbohydrate) feeds have been substituted for the corn meal, such as hominy or cerealine feeds, rye and wheat meals ("grain").

Tables VII., VIII. and IX. show the results where milk and corn meal were fed, and, in addition, wheat bran, gluten meal, etc. ("other grains").

Tables X. and XI. show the average of all the preceding, being the results with 140 pigs, weighing 37 pounds at the beginning, and 183 pounds at the close of the experiments.

TABLE I. — *Milk and Corn Meal.*

Feeds Consumed, etc.	Quarts.	Pounds.
Total milk consumed by 21 pigs,	16,421	35,797.78
Total corn meal consumed by 21 pigs,	-	5,531.10
Live weight, actually gained,	-	3,012.25
Dressed weight, calculated,	-	2,409.80

TABLE II. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.48	.63	.77	.44	.58	.73	.39	.54	.69
Per 100 pounds (cents),	22.02	28.90	35.37	20.19	26.61	33.48	17.89	24.77	31.19

TABLE III. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 per ton, and milk at ¼ cent per quart,	2.74	3.44
With corn meal at $15 per ton, and milk at ½ cent per quart,	4.11	5.13
With corn meal at $17.50 per ton, and milk at ¼ cent per quart,	2.98	3.72
With corn meal at $17.50 per ton, and milk at ½ cent per quart,	4.33	5.41
With corn meal at $20 per ton, and milk at ¼ cent per quart,	3.21	4.02
With corn meal at $20 per ton, and milk at ½ cent per quart,	4.59	5.71

TABLE IV. — *Milk and Different Starchy Feeds.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 22 pigs, ...	13,153	28,630
Total " grain " consumed by 22 pigs, ...	-	5,135
Live weight, actually gained, ...	-	2,597
Dressed weight, calculated, ...	-	2,078

TABLE V. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH "GRAIN" AT $15 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound)
Per quart (cents),	.50	.65	.81	.45	.60	.76	.40	.56	.87
Per 100 pounds (cents),	22.90	30.10	37.10	20.60	27.80	35.10	18.35	25.69	39.91

TABLE VI. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With "grain" at $15 per ton, and skim-milk at ¼ cent per quart,	2.75	3.43
With "grain" at $15 per ton, and skim-milk at ½ cent per quart,	4.01	5.01
With "grain" at $17.50 per ton, and skim-milk at ¼ cent per quart,	3.00	3.75
With "grain" at $17.50 per ton, and skim-milk at ½ cent per quart,	4.26	5.32
With "grain" at $20 per ton, and skim-milk at ¼ cent per quart,	3.24	4.05
With "grain" at $20 per ton, and skim-milk at ½ cent per quart,	4.51	5.63

TABLE VII. — *Milk, Corn Meal, Bran, Gluten Meal, etc.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 97 pigs,	62,319	135,855
Total corn meal consumed by 97 pigs,	-	21,602
Total "other grains" consumed by 97 pigs,	-	12,663
Live weight actually gained,	-	15,080
Dressed weight calculated,	-	12,064

Table VIII. — *Price obtained for Skim-milk.*

Price obtained for Skim-milk.	With Corn Meal at $15 per Ton, "Other Grains" at $17.50 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	With Corn Meal at $17.50 per Ton, "Other Grains" at $20 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	With Corn Meal at $20 per Ton, "Other Grains" at $22.50 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.53	.72	.92	.45	.65	.85	.39	.59	.78
Per 100 pounds (cents),	24.30	33.20	42.10	21.20	30.00	39.00	18.00	27.00	36.00

Table IX. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50 and milk at ¼ cent per quart, ...	2.84	3.55
With corn meal at $15 "other grains" at $17.50 and milk at ½ cent per quart, ...	3.87	4.84
With corn meal at $17.50 "other grains" at $20 and milk at ¼ cent per quart, ...	3.13	3.90
With corn meal at $17.50 "other grains" at $20 and milk at ½ cent per quart, ...	4.16	5.20
With corn meal at $20 "other grains" at $22.50 and milk at ¼ cent per quart, ...	3.41	4.26
With corn meal at $20 "other grains" at $22.50 and milk at ½ cent per quart, ...	4.44	5.55

Table X. — *Price obtained for Skim-milk (All Experiments).*

Average Price obtained for Skim-milk.	With Corn Meal and Other Starchy Foods at $15 per Ton, "Other Grains" at $17.50 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	With Corn Meal and Other Starchy Foods at $17.50 per Ton, "Other Grains" at $20 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	With Corn Meal and Other Starchy Foods at $20 per Ton, "Other Grains" at $22.50 per Ton, and Dressed Pork at — Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.50	.67	.83	.45	.61	.78	.39	.56	.78
Per 100 pounds (cents),	23.07	30.73	38.19	20.66	28.14	35.86	18.08	25.82	35.70

Table XI. — *Average Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50, milk at ¼ cent per quart,	2.78	3.47
With corn meal at $15 "other grains" at $17.50, milk at ½ cent per quart,	4.00	4.99
With corn meal at $17.50 "other grains" at $20, milk at ¼ cent per quart,	3.04	3.79
With corn meal at $17.50 "other grains" at $20, milk at ½ cent per quart,	4.25	5.31
With corn meal at $20 "other grains" at $22 50, milk at ¼ cent per quart,	3.63	4.53
With corn meal at $20 "other grains" at $22.50, milk at ½ cent per quart,	4.51	5.63

D. Rations for Growing Pigs.

Ration No. I. — *With Unlimited Supply of Milk.*

Weight of Pigs.	Rations.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk.
60 to 100 pounds,	6 ounces of corn meal to each quart of milk.
100 to 180 pounds,	8 ounces of corn meal to each quart of milk.

Ration No. II. — *With Limited Supply of Milk (5 to 6 quarts per Pig daily).*

Weight of Pigs.	Rations.
20 to 60 pounds, 60 to 100 pounds, 100 to 180 pounds,	3 ounces of corn meal * to each quart of milk, and then gradually increase corn meal to satisfy appetites.

* Wheat, rye or hominy meals can be substituted for corn meal.

Ration No. III.

Weight of Pigs.	Rations
20 to 60 pounds,	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran and one-third gluten meal, to satisfy appetites.
60 to 100 pounds,	Milk at disposal, plus mixture of one-half corn meal, one-quarter wheat bran and one quarter gluten meal, to satisfy appetites.
100 to 180 pounds,	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran and one-sixth gluten meal, to satisfy appetites.

REPORT OF THE AGRICULTURIST.

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

Soil Tests.

During the past season four soil tests upon the co-operative plan agreed upon in Washington in 1889 have been carried out. Two of these were upon our own grounds, — one with corn and the other with onions as the crop; one in Norwell, Plymouth County, with oats; and one in Montague, Franklin County, also with oats.

1. Soil Test with Corn. Amherst.

The past is the tenth season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch crop, rye, soy beans, white mustard, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three have received but a single important manurial element, — every year the same; three have received each year two important elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produce this year an average of about twelve bushels of shelled corn per acre; and even this figure is somewhat too high, owing to the fact that after this long period one of the nothing plots which adjoins the plot which has been yearly manured at the rate of five cords per acre begins to feel the effect of the high fertility of its neighbor, although separated from it by a strip three and one-half feet wide.

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in any combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulphate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of the muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other home-test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulphate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study.

Conclusions.

1. The yield of the plot which for ten years has received only phosphoric acid and potash (41.2 bushels per acre) illustrates in a striking way the comparative independence of the corn crop of supplied nitrogen upon this soil.

2. The crop raised where nitrogen, phosphoric acid and potash have been yearly applied (nitrate of soda, dissolved bone-black and muriate of potash) for ten years shows that profitable results may be obtained by the use of fertilizers alone. The yearly cost of the application to this plot has been from $10 to $12. The crops have not been much inferior to those on the plot to which manure at the rate of 5 cords per acre has been yearly applied. The two crops this year are, respectively: for the fertilizer, 55.9 bushels; for the manure, 67.7 bushels. The extra 11 bushels of corn will not cover the added cost of the manure, as compared with the fertilizer; and in earlier years the differences in yield have been relatively much smaller than this year.

3. The problems suggested by the results of the year must be regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

2. *Soil Test with Onions. Amherst.*

This experiment occupied a field which has been employed in work of this kind for nine years, the several plots having been every year manured alike, as described under the "Soil test with corn." The crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The land was ploughed in the fall of 1897, and sown with winter rye as a cover crop. The rye was turned in before it had made much of a spring growth, April 21. Fertilizers were employed this year in double the usual quantities; viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together.

The seed was sown in the customary manner, but more thickly, on May 9. Germination was prompt and perfect. The development of the crop throughout the season was most suggestive in problems for future solution. At the start plants upon the four plots, potash alone, potash and bone-black, potash and nitrate, and potash with both bone-black and nitrate, were much ahead of those on the plots not manured with potash. There was every indication that this element would almost entirely control the crop, for there was good growth wherever potash was applied, and but feeble growth elsewhere. The potash plots, however, after about four weeks, began to lose their superiority; and it was not long ere many of the plants upon these plots became manifestly very unthrifty, and before the end of the season many of them had died. Meanwhile, the phosphoric acid plots began to gain; and the results show that this, more than either the nitrogen or the potash supply, controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

The Proper Course as regards Potash Supply.

What, then, in view of such results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions; viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulphate: or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulphate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, supply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Again, in conclusion it may be said the most profitable results of the year's work are the suggestions for future lines of work, which, being completed, must throw much needed light upon the problems connected with the use of fertilizers.

3. Soil Test with Oats. Norwell.

The past was the third season of soil test work upon this acre, the two preceding crops having both been corn. The results with both of the tests with corn have indicated a strong demand for potash by corn on this soil. These results were thus in entire agreement with those obtained in almost all of the large number of soil tests with this crop that during the past ten years have been carried out under my direction in all the counties of the State.

The results the past season with oats seem also to be in general accord with results previously obtained in other sections with this crop. This is not shown clearly by the figures giving the yields, for the reason that excessive rains flooded parts of the field which is nearly flat soon after the seed was sown, rendering germination poor and uneven.

From examination during the growing season I feel certain that in this experiment it was the nitrate of soda which most largely benefited the crop. The crop on dissolved bone-black was at the rate of 9.7 bushels per acre; on dissolved bone-black and nitrate of soda it was 13 bushels. On muriate of potash the crop was 10 bushels; on the muriate and nitrate of soda it was 13.6 bushels. On the bone-black and muriate of potash the crop was at the rate of 9.8 bushels per acre; on these two fertilizers and nitrate of soda it was 17.8 bushels. The soil is clearly in need also of both phosphoric acid and potash for good crops, although the figures of this year afford no certain index to its condition, owing to the damage by water above mentioned.

4. Soil Test with Oats. Montague.

The present is also the third season of soil test work upon this soil, the preceding crops having been corn, which, owing to accidental conditions, did not give decisive results. The experiment of the past season is eminently satisfactory. The five nothing plots have given fairly even crops, varying from 18.8 to 24.4 bushels per acre of grain, averaging 21.5 bushels; while the straw yield has varied on these plots from 1,470 to 1,830 pounds, averaging 1,554 pounds, per acre. The crop on nitrate of soda alone was 30.3 bushels of grain and 2,210 pounds of straw; on dissolved bone-black, 24.4 bushels and 1,550 pounds; on muriate of potash, 21.3 bushels and 1,470 pounds. This marked increase on the nitrate of soda, as compared with the almost complete absence of effect of the other fertilizers used alone, is striking.

The dissolved bone-black and muriate of potash together gave 23.8 bushels of grain and 1,810 pounds of straw. Again we see practically no effect; but when we use nitrate of soda with these two fertilizers, we have a crop of 31.3 bushels of grain and 2,710 pounds of straw. Nitrate of soda with muriate of potash gives 30.3 bushels and 2,350 pounds, and with dissolved bone-black it gives 31.3 bushels and 2,330 pounds.

It will be seen, then, that in this experiment it was the nitrate of soda alone which proved effective. Alone and in all its combinations it gave a large increase in crop, and in all cases practically the same. The average increase apparently due to the use of this fertilizer amounted to 8 bushels of grain and 804 pounds of straw. The average increases apparently due to the use of dissolved bone-black were 2.1 bushels of grain and 193.4 pounds of straw; those apparently due to the muriate of potash were 1 bushel of grain and 175 pounds of straw.

Manure at the rate of 5 cords per acre gave about 806 pounds more straw, but only .7 bushels more grain than the complete fertilizer, costing some $13 per acre less; and the manure crop did not indeed surpass the crop on nitrate of soda alone in much greater degree. The latter application cost $3.20 per acre, while the manure can scarcely be estimated at less than $25.

This Montague experiment is one of the most perfectly satisfactory in a long series of such experiments; and it is a pleasure to see that its teaching as to the value of nitrate of soda for the oat crop is so entirely in agreement with that of other experiments with this crop.

For convenience is appended a statement giving the arrangement of plots and the system of manuring in nearly all our soil test work, which now extends over ten seasons: —

Plot 1, nothing.
Plot 2, nitrate of soda, 160 pounds per acre.
Plot 3, dissolved bone-black, 320 pounds per acre.
Plot 4, nothing.
Plot 5, muriate of potash, 160 pounds per acre.
Plot 6, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre.
Plot 7, { nitrate of soda, 160 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 8, nothing.
Plot 9, { dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 10, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 11, plaster, 160 pounds per acre.
Plot 12, nothing.
Plot 13, manure, 5 cords per acre.
Plot 14, lime, 160 pounds per acre.
Plot 15, nothing.

Manure Alone *v.* Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field includes four plots, of one-fourth an acre each. The average results for 1897 are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): hay, 961¼ pounds; rowen, 536½ pounds.

This field was continued in grass and clover during the present season, but manure and potash were applied as shown below: —

Plot 1, manure, 1 cord; weight, 5,087.5 pounds.

Plot 2, { manure, .5 cord; weight, 2,712.5 pounds.
muriate of potash; weight, 40 pounds. }

Plot 3, manure, 1 cord; weight, 5,372.5 pounds.

Plot 4, { manure, .5 cord; weight, 2,855 pounds.
muriate of potash; weight, 40 pounds. }

The manure applied to each plot was sampled and analyzed, and from the analyses the amounts of the three most essential elements of plant food applied per acre were calculated, with results shown below: —

Manurial Ingredients per Plot.

Plots.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1, in manure,	20.9	14.2	25.9
Plot 2, in manure,	11.4	6.2	15.2 } 35.1
Plot 2, in muriate of potash,	-	-	19.9 }
Plot 3, in manure,	22.0	15.0	26.9
Plot 4, in manure,	15.1	9.7	18.0 } 37.9
Plot 4, in muriate of potash,	-	-	19.9 }

The manure was applied on April 1, the muriate of potash to plots 2 and 4 on April 9.

During the later growth of the mixed grasses and clovers upon these plots it was plainly evident that the clover was relatively more prominent upon plots 2 and 4. The first crop was cut on June 20; the second, on August 26, and both were secured in excellent condition.

Yield per Plot.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1,	1,395	840
Plot 2,	1,120	730
Plot 3,	1,460	810
Plot 4,	1,497	830

Average Yield per Acre.

Plots 1 and 3 (manure alone),	5,710	3,300
Plots 2 and 4 (manure and potash),	5,235	3,120

Combining the figures showing the yields in hay and rowen, we find that the average of plots 1 and 3 is at the rate of 9,010 pounds per acre; and of plots 2 and 4, 8,355 pounds. There is, then, a difference of 655 pounds only in total yields per acre, in favor of the large application of manure alone. This amount is quite insufficient to cover the larger cost of the acre application ($6.80 in the case of the manure alone). This field has now been broken up, and will next year be put once more into corn, when it is believed the beneficial effect of the large growth of clover upon plots 2 and 4 will become apparent.

"SPECIAL" CORN FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special" corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	13.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash,	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

In 1897 the average (both hay and rowen) produced by plots 1 and 3 was 873.5 pounds, or 3,494 pounds per acre; on plots 2 and 4, 860.5 pounds, or 3,442 pounds per acre. This difference is too small to be of practical significance. The rowen crop was heavier on plots 2 and 4 than on plots

1 and 3, showing an apparent influence of the greater amount of potash used on these plots in a larger proportion of clover.

For the present season the fertilizers were applied as last year, being evenly broadcasted on April 11. The first crop was cut June 21. It consisted largely of red-top, which was then not fully in bloom. The second crop was cut August 26. Both crops were well secured, and the yields are shown below: —

Yield of Hay and Rowen, 1898.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1 (lesser potash),	670	530
Plot 2 (richer in potash),	585	440
Plot 3 (lesser potash),	540	365
Plot 4 (richer in potash),	550	415

Average Rates per Acre.

Plots 1 and 3,	2,420	1,790
Plots 2 and 4,	2,270	1,710

We have then, as will be seen, an average product, from the application richer in nitrogen and phosphoric acid, at the rate of 150 pounds of hay and 80 pounds of rowen per acre more than from the application poorer in these elements and richer in potash. It is believed that the failure of plots 2 and 4 to show greatly superior development of clover is in part due to variations in physical characteristics of the soil of the different plots, leading to unfavorable moisture conditions, which prevented an even catch of clover on plots 2, 3 and 4, but did not injuriously affect Plot 1. Further, it should be pointed out that results which will be published later in this report in the case of clover experiments on a series of plots manured alternately with muriate of potash and with sulphate of potash indicate that the long-continued use of muriate of potash in liberal amounts without liming is unfavorable to the healthy development of clover. This field has now been broken up, and will be again put into corn next season.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have received no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6, and 8), sulphate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All the plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past two seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulphate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulphate of ammonia.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the

* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

average in the following order: nitrate of soda, farm-yard manure, dried blood and sulphate of ammonia.

After the oat crop of 1897 was harvested the land was ploughed, and late in July sown to Mammoth red clover. Germination was quick and good; but the young plants on all plots failed to flourish, and soon took on a most unhealthy appearance on all except the manure plot, and even on this their development was not what could be desired. In April of this year the plots were most carefully examined, and the clover ranked as follows: plot 0, good; 1, fair; 2, poorer than 1; 3, like 2; 4, mostly dead; 5, all dead; 6, all dead; 7, like 2; 8, best in field (limed in 1896); 9, like 2; 10, somewhat better than 2.*

The general average of condition was so poor that it was decided to plough the field, which was done on April 18. From previous observations upon this series of plots it was decided that liming was called for, and accordingly 200 pounds per plot of partially air-slaked lime was spread on and harrowed in on April 20. Eight hundred pounds of manure was applied to plot 0 on April 23, and on April 26 the fertilizers were applied.

The plots were all sown to Clydesdale oats on April 27, 8½ pounds per plot. The analysis of the manure and a table showing fertilizer treatment and yields follow: —

Analysis of Manure Used.

	Per Cent.
Moisture,	72.53
Nitrogen,	.43
Phosphoric acid,	.16
Potash,	.26

* For manuring of these plots, see page 58.

Nitrogen Experiment. — Fertilizer Treatment and Yields of Oats, 1898.

Plots	Fertilizers.	Pounds.	Weight of Oats (Pounds).	Weight of Straw (Pounds).	Bushels Oats per Acre.	Weight of Straw per Acre (Pounds).
Plot 0,	Barn-yarn manure, Potash-magnesia sulphate, Dissolved bone-black,	800.0 32.0 18.0	83.0	125	25.90	1,250.0
Plot 1,	Nitrate of soda, Potash-magnesia sulphate, Dissolved bone-black,	29.0 48.5 50.0	103.0	150	32.20	1,500.0
Plot 2,	Nitrate of soda, Potash-magnesia sulphate, Dissolved bone-black,	29.0 48.5 50.0	115.0	175	35.90	1,750.0
Plot 3,	Dried blood, Muriate of potash, Dissolved bone-black,	43.0 25.0 50.0	96.0	155	30.00	1,550.0
Plot 4,	Muriate of potash, Dissolved bone-black,	25.0 50.0	56.0	80	17.50	800.0
Plot 5,	Ammonium sulphate, Potash-magnesia sulphate, Dissolved bone-black,	22.5 48.5 50.0	103.0	135	32.20	1,350.0
Plot 6,	Ammonium sulphate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	109.0	160	34.10	1,600.0
Plot 7,	Muriate of potash, Dissolved bone-black,	25.0 50.0	72.5	95	22.70	950.0
Plot 8,	Ammonium sulphate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	123.0	155	38.40	1,550.0
Plot 9,	Muriate of potash, Dissolved bone-black,	25.0 50.0	76.5	95	23.90	950.0
Plot 10,	Dried blood, Potash-magnesia sulphate, Dissolved bone-black,	43.0 48.5 40.0	112.0	135	35.00	1,350.0
Average of no-nitrogen plots,					21.40	900.0
Average of muriate of potash plot (as far as comparable),					32.05	1,595.0
Average of sulphate plots (as far as comparable),					35.20	1,416.7

It is important to point out that the oats on the several plots ripened at different times. An effort was made to harvest the crop upon all at the same stage of maturity. With this end in view, plots 1, 2 and 5 were cut on July 29; plots 6, 8, 9 and 10, on July 30; and the balance on August 2. Meanwhile, there had occurred the phenomenally heavy rain and wind of July 30, P.M., and numerous other heavy showers; moreover, the weather continued persistently bad much of the time until the middle of August, and there was much loss through shelling of the grain. The straw, therefore, perhaps better than the grain, affords an index to the relative value of the several manurings. The rank of the different sources of nitrogen, taking straw production as the basis of estimation, is nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure.

After the oats were harvested the land was ploughed, and without further manuring sown to Mammoth red clover, which at the time winter set in was in excellent condition.

The reader will naturally, perhaps, conclude that the better condition of the clover this year as compared with last is a consequence of the liming, and I am of opinion that this may be the case; but nevertheless I cannot regard this as certain, for the reason that upon Field B (reported upon below), where clover sown in the summer of 1897 failed, we have now an excellent stand of this crop obtained by sowing seed where it had failed this spring, without liming or reploughing.

Muriate *v.* Sulphate of Potash for Clover. (Field B.)

Field B is laid off in eleven equal plots, of two-fifteenths of an acre each. The manuring has been uniform since 1884. These plots are numbered from 11 to 21. *Every year each plot has received an application of ground bone at the rate of 600 pounds per acre. The odd-number plots have yearly received muriate of potash and the even-number plots the high-grade sulphate, in each case at the uniform rate of 400 pounds per acre.* This series of plots has produced a great variety of crops, including potatoes, corn, grasses, oats and barley each, with vetches, rye and clovers. The crops have been generally excellent. Full details will be found in the tenth and twelfth annual reports of the State Experiment Station, and the reports of the Hatch Experiment Station for the last three years. In the summer of 1895 two plots (one muriate the other sulphate) of each of the following clovers were sown: sweet clover (*Melilotus alba*), mammoth red clover, medium red clover and alsike clover. Between the crops produced respectively on the muriate and sulphate of potash no marked difference in yield was observed in either 1896 or 1897. It was, however, noticed in 1896 that the clover raised on the sulphate of potash was richer in starch and similar extractive substances, in the case of the mammoth, medium and alsike clovers, than that raised on the muriate, thus making the sulphate clover the more valuable.

Bad Effect of the Muriate.

In August of 1897 the plots were ploughed and all again seeded to the same varieties of clover. Germination was excellent, but within a very few weeks after the young plants appeared it was observed that in the case of the mammoth, medium and alsike varieties the plants were doing very poorly upon the muriate plots. As the autumn advanced, these plants for the most part grew more and more feeble, and many died. The winter was favorable to newly seeded land; but in the spring it was found that a large proportion of the plants upon the muriate plots were dead, in the case of the varieties above named. The sweet clover showed no difference between the two fertilizers. The condition of the clovers upon the sulphate plots was not entirely satisfactory, although far superior to that upon the muriate.

It was decided to sow additional seed upon all the plots without reploughing. Accordingly, on April 2, 4 pounds of seed of the appropriate variety were sown upon each of the plots. The conditions were favorable to germination, and a good stand of young clover was obtained upon all the plots. The sulphate plots gave much the larger yields of clover this season, because they contained a far larger proportion of the older plants from last summer's sowing. At the present time, however, the condition of the clover upon the muriate and sulphate plots is fairly even, for the spring-sown clover has done equally well upon both the potash salts.

This record of facts is made without comment, as without further investigation it appears to be impossible to explain why the summer-sown clover failed on the muriate, while the spring-sown has flourished upon the same plots without reploughing or any change in treatment.

MURIATE *v.* SULPHATE OF POTASH FOR CORN. (FIELD B.)

Two plots in Field B, one muriate and one sulphate, were planted to Sibley's Pride of the North corn, with a view to testing the relative value of these two potash salts for this crop. It will be remembered that these plots have been under the same manurial treatment since 1884. The fertilizers were broadcasted after ploughing, and harrowed in, and the corn was planted on May 30, in drills 3½ feet apart. It was later thinned to 1 foot in the drills. The crop was cut September 9 and husked the middle of October.

Corn on Muriate and on Sulphate of Potash.

Manuring per Acre.	Corn (Pounds).	Stover (Pounds).	Yield per Acre.	
			Corn (Bushels).	Stover (Pounds).
Plot 19, { Muriate of potash, 400 pounds, Ground bone, 600 pounds, }	488.5	866	45.8	6,495
Plot 20, { Sulphate of potash, 400 pounds, Ground bone, 600 pounds, }	428.5	652	40.1	4,890

The apparent superiority of the crop raised on the muriate of potash is considerable. During the growth of the crop, as the result of frequent examinations, no such difference was evident; and it is regretted that the moisture test has not been completed in season for this report, as it is felt that there may have been a difference in condition of the two crops when weighed, owing to the very rainy weather of the autumn.

SWEET CLOVER (*Melilotus alba*).

As has been stated under "Muriate *v.* Sulphate of Potash for Clovers," sweet clover occupied two of the plots in Field B. The present is the third successive year that this clover has been grown upon these plots, and the soil appears now to have become thoroughly stocked with the nodular bacteria peculiar to the plant. As reported in 1896, but few of the plants on these plots in that year possessed bacteria, and only those which did made vigorous growth. The next year, as already reported, about one-half of the plants apparently possessed nodules and made vigorous growth early in the season. Later all seemed to acquire the ability to make use of the atmospheric nitrogen which these nodular bacteria give. The crop of this season has been extremely vigorous from the very first. The rapid growth of this legume in early spring seemed to indicate its possible value as a cover crop for green manuring; and to test this point one square yard (believed to be average) was harvested at each of three different dates, and a determination of dry matter and of nitrogen contained therein was made. The results calculated per acre were: —

Date.	Height (Feet).	Dry Matter (Pounds).	Nitrogen (Pounds).
June 6, ...	$2\frac{1}{2}$	3,661.6	136.8
June 15, ...	$3\frac{1}{2}$	3,961.7	130.2
July 10, ...	$5\frac{1}{2}$	7,573.0	192.5

The crop was in full bloom at the time the last cutting was made, but it goes on blooming freely for almost the entire summer.

Corn for the silo may here be planted up to the middle of June, with a good prospect of success; and, as will be seen, previous to that date the sweet clover makes a large growth and contains a heavy amount of nitrogen. The amount of this element at the date of the second cutting is equivalent to that contained in about 6 cords of rich manure. To what extent, however, this nitrogen has been taken from the soil, and to what extent from the air, our experiments afford us no means for determining. Kühn has pointed out that the acquisition of atmospheric nitrogen by plants of the clover family takes place most abundantly in the later stages of their growth; and that, if they be ploughed under immature, we can hope for but little gain in that element. Our experiment, then, is not conclusive, as yet, as to the value of this clover as a green manuring crop. Since, however, being sown in the latter part of July or early in August, it will afford winter protection to the soil and furnish a large growth before late corn planting time, it seems worthy of further trial.

Value for Bees.

As is known to many, this clover furnishes an abundant and long-continued supply of honey. For many weeks the plants in our plots were daily visited by countless myriad bees, and the rate of honey production of those kept near by was very rapid, The honey is of good quality.

High-priced Seed an Obstacle to the Use of Sweet Clover.

The high price at which the seed of this clover is at present offered in our markets constitutes a great obstacle to its use as a green manuring crop. Recognizing this fact, and wishing to determine whether the seed might not be more cheaply offered, our crop of this year was allowed to mature. The sulphate of potash plot (two-fifteenths acre) gave a product of 43.5 pounds and the muriate plot 46.5 pounds of rather poorly cleaned seed. It is true that the season was unfavorable to the ripening of the seed; but the indication of this single experiment is that the species can not be counted upon for a liberal seed product, and that, therefore, the seed must remain high in price.

Nitragin, a Germ Fertilizer.

In connection with my report upon sweet clover, it has been shown that in the early attempts to cultivate this crop but partial success was obtained, because the germs of the appropriate nodular bacteria (microscopic plants, which, growing in nodules upon the roots, give the power of assimilating the free nitrogen of the air) were not present in sufficient numbers. It is there pointed out that, after three years' culture of the sweet clover upon the same plots, these bacteria so multiplied in the soil that complete success with the clover followed. Similar results in the first attempts to cultivate plants of the "pod" family (*Leguminosæ*) in localities where they had not been before grown have many times been observed; and many times, also, has ultimate success crowned the effort to produce the new plant, and for the reason above alluded to. The attainment of success in this manner, however, requires some few years; and time is precious. Recognizing this fact, an attempt to propagate the bacteria connected with nitrogen assimilation artificially and to put them upon the market was some few years ago made by Professor Nobbe of Tharandt, Germany. The effort was successful, and the product, under the name *Nitragin*, has been offered for the past few years by a German firm with which Professor Nobbe completed arrangements for its production and sale. Full particulars concerning *Nitragin*, and directions for its use, will be found in our eleventh annual report. The unsuccessful results of its trial upon clover in 1897 are published in our last annual report.

The scientific standing of Professor Nobbe is such and the general importance of the subject so great that further trials and with other plants seemed desirable. Accordingly, nitragin for the following species was ordered direct from the makers: crimson clover, red clover, alfalfa, sweet clover, soy bean, vetch and pea.

The experiments are not yet complete, but are being carried out upon poor plain land hired for the purpose, where most of these crops have never been cultivated, as well as upon our own grounds. The plan of the experiment upon the plain land is shown below.

Plan of Nitragin Experiments.

The plots are one-twentieth of an acre each, duly separated by dividing strips. The treatment of the several plots for each crop will be clear from the table: —

Plot 1, no fertilizers. No nitragin.
Plot 2, no fertilizers. Nitragin.
Plot 3, { acid phosphate, 400 pounds per acre. muriate of potash, 250 pounds per acre. lime, 1,000 pounds per acre, } No nitragin.
Plot 4, manurial treatment, like Plot 3. Nitragin.
Plot 5, same manures as 3, and, in addition, 180 pounds per acre of nitrate of soda. No nitragin.

The plan upon the home grounds is similar, with two exceptions: (1) The plots are smaller, and (2) there are no plots left unfertilized.

The crops started in the spring upon the "plain" include field peas, alfalfa, alsike clover and common red clover. The peas were harvested early in August. The yields of the several plots were very small, and showed no favorable influence from the nitragin. Of all the other crops, it can be reported to-day that the general condition is poor; that the best condition is to be found in every case upon Plot 5 (supplied with available fertilizer nitrogen), and that the crop upon mineral fertilizers with nitragin (4) appears somewhat better than the corresponding plot (3) without nitragin. Between plots 1 and 2 there appears to be no appreciable difference.

Upon our home grounds the field pea with nitragin gave a slightly better crop on mineral fertilizers alone than on mineral fertilizers without nitragin. Alfalfa upon mineral fertilizers and nitragin now looks better than on the same fertilizers without nitragin. It will be seen, then, that thus far the experiments of this season afford indications that some slight benefit has followed the use of this germ fertilizer.* Of the crops sown in late summer it is as yet too early to report.

Fertilizers for Garden Crops.

This series of experiments, begun in 1891, was originally intended to test the value for the different garden crops of nitrate of soda, sulphate of ammonia and dried blood as sources of nitrogen; but in the second year it was made to include also a comparison of muriate with sulphate of potash, each used with each of the three nitrogen fertilizers, for the same class of crops. Dissolved bone-black has been applied equally to all the plots from the first. The number of plots and the fertilizers annually applied to each up to the present year are shown in the following table: —

* It may be useful, though this fact has already many times been pointed out, to remark here that a third, and often very satisfactory, method of securing a stock of nodular bacteria consists in taking earth from soil where the crop under trial flourishes, and incorporating a little, as one might fertilizer, with the soil where the new crop is to be grown. This method is now under trial here with alfalfa with soil from Kansas.

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply, at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The management of the experiment and results and conclusions are presented in great detail in our eighth, ninth and tenth annual reports, and to these the student of these experiments is referred. It suffices for our present purpose to call attention to the general results up to the end of the year 1897, which are shown below: —

Averages of Garden Crops, 1892 to 1897, inclusive.

Plots.	Spinach, grown Three Years (Pounds).	Lettuce, grown Three Years (Pounds).	Tomatoes, grown Four Years (Pounds).	Beans, grown Three Years (Pounds).	Onions, grown Two Years (Pounds).	Sweet Corn, grown Two Years (Pounds).	Green Peas, grown One Year (Pounds).	Table Beets, grown Two Years (Pounds).
Plot 1,	153	37	482	43	111	144	177	255
Plot 2,	210	43	707	49	326	179	203	479
Plot 3,	182	42	577	50	259	160	281	372
Plot 4,	196	63	717	44	221	151	348	425
Plot 5,	232	66	790	59	298	143	343	591
Plot 6,	149	41	503	51	235	154	307	483

It is important to point out that none of the crops included above has in any year occupied the whole of the area under experiment. Each year we have had some four or five crops, and the areas in each have varied. The above figures are valuable, then, solely as a basis of comparison between the several plots.

Conclusions based on Results up to 1897.

The chief conclusions which seemed justified by the results above given are the following: —

1. Sulphate of potash in connection with nitrate of soda (Plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with muriate or the sulphate of potash.

3. The combination of sulphate of ammonia and muriate of potash (Plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1898.

In the fall of 1897 the plots were ploughed, and rye sown on all (without further manuring) as a cover crop, chiefly to prevent soil washing. The growth on Plot 1 (sulphate of ammonia and muriate of potash) was sickly and feeble, but no particular difference was noticed between the other plots.

Change in Plan.

In view of the fact that market gardeners, in whose interests chiefly these experiments are being carried out, almost invariably use large quantities of stable manure, and employ fertilizers, if at all, simply to supplement the manure, it was decided to make a change in the plan of the experiment, in order that the conditions under which we are working may more nearly conform to those of the average market gardener.

Accordingly, it was decided to apply equal amounts of thoroughly mixed stable manure to each plot, and to use on each, in addition, the same fertilizers as heretofore. Further, in order to have a basis for determining whether the fertilizers should prove in any degree useful, another plot was added, to which manure alone is applied. It was impossible to secure for this purpose a plot of exactly the same shape as the others, and of course it has not had the same history. It is, however, contiguous, and it has the same elevation and similar soil. This plot, which will be called plot 0, has for the past fifteen years received an annual application at the rate of ground bone 400 pounds and muriate of potash 200 pounds per acre. It has been planted yearly with a variety of the newer forage crops. Manure was applied at the rate per acre of twelve cords to all of the seven plots. The manure was applied by measure, but it was also weighed. The table shows the weight applied to each plot and the quantities of plant food which it carried: —

Plots.	Manure (Pounds).	Nitrogen (per Cent.).	Potassium Oxide (per Cent.).	Phosphoric Acid (per Cent.).
Plot 0,	6,720	28.8960	10.7520	17.4720
Plot 1,	6,977	30.0011	11.1632	18.1402
Plot 2,	6,775	29.1325	10.8400	17.6150
Plot 3,	7,065	30.3795	11.3040	18.3690
Plot 4,	6,617	28.4531	10.5872	17.2042
Plot 5,	7,210	31.0030	11.5360	18.7460
Plot 6,	6,945	29.8635	11.1120	18.0570
Manure contained,	–	.0043	.0016	.0026

Details.

The manure was evenly spread upon the surface April 18–23. The land was ploughed April 27, a thin crop of rye, previously alluded to, being turned under. The fertilizers were applied evenly, broadcast as in previous years, on May 2, and harrowed in. The land was once more harrowed on May 5. Throughout the season all plots received clean culture.

The crops the past season have been: strawberries (Clyde), spinach, lettuce, table beets, tomatoes, cabbage, celery and potatoes: and, as a second crop, turnips.

Clyde Strawberries. — Three rows were set in each plot. The growth was vigorous and healthy on all plots. Plots 4, 5 and 2 now show a slight superiority over the others, while Plot 0 is the poorest. All are well stocked, in matted rows.

Long Standing Spinach. — Three rows of this crop were planted in each plot May 7. All germinated well, but by June 9 many plants were dying on plots 1 and 4 (sulphate of ammonia and muriate of potash, and sulphate of ammonia and sulphate of potash), while nearly all the plants in these plots appeared yellow and sickly. All the spinach was harvested in two cuttings. The yields in pounds were as follows: Plot 0, 69; Plot 1, $1\frac{1}{4}$; Plot 2, $156\frac{1}{2}$; Plot 3, $77\frac{3}{4}$; Plot 4, $13\frac{1}{2}$; Plot 5, $159\frac{1}{2}$; Plot 6, $73\frac{3}{4}$.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (Plot 0),	88.7
Average of manure and muriate of potash (plots 1, 2 and 3),	78.5
Average of manure and sulphate of potash (plots 4, 5 and 6),	82.3
Average of manure and sulphate of ammonia (plots 1 and 4),	7.4
Average of manure and nitrate of soda (plots 2 and 5),	158.0
Average of manure and dried blood (plots 3 and 6),	75.8

It will be noticed that the muriate of potash plots are inferior to those receiving sulphate of potash, though the difference is small. The sulphate of ammonia plots proved almost an absolute failure, while the dried blood gave a much smaller crop than the nitrate of soda. The most important fact brought out is the marked superiority of the latter as a source of nitrogen for spinach.

Hanson Lettuce. — Two rows of this crop, planted May 7, were grown in each plot, the plants being brought by

* To enable the reader the better to make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulphate of potash," etc. It should be remembered that dissolved bone-black was applied to all except Plot 0, and that every plot received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 66.

thinning and resetting to a uniform distance of 1 foot in the rows, except on plots 1 and 4, where a large number of the plants died soon after coming up. In harvesting, the heads of market size were cut from day to day. The total crop in pounds on the several plots was: Plot 0, 179¼; Plot 1, 40; Plot 2, 194¼; Plot 3, 220¾; Plot 4, 135; Plot 5, 219; and Plot 6, 231¼.

The average yields, in pounds, produced by the different fertilizers were: —

Manure alone (Plot 0, *corrected for area*),	230.5
Manure and muriate of potash (plots 1, 2 and 3),	151.7
Manure and sulphate of potash (plots 4, 5 and 6),	195.1
Manure and sulphate of ammonia (plots 1 and 4),	87.5
Manure and nitrate of soda (plots 2 and 5),	206.6
Manure and dried blood (plots 3 and 6),	226.0

The manure alone gave, as will be seen, a larger yield than any of the plots to which fertilizers as well as manure were applied. The only point clearly indicated is the apparent highly injurious effect of the sulphate of ammonia, particularly where used with the muriate of potash.

Dewing's Blood Turnip Beet. — Six rows of this crop, planted May 7, were grown in each plot. In plots 1 and 4 most of the plants soon became weak and sickly and many died, and there were not enough to restock to the uniform distance of 4 inches in the row, to which all the other plots were brought by thinning and resetting where needed. The few plants in plots 1 and 4 which survived until about July 1 then appeared to recover their vigor, and grew very rapidly. The yields of roots and tops were as shown below: —

Plots.	Beets (Pounds).	Tops (Pounds).
Plot 0,	340	440
Plot 1,	80	160
Plot 2,	440	570
Plot 3,	365	515
Plot 4,	260	470
Plot 5,	460	490
Plot 6,	325	335

The average yields in pounds per plot were as follows: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	374.7	484.9
Manure and muriate of potash (plots 1, 2 and 3),	295.0	415.0
Manure and sulphate of potash (plots 4, 5 and 6),	348.3	431.7
Manure and sulphate of ammonia (plots 1 and 4),	170.0	315.0
Manure and nitrate of soda (plots 2 and 5),	450.0	530.0
Manure and dried blood (plots 3 and 6),	345.0	425.0

The general result here is similar to that with spinach; *i.e.*, muriate is inferior to the sulphate of potash; nitrate of soda is the best source of nitrogen; and sulphate of ammonia shows itself to have been actually injurious, particularly so with muriate of potash.

Dwarf Champion Tomato. — Two rows were set in each of the original six plots and three in Plot 0, the plants, purchased of the Horticultural Department, being rather small and uneven. The crop was picked as it ripened until September 23, when the balance of the fruit was picked green. The weights of ripe and of green fruit in pounds per plot are shown below:* —

Plots.	Ripe Fruit.	Green Fruit.
	Lbs. oz.	Lbs. oz.
Plot 0,	422 3	179 8
Plot 1,	387 7	223 0
Plot 2,	501 4	160 0
Plot 3,	328 2	178 0
Plot 4,	430 6	181 0
Plot 5,	413 1	84 8
Plot 6,	405 4	181 8

The averages of ripe fruit and total yield in pounds per plot were as shown in the table: —

* The record of one day's picking of ripe fruit was lost, but this does not change the relative standing of the plots.

	Ripe Fruit.	Total.
Manure alone (Plot 0, corrected for area), ...	361.9	515.7
Manure and muriate of potash (plots 1, 2 and 3), . . .	405.6	592.6
Manure and sulphate of potash (plots 4, 5 and 6), . . .	416.2	565.2
Manure and sulphate of ammonia (plots 1 and 4), . . .	408.9	610.9
Manure and nitrate of soda (plots 2 and 5), ...	457.2	579.4
Manure and dried blood (plots 3 and 6), ...	366.7	546.4

The differences brought out by these averages are much smaller than in the case of the spinach and beets, but are in the same direction for ripe fruit; *i.e.*, sulphate of potash gives somewhat better returns than muriate, and nitrate of soda gives the largest yield of any of the sources of nitrogen. It is noteworthy that the sulphate of ammonia does not appear to have injuriously affected this crop. This is perhaps due to the fact that the tomato is not set until about the first of June, and makes most of its growth when the season is well advanced. The crops shown to have been injured by the sulphate of ammonia, spinach and beets, are sown early, and make most of their growth before the season is far advanced.

Fotler's Drumhead Cabbage. — Two rows in each of the original six plots and three in Plot 0 were grown. The seed was planted May 23, in hills, and later thinned to one in each hill, those destroyed by maggots being replaced. Owing to the unusually hot season, the crop was well grown by September 1, and numerous heads were beginning to crack. They were harvested as they matured, September 8 to November 5. The yield in pounds of heads, practically all well filled and hard, was as follows: Plot 0, 729; Plot 1, 720; Plot 2, 780; Plot 3, 710; Plot 4, 755; Plot 5, 744; and Plot 6, 651.

The average yields in pounds per plot were as follows: —

Manure alone (Plot 0, corrected), ...	624.9
Manure and muriate of potash (plots 1, 2 and 3), . .	736.7
Manure and sulphate of potash (plots 4, 5 and 6), . .	716.7
Manure and sulphate of ammonia (plots 1 and 4), . .	737.5
Manure and nitrate of soda (plots 2 and 5), . . .	762.0
Manure and dried blood (plots 3 and 6), . . .	680.5

Here we find the fertilizers have apparently produced a moderate increase in crop. The differences between them are far less marked than in the case of most of the other crops grown this year. The nitrate of soda appears to have been the best source of nitrogen for the cabbage.

Early Maine Potatoes. — The seed planted was grown in the State of Maine. It was treated with corrosive sublimate solution, for prevention of scab, and sun-sprouted. Before planting, the tubers were cut to pieces with two eyes each. Three rows per plot (4 on Plot 0) were grown. The seed was planted on May 9 in rows 3 feet apart, the pieces being dropped 1 foot apart in the rows. Ordinary thorough culture was given until the vines covered the ground. The vines were sprayed with Bordeaux mixture (first on June 7) to repel the flea beetle. They were sprayed with sufficient frequency to keep the vines well covered with the mixture until the middle of August, the last application being made August 8. The Bordeaux mixture was applied nine times in all, frequent re-application being necessary, on account of the numerous heavy rains. The vines were slightly attacked by blight about the middle of July; but later in August new shoots were thrown out from the axils of the lower leaves, making a healthy growth, which remained green until very late in September. The tubers averaged large and smooth, and showed very little rot when dug. A few weeks after storing there were a few more decayed tubers. The yield in pounds was as follows: —

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	441.5	41.0
Plot 1,	449.0	40.0
Plot 2,	426.0	40.0
Plot 3,	409.0	62.5
Plot 4,	550.0	35.0
Plot 5,	482.0	31.5
Plot 6,	482.0	51.5

Yield per Acre (Bushels).

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0, ...	381.5	35.4
Plot 1, ...	447.2	35.8
Plot 2, ...	381.7	35.8
Plot 3, ...	366.5	56.0
Plot 4, ...	492.8	31.4
Plot 5, ...	431.9	28.3
Plot 6, ...	431.9	46.1

The averages calculated to show the relative effect of the different fertilizers are given below in pounds per plot: —

Plots.	Merchantable Tubers.	Small Tubers.
Manure alone (Plot 0, corrected), ...	425.7	39.5
Manure and muriate of potash (plots 1, 2 and 3), . . .	444.7	47.5
Manure and sulphate of potash (plots 4, 5 and 6), . . .	504.7	39.3
Manure and sulphate of ammonia (plots 1 and 4), . . .	524.5	37.5
Manure and nitrate of soda (plots 2 and 5), ...	454.0	35.8
Manure and dried blood (plots 3 and 6), ...	445.5	57.0

It becomes evident from a study of these figures that the fertilizers proved moderately beneficial to this crop, and that the sulphate of potash is superior to the muriate. The various sources of nitrogen rank in the order, sulphate of ammonia, nitrate of soda and dried blood, the first giving a much larger average crop than either of the others. It seems further important to point out that the combination sulphate of ammonia with muriate of potash, which has proved both in previous years and in this year so fatal to most crops, has given a fine crop of potatoes, at the rate of 447 bushels to the acre, the second in rank among the seven plots. No explanation can be offered, beyond that already suggested in the case of tomatoes, viz., that the potato has a much longer growing season than the crops doing so very poorly on this combination of fertilizers. It seems reasonable to suppose that, as the season advances, the injurious ammonium chloride formed at first is either washed out of the soil or destroyed by further chemical changes. This question will be made a matter of further study.

The spraying with Bordeaux mixture, although necessarily nine times repeated on account of the unusual number of heavy rains, must be considered to have been profitable, as the yield was very heavy, while in general the crop this year was light where spraying was not practised.

Giant Pascal Celery. — Two rows were grown in each plot; the plants, large and well grown, were set 1 foot apart in rows 5 feet apart on July 19. Banking began September 29, and the crop was put into the cellar in good condition on November 4. The growth on plots 0, 1 and 4 was fair; on the other plots, excellent. There was considerable rust on Plot 0, while there was little or none on the other plots. The weights in pounds of the plants (including roots and a little earth) were as follows: Plot 0, 443; Plot 1, 328; Plot 2, 478; Plot 3, 478; Plot 4, 348; Plot 5, 568; Plot 6, 488.

The calculated averages will not be given until the crop is blanched, since the earth, of necessity left adhering to the roots of the plants as put into the cellar, is an element of uncertainty. It may be of interest to state that these averages indicate little if any increase which can be attributed to the fertilizers.

White Egg Turnips. — This crop followed spinach, lettuce and table beets, without further manuring. The land was reploughed and fitted and the seed sown on July 28, in rows 14 inches apart. Soon after sowing a heavy shower caused some washing across the plots, which was particularly injurious on Plot 0. The crop was harvested November 8 and 9, and was of excellent quality. The yields in pounds are shown in the following table: —

Plots.	Roots.	Tops.
Plot 0,	580.0	185
Plot 1,	702.0	348
Plot 2,	753.5	315
Plot 3,	735.0	315
Plot 4,	938.0	335
Plot 5,	655.0	260
Plot 6,	690.0	215

The calculated averages in pounds are given in the following table: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	688.3	219.7
Manure and muriate of potash (plots 1, 2 and 3),	730.3	326.0
Manure and sulphate of potash (plots 4, 5 and 6),	761.0	270.0
Manure and sulphate of ammonia (plots 1 and 4),	820.0	341.5
Manure and nitrate of soda (plots 2 and 5),	704.3	287.5
Manure and dried blood (plots 3 and 6),	712.5	265.0

The fertilizers are shown to have been moderately beneficial, there is not much difference between the two potash salts, and the sulphate of ammonia gives a much better crop than either of the nitrogen fertilizers. This is not strange, in view of these facts: (1) the plots to which this had been applied had produced but very small first crops, while the others had yielded heavily; and (2) that the turnips made their growth so late in the season that the injurious compounds often formed by this salt had become dissipated, or destroyed by further chemical changes.

Experiments in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and three acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring; this year April 8 and 9.

Plot 1, which this year received bone and potash, gave a yield at the rate of 5,137 pounds of hay and 2,370 pounds of rowen per acre. Plot 2, which received ashes, yielded 4,602 pounds of hay and 2,142 pounds of rowen. Plot 3, which was dressed with manure in the fall of 1897, yielded 5,233 pounds of hay and 2,823 pounds of rowen per acre. This field has now been ten years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,808 pounds per acre. The plots when dressed with manure have averaged 7,211 pounds per acre; when receiving bone and potash, 6,671 pounds per acre; and when receiving wood ashes, 6,541 pounds per acre.

Variety Tests.

Our work in testing varieties this year has been confined to testing the potato. With this it has been extensive. The tests have been of two sorts; (1) a preliminary test with varieties grown for the first time; and (2) a test of the best twenty-five varieties, as indicated by the trial of last year.

1. *Preliminary Test.* — As has been stated in my previous reports upon variety work with the potato, I consider several years' trial necessary to the formation of a judgment. The seed of new varieties as they are brought out must of necessity come from many widely separated localities. Such seed is unfit to serve as a basis for comparison, with the object of determining the relative merits of varieties, as it is well known to many and quite generally admitted that the place where any given variety of seed potatoes is produced may greatly influence its product. Newly obtained varieties must also of necessity have been subjected to widely variant conditions of handling, preservation and

transportation, and all these factors influence product. For all these reasons our practice is to obtain but a small quantity of seed of new varieties as they come to our attention, and to plant this for the purpose of raising seed for the next year's trial, which shall have been produced under similar conditions and similarly handled. This constitutes our "*preliminary test.*"

This test the past season included seventy-five varieties, obtained from almost as many seedsmen, scattered all over New England, the middle and central States and Canada. The seed of all was treated with corrosive sublimate solution and sun-sprouted. It was then cut to pieces of two good eyes each, and planted one piece to a foot, in rows 3 feet apart. The soil was a good medium loam, naturally well drained. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed just before using, and scattered broadly in the drills before dropping the seed. The planting took place May 11 and 12. All varieties were injured by hot, dry weather, which came just as the tubers were forming, and by blight, although sprayed with Bordeaux mixture six times between June 13 and August 2. The varieties on which blight was first noticed were Salzer's Earliest, Bliss Triumph, King of the Earliest and Lincoln, — July 24 and 25. All other varieties showed blight between July 28 and August 1, and to about an equal degree. It is thought that no varieties blighted long before they were mature; but, nevertheless, the blight undoubtedly greatly reduced the yields. Owing to the blight, the period of apparent ripening of all varieties was nearly the same, viz., August 27 to September 8. The potatoes were dug late in September. The average number of sets for each variety was about forty, and to this number the yield of all has been corrected. Such correction, in our experience, always proves unduly favorable to the varieties of which we have the least seed. Our effort has always been to obtain just three pounds of each variety; but sometimes we are unable to obtain so much, or it may be that some tubers obtained prove unfit to plant, owing to bruising or decay.

The yield this year has varied from 8.5 to 46.7 pounds of merchantable tubers for 40 sets.* Six varieties have given a yield of 40 pounds or above of merchantable tubers from 40 sets, viz., Ford's No. 31, 46.7; Early Minnesota, 44.7; Champion of the World, 41.8; Burr's No. 1, 40.8; and American Wonder and Early Dawn, 40 each. Eight varieties gave under 20 pounds from 40 sets, viz., Lady Finger, 8.5; Mayflower, 13.9; Salzer's Earliest, 14.2; Potentate, 15.3; Mills's Long Keeper, 16; Livingston's Pinkeye, 16.8; and King of the Earliest and White Beauty, 18.5 each.

2. *Test with Twenty-five Varieties (the Best of Last Season).* — The seed of these varieties, it will be understood, was all of our own growing, and was of most excellent quality. It was prepared for planting as above described, and was planted upon similar soil and similarly manured. One hundred sets of each variety were planted on May 13. These varieties were sprayed six times, as were those in the preliminary test. They, however, showed considerable blight, and doubtless gave diminished yields because of this affection. The yields have been calculated to 40 sets, to make them comparable with the varieties in the other test. These are shown in the table following: —

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* Forty pounds for 40 sets corresponds to a yield of 242.4 bushels per acre.
Thirty pounds for 40 sets corresponds to a yield of 181.8 bushels per acre.
Twenty pounds for 40 sets corresponds to a yield of 121.2 bushels per acre.

Variety Test of Potatoes. Yield in Pounds from 40 Sets.

Variety.	Merchantable Tubers.	Small Tubers.
Beauty of Hebron,	33.40	7.00
Bliss's Triumph,	20.40	9.60
Carmen No. 1,	23.40	12.80
Dakota Red,	19.20	10.80
Dutton's Seedling,	32.20	15.20
Early Maine,	21.20	2.80
Early Rose,	28.00	9.00
Early Sunrise,	26.40	10.80
Empire State,	12.40	7.60
Enormous,	36.80	4.20
Fillbasket,	37.60	5.60
Late Puritan,	26.80	9.60
Money Maker,	26.60	7.40
New Satisfaction,	26.60	6.00
Prolific Rose,	28.20	8.00
Restaurant,	34.80	7.60
Rochester Rose,	29.60	8.80
Rose No. 9,	34.00	5.20
Sir William,	26.80	6.20
State of Maine,	34.00	4.80
Thorburn,	35.80	6.40
Uncle Sam,	28.40	3.80
Vanguard,	31.80	9.00
White Elephant,	40.20	8.00
Woodbury's White,	35.90	5.00

Last year the eleven best varieties ranked in yield of merchantable tubers in the following order: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these then gave a product at the rate of more than 220 bushels of merchantable tubers per acre.

This year the relative rank, as will be seen, is quite different. The yields are in general much lower. The results of this year, however, owing to the blight, cannot be regarded as affording a reliable index to the relative merits of the varieties. Their publication, however, serves to illustrate how almost impossible it is, in the making of such tests, to establish the relative merits of varieties. As I have remarked in previous reports, it is significant that the old standard, Beauty of Hebron, is once more one of the first ten varieties.

Identical Varieties under Different Names.

As far as we are able to judge, there is no difference between King of the Earliest and Early Ohio; Salzer's Earliest and Bliss's Triumph; Mills's Banner and Livingston's Banner; while White Beauty and Cambridge Russet differ but very slightly, the latter having a slightly more russetted skin than the former.

Test of Seed of the Same Variety from Different Localities.

In order to test the soundness of the *a priori* conclusion that, to make the results of a variety test comparable for the purpose of determining relative merits, the seed of all should have been produced in the same locality and handled in all respects alike, an experiment was carried out with two of the old standard sorts, — Beauty of Hebron and Early Rose, — with seed of each from a considerable number of sources. The seed of the former came from eight different producers; that of the latter, from six. The methods pursued in seed preparation, soil, manuring, spraying, etc., were in all respects as in the variety test.

Comparison of Seed Potatoes from Different Localities. Yield in Pounds of 40 Sets.

SOURCE OF THE SEED.	VARIETIES.			
	BEAUTY OF HEBRON.		EARLY ROSE.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario, D. of C,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	21.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N.Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, N. Y.,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

The range of variation in yield, as will be seen, is large, amounting to almost 50 per cent. in the yield of merchantable tubers for the Beauty of Hebron and to rather over 50 per cent. for the Early Rose. In view of this wide difference in the yield of the same variety, it must be admitted that variety tests in which the seed is brought together from many sources can have but a doubtful value.

The extent of the variation in the type of the potatoes grown in this test was considerable, so great, indeed, as to make it doubtful whether in all cases the seed was true to name, although obtained from the most reliable parties in every instance. The extent of the variation is in part shown in the table below, in which each lot is compared with the crop from our home-grown seed of the same variety: —

Potatoes. — Comparison of Crops, Seed from Different Sources.

Origin of the Seed.	Shape.	Color.	Size.	Eyes.
Beauty of Hebron.				
Home grown,	Long, elliptical, slightly flattened, tapering strongly towards tip.	Light flesh, mottled with darker shades.	Medium,	Medium, rather deep.
J. J. H. Gregory,	Same,	Same,	Same,	Smaller, less deep.
Dreer, Pennsylvania,	Shorter,	Same,	Larger,	Same.
Olds Company, Wisconsin.	Oval, slightly flat, same at both ends.	Lighter,	Smaller,	Small.
Weeks Company, Maine.	Same,	Same,	Larger,	Less deep.
Cornell Experiment Station.	Same,	Light, bright pink,	Larger,	Smaller.
Guelph, Ontario, Experiment Station.	Same,	Same,	Same,	Same.
Dibble Company, N. Y.,	Same,	Lighter,	Same,	Same.
Early Rose.				
Home grown,	Long, flattened, tapering towards seed end, curved.	Light pink, bright pink at seed end.	Medium,	Medium large.
Dreer, Pennsylvania,	Broader, more compact.	Lighter,	Same,	Same.
Farmer Company, Minnesota.	Much broader, less curved.	Same,	Smaller,	Same.
Cornell Experiment Station.	Longer, more curved.	Same,	Larger,	Same.
Kansas, Barteldes & Co.,	Broader, more like Hebron.	Same,	Same,	Smaller, more shallow.
Dibble Company, N. Y.,	Same,	Same,	Larger,	Large, shallow.

Individual Variation, Tubers of the Same Variety.

In view of the frequently reported tests of varieties in which some two or three tubers only of each are used, it was thought best to carry out an experiment to determine if possible the extent to which the product of single tubers will vary when grown under conditions as favorable as possible to uniformity of yield. As a preparation for this test, tiles two feet in diameter and four feet long were set into the ground in a single row, the distance between them being about two and one-half feet. To insure equal drainage conditions, a drain tile was laid at about the level of the lower edge of the tile, being given just enough pitch to carry off water. The plot of land in which the tiles were set was surrounded with drain tile, to prevent the ingress of soil water from outside. This plot had been uniformly manured for many years, so that the subsoil conditions below the tiles must have been practically uniform. The plots were set so that the surface water from outside was excluded, but the earth outside was brought to within about one inch of the upper edge.

These tiles so set were filled to within one foot of the top with carefully mixed subsoil, consisting of a very fine sand, this subsoil being settled by the liberal use of water. After this subsoil had thoroughly settled and somewhat dried, equal weights of carefully mixed medium loam were put into each tile, the quantities being sufficient to fill them. The amount used was two hundred and twenty-five pounds for each tile. Conclusive evidence that the work was well and uniformly done is afforded by the fact that the earth in the several tiles remained at practically uniform height throughout the season.

With the upper four inches in depth of soil in these tiles were most carefully mixed the fertilizers applied, precisely the same weights as determined by chemical balances to each tile. The materials used supplied per tile and at the rate per acre as follows: —

Materials Used.	Per Tile (Grams).	Rate per Acre (Pounds).
Nitrate of soda,	8.07	250
Dried blood,	3.23	100
Tankage,	8.07	250
Acid phosphate,	12.92	400
Sulphate of potash (high grade),	9.69	300

This fertilizer was applied May 9, and the seed was planted the same day. The variety was Carmen No. 1. The tubers selected were uniform in form, weight and all external characteristics, as far as it was possible to obtain such. The weights of the tubers were as follows: No. 1, 160 grams; No. 2, 135 grams; No. 3, 160 grams; No. 4, 140 grams; No. 5, 135 grams; No. 6, 140 grams; No. 7, 140 grams; No. 8, 140 grams. The first seven tubers were treated with corrosive sublimate solution, and sun-sprouted; No. 8 was not treated. Each tuber was cut to exact halves by weight, and the number of eyes on each half reduced to five in the same part of the tuber. The tubers were all typical of the variety, and all were entirely free from scab, but there had been a few scabbed potatoes in the crop from which they came. They were all planted face downward at the same depth, the halves of tuber No. 1 in tiles 1 and 2, the halves of tuber No. 2 in tiles 3 and 4, and so on, — and finally one-half of tuber No. 8 in tile 15. They all came up in good season, but somewhat irregularly, May 26 to May 28. They were most carefully cultivated by hand, kept entirely free from weeds and from bugs by hand pulling and picking. Bordeaux mixture was applied six times, June 6 to July 25. There was practically no injury from either flea beetle or blight. The vines in different tiles showed quite different minor characteristics, and ripened unevenly, September 20 to October 1, when the crop was harvested. At that time there was a very little yellowish-green color on part of one stalk in tile 9 and on one entire stalk in tile 8. All leaves had for some time been dead. The yields and remarks are given in the table: —

Yield of Different Tubers, Carmen Potato.

No. of Tuber.	Tile.	Number of Tubers.	Weight (Kilograms).*	Remarks.
Tuber No. 1, ...	1 2	10 14	1.470 1.520	
Tuber No. 2, ...	3 4	14 11	1.300 1.340	One scabby.
Tuber No. 3, ...	5 6	15 10	1.440 1.440	Several slightly scabby.
Tuber No. 4, ...	7 8	12 8	1.180 1.330	Small amount of scab.
Tuber No. 5, ...	9 10	17 15	1.440 1.620	A very little scab.
Tuber No. 6, ...	11 12	19 9	1.460 1.340	A little scab.
Tuber No. 7, ...	13 14	13 14	1.240 1.450	A little scab.
One-half of Tuber No. 8, .	15	16	1.320	Considerable scab.

* The kilogram equals almost exactly 2.2 English pounds.

The above weights were taken after the tubers had been carefully washed and dried. They showed a range of variation amounting between halves to a little over 37 per cent., and between tubers of about 22 per cent. The differences in number and size of tubers are equally striking. In view of these facts, I submit that variety tests of potatoes upon a small scale can have but a small value for determining the probable relative yield of varieties.

Poultry Experiments.

The experiments with poultry completed since our last annual report were begun in the late fall of 1897, and extended through the winter of 1897 and 1898, and a part of them through the past summer and into the fall. The points upon which these experiments were designed to afford information are the following: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of flesh or animal meal and cut fresh bone.

3. Comparison for egg-production of a wide nutritive ration with a narrow; or, in other words, of a ration in

which corn meal and corn were prominent with one in which these feeds were replaced wholly or in large part with more nitrogenous foods, such as wheat middlings, gluten feed, wheat and oats.

4. The influence of the presence of a cock with the hens upon egg-production.

General Conditions.

In all these experiments pullets purchased in Plymouth County and reaching us about the middle of October were used. These pullets were well-bred Barred Plymouth Rocks, not fancy stock (*i. e.*, as to feather), but bright, healthy stock, hatched in April. These pullets were evenly divided into lots of twenty each, being matched in sets of two lots as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began December 12 and ended April 30. The latter part of March a few hens were removed from each house for sitters, the same number from each. Egg records of the separate lots were kept from the time laying began to the time of beginning experiments, for the purpose of affording an index as to the equality or otherwise of the matched pairs of lots. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. This was mixed the night before with boiling water until January 8, and fed at the temperature of about 70° F. After January 8, the mashes were mixed with boiling water in the morning, and fed hot. At noon a few oats were scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed once each month.

No male birds were kept in any of the pens in the winter experiments, nor, indeed, in any except where the influence of the cock was the subject of experiment. Sitters, except those taken out, above alluded to, were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below: —

Wheat,	$1 75
Oats,	1 00
Wheat bran,	60
Wheat middlings,	75
Gluten feed,	2 00
Animal meal,	2 00
Cut clover rowen,	1 50
Cabbage,	25
Cut bone,	2 00
Gluten meal,	80
Corn meal,	85
Corn,	85

Composition of Foods (Per Cent.).

Kind.	Moisture.	Air Dry Food contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Whole wheat,	10.51	1.85	12.64	2.55	71.01	1.44
Whole oats,	8.06	3.21	11.96	11.64	61.48	3.65
Cut clover rowen,	9.80	7.36	17.88	22.18	39.70	3.08
Wheat middlings,	9.25	4.63	17.52	9.91	53.11	5.58
Animal meal,	5.06	39.26	37.66	1.01	5.56	11.45
Whole corn,	12.11	1.31	9.55	1.90	71.26	3.87

Kind.	Moisture.	Dry Matter contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Bran,	12.72	6.96	18.01	11.65	57.92	5.46
Gluten feed,	9.10	0.92	24.59	7.17	63.43	3.89
Corn meal,	13.43	1.46	11.01	1.96	81.44	4.13
Cabbage,	89.45	7.94	25.69	9.31	54.76	2.30
Cut bone,	26.29	21.50	20.62	–	–	31.38
Gluten meal,	8.77	1.50	37.64	3.87	54.59	2.40

1. Effect of Condition Powder upon Egg-production.

Each coop contained twenty pullets at the beginning of the experiment; the fowls in the no condition-powder coop weighing 103 pounds, and having laid, November 18 to December 12, 46 eggs; the fowls in the condition-powder coop weighing 97 pounds, and having laid 14 eggs. The rations of the two lots of fowls were the same, except to the morning mash of one lot was added condition powder to the full amount recommended by makers; viz., 3 scoops (provided for measuring) heaping full. This amount of condition powder was enough to make the mash several shades darker than the one without it, and to impart a strong odor. Being mixed sometimes in the room where milk was standing, it imparted a flavor to butter made therefrom which was recognized by our expert butter maker, who knew nothing concerning its use, and who worked in rooms a quarter of a mile distant, to which the milk was taken. The pen receiving the powder consumed during the winter four two-pound cans of it, costing at retail $4.

Both lots of fowls were healthy throughout the entire test. Two fowls were stolen from the lot receiving no condition powders on the night of March 27. One soft-shelled egg was laid by a fowl receiving condition powder. The tables give all details necessary to a comparison of the results: —

Foods consumed, Condition-powder Experiment.

Kinds of Food.	Amount.			
	Condition Powder.		No Condition Powder.	
	Lbs.	oz.	Lbs.	oz.
Wheat,	269	0	250	0
Oats,	155	0	152	0
Bran,	44	0	44	8
Middlings	44	0	44	8
Gluten feed,	44	0	44	8
Animal meal,	52	0	52	8
Clover,	43	0	44	8
Cabbage,	15	15	15	3

Average Weights of the Fowls (Pounds).

Dates.	Condition Powder.	No Condition Powder.
December 12,	4.85	5.15
January 31,	5.21	5.41
February 25,	5.44	5.53
March 30,	5.25	5.48
April 30,	5.11	4.88

Eggs per Month (Number).

Months.	Condition Powder.	No Condition Powder.
December,	28	59
January,	90	66
February,	86	101
March,	217	288
April,	298	291
Totals,	719	745

Condition Powder for Egg-production (December 12 to April 30).

	Condition Powder.	No Condition Powder.
Hen days,	2,751	2,656
Gross cost of food,	$8 91	$8 59
Cost per hen day,	$0 0032	$0 0032
Total number of eggs,	719	745
Cost per egg, not including powder,	$0 0124	$0 0115
Cost per egg, including powder,	$0 0180	$0 0115
Eggs per hen day,	.26+	.28+
Total weight of eggs (pounds),	88.08	90.80
Average weight of eggs (ounces),	1.96	1.95
Dry matter to produce 1 egg (pounds),	.82	.77
Dry matter consumed per hen day (pounds),	.22−	.22−
Nutritive ratio,	1:4.6+	1:4.6−
Sitters,	8	14

Eggs from both lots of fowls were tested under numbers by two families. One family reports no difference; the other found the eggs from the hens not getting the powder "much preferable" to the others.

Conclusion.

A study of the figures showing results shows that the hens not getting the condition powder laid more eggs, of practically the same average weight. The food required to produce a single egg was less, and the cost was very materially less. The average weight of the fowls not getting the powder at the close of the experiment was about one-quarter of a pound less than that of the other.

We have now carried through three experiments to test the value of condition powder for egg-production. The differences have in every case been small. In favor of the condition powder we have one experiment, against it we have two experiments. It is not, however, my disposition to claim that the powder is injurious, but simply *that it is not beneficial.* This the four experiments, carried out with the utmost fairness and with every care, certainly prove. *In the light of these results, it is believed that poultry keepers throw away money expended for condition powder.*

2. Animal Meal v. Cut Bone for Egg-production (December 12 to April 30).

In this experiment there were nineteen pullets in each house when the experiment began. Those in the animal-meal house weighed 101.5 pounds, and had laid, November 8 to December 12, 82 eggs. The pullets in the cut-bone coop weighed 101.25 pounds, and had laid 41 eggs.

In the morning mash of one lot one part animal meal to five parts total dry materials was used; in the mash of the other lot, the same proportion of fresh-cut bone was mixed. The large, flat bones, comparatively free from meat or fat, were used.

In the animal-meal coop the health of the birds was good, but one fowl being out of condition in any way. She became sick about April 1, and was killed, as she seemed to be growing gradually worse, on April 10. The nature of the trouble was unknown. Almost from the first, bowel troubles were not uncommon in the cut-bone coop. Two fowls died (December 23 and January 11) after short illness. On April 11 one hen was found with a disjointed leg, and she was killed. The animal-meal coop laid three soft-shelled eggs; the other, two.

The bone fed amounted to only .27 ounce per hen daily. One-half ounce and over is the usual recommendation by writers upon the subject. We find it impossible to feed so largely without serious bowel trouble.

Foods consumed, Animal Meal v. Cut Bone.

Kinds of Food.	Animal Meal.	Cut Bone.
	lbs. oz.	lbs. oz.
Wheat,	256 0	262 0
Oats,	143 0	145 0
Bran,	44 8	39 0
Wheat middlings,	44 8	39 0
Gluten feed,	44 8	-
Gluten meal,	-	39 0
Animal meal,	44 8	-
Cut bone,	-	40 0
Clover rowen,	44 8	39 0
Cabbage,	19 3	18 8

Average Weights of the Fowls (Pounds).

Dates.	Animal Meal.	Cut Bone.
December 12,	5.34	5.38
January 31,	5.64	5.66
February 25,	5.66	5.88
March 30,	5.09	5.27
April 30,	5.06	5.53

Eggs per Month (Number).

Months.	Animal Meal.	Cut Bone.
December,	63	57
January,	92	83
February,	184	120
March,	263	259
April,	210	209
Totals,	812	728

Animal Meal v. Cut Bone for Egg-production.

	Animal Meal.	Cut Bone.
Total number of eggs,	812	728
Hen days,	2,561	2,331
Gross cost of foods,	$8 45	$8 29
Cost per egg,	$0 0104	$0 0114
Cost per hen day,	$0 0033	$0 0035
Total weight of eggs (pounds),	100.5	88.7
Average weight per egg (ounces),	1.98	1.95
Eggs per hen day,	.32	.31
Dry matter consumed per hen day (pounds),	.22	.23
Dry matter to produce 1 egg (pounds),	.695	.739
Nutritive ratio,	1:4.6	1:4.7
Sitters,	22	13

A test of the eggs both raw and boiled was made by an expert, who found the animal-meal eggs inferior, in color and flavor, to the others.

Conclusion.

In conclusion, then, I may quote the closing summary of results made in my report upon a similar experiment last year. "The advantage in this trial lies, then, clearly with the animal meal as a food for egg-production. It has given more eggs of greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer." In one respect only is the animal meal apparently inferior to the bone this year, viz., the fowls getting it weigh less at the close of the experiment than the others. This loss in weight is, however, far more than covered by the greater value of eggs produced.

We have now carried through five experiments, comparing these two feeds. Two have given results slightly favorable to the bone in number of eggs; one a similar result in favor of the animal meal; and two — the two last, which have been the most perfectly carried out — have been most decisively favorable to the animal meal. The latter has also been found the safer food. *The greatly preponderating weight of the evidence afforded by these experiments, which have been most carefully conducted, is, therefore, in favor of the animal meal.*

3. Narrow v. Wide Ration for Egg-production.

The experiments coming under this head have been two, one extending from December 12 to April 30, the other from May 1 to October 4. The object in view was to test the correctness of the generally held opinion that the food of the laying hen must be very rich in nitrogenous constituents. As we have carried out the experiment, it amounts to a substitution of corn meal for wheat middlings and gluten feed in the morning mash, and the replacement of about one-half of the oats and the wheat fed at night with the corn. The proportions of cut clover and of animal meal have remained the same in the two rations.

The health of the fowls on both rations has been uniformly good throughout both the winter and summer test, with a single exception, — the loss of one fowl from the effects of indigestion, — on the wide ration. It was found to require the exercise of more judgment in feeding to keep the fowls on the heavier corn ration in perfect condition. They were more easily overfed, and on two or three occasions lost appetite for their feed for short periods.

The Winter Experiment.

On December 12 the pullets, 19 in each lot, weighed as follows: narrow ration, 101.75 pounds; wide ration, 102.5

pounds. The first lot had laid, November 12 to December 12, 127 eggs; the other lot, 85 eggs, and one in this lot was broody. The foods consumed during the winter experiment and other details are shown in the following table: —

Foods consumed, Narrow v. Wide Ration (December 12 to April 30).

Kinds of Food.	Narrow Ration. lbs.	Narrow Ration. oz.	Wide Ration. lbs.	Wide Ration. oz.
Wheat,	257	0	126	0
Oats,	147	0	63	0
Bran,	43	0	39	0
Middlings,	43	0	-	
Gluten feed,	43	0	-	
Animal meal,	43	0	39	0
Clover,	44	0	39	0
Corn meal,	-		108	0
Corn,	-		136	0
Cabbage,	18	5	16	5

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
December 12,	5.36	5.39
January 31,	5.41	5.84
February 25,	5.45	5.80
March 30,	5.16	5.57
April 30,	5.17	5.31

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

Months.	Narrow Ration.	Wide Ration.
December 12 to 31,	94	89
January,	99	148
February,	147	258
March,	310	317
April,	210	259
Totals,	860	1,071

Narrow v. Wide Ration for Egg-production, Winter Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,529	2,538
Gross cost of foods,	$8 54	$6 56
Cost per hen day,	$0 0033	$0 0026
Total number of eggs,	860	1,071
Cost per egg,	$0 0099	$0 0061
Eggs per hen day,	.34—	.42+
Total weight of eggs (pounds),	102.425	130.53—
Average weight of eggs (ounces),	1.98	1.95
Dry matter to produce one egg (pounds),	.655	.46
Dry matter consumed per hen day (pounds),	.22	.19
Nutritive ratio,	1:4.7 —	1:5.6 —
Number of sitters,	30	24

Summer Experiment.

The summer experiment was continued with the same fowls that had been used in the winter. The method of feeding remained the same, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week, to each lot the same; and (2) the feeding of cabbages was discontinued. The yards (fifty by twenty-four feet) were kept fresh by frequent use of the cultivator. The health of one fowl only suffered during the experiment. One of the corn-fed fowls appeared dumpy for a few days, but was fully recovered in two weeks. As in the winter test, the fowls fed largely on corn showed less relish for their whole grain than the others. Food consumed and other details are shown below: —

Foods consumed, Narrow v. Wide Ration (May 1 to October 4).

Kinds of Food.	Narrow Ration.	Wide Ration.
	Lbs.	Lbs.
Wheat,	276	131½
Oats,	97	43
Bran,	43	40
Middlings,	43	-
Animal meal,	43	40
Corn meal,	-	106½
Corn,	-	217½
Gluten feed,	43	16

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
April 30,	5.17	5.31
June 11,	5.00	5.25
July 16,	5.47	5.22
August 11,	5.05	5.50
Before killing,	5.07	5.44
Dressed,	4.37*	4.81†

* Or 86 per cent. † Or 88 per cent.

Eggs per Month (Number).

Months.	Narrow Ration.	Wide Ration.
May,	216	292
June,	182	204
July,	157	210
August,	151	197
September,	139	174
October 1-14,	14	18
Totals,	859	1,095

Narrow v. Wide Ration for Egg-production, Summer Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,355	2,512
Gross cost,	$7 56	$6 64
Cost per hen day,	$0 0032	$0 0026
Total number of eggs,	859	1,095
Cost per egg,	$0 0088	$0 0061
Eggs per hen day,	.36	.44
Total weight of eggs (pounds),	106.3	130
Average weight of eggs (ounces),	1.98	1.90
Dry matter to produce one egg (pounds),	.57+	.48+
Dry matter consumed per hen day (pounds),	.21—	.21+
Sitters,	67	60

The fowls on the wide (corn) ration laid three soft-shelled eggs during the winter test and one during the summer. These are not included in the tabular reports.

Study of the results reveals the following facts: —

1. The hens on the wide (rich in corn) ration laid a great many more eggs in both the winter and in the summer experiments than those on the narrower ration.

2. The difference in favor of the wide ration amounts to 25 per cent. in the winter trial and to 33⅓ per cent. in the summer trial, upon the basis of equal number of hen days.

3. The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one hundred dozen eggs the saving on the basis of our winter test would amount to $4.56; on the basis of the summer test, to $3.24.

4. In average weight of the eggs produced there is a small difference in favor of the narrow ration; but in quality the weight of family evidence shows the eggs produced by the corn-fed hens to have been somewhat superior. They were deeper yellow and of a milder flavor than the eggs from the narrower ration.

5. The fowls on the wide ration gained somewhat in weight and were heavier at the close of the experiment than the others, notwithstanding the much larger number of eggs laid.

At the close of the experiment the fowls were closely judged as to the condition of the plumage while still living, and it was decided that the corn-fed hens were farther advanced in moulting than the others. The fowls were slaughtered, and the judgment of the men removing the feathers coincided with the judgment on the living fowls.

The averages before and after dressing were as follows: narrow-ration fowls, 5.07 pounds; dressed weight, 4.37 pounds; wide-ration fowls, 5.44 pounds; dressed weight, 4.81 pounds. The narrow-ration fowls gave 86 per cent. dressed weight; the others, 88 per cent. The dressed fowls were judged by a market expert, who pronounced the corn-fed fowls slightly superior to the others.

The results are thus greatly in favor of the ration richer in *corn meal and corn; and so important will a knowledge of this fact prove (if confirmed by further trials), because of the cheapness of these foods as compared with wheat, that the experiment is being repeated this year with three different breeds of fowls, using corn yet more largely than last year.*

4. *Influence of the Cock on Egg-production.*

At the close of the winter tests the hens that had been used in the condition-powder and cut-bone experiments were matched in such a manner as to equalize previous feed conditions in four coops of sixteen fowls each. The fowls were all put upon the same feed, and egg records were kept for two weeks, to determine whether the fowls seemed evenly matched. At the end of the time a vigorous White Leghorn cock was placed in two of the coops. We had thus two experiments co-incidently running. These will be designated respectively test No. 1 and test No. 2.

Test No. 1. Influence of the Cock on Egg-production. — In the preliminary trial the hens in pen 1 laid 129 eggs; those in pen 2, 107 eggs. In the first pen five hens were brooding; in the second, seven. The fowls in both pens were fed alike, each receiving, in addition to the feed recorded, lawn clippings three times per week. The experiment began May 13 and extended to September 2. In calculating the food cost per hen day the cock is included in the hen days, but in calculating the number of eggs per hen day the cock is not included. No ill health or accidents of any kind occurred. The cock in the trial was in pen 1.

Foods consumed (May 14 to September 2).

Kinds of Food.	Pen 1.	Pen 2.
	Lbs.	Lbs.
Wheat,	194	194
Oats,	82	78
Bran,	32	32
Middlings,	32	32
Gluten feed,	32	32
Animal meal,	32	32

Average Weight of Fowls (Pounds).

Dates.		Pen 1.	Pen 2.
May	14, beginning,	5.12	5.09
June	11,	4.69	4.91
July	16,	4.91	4.94
August	11,	4.87	5.09
September	1, end,	4.82	4.95

Influence of Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days, including cock,	1,904	-
Hen days, without cock,	1,792	1,792
Gross cost of food,	$5 53	$5 49
Cost per hen day,	$0 0029	$0 0031
Total number of eggs,	631	630
Cost per egg,	$0 0088	$0 0087
Eggs per hen day,	.35+	.36—
Total weight of eggs (pounds),	77.3	76.79
Average weight of eggs (ounces),	1.96	1.95
Dry matter consumed per hen day (pounds),	.19	.20
Dry matter consumed per egg (pounds),	.58—	.57+
Nutritive ratio,	1:4.7—	1:4.7
Sitters,	41	45

Test No. 2. Influence of the Cock on Egg-production. — During the preliminary period the fowls in pen 5 laid 90 eggs, three offering to sit; those in pen 6 laid 107 eggs, five offering to sit. The cock was placed in pen 6. One hen in pen 6 was lame from July 6 to the end of the test; one in pen 5 was injured in the back on July 22, and died August 4. This test closed August 25.

Foods consumed (May 14 to August 25).

Kinds of Food.	Pen 6.	Pen 5.
	Lbs.	Lbs.
Wheat,	179	161½
Oats,	80¾	81¾
Bran,	31½	30¼
Middlings,	31½	30¼
Gluten feed,	31½	30¼
Animal meal,	31½	30¼

Average Weight of Hens (Pounds).

Dates.	Pen 6.	Pen 5.
May 14,	4.91	5.06
June 11,	4.79	4.94
July 16,	4.91	5.09
August 11,	4.94	5.17
August 23,	4.72	5.02

Influence of the Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days,	1,664	1,643
Hen days with cock,	1,768	-
Gross cost of foods,	$5 24	$4 89
Cost per hen day,	$0 0030	$0 0030
Total number of eggs,	629	526
Cost per egg,	$0 0083	$0 0093
Eggs per hen day,	.38+	.33—
Total weight of eggs (pounds),	77.84	64.76
Average weight of eggs (ounces),	1.98	1.97
Dry matter to produce 1 egg (pounds),	.55	.63—
Dry matter consumed per hen day (pounds),	.20	.20
Nutritive ratio,	1:4.8	1:4.7
Sitters,	35	33

Study of these results shows that the cock was without apparent influence upon the egg product of these fowls. The differences are very small, too insignificant to have much weight, even if in both trials of the same nature. When we note, however, that in one trial the balance was very slightly in favor of the set of fowls with which the cock was kept, and that in the other trial it was with the fowls kept without the cock, we must conclude that the results prove neither benefit nor injury due to the presence of the male. In one respect only is there agreement in the results of the two trials; the average weight of the eggs from the hens with which a male was kept was slightly the greater in both trials. It seems not impossible that this effect may be due to the fact that the eggs had been fertilized. The difference is, however, exceedingly small, and would be wholly without significance to the producer of eggs for market or for table use.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

The work of the past season has been along the lines indicated in a previous report, so far as time and circumstances would permit. It has seemed desirable to give especial attention to the immediate needs of the citizens of this Commonwealth, as indicated by the extensive correspondence, from which one is enabled to gain a pretty clear idea of the insects especially troublesome, and upon which help is needed, from year to year. The work on the gypsy and brown-tail moths has demanded a large amount of time, not only in frequent inspections of the field work in the infested territory, but also in planning and directing the scientific part of the work.

A monograph of the plume-moths (*Pterophoridæ*) of North America was prepared and published in the last college report, and a revised edition was issued in July as a special bulletin from this station. Such monographs are absolutely essential as foundation work in economic entomology. I am now at work, when other duties permit, on a similar monograph of the two remaining families of the *Pyralidæ*. Mr. Cooley's monograph on the genus *Chionaspis*, a group of very pernicious scale insects, is now quite far advanced, and will soon be ready for publication.

The San José Scale.

This insect has now unfortunately become established in various parts of the State, and has been sent here for determination during the past season more frequently than any other. This pest, as well as several other injurious scale insects, has been brought into the State and distributed among our fruit growers on nursery stock; and, unless present in large numbers, they are liable to be entirely overlooked, both by the nurseryman and the purchaser, but when they are discovered, not only does the purchaser suffer from the loss of his trees, but the nurseryman is sure to lose his trade. As a result, some of our more progressive dealers in nursery stock, by my advice, have built fumigating houses, and treat all stock received and sent out, with hydro-cyanic acid gas.

Many of the other States have enacted laws for the regular examination of their nurseries, and also prohibiting the introduction of nursery stock that has not been examined by an expert entomologist, appointed for that purpose by the State from which the stock was shipped, and accompanied by his certificate of examination. This has shut out the trade of our nurserymen more or less from all those States where such laws exist, and, at the same time, leaves Massachusetts as a dumping ground for the infested nursery stock of other States. It is evident, therefore, that we need some law to protect us against the introduction of the San José scale and other injurious insects.

The Grass Thrips.

The amount of damage to grass done by this insect has been estimated at more than that of all others combined. This may be an overestimate, but there is no doubt that it is one of the most destructive grass insects in this Commonwealth. Very little has been known of it, beyond the fact that it is very injurious; but no method of dealing with it has been suggested that promised any great degree of success. One of my assistants has worked out its life history and bred it through all of its stages, and will prepare a bulletin on it soon.

The Small Clover-leaf Beetle.

This insect (*Phytonomus nigrirostris*) is very common on the college farm, and is quite destructive to the clover on which it feeds. Its habits and life history will be published when the investigations now being made on it are completed. An allied species, the clover-leaf beetle (*Phytonomus punctatus*), is reported in various parts of this country, and is said to have done a great deal of damage.

The Buffalo Carpet Beetle.

The Buffalo carpet beetle has caused housekeepers more or less trouble for a long time, and the correspondence about this insect has been more extensive during the last ten years than on almost any other. My attention has recently been called to an invasion of this insect in the storehouse of the Geo. Gilbert Manufacturing Company, in Ware, where it was destroying woolen goods. After considering the matter very fully, the owners were advised to close the house as tightly as possible, and fumigate it with hydro-cyanic acid gas. Full instructions were given, in order that no accidents might occur from the use of this deadly gas.

Arsenate of Lead and Bordeaux Mixture.

Arsenate of lead has proved so valuable an insecticide for the destruction of the gypsy moth, as well as other insects, that several correspondents have inquired if it could be used with Bordeaux mixture. A trial was therefore made on several apple trees on my own grounds, with most excellent results and without any injury to the foliage, though the arsenate of lead was used in the proportion of five pounds to one hundred and fifty gallons of water. The fruit of these trees had been badly affected by the scab for several years, but after a single spraying with the above preparation the fruit in the fall was in excellent condition. Experiments will be performed with these substances another year, before giving a detailed account of the work.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

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Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1898.

CHARLES A. GOESSMANN.

The number of licensed manufacturers and dealers in commercial fertilizers and agricultural chemicals during the past year is sixty-one. Thirty-five of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, four in Connecticut, three in Vermont, three in Rhode Island, one in Maine, one in New Jersey, one in Illinois and two in Canada.

The distinct brands of fertilizer, including chemicals, licensed in the State, are two hundred and sixty-four.

Three hundred and seventy-eight samples of fertilizers have thus far been collected in the general market by experienced delegates of the station; of these, three hundred and sixty-three samples were analyzed at the close of November, 1898, representing two hundred and sixty-four distinct brands. The results of these analyses were published for distribution in three bulletins, Nos. 51, 54 and 57, of the Hatch Experiment Station of the Massachusetts Agricultural College, during the months of February, July and November, 1898.

The remaining samples and others coming into our hands before the expiration of the license, May 1, 1899, will be analyzed in due time, and the results published in conformity with our State laws for the regulation of the trade in commercial fertilizers.

The modes of chemical analysis adopted in our examination of fertilizers are, in all essential points, those recommended by the Association of Official Chemists.

For a better understanding and due appreciation of the trade in commercial fertilizers during the past year, the following abstract of our results is here inserted. To arrive at a correct conclusion, it must be borne in mind that only the lowest stated guarantee is legally binding on all sales: —

	1897.	1898.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	3	5
Number with two elements above the highest guarantee,	2	17
Number with one element above the highest guarantee,	60	77
Number with three elements between the lowest and highest guarantee,	69	85
Number with two elements between the lowest and highest guarantee,	63	93
Number with one element between the lowest and highest guarantee,	16	54
Number with two elements below the lowest guarantee,	6	19
Number with one element below the lowest guarantee,	29	90
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	3	5
Number with one element above the highest guarantee,	10	24

	1897.	1898.
Number with two elements between lowest and highest guarantee,	13	25
Number with one element between lowest and highest guarantee,	12	17
Number with two elements below the lowest guarantee,	3	2
Number with one element below the lowest guarantee,	6	8
(c) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	18
Number between lowest and highest guarantee,	13	23
Number below the lowest guarantee,	1	15

A comparison of the above-stated results of our inspection during the years 1897 and 1898 shows no material differences regarding the general character of the fertilizers sold in our market. In a few cases it became our duty to communicate with the manufacturers, and ask for an explanation. Imperfect mixing proved in most of these cases the cause of differences between guarantee and our analysis. As the commercial value of the brand was not materially affected, with only two or three exceptions, the cases were passed over, after a satisfactory explanation from the party interested.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the successful raising of farm and garden crops congenial to climate and soil. The fact that the most important essential articles of plant food, as nitrogen, potash and phosphoric acid, are freely offered for sale in our markets in forms suitable to change the manurial refuse of the farm as stable manure and vegetable compost into complete manures for the crops to be raised, deserves the most serious attention of farmers. *To render the stated waste products of the farm in a higher degree efficacious as a manure supply cannot be otherwise considered than as a most promising step in the direction of an economical supply of plant food for the production of farm and garden crops.*

As the manufacturer at best can only prepare his special or so-called complete fertilizers on general lines, not knowing the particular character and condition of the soil which receives them, it becomes the business of the farmer to make his selection with due care. An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

As the physical conditions and chemical resources of soils in available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised in preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station, at Amherst, Mass.

In making choice from among the so-called complete fertilizers, two points in particular seem to be worth remembering. *First*, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to the cost per ton; *mere trade names are no guarantee of fitness.* High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. *Second*, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of the three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in the form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897 and 1898: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 and 1898 (Cents per Pound).

	1897.	1898.
Nitrogen in ammonia salts,	13.5	14.0
Nitrogen in nitrates,	14.0	13.0
Organic nitrogen in dry and fine ground fish, meat blood, and in high-grade mixed fertilizers,	14.0	14.0
Organic nitrogen in cotton-seed meal,	12.0	12.0
Organic nitrogen in fine bone and tankage,	13.5	13.5
Organic nitrogen in medium bone and tankage,	11.0	10.0
Phosphoric acid soluble in water,	5.5	4.5
Phosphoric acid soluble in ammonium citrate,	5.0	4.0
Phosphoric acid in fine bone and tankage,	5.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace, wood ashes and fine-ground fish,	5.0	4.0
Phosphoric acid in coarse bone and tankage,	2.5	3.5
Phosphoric acid insoluble (in ammonium citrate) in mixed fertilizers,	2.0	2.0
Potash as sulphate (free from chlorides),	5.0	5.0
Potash as muriate,	4.5	4.25

From these figures it is apparent that some of the best forms of nitrogen and phosphoric acid have suffered, as a rule, a reduction in cost, as compared with preceding years.

For further details I have to refer to preceding annual reports.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties.

The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home composition, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1898, to May 1, 1899), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Butchers' Rendering Association, Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N.Y.: —
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Complete Cabbage Manure.
- A. A. Ammoniated Superphosphate.
- Complete Manure for General Use.
- Grass and Lawn Dressing.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport Conn.: —
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, H B.
- Fish Scrap No. 2, H B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R. I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.
- Corn Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Dissolved Bone.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.

Clark's Cove Fertilizer Co. —*Con.*
Great Planet Manure.
Potato Fertilizer.
King Philip Guano.
Potato Manure.
Fish and Potash.
White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
Superphosphate.
Potato Phosphate.
Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
High-grade Potato Fertilizer.
Tobacco and Onion Fertilizer.
High-grade Ammoniated Bone Superphosphate.
Gold Brand Excelsior Guano.
Fish Guano and Potash.
Bay State Phosphate.
Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Ammoniated Bone Superphosphate.
Potato, Hop and Tobacco Phosphate.
Ammoniated Wheat and Corn Phosphate.
New Rival Ammoniated Superphosphate.
Vegetable Bone Superphosphate.
General Crop Phosphate.
Universal Grain Grower.
Special Potato Manure.
New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Superphosphate.
Potato Fertilizer.
Concentrated Phosphate.
Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Animal Fertilizer.
Potato and Root Crop Manure.
Tobacco Grower.
Blood, Bone and Potash.
Special Formula.
Fine-ground Bone.
Muriate of Potash.
Nitrate of Soda.
Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
Nitrogenous Superphosphate.
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.

W. E. Fyfe & Co., Clinton, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
General Fertilizer.
Vegetable, Vine and Tobacco Fertilizer.
Garden Special.
Grass and Oats Fertilizer.

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

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Celebrated Onion Fertilizer.
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Special Tobacco Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
Bone Fertilizer for Corn and Grain.
Animal Fertilizer.
Potato Phosphate.
Bone and Potash.
Lawn Dressing.
Tobacco Manure.
Fruit and Vine Fertilizer.
Market-garden Fertilizer.
Ground Bone.

Lowe Bros., & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunville, Ontario, Can.: —
Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Bone Manures.
- Superphosphates.
- Special Crop Manures.
- Sulphate of Potash.
- Double Manure Salts.
- Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
- Unleached Hard-wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
- Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Complete Fertilizers.
- Ammoniated Bone.
- Market-garden Manure.
- Potato Phosphate.
- Fish and Potash.
- Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
- Wheat and Corn Producer.
- Potato, Tobacco and Hop Fertilizer.
- Niagara Triumph.

Packers Union Fertilizer Co., New York, N. Y.: —
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Animal Corn Fertilizer.
- Potato Manure.
- Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass.: —
- Soluble Pacific Guano.
- Special Potato Manure.
- Nobsque Guano.
- High-grade General Fertilizer.
- Grass and Grain Fertilizer.
- Fish and Potash.
- Pacific Guano with 10 per cent. Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Star Brand Superphosphate.

Parmenter & Polsey Fertilizer Co. — *Con.*
- Special Potato.
- Strawberry and Small Fruits.
- Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- P. & P. Potato Fertilizer.

A. W. Perkins & Co., Rutland, Vt.: —
- Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
- Pioneer.
- Potato Fertilizer.
- Superphosphate, I.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Market-garden Manure.
- Fish and Potash.
- Grass Fertilizer.
- Corn Manure.
- Potato Phosphate.
- Climax Phosphate.
- Pure Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Kainit.
- Dissolved Bone-black.

Benjamin Randall, East Boston, Mass.: —
- Market-garden Fertilizer.
- Farm and Field.
- Ground Raw Bone.

Read Fertilizer Co., New York, N. Y. (H D. Foster, general agent): —
- Standard Fertilizer.
- High-grade Farmers' Friend.
- Practical Potato Special.
- Vegetable and Vine.
- Fish, Bone and Potash.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

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

Russia Cement Co., Gloucester, Mass.:—
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Odorless Lawn Dressing.
Potato Fertilizer.
Dry Ground Fish.
Special Manure for Carnations.

Lucien Sanderson, New Haven, Conn.:—
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.
Sanderson's Old Reliable Superphosphate.
Sanderson's Potato Manure.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Standard Guano.
Complete Manure.
Special for Potatoes.

C. F. Sturtevant, Hartford, Conn.: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.
Bay State Special.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithead, Lowell, Mass.: —
Champion Garden Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
High-grade fish and potash.
Dry Ground Fish Guano.
Fish and Potash 1895 Brand.

Williams and Clark Fertilizer Co, Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato Manure.
Grass Manure.
Fish and Potash.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.

A. L. Warren, Northborough, Mass.: —
Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
Fine-ground Bone.

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

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Wood Ashes, Condition of Trade, etc.
3. Notes on Fertilizers for Pot Cultivation and Greenhouses.
4. Observations regarding the Action of Acid and Basic Phosphates on the Availibility of the Nitrogen in Blood, Steamed Leather and Leather Scraps.
5. Notes on the Determination of the Available Phosphoric Acid in the Soil.
6. Analyses of Drainage Waters obtained in Connection with Some Field Experiments carried on upon the Grounds of the Station.

1. Analyses of Materials sent on for Examination.

The number of substances tested in this connection amount to several hundred. The results of our examination are already published in detail in Bulletins 51, 54 and 57 of the Hatch Experiment Station of the Massachusetts Agricultural College, in connection with the results of the official inspection of commercial fertilizers collected from original packages by an efficient delegate of the station.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for the analysis. Our publication of the results refers merely to the locality they come from, to avoid misunderstandings. The work carried on in this connection is growing from year to year in importance.

A large proportion of commercial manurial substances consist of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason, arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers, to the full extent of the resources placed at the disposal of the officer in charge of this work.

These investigations are carried on free of charge to farmers of the State, and as far as the financial resources of the laboratory admit. The examination of the materials is, as a rule, carried on in the order they arrive at the station, and the results are considered public property.

The following statement of the names of the different articles sent on and thus far analyzed may suffice here to convey some more definite idea concerning the general character of the work: —

Materials sent on, Dec. 1, 1897, to Dec. 1, 1898.

Air-dried potatoes,	9	Peat,	1
Acid phosphate,	2	Nitrate of soda,	3
Ashes from cremation of garbage,	1	Sulphate of ammonia,	1
Bleachery refuse,	2	Sulphate of potash and magnesia,	1
Broom corn seed,	1	Sulphate of potash,	2
Cotton-seed meal,	2	Sweet clover hay,	3
Compound fertilizers,	21	Sulphate of magnesia,	1
Cremation ashes,	1	Soya bean refuse,	1
Dissolved bone-black,	1	Starch,	2
Fodder material,	1	Sewage,	1
Ground bone,	9	Soil,	12
Ground fish,	1	Silicate of potash,	1
Hop refuse,	1	Tankage,	3
Lime-kiln ashes,	2	Tobacco stems,	1
Liquid fertilizer,	1	Tobacco refuse,	1
Manure,	12	Teopik fibre,	1
Marl,	1	Wood ashes,	79
Muriate of potash,	3	Wool waste,	1
Muck,	5	Whale-bone scrapings,	1
Minerals,	3	Vat deposit,	1
Oxalic acid,	1		

A few of the more important of the above-stated materials, as wood ashes, etc., are discussed more at length in subsequent pages.

2. Notes on Wood Ashes.

Wood ashes for manurial purposes are in our State subject to official inspection, and dealers in that commodity have to secure a license to sell in our State before they can legally advertise their articles for sale. This circumstance makes it obligatory on the dealers to state the amount of potash and of phosphoric acid they guarantee in these materials, and to fasten that statement upon the package or car, etc., which contains them.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered, in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both, as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid. Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given measure.

During the past year (1898) 40.1 per cent. of the materials sent on for analysis consisted of wood-ash samples; during the preceding year (1897) they amounted to 40 per cent.

The general character of the wood ashes sold during the stated years may be judged from the following classified statement of our results: —

	No. of Samples. 1897.	No. of Samples. 1898.
Moisture from 1 to 3 per cent.,	10	9
Moisture from 3 to 6 per cent.,	8	6
Moisture from 6 to 10 per cent.,	13	20
Moisture from 10 to 15 per cent.,	19	22
Moisture from 15 to 20 per cent.,	11	16
Moisture from 20 to 30 per cent.,	10	6
Moisture above 35 per cent.,	1	–
Potassium oxide above 8 per cent.,	3	4
Potassium oxide from 7 to 8 per cent.,	8	6
Potassium oxide from 6 to 7 per cent.,	21	8
Potassium oxide from 5 to 6 per cent.,	28	22
Potassium oxide from 4 to 5 per cent.,	10	25
Potassium oxide from 3 to 4 per cent.,	3	11
Potassium oxide below 3 per cent.,	–	3
Phosphoric acid above 2 per cent.,	4	6
Phosphoric acid from 1 to 2 per cent.,	45	60
Phosphoric acid below 1 per cent.,	24	13
Average per cent. of calcium oxide (lime),	34.29	33.60
Per cent. mineral matter insoluble in diluted hydrochloric acid, from — below 5,	–	1
6 to 10,	10	16
10 to 15,	30	31
15 to 20,	15	15
20 to 30.	3	13
above 30.	1	–

As the majority of dealers in wood ashes guarantee from 4.5 to 6 per cent. of potassium oxide in their articles, it will be seen that a large number of the samples are below even the lowest guarantee; showing, on the whole, that the quality of wood ashes sold in 1898 as a potash source has been inferior, when compared with the preceding year. Whether this circumstance is due to a general decline of the article or to the management of any particular importer or dealer is difficult to decide on our part, as long as farmers do not state the name of the party from whom they have bought, or the cost per ton of the ashes they send on for examination.

It is most desirable to ascertain whether the general character of the wood ashes is gradually declining from natural causes, or whether some parties are handling inferior goods. All interested in the solution of this question will confer a favor on us by sending with their samples of wood ashes the names of the party from whom they bought the article, and state the price per ton asked at the nearest depot for general distribution.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

3. Notes on Fertilizers suitable for raising Plants in Pots and Greenhouses.

The interest in raising plants in pots and under glass in greenhouses, by the aid of commercial fertilizers, is gradually increasing, judging from numerous applications for information.

The following analyses represent two samples of fertilizers recommended for that purpose; they were sent on for a general analysis by parties interested in the matter: —

1. Plant Food in Pellet Form, sent on from Newtonville, Mass.

	Per Cent.
Moisture,	3.39
Organic and volatile matter,	41.15
Ash constituents,	58.85
Water soluble material,	82.40
Insoluble residue (in water),	17.60
Total phosphoric acid,	16.59
Soluble phosphoric acid,	14.58
Reverted phosphoric acid,	1.67
Insoluble phosphoric acid,	.34
Potassium oxide, total,	7.96
Potassium oxide, water soluble,	7.63
Sodium oxide,	6.19
Calcium oxide,	4.04
Magnesium oxide,	5.30
Chlorine,	6.05
Sulphuric acid (SO_3),	17.17
Total nitrogen,	7.65
Nitrogen as ammoniates,	7.06
Nitrogen as nitrates,	.50
Nitrogen as organic matter,	.09
Insoluble matter in dilute hydrochloric acid (clay),	14.33

Water solution strongly acid.

2. Liquid Fertilizer sent on from Natick, Mass.

	Per Cent.
Moisture,	90.46
Solid residue,	9.54
Phosphoric acid,	1.24
Potassium oxide,	2.79
Sodium oxide,	1.67
Calcium oxide,	1.82
Magnesium oxide,	.07
Chlorine,	.02
Sulphuric acid (SO_3),	–
Total nitrogen,	1.12
Nitrogen as ammoniates,	.39
Nitrogen as nitrates,	.73
Reaction strongly acid.	

The importance of the interests involved induced the writer some years ago to enter upon a series of experiments, to assist in the development of a more efficient system of manuring several important industrial crops, fruits and garden vegetables. The first results of that investigation are published in the eleventh and twelfth reports of the director of the Massachusetts State Agricultural Experiment Station, to which I have to refer for details. Those of later years are contained in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1896 and 1897.

In the course of my discussion of the lessons to be derived from the above-stated experiment in field and vegetation house, it was recommended to observe the following rules : —

1. To avoid an accumulation of half-decayed vegetable matter in the soil, and to enrich the latter in the desired direction by means of concentrated chemical manures.

2. To change, wherever practicable, from season to season the position of the various crops, to favor the destruction of parasites and to economize the inherent sources of plant food.

3. To avoid an accumulation of salines in the soil, not called for by the crops, or considered injurious to the chemical or physical properties of the soil.

4. To prevent a marked acidity of the soil, by a periodical application of air-slacked lime, wood ashes, etc.

5. To select the various commercial forms of nitrogen, and potash in particular, with special reference to the kind and the desired character of the crop to be raised.

6. To use as a general fertilizer a mixture of two parts of available potassium oxide, one part of available nitrogen and one part of available phosphoric acid, in such quantities per acre as the conditions of the soil and composition of the crop to be raised called for; allowing, for the composition of one thousand pounds of green garden vegetables, on an average: —

	Pounds.
Nitrogen,	4.01
Phosphoric acid,	1.90
Potassium oxide,	3.90

On account of the frequent cultivation of beans and peas as garden crops, a fertilizer of the following composition suggested itself to me: —

	Parts.
Available nitrogen,	1
Available potash,	2
Available phosphoric acid,	1

More recent observations confirm the advisability of the previously stated rules in a general way; yet they also emphasize the fact that, wherever the quality of the crop controls its economical and commercial value, it seems advisable that care should be taken to secure the exclusion of an accumulation of soluble saline substances not called for by the crop. This circumstance deserves particular attention in cultivation under glass, where the body of the soil is limited, and the removal of such substances by percolation to the lower layers offers but little chance of relief.

In our experiments above described this view of the question of supplying plant food in the greenhouse has aided us in selecting a series of concentrated chemical manures, which for the above reason are now recommended for patronage: —

Name of Substance.	Potassium Oxide (Per Cent.).	Phosphoric Acid (Per Cent.).	Nitrogen (Per Cent.).
High-grade muriate of potash,	50.00	-	-
High-grade sulphate of potash,	50.20	-	-
Potash-magnesia sulphate,	24.32	-	-
Carbonate of potash-magnesia,	18.48	-	-
Phosphate of potash,	32.56	35.70	-
Dissolved bone-black,	-	13.88	-
Odorless phosphate, phosphatic slag,	-	18.42	-
Double superphosphate,	-	47.80	-
Phosphate of ammonia,	-	43.86	10.37
Dried blood,	-	4.02	10.00
Nitrate of soda,	-	-	14.28
Sulphate of ammonia,	-	-	19.59

As the local conditions of the soil and the composition of the individual characteristics of the plants to be raised deserve especial attention, when selecting from the above-stated commercial manurial substances the constituents for the fertilizer mixtures to be used, it cannot be considered judicious to recommend any particular combination as being unfailing and best in all cases. For this reason it has been thought best to state in this connection, as a mere matter of illustration, a few combinations of manurial substances which served us well, as may be noticed from a few preceding annual reports, — State Experiment Station, 1893, pages 241 to 261; and 1894, pages 274 to 285.

The amount of fertilizer recommended per acre, under fair conditions of the soil, contains: —

	Pounds.
Available nitrogen,	60
Available phosphoric acid,	60
Available potash,	120

Some Combinations of High-grade Substances for Use in Garden, Greenhouse and Pots.

1. Nitrate of soda.
   High-grade sulphate of potash.
   Dissolved bone-black.

2. Sulphate of ammonia.
   High-grade sulphate of potash.
   Dissolved bone-black.

3. Dried blood.
   High-grade sulphate of potash.
   Dissolved bone-black.

4. Nitrate of soda.
   Muriate of potash.
   Dissolved bone-black.

Mixtures of muriate of potash and sulphate of ammonia have proved in our experience in many cases objectionable, on account of a mutual decomposition into chloride of ammonia and sulphate of potash.

4. Observations with Dried Blood and Two Kinds of Leather Refuse as the Sources of Nitrogen for growing Rye in Presence of Acid and of Alkaline Phosphates.

In a preceding report an experiment has been briefly described in which dried blood has been compared with leather refuse as a nitrogen source for growing plants, when used in connection with double phosphate and muriate of potash. The differences of the crops raised were more marked with reference to the yield of the straw than to that of the grain. (For details, see annual report of the Massachusetts State Agricultural Experiment Station for 1894, pages 283–285.) It seemed advisable to repeat the experiments, with such modifications as experience suggested, to secure, if possible, *more decisive results*, and to ascertain whether the degree of availability of the nitrogen contained in the dried blood and in the leather refuse would not be more strikingly modified by using *alkaline phosphates* instead of *acid phosphates* as the phosphoric acid source.

The following course was adopted. Winter rye was again selected for the observation. The soil used was taken from the same locality, at eighteen inches below the surface, and freed from coarse materials by repeated screening through a sand screen, as in the first experiment. The fertilizers used were in each case carefully distributed throughout the entire body of the soil. The boxes were the same which had been used in the preceding experiments, containing from seventy-five to eighty pounds of soil, having a depth of eighteen inches.

Six boxes were employed in the experiment; three served for the trial with acid phosphate, — dissolved bone-black; and three with an alkaline phosphate, — phosphatic slag meal. The following mixtures of fertilizers were used (weights are stated in grams; thirty grams equal to one ounce): —

First Lot, Nos. 1, 3 and 5.

Box 1.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Dried blood,	40.22

Box 3.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 5.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Raw-leather waste,	56.64

Second Lot, Nos. 2, 4 and 6.

Box 2.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Dried blood,	40.22

Box 4.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 6.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Raw-leather waste,	56.64

The Seed. — Winter rye was planted in all boxes Oct. 2, 1894. The young plants came up uniformly in all boxes October 5. They reached a height of from five to six inches before frost set in. After being fully developed, they were reduced in all the boxes to a corresponding number, as in the first experiment.

The watering of the soil was partly by subirrigation and partly by surface application, maintaining as far as practicable the moisture of the soil from 15 to 18 per cent. during the growing season. The experiment was conducted with a view to expose the soil to the unrestricted influence of the local temperature of the various seasons. A layer of snow served as protection to the young growth during severe spells of frost in winter.

The manurial substances used consisted of high-grade sulphate of potash, dissolved bone-black, phosphatic slag meal, dried blood, Philadelphia tankage (a steamed leather), and ground sole leather waste. The amount of nitrogen and potassium oxide applied was the same in each case, while the amount of total phosphoric acid applied in case of the phosphatic slag meal was one-fourth more than in the case of the dissolved bone-black, which is practically all soluble in water.

Composition of the Manurial Substance used, with Reference to Potash, Phosphoric Acid and Nitrogen (Per Cent.).

	Potassium Oxide.	Phosphoric Acid.	Nitrogen.
Sulphate of potash,	50.20	-	-
Dissolved bone-black,	-	14.00	-
Phosphatic slag meal,*	-	18.40	-
Dried blood,	-	4.00	10.00
Philadelphia tankage (steamed leather),	-	-	7.80
Ground leather waste,	-	-	7.02

* Calcium oxide, 48.6 per cent.

They grew at a similar rate during spring until the latter part of April, when those which had received dried blood as nitrogen source (boxes 1 and 2) became more stalky, developing more and broader leaves than the plants in boxes 3, 4, 5 and 6. This difference in their growth became more marked as the season advanced.

The following statement gives the average height of the plants at various stages of observation (inches): —

	May 1.	May 9.	May 20.	June 1.
Box 1,	8.0	21.5	34.0	50.0
Box 3,	7.0	16.5	24.0	32.0
Box 5,	6.0	14.0	22.5	30.5
Box 2,	9.0	26.0	38.0	56.5
Box 4,	7.0	17.5	25.0	32.5
Box 6,	7.0	17.5	26.0	35.0

The plants in all boxes began blooming about the same time, the first week of June; they were harvested the first week of July. There was no marked difference in regard to time of maturing. The general character of the matured growth will be seen from the subsequent statement of the weights of the average plant in each case (grams): —

	Box 1.	Box 3.	Box 5.	Box 2.	Box 4.	Box 6.
Moisture,	8 9	8-9	8-9	8-9	8 9	8 9
Total plant,	57.87	26.02	28.80	115.99	30.27	36.21
Kernels,	12.77	5.43	5.80	28.89	6.18	9.75
Chaff and straw,	45.12	20.69	23.00	87.10	24.09	26.46
One hundred kernels,	1.58	1.44	1.48	1.79	1.58	1.62

The plants were in all cases cut two inches above their roots. As it was of interest to know the amount of nitrogen in the kernels of the highest and lowest weights, a nitrogen determination of the kernels obtained in boxes 1 and 3, and 2 and 4 was carried out. The analyses gave the following results: —

No. of Box.	Per Cent. Nitrogen.	Fertilizing Elements Used.
1,	1.84	Dried blood, dissolved bone-black.
3,	1.91	Philadelphia tankage, dissolved bone-black.
2,	2.31	Dried blood, phosphatic slag.
4,	2.19	Philadelphia tankage, phosphatic slag.

Fodder Analyses of Rye Samples (Kernels) as far as Material on Hand sufficed for a Complete Analysis. Samples grown in Boxes 1, 2, 3 and 4 (Per Cent.).

	Box 1.	Box 2.	Box 3.	Box 4.
Moisture,	10.45	9.92	4.87	8.50
Dry matter,	89.55	90.08	95.13	91.50
	100.00	100.00	100.00	100.00

Analysis of Dry Matter.

	Box 1.	Box 2.	Box 3.	Box 4.
Fat,	2.05	2.00	2.12	1.97
Protein,	11.50	14.44	11.94	13.69
Cellulose,	1.55	1.65	1.65	1.62
Ashes,	1.95	1.52	2.20	1.44
Carbohydrates,	82.95	80.39	82.09	81.28
	100.00	100.00	100.00	100.00

Judging from the results obtained in connection with the described experiment the following conclusions suggest themselves: —

Conclusions. — The alkaline phosphate (phosphatic slag meal) has under fairly corresponding conditions increased the availability of the nitrogen contained in steamed leather, in leather scraps and in dried blood in a higher degree than the acid phosphate. The influence is apparent alike in the general character of the entire plant and in the composition of the kernels. The difference in the relative agricultural value of both articles as nitrogen sources remains, however, the same; for leather in any form, without a previous destruction of the tanning principle, tannin, is worthless for manurial purposes.

5. Contribution to the Determination of the Available Phosphoric Acid in Soils under Cultivation.

The fact that agricultural chemists have thus far failed to point out any mode of soil analysis as reliable, by which the amount of phosphoric acid available to crops can be ascertained, is pretty generally recognized. Attempts are not wanting to solve this important question. Among the well-known investigations in that direction are those of Dr. B. Deyer (1894). Results of later years obtained in this connection upon soils of well-known history at Rothamsted in England are pronounced very encouraging by Dr. Gilbert. The American Association of Official Chemists has during the past year entered upon a systematic investigation regarding the best course to be adopted to determine the available phosphoric acid; in this work the writer has taken some part. A compilation of the contributions to these more recent experiments is to be published soon by the United States Department of Agriculture.

Our local observations at Amherst are briefly described in a few subsequent pages upon a field which had been under careful observation for five years, 1890–95. The following brief abstract of the management of the field work shows the condition of the soil which served for our investigation: —

Field F.

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by a systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition to the full extent of existing circumstances. During the same period a crop was raised every year. These crops were selected, as far as practicable, with a view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow-pea, vetch and serradella) followed each other in the order stated.

1890. — The field was subdivided into five plats, running from east to west, each twenty-one feet wide, with a space of eight feet between adjoining plats.

The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and of nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate (floats) and dissolved bone-black. The market cost of each of these articles controlled the quantity applied, for each plat received the same money value in its particular kind of phosphate.

Analyses of Phosphates used.

[I., phosphatic slag; II., Mona guano; III., Florida phosphate; IV., South Carolina phosphate; V., dissolved bone-black.]

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture,	.47	12.52	2.53	.39	15.96
Ash,	-	75.99	89.52	-	61.46
Calcium oxide,	46.47	37.49	17.89	46.76	-
Magnesium oxide,	5.05	-	-	-	-
Ferric and aluminic oxides,	14.35	-	14.25	5.78	-
Total phosphoric acid,	19.04	21.88	21.72	27.57	15.82
Soluble phosphoric acid,	-	-	-	-	12.65
Reverted phosphoric acid,	-	7.55	-	4.27	2.52
Insoluble phosphoric acid,	-	14.33	-	23.30	.65
Insoluble matter,	4.39	2.45	30.50	9.04	6.26

The following fertilizer mixtures have been applied annually to all the plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag,	127
	Nitrate of soda,	43
	Potash-magnesia sulphate,	58
Plat 2 (6,565 square feet),	Ground Mona guano,	128
	Nitrate of soda,	43½
	Potash-magnesia sulphate,	59
Plat 3 (6,636 square feet),	Ground Florida phosphate,	129
	Nitrate of soda,	44
	Potash-magnesia sulphate,	59
Plat 4 (6,707 square feet),	South Carolina phosphate,	131
	Nitrate of soda,	44½
	Potash-magnesia sulphate,	60
Plat 5 (6,778 square feet),	Dissolved bone-black,	78
	Nitrate of soda,	45
	Potash-magnesia sulphate,	61

The phosphatic slag, Mona guano, South Carolina phosphate and Florida phosphate were applied at the rate of 850 pounds per acre; dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the rate of 390 pounds per acre.

Potatoes were raised upon the plats in 1890; in 1891 winter wheat was employed (for details see ninth annual report); in 1892 serradella was the crop experimented with (see tenth annual report); and in 1893 a variety of Dent corn, Pride of the North (see eleventh annual report).

1894. — During the preceding season it was decided to ascertain the after-effect of the phosphoric acid applied during previous years by excluding it from the fertilizer applied. In addition, to secure the full effect of the phosphoric acid stored up, the potassium oxide and nitrogen were increased one-half, as compared with preceding seasons. A grain crop (barley) calling for a liberal amount of phosphoric acid was chosen for the trial. The field was ploughed April 17, the fertilizer being applied broadcast April 20, and harrowed in. Below is given a statement of fertilizer applied: —

Plat 1 (6,494 square feet),	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet),	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet),	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet),	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet),	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

Yield of Crop (1894).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1,	490	169	221	34.49	65.51
Plat 2,	405	148	251	34.07	65.93
Plat 3,	290	78	212	26.89	73.11
Plat 4,	460	144	216	31.30	68.70
Plat 5,	390	118	272	30.26	69.74

Summary of Yield of Crop (1890–94).

Plats.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.
Plat 1,	1,600	380	4,070	1,660	490
Plat 2,	1,415	340	3,410	1,381	405
Plat 3,	1,500	215	2,750	1,347	290
Plat 4,	1,830	380	3,110	1,469	460
Plat 5,	2,120	405	2,920	1,322	390

Phosphoric Acid applied to and removed from Field.

[Pounds.]

Plats.	1890.		1891.		1892.		1893.		1894.		Total Amount Added.	Total Amount Removed.	Total Amount Remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1,	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	-*	1.92	96.72	21.86	75.86
Plat 2,	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	-*	1.64	72.04	19.02	53.02
Plat 3,	109.68	2.40	-*	.69	28.01	6.05	28.01	5.95	-*	.76	165.70	15.85	149.85
Plat 4,	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	-*	1.72	144.48	19.84	124.64
Plat 5,	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	-*	1.49	49.36	18.57	30.79

* None.

Conclusions.

From the previous statement of comparative yield we find that the plat receiving dissolved bone-black leads in yield during the first two years, while for the third, fourth and fifth years the plats receiving insoluble phosphates are ahead, phosphatic slag being first, South Carolina floats second and Mona guano third.

Description of Modes of Analysis adopted in our Investigations of Samples of Soil taken from the Above-mentioned Five Plats in September, 1894, in the Manner recommended by the Committee of the American Association of Official Chemists, Prof. Harry Snyder of Minnesota, Chairman.

I. — Total Phosphoric Acid.

Ten grams of soil are digested with 100 c.c. of pure hydrochloric acid, of specific gravity 1.115, for ten consecutive hours in a boiling-water bath, shaking once each hour. The stopper of the flask should carry a condensing tube, to prevent evaporation. The material is filtered, and the residue is washed with distilled water until free of acid. The organic matter in filtrate is oxidized with nitric acid and evaporated to dryness on the water bath, finishing on sand bath to complete dryness. The material when cool is taken up with hot water and a few cubic centimeters of hydrochloric acid, and again evaporated to complete dryness. It is taken up as before, filtered and washed thoroughly with cold water, cooled and made up to 500 c.c.

II. — Directions of the Association of Official Agricultural Chemists for the Determination of Available Phosphoric Acid in Soils, Fifth Normal Hydrochloric Acid being used as the Solvent.

1. Determination of Moisture. — Use the official method described in Bulletin 46, page 48, Division of Chemistry, United States Department of Agriculture. Calculate all results to the water free basis.

2. Determination of Phosphoric Acid Soluble in Fifth Normal Hydrochloric Acid. — (*a*) Preliminary treatment: Digest 20 grams of soil with 200 c.c. of fifth normal hydrochloric acid at 40° C. for five hours. Titrate 20 c.c. of the clear filtrate against a standard caustic soda solution, using phenolphthaline for the indicator. From this data calculate the amount of hydrochloric acid necessary to be added, so that the solution will be fifth normal after allowing for the acid neutralized. (*b*) The determination: Weigh out 50 to 100 grams of soil into an Erlenmeyer flask, and add 10 c.c. of acid, corrected for neutralization as directed under (*a*) for every gram of soil used. The flask is corked with a rubber stopper, which carries a thermometer. The flask is then placed in a water bath previously heated to 40° C., and the contents of the flask are thoroughly shaken every half hour during the digestion. The solution is then filtered through a ribbed filter of two thicknesses of paper, refiltering the first portion, if cloudy. The filter should be large enough to receive the entire contents of the flask. Before filtering the contents, the flask should be well shaken. Four hundred to 600 c.c. of the filtrate (at 20° C.) are evaporated to dryness after adding 1 to 3 c.c. of nitric acid. If there is any appreciable amount of organic matter present, the residue is to be carefully charred. Moisten the residue with hydrochloric acid and add 50 to 100 c.c. of distilled water, and then digest. Filter, neutralize with ammonia, add 5 c.c. of strong nitric acid and 15 grams of nitrate of ammonia in solution. Complete the determination according to one of the official methods given for the determination of phosphoric acid, or use the Goss method as given in Circular No. 4 to accompany Bulletin No. 46.

III. — Determination of the Available Phosphoric Acid in Soils by Means of a One Per Cent. Solution of Citric Acid (Dr. B. Deyer).

Preliminary Treatment. — Twenty grams of soil are digested with 200 c.c. of a one per cent. citric acid solution for five hours, at ordinary temperature (18° to 21° C.). The material is filtered and solution is titrated against a standard alkali solution, to determine the amount of acid neutralized by alkalies in the soil. For the estimation of the "available" potash and phosphoric acid, one per cent. citric acid solution has been employed, digesting 100 grams of air-dried soil with 500 c.c. of the solvent, as directed in the preliminary test, corrected for neutralization, for five hours at room temperature. The filtered solution is evaporated to dryness, charred, and the residue abstracted with dilute hydrochloric acid and water. The filtrate from this operation is treated for the determination of phosphoric acid as directed in one of the official methods.

IV. — Determination of the Available Phosphoric Acid in Soils by Means of a Neutral Solution of Citrate of Ammonia.

Ten grams of the soil are digested for one-half hour, at 65° C., with 500 c.c. of strictly neutral solution of citrate of ammonia, specific gravity 1.09. The flask carries a rubber stopper, and is thoroughly agitated every five minutes. At the expiration of thirty minutes, remove flask from bath and filter as rapidly as possible. Wash thoroughly with water at 65° C. Evaporate the solution to dryness, char, and abstract with dilute nitric acid. Filter and wash thoroughly with water. Burn the residue to a white ash, add it to the solution and bring to complete dryness on sand bath. Take up with hot water and a few cubic centimeters of nitric acid. Digest for one-half hour. Filter and wash thoroughly, and determine phosphoric acid in the solution in the usual way.

Results of Analyses of Soils for Available Phosphoric Acid, by Methods previously described (Soil from Fields of Massachusetts Agricultural College Farm).

No. of Samples.	Moisture.	Total Phosphoric Acid.	Available Phosphoric Acid by $\frac{n}{5}$ Hydrochloric Acid.	Available Phosphoric Acid by 1 Per Cent. Citric Acid.	Available Phosphoric Acid by Neutral Citrate of Ammonia.
1, ...	.77	.255	.0285	.01325	.0735
2, ...	.87	.290	.0338	.01650	.0945
3, ...	.95	.210	.0407	.01420	.0865
4, ...	1.07	.220	.0330	.01920	.0925
5, ...	1.02	.180	.0345	.01430	.1070

Analysts: Henri D. Haskins.
Charles I. Goessmann.

Conclusion.

The several modes used by us in determining the amount of available phosphoric acid contained in the soil under examination have given different results. The difference in the amount of available phosphoric acid found by any of the modes of analysis employed does not correspond with the actual yield of the several plats in the field. The results of our investigation are more of a suggestive than decisive character. The work will be continued as far as resources on hand will permit.

6. Analysis of Drainage Waters obtained from Field A of the Hatch Experiment Station.

The field under discussion has been from 1883 to date treated in a systematic way with commercial fertilizers, in the manner briefly described in the following pages. The field consisted of eleven plats, one-tenth of an acre each, with a space of from five to six feet between the adjoining plats. This space was cultivated in connection with the planted plats, yet received no fertilizing material of any description, nor were they seeded down at any time during the experiment. Each plat was provided in the centre with a tile drain running at a depth of from three and a half to four feet through the entire length, which terminated in an open well, to allow the collection of the drainage water for examination whenever desired, to study the character of the soil constituents carried off. The entire field of eleven separate plats were surrounded by a tile drain with an independent outlet, to prevent an access of drainage waters from adjoining fields. A marked gradual decline in the yield of several plats, in spite of a uniform liberal supply of the fertilizer used during the earlier years of the experiment, rendered an examination into the cause or causes of the reduction in the annual yield desirable.

As an examination of the drainage waters coming from the different plats promised to throw some light on the action of the several mixtures of fertilizers used on the soil resources of the field employed in the observation, it was decided to subject them to a careful chemical analysis. The samples used for these analyses were collected in all cases as far as practicable soon after each tile drain began to discharge drainage water. As the temporary flow of the drains in the different plats differed widely in quantity, no attempt was made to ascertain in each case the exact amount discharged in a given time. The examination was instituted for the purpose of ascertaining the general character of the discharge of the drains, and to determine the *relative proportion of various soil constituents they contained.* The results of this investigation are stated farther on, after a brief description of the general management of the field, as well as a detailed statement of the fertilizers used.

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	80 pounds.
	Potassium oxide, . . .	125 pounds.
Plats 4, 7, 9, ...	Nitrogen, . . .	none.
	Phosphoric acid, . . .	80 pounds.
	Potassium oxide, . . .	125 pounds.

One plat, marked 0, received its main supply of phosphoric acid, potassium oxide and nitrogen in form of barn-yard manure; the latter was carefully analyzed before being applied, to determine the amount required to secure, as far as practicable, the desired corresponding proportion of the three essential fertilizing constituents. The deficiency in potassium oxide and phosphoric acid was supplied by potash-magnesia sulphate and dissolved bone-black. The fertilizer for this plat consisted of 800 pounds of barn-yard manure, 32 pounds of potash-magnesia sulphate and 18 pounds of dissolved bone-black.

The mechanical preparation of the soil, the incorporation of the manurial substances, — the general character of the latter being the same, — the seeding, cultivating and harvesting were carried on year after year in a like manner and as far as practicable on the same day in case of every plat during the same year.

The subsequent tabular statement shows the annual application and special distribution of the manurial substances with reference to each plat since 1889. The fertilizers were in every case applied broadcast as early in the spring as circumstances permitted. They were well harrowed under before the seed was planted in rows by a seed drill.

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 0, . .	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

Plats (One tenth Acre).	Annual Supply of Manurial Substances.
Plat 2, . . .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 3, . . .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 25 lbs. murlate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. phosphoric acid).
Plat 4, . . .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 5, . . .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen) 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 6, . . .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 7, . . .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 8, . . .	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 9, . . .	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 10, . . .	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

The above-described course of the general management of the experiment has been followed thus far for five consecutive years (1889–93, inclusive).

Kind of Crops Raised.

Corn (maize), ...	in 1889.
Oats, ...	in 1890.
Rye, ...	in 1891.
Soy bean, ...	in 1892.
Oats, ...	in 1893.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.
Plats 4, 7, 9, ...	Nitrogen, ...	none.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.

PLATS (One-tenth Acre).	Manurial Substances Applied.
Plat 0, . .	800 lbs. barn-yard manure, 80½ lbs. potash-magnesia sulphate and 77 lbs. dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 2, . .	29 lbs. nitrate of soda (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 4, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 5, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 6, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 7, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 8, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 9, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone black (=16 to 17 lbs. phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=4 to 5 lbs. nitrogen), 97 lbs. sulphate of potash-magnesia (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).

Analysis of Drainage Water (Per Cent).

100 parts of total solids contain: —

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Potassium oxide,	.600	.380	1.210	.637	.700	.125	.544	2.080	.2740	.5100	.410
Sodium oxide,	21.630	23.850	50.180	5.310	16.670	6.290	6.960	20.890	13.6200	25.6400	5.000
Calcium oxide,	14.210	10.660	12.090	18.340	21.870	23.070	20.720	22.800	26.1900	20.7700	7.240
Magnesium oxide,	6.630	5.390	4.160	5.120	5.340	6.980	4.846	4.680	3.8750	3.9600	2.380
Actual ammonia,	.076	.027	.070	.023	.038	.021	.018	.031	.0068	.0100	.025
Albuminoid ammonia,	.525	.043	.108	.185	.077	.302	.338	.068	.0500	.0560	.073
Ammonia as nitrates,	.565	.242	.765	.349	.331	.298	.708	.153	.3920	.0289	.105
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	.trace	.1210	trace	trace
Sulphuric acid,	20.260	2.010	22.810	7.920	1.470	52.820	18.970	6.090	5.7500	4.4600	28.530
Chlorine,	16.150	26.390	6.040	28.380	38.210	2.420	24.610	35.470	32.0700	36.4100	1.020
Silica,	7.700	3.580	.637	4.950	3.160	3.220	5.576	2.570	2.2260	2.8900	.864

Analysts: HENRI D. HASKINS.
ROBERT H. SMITH.

Drainage Water (Results computed in Percentages).

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Total solids,	.0080500	.0265000	.0182000	.0303000	.0256500	.0248000	.0260000	.0265000	.0530000	.0346000	.0787000
Potassium oxide,	.0000480	.0001000	.0002200	.0001930	.0001780	.0000310	.0001415	.0005500	.0001450	.0001770	.0003260
Sodium oxide,	.0017409	.0062205	.0091333	.0016100	.0042728	.0015600	.0018100	.0055366	.0072200	.0088740	.0039344
Calcium oxide,	.0012441	.0028259	.0021997	.0055600	.0056106	.0057200	.0053880	.0059319	.0138820	.0071880	.0057012
Magnesium oxide,	.0005333	.0014272	.0007567	.0015500	.0013693	.0017300	.0012600	.0012396	.0020540	.0013690	.0018738
Free ammonia,	.0000610	.0000072	.0000118	.0000070	.0000098	.0000052	.0000048	.0000078	.0000036	.0000036	.0000197
Albuminoid ammonia,	.0000420	.0000114	.0000198	.0000562	.0000195	.0000750	.0000880	.0000184	.0000267	.0001094	.0000432
Ammonia as nitrates,	.0000460	.0000640	.0001400	.0001060	.0000830	.0000740	.0001840	.0000410	.0002080	.0000100	.0000830
Total ammonia,	.0001490	.0000826	.0001716	.0001692	.0001123	.0001540	.0002770	.0000672	.0002383	.0001230	.0001459
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.0000640	trace	trace
Sulphuric acid,	.0016311	.0005322	.0041511	.0024000	.0003777	.0131000	.0049340	.0016139	.0030500	.0015450	.0224548
Chlorine,	.0013000	.0070000	.0011000	.0086000	.0098000	.0006000	.0064000	.0094000	.0170000	.0126000	.0008000
Silica,	.0006200	.0009500	.0011600	.0015000	.0008100	.0008000	.0014500	.0006800	.0011800	.0010000	.0006800

Without any intention to discuss here in detail the causes of the variations noticed in the composition of the saline residues left when evaporating a definite amount of the drainage water collected from the various plats, it remains of especial interest to call attention to the fact that wherever muriate of potash had been used as a potash source of plant food exceptional quantities of the chlorides of calcium and magnesium proved to be present (plats 1, 3, 4, 6, 7, 8 and 9). The belief that a liberal use of muriate of potash had resulted in wasting in an exceptional degree in particular the lime resources of the soil, and thereby reducing the yield of the crops, has since been confirmed. The annual yield of the crops has been restored to its former satisfactory condition, after a liberal addition of air-slaked lime to the manures used for years upon the field in question.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Scope of Work.

This division has during the past year made special effort to come into direct contact with a large number of market gardeners and greenhouse growers; and, largely as a result of this more direct contact and the numerous visits made to their establishments, our correspondence has during the past year doubled that of any other year, and has covered a multitude of subjects relating to botany.

We have paid some attention this summer to the asparagus rust, which caused so much damage in this State in 1897. A study of the conditions which caused the rust has been made at various places throughout the State, and spraying experiments have been carried on in co-operation with different asparagus growers.

The results of the study of nematode worms in greenhouses, which has received a great deal of attention by this division for over three years, have been published in Bulletin No. 55, which can be had on application. This bulletin, containing 67 pages and 14 plates, gives a full account of the parasitic species of nematode, its life history and development, together with the results of an extensive series of experiments on the methods of controlling the pest. In these investigations the worthlessness of many supposed remedies has been brought out, and a practical method of treatment developed by which the trouble can be successfully and economically avoided. From a considerable amount of data accumulated during the last three years it appears that the loss experienced by cucumber growers who have been troubled with nematodes in the greenhouse equals 25 to 85 per cent. of the marketable crop; and it is hoped, from the positive results obtained, that little trouble may be experienced hereafter with this pest. There are still, however, some further experiments being made upon nematode-control methods, in co-operation with large greenhouse growers, along lines which promise cheaper and efficient results.

The principal investigations with which this division is concerned at present are largely in connection with market-garden crops such as are cultivated in greenhouses. The division is supplied with greenhouses excellently arranged for experimental purposes, and containing space enough to carry on investigations from which reliable deductions can be drawn. The more important greenhouse crops grown in our greenhouses for experimental purposes are those representing considerable importance in this State, namely, lettuce, cucumbers and tomatoes; and it may be justly said that there is no class of agricultural pursuits which is represented by men of greater intelligence, skill and knowledge.

A brief outline of some of the investigations may not be out of place: —

(*a*) Experiments on the control of the "drop" in lettuce, and a study of the little known habits of the fungus causing the same. A lettuce house, 40 by 12 feet, is devoted to these experiments.

(*b*) Observations on the "top-burn" in lettuce.

(*c*) Experiments on the mechanical conditions of the soil, as affecting the growth of lettuce.

(*d*) Sub-irrigation, as affecting lettuce diseases.

(*e*) Experiments on the pruning of cucumbers, in relation to the maturity and production of fruit; also, observations on the various fungous diseases of the cucumber, and the conditions which favor them.

(*f*) Experiments on the pruning of tomatoes, in relation to the production and maturity of fruit; a study of the fungous diseases of the tomato.

(*g*) Experiments on the growth of violets in sterilized soil and nematode-infested earth, with special reference to the relationship existing between the size, maturity and production of flowers in the plants, and abundance of leaf spots.

(*h*) Experiments with gases and chemical solutions for disinfecting greenhouses and repression of fungi.

(*i*) Further experiments on the relationship existing between electricity and plant growth.

There are a host of fungous diseases common to our out-of-door plants, some of which have received special attention, such, for example, as the asparagus rust, aster disease, etc.; but the practice of spraying fruit trees and garden crops has for many years been largely carried out by the horticultural division, which is well equipped with all of the modern spraying appliances.

A few years ago it was generally believed by the majority of people that botany was incapable of being made of any practical use, and it is doing no injustice to truth to state that it did possess little at that time. To-day, however, this state of affairs has entirely changed, and botany, like chemistry and other allied sciences, has taken its place in the industrial arts, — a fact which is due to the advance of science in general, but more especially to the inherent genius characteristic of the American investigator, which naturally emphasizes the utilitarian aspect of science. The annual loss in the United States to agricultural, horticultural and floricultural products caused by pathogenic fungi and their allies will probably equal $10,000,000. It is, therefore, not only important, but perfectly legitimate, that the principal work of botanists in our numerous experiment stations should consist in studying the life history of these organisms with a view to their repression. In regard to the industrial side of botany, it should not be forgotten that it owes a great deal to the patient investigations of the many scientific workers of the past, who have devoted their attention to matters of purely scientific interest; and our stations would not be where they are to-day were it not for the labors of these men.

In connection with the characteristic utilitarian features of the present American botanists, it may be of some interest to observe the differences existing between European and American methods of combating pests. Some of the most effective spraying solutions were discovered in Europe, but the methods of applying them and the results obtained by their use to our crops far exceed anything ever accomplished there. To one who has paid any attention to the manner of growing plants in Europe and the methods which are pursued in the control of plant diseases, it would seem no exaggeration to state that more is accomplished in this direction in the United States in one year than in Europe in five years.

The past season has been what might be termed a normal one, although, as in every season, some fungi were especially predominant. There are, however, every year types of fungous diseases which affect our shade trees.

Pathogenic Fungi.

The fungous diseases which have been specially common upon our shade trees this last season are as follows: —

Black Spot of the Maple (Rhytisma acerinum, (P), Fr.).

This fungus is characterized by elevated black spots or blotches upon the surface of the leaf, and, while it is not uncommon to a few maples, it has been especially abundant on the silver maple.

Oak Leaf Blight (*Gloeosporium nervisequum*, (*Fckl.*), *Sacc.*).

A fungus apparently identical with that which causes the blight of the sycamore is sometimes found upon the white oak. This produces large dead blotches upon affected leaves, and causes great disfiguration of white oak trees.

Walnut Leaf Blight (*Gloeosporium Juglandis*, (*Lib.*), *Mont.*).

This disease was mentioned in our last report as having been especially abundant during 1897. It has also occurred this year, but to a much less extent.

These diseases are briefly mentioned because complaint has been frequent during the past summer in regard to them, largely, however, from people who possess shade trees which they value. From what we know in regard to the treatment of similar fungi occurring on other plants, it would seem that spraying might hold some of these in check; and the only reply which can be made is, Are the trees valuable enough to receive treatment? Some of these fungi attack large groves, and the expense of spraying would amount to considerable. As a rule, these fungi only make their appearance at intervals, and do not injure the trees to any great extent. In consideration of this fact, it appears questionable to us whether they are worth the trouble; but, should spraying be deemed necessary, it would have to be done early and continued each year.

The disease of the peach known as the "leaf curl" (*Exoascus deformans*, Fckl.) has been unusually abundant during the past season. This disease is well known to most peach growers, causing the leaves to become wrinkled and curled and greatly deformed, finally resulting in their falling to the ground. It is not ordinarily regarded as an especially destructive disease, and does not often cause any appreciable damage to the tree; but, when so abundant as to cause a large proportion of the leaves to fall, it cannot but injure the tree to some extent.

Another disease of the stone fruits, the so-called "plum pockets" (*Exoascus Pruni*, Fckl.), which causes young plants to become swollen and distorted in a peculiar manner, has been received several times this year. Besides the plum (*Prunus domestica*), the wild cherry (*Prunus Virginiana*) is also affected by the same fungus. The disease is not often very abundant, but occasionally causes a considerable diminution of the crop.

For methods of controlling the various diseases of the peach, plum and cherry, consult the spraying bulletin annually issued by the horticultural division of this station.

A Musk-melon Disease.

During the latter part of August our attention was called to a field of musk-melons, in which a destructive disease of the leaves had appeared and seemed to be rapidly increasing. The owner informed us that he had lost his entire crop the year before in the same way. It was evident that the trouble began in the centre of the hills. Here the leaves at the time of our first visit had in many hills wilted and begun to turn yellow and partially died. They were covered with yellow spots, or, in the worst cases, with dead areas of considerable size. At this time the general appearance of the field was good, the only very noticeably affected places being these centres of some of the hills. Still, it could be seen on closer examination that scarcely a leaf in the whole field was entirely healthy. On almost every one there were small yellow spots, more or less abundant, some were slightly wilted, and it was evident enough that the disease was spreading in each hill from the centre outward. The dead areas on the most affected leaves were dry and brittle, marked with slight concentric rings, and a dark, mould-like growth could be seen upon them. Examined with the microscope, this proved to be a fungus, and a species of *Alternaria*. It grew abundantly in the tissue of the leaf as well as upon the surface, where the dark-brown, club-shaped spores were produced. No other fungus or other organism could be found on the affected leaves, and there seemed but little doubt that this was the direct cause of the trouble. Furthermore, Dr. W.

C. Sturgis,* who describes what is evidently the same disease in Connecticut, has succeeded in producing it by inoculating sound leaves with the fungus, thus leaving no doubt that the *Alternaria* is the cause of the trouble. This fungus is a mould-like growth, consisting of a mass of fine filaments which grow upon and in the leaf, consuming its substance and vitality. It reproduces itself by the above-mentioned spores, which are blown by the wind from the surface of the affected leaves to fresh ones, and there germinate and produce the disease. It is not entirely clear why the leaves near the centre of the hill should be the first to show the disease, unless, perhaps, it is because they are the oldest leaves, and thus are growing less vigorously than the outer ones, and less able to resist the attacks of such a fungus. It should not be supposed that the disease spreads outward to the other leaves through the plant itself, as the nature of the fungus shows that this is not the case, but that it spreads entirely by means of the spores which are carried through the air.

As the disease was so far advanced when we first saw it, it was pretty evident that no treatment would be of much avail in checking it. A portion of the field was sprayed with Bordeaux mixture, but the weather continued, as it had been for some time previous, very rainy, and before a second spraying could be made almost every leaf in the field was dead and withered. Some of the melons had reached sufficient size to mature, but nothing like a full crop was obtained. The same disease was met with in one other locality during the season, and no doubt occurred in various parts of the State, though melon-raising is not much practised here. There is no apparent reason why this disease should not be as successfully treated by spraying with Bordeaux mixture as are many similiar ones which are largely prevented by this means. Experiments will be made another season by spraying at the time of blossoming, and several times thereafter during the season. Knowing the nature of

* Report Connecticut Agricultural Experiment Station, 19 (1895), p. 186, and 20 (1896), p. 267. See also Ohio Bulletin 73, p. 235, and 89, p. 117; Journal Mycology, vii, p. 373.

the disease, it will of course be at once understood that it is very advisable to destroy all affected vines and leaves by burning. It might also be safer not to plant melons on land where the disease had already occurred during the previous season. We do not, however, lay great stress on this, as many farmers have a particular area especially suited to this crop, which they do not like to give up, and the disease is probably disseminated widely enough so that it is about as likely to occur in one place as another.

Rotting of Cabbage.

The rotting of cabbage in the field, caused by a species of bacteria, which has recently been so thoroughly investigated by Russell* and Smith,† appeared this year in a field upon the station grounds, and also occurred to our knowledge in several other places in the State. It is a most destructive disease, causing dead spots to appear upon the outer leaves of the cabbage, and usually resulting in a complete decay of the whole head. Cauliflower is quite susceptible, as also cabbages and turnips. A full description of the disease may be obtained in the above-cited Farmers' Bulletin, which can be obtained upon application to the Secretary of Agriculture, Washington, D. C. No practical remedy is known except a rotation of crops. As the disease occurred here on land which had never been in cabbages before, even this seems rather uncertain.

Further Considerations in Regard to the Drop in Lettuce.

We have already referred to this disease in our last annual report, and it may not be out of place to briefly call attention to the progress which has been made towards the control of this troublesome fungus. The study of the organism which causes the disease has given some suggestive results in regard to its treatment. The ordinary "damping fungus" (*Botrytis*), has been generally regarded as the source of the trouble, and we have so referred to it in our previous report. Further observation has shown, however, that, whatever may

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* Bulletin 65, Wisconsin Experiment Station.

† Farmers' Bulletin 68, United States Department Agriculture.

be the relation between the drop fungus and *Botrytis*, it is certain that the disease is not spread by *Botrytis* spores in the air, but by a mycelium or mould-like growth in the soil itself.

Our control experiments have so far been along three different lines; namely, those in which chemical substances were used on the soil, the application of various gases to the greenhouse, and the effect of different layers of sand and sterilized earth. The results obtained by the use of chemical substances have been entirely negative, and the use of gases does not at the present time give great encouragement. In our last report we called attention to the use of sterilized soil as a possible control method, and during the past winter and also at the present time this method has been in use. Our experiments have shown that the heating method is the only absolute one, although some gain has been made by the use of three-fourths of an inch of sand upon the beds. The sand which was sterilized showed better results than the unsterilized. In both instances, however, cleaner and better plants have been obtained by the use of three-fourths or one-half of an inch placed upon the surface of the soil. Experiments in which three or four inches of the top soil was sterilized gave absolute results in the control of the drop, and those in which two inches of the infected top soil was sterilized have not as yet shown any evidences of the drop. Where one inch of sterilized soil was used and carefully distributed, the loss from the drop has been about four per cent., while in the adjacent beds which were not sterilized the loss was about fifty per cent. These experiments have been carried out in another badly infested house, managed by an experienced lettuce grower, on a much larger scale, with quite similar results.

While this method gives promise of being a practical one, we are not quite certain as yet whether it is the cheapest one which can be utilized, and other control methods are being experimented with. Some growers clean their houses out every year, and put in fresh subsoil mixed with horse manure; but such a method is expensive, probably more so than the heating of an inch or two of the top soil previous to planting the crop. If one is provided with a good steam boiler, as most lettuce growers are, probably two hundred cubic feet of soil could be heated sufficiently in one or two hours' time. This amount of earth will cover twenty-four hundred square feet of soil one inch deep, or a bed twenty-four feet wide by one hundred feet long. Of course this heating will have to be done with every crop, as the stirring of the soil subsequent to planting would redistribute the fungus. As a necessary precaution against the drop, it would also be necessary to have all the soil sterilized in which the prickers are started, and also that which contains the first transplanting. By this means alone much lessening of the drop could be accomplished; but in conjunction with sterilized layers one inch thick in the house, it would in most cases reduce the infection still further. The amount of earth that is employed in the seed bed and also that in which the first transplanting is done is not so large but that it could be entirely sterilized. When this is once accomplished, it would be sufficient for some time to come, provided precautions were taken against outside contamination. The benefits gained from the use of sterilized soil are in themselves, regardless of the drop, sufficient to pay for the process, according to some who have used it, inasmuch as the lettuce plant shows a better color and makes a quicker and larger growth.

The Chrysanthemum Rust.

This comparatively new disease has been not uncommon in the State during the past season; but it is encouraging to note that its attacks seem in most cases where it has occurred to have had but little appreciable effect, and the indications now are that this disease is one which may be fully controlled by proper methods of cultivation and management. We noticed especially a case where a lot of plants were brought in in August to set out in the open bed for fall blooming. Fifteen plants were left over, and remained standing on a greenhouse bench in pots. Later in the season this bench was filled up with other potted plants which had remained out of doors. Though all were of the same lot, the fifteen became badly rusted, while none of the others or those set out in open beds showed any signs of the disease. It seemed pretty evident, therefore, that the high August temperature of the house had a bad effect upon the plants confined in pots, causing them to be more susceptible to the disease. Some of the plants which were still out of doors in a cold frame also became rusted, but these were crowded together so that all the lower leaves had fallen off, and were plainly in poor condition. Of the many plants which were set out in open beds in August or placed on benches with space between them in September, not one showed any noticeable rusting.

It remains to be said that the rusted plants, though badly affected, produced blossoms as good, apparently, both in quality and quantity, as similar healthy plants, and, furthermore, did not spread the disease to other plants, though kept in close proximity to them. Judging, therefore, from this year's experience, it seems probable that the skilful gardener has no great cause for apprehension in this disease.

A New Pansy Disease.

During the past summer our attention was called to a field of pansies at the establishment of a local seed grower, in which the plants were badly affected by a disease of the leaves and blossoms. Upon the affected leaves first appeared small dead spots, each surrounded by a definite black border. These spots soon increased in size, and in the later stages of the disease the affected leaves had an appearance very similar to that of the violet leaf spot (*Cercospora Violæ*, Sacc.). Many plants were killed outright by the disease, and all affected ones were in very poor condition. Besides the spotting of the leaves, many of the blossoms also were affected, the petals being disfigured by dead spots and blotches upon them, while some of the flowers were malformed or only partly developed. The latter was indeed one of the most serious features of the trouble, as the plants were raised for seed, and the yield was greatly reduced by this failure of the blossoms to develop properly.

It was thought at first, from the general resemblance of the leaf spots and close relationship of the two plants, that this might be identical with the violet disease. This, however, did not prove to be the case. Examination showed that the cause of the trouble was a fungus, but one of quite a different nature from *Cercospora*, and belonging to the genus *Colletotrichum*, being apparently a new and undescribed species. This form has therefore been described in the "Botanical Gazette" of March, 1899, under the name *Colletotrichum Violæ — tricoloris.*

This same disease has been seen in a few other localities in the State, and Prof. B. D. Halsted has also very kindly sent us specimens of it from New Jersey, so that the trouble is doubtless widespread. Its occurrence, however, seems to have been comparatively slight, except in the one instance described above. In this case the number of plants was very large, and pansies had been grown upon the same field for several years, which may account for the severe outbreak of the disease.

A portion of this field was sprayed twice with strong Bordeaux mixture; but, as it was already late in the season, and heavy rains prevailed at the time, little success from the treatment was looked for. The owner, however, thought that a beneficial result appeared from the treatment, and from our own observation we can claim at least that later in the season the sprayed portion of the field was certainly in the best condition of any. If this did indeed result from the spraying under such adverse conditions, it seems likely that the disease could be kept well in check by proper treatment.

Physiological Disorders.

Seasonal Peculiarities of Certain Shade Trees.

Some complaints have been made in regard to the falling of leaves on the elm, maple and apple trees. This was especially noticeable on the elm in various sections. We had many specimens sent in for examination, and our attention was called to a number of trees in which certain branches had only half-developed leaves on them. These leaves would linger along a while in this condition, when they would gradually turn yellow and drop to the ground.

Examination made of a great many leaves and branches revealed no fungous or insect pest preying upon them. The condition of the apple trees was similar, although not so prevalent; and in the maple the cast-off leaves were mature ones. The exact cause of this trouble is not obvious, but there can be little doubt that it was a functional disorder. We have observed fine specimens of elm trees, which, after a period of excessive seasons, would suddenly lose all their leaves in midsummer, yet a year or two later would appear as vigorous as ever. Inasmuch as the trees are not materially injured by the falling of a few leaves in midsummer, remedial measures are not necessary.

Over-feeding of Plants.

The over-feeding of plants is not an uncommon occurrence at the present time, when so much concentrated fertilizer is used, and where attention is not given to the proper amounts that should be employed. This trouble not only occurs among florists, etc., but among those who cultivate house plants as well; and the cause of the trouble is usually traceable to the fact that most people are not aware of the strength of the constituents serving as plant food. The normal strength of chemically pure solutions, available for plants, is about one to one thousand or one to two thousand parts, and when these solutions are put on at the rate of one to one hundred or so, ill results must be expected to follow their use.

We now and then have specimens of abnormal plants sent in to us which are merely suffering from some such treatment. A potted specimen of a Johnsonian lily, which had a number of reddish eruptions or blisters upon its leaves, was sent in for examination. These reddish blisters were examined under the microscope, and they showed no evidence of fungi or insects being present. The cells, however, in the vicinity of the blisters showed that they had been stimulated exceedingly, which manifested itself in excessive cell division, giving rise to the blisters; and where this action had taken place excessively the tissues were ruptured, thus producing a ragged, wounded appearance. This trouble could be readily referred to some abnormal features in connection with nutrition, and an inquiry showed that the plants had been heavily fertilized with Chili saltpetre. The same treatment was applied by us to a perfectly healthy Johnsonian lily, with the result that the same activity was shown in the division of the leaf cells, which subsequently gave rise to blisters or ragged eruptions identical with those described.

A number of potted specimens of cyclamens grown by a florist were also brought to our notice last winter, which showed somewhat similiar peculiarities in the leaf. These leaves were blistered, although in quite a different manner from the Johnsonian lily mentioned above. There were no ragged or lacerated eruptions or pustules on the cyclamens, and the manner of blistering was quite different, although it was evidently caused by over-feeding, or at least by injudicious feeding, as it was found that the plants had been heavily treated with nitrate of soda.

A singular case of over-fertilizing or perhaps over-watering was seen in some specimens of carnations sent in to us by a grower. We subsequently visited the greenhouse where they were found, and had an opportunity of seeing these abnormal plants in the benches, beside other plants of the same variety that were not affected. About fifty plants in this house showed this trouble, and it was confined to the most robust specimens of the variety known as the Edith Foster, and in some instances to the Mrs. Fisher. The characteristics of these diseased plants were whitish stems and foliage, which were enlarged to about twice the size of normal ones growing next to them. Repeated examinations of the tissues of the affected plants seem to show that there was nothing the matter with them except what might be expected from improper nutritive conditions, such as might be brought about by too much fertilizer or excessive watering, which caused the plants to be stimulated abnormally in their growth. In the spring the plants were removed from the greenhouse into fresh garden soil, but they failed to recover. The same variety of carnations has already shown similar symptoms this season.

Injudicious use of fertilizers is not an uncommon matter, and more care should be exercised in their application. Most fertilizer companies give explicit directions as to the amounts which should be employed, and the excessive use of them is generally traced to the carelessness of the gardener in applying them. The results of over-feeding generally manifest themselves in some abnormal stimulation to the plant; but these results, even when the same fertilizer is used, do not show themselves in a similar manner on different species of plants. What would give rise to a multiplication of cells and the formation of blisters in the leaf of one plant, would not do it in the leaf of another. In short, stimuli in plants manifest themselves specifically and manifoldly.

The Bronzing of Rose Leaves.

A peculiar bronzing or irregular spotting of rose leaves was brought to our attention last winter by Mr. Alexander Montgomery, Jr., a member of the senior class. This peculiarity in the spotting or bronzing of the leaf is common to grafted varieties of the Tea, Bride and Bridesmaid roses, grown at the extensive Waban conservatories at Natick; and Mr. Montgomery, who was working in the botanical laboratory at that time, made, at my request, some investigations into the cause of the trouble. Both Mr. Montgomery and his father, who is in charge of the Waban conservatories, have had ample opportunity to observe bronzing; and it therefore became a very easy matter to secure valuable data. The only mention which we have noticed in connection with this disease is that given by Professor Halsted of New Jersey, who briefly referred to it in his annual report of 1894.* In this report he gives a figure of the black spot of the rose, and in connection with it is shown what he designates a "discoloration that is most frequently met with on the foliage of the La France, and may be called bronzing." This he states, so far as he knows, is "not due to any fungus, and is likely due to a structural weakness." This reference to the disease by Professor Halsted was not observed until Mr. Montgomery had finished his investiga-

* New Jersey Experiment Station Report, 1894, p. 384.

tions; and, in order to ascertain whether the trouble with which we were concerned was the same which he had briefly alluded to, we forwarded him specimens for examination, which resulted in establishing the identity of the two. There is a certain resemblance between the spots which give rise to bronzing and those which are caused by the black spot; and we found that the impression prevailed among some rose growers that bronzing was simply an immature stage of the black spot. To any one thoroughly familiar with the characteristics of both diseases, the differences between them would be evident, and they would not be likely to confound one with the other.

The investigations of Mr. Montgomery showed that the abnormal condition of the rose leaves subject to bronzing was not in any way connected with fungi, but is of a physiological nature, or structural weakness, as Professor Halsted had correctly surmised. The first symptoms are manifested in a mottled, bronzing coloration of the leaf. These spots subsequently become more prominent, ranging from one-sixteenth of an inch to one inch in size; the infected portions of the leaf frequently turn yellow, and eventually the leaflets and leaf stalk drop to the ground. Sometimes, however, a whole leaflet becomes bronzed, and the yellowish color is not observed. Numerous microscopic cross-sections made of the bronzed leaf spots showed that the epidermal and adjacent cells were in an abnormal condition. The living contents of the cells were disintegrated, the protoplasm and cell walls had turned a reddish-brown color, and numerous very minute bodies about the size of micrococci filled the affected cells. These minute bodies proved upon examination to be crystals of calcium oxalate. The excessive deposits of calcium oxalate indicate that the leaf cells, being unable to obtain sufficient nourishment, were not able to assimilate the calcium salts, and consequently it is deposited in the cells in the form of calcium oxalate. It may be said that all of this phenomenon is nothing extraordinary, but merely concomitant with the death of the leaf, and can be observed in other species of plants. Mr. Montgomery states that the bronzed leaves are more susceptible to disease, and he has observed the occurrence of rust upon them, while healthy leaves would be entirely free.

A further examination of the affected plants at the Waban conservatories, made by Mr. Montgomery and myself, showed that all leaves even of plants subject to it were not affected, but that it was confined in every instance to two places: first, where a stem is cut and a new branch starts, the leaf at the base of the branch begins to bronze; second, when an eye or axillary bud is rubbed off, the leaf generally becomes bronzed.

There is a difference in susceptibility between young plants and old ones. Roses planted in the middle of June show bronzing the first of August, but it is scarcely noticed after the first year's growth. Bronzing appears to occur more largely upon plants which show rapid growth than on those which have grown more slowly; for this reason apparently the root plants or ungrafted ones at the Waban conservatories which are not so vigorous as the grafted ones are not susceptible to it. Bronzing sometimes occurs upon small, weak stock.

It should be stated, however, that, since bronzing occurs on leaves at the axils of the shoots which bear the flowers, no real harm is done to the marketable foliage, as the cutting of the flower stalk is always above the position of the leaves which are bronzed. The most intelligent and successful rose growers always take the most care and pride in their plants, and they are suspicious of any abnormal feature which in any way mars the beauty of them; and this is, so far as we have observed, the only inconvenience which this trouble of bronzing gives rise to.

It is quite evident that we have in the bronzing of rose leaves a physiological phenomenon which is not uncommon to other plants. We have observed a similar falling of the axillary leaves in other species of plants. In the rose it is probably a correlative phenomenon, which is brought about, or at least augmented, by years of cultivation and development along certain lines. Any form of mutilation, whether it be a cut or a mere scratch, acts as a stimulus to a plant; but the manner of reaction of the plant may not always be the same either in kind or degree. As a rule, the cutting of primary organs, such as a shoot, will give rise, among other things, to increased activities in the secondary organs, such as a side shoot or side root; and conversely the cutting of a secondary organ or branch will stimulate the primary organ or main shoot. Then, again, the effects of stimuli caused by cutting are more marked near the source of injury, and less marked the further away an organ is from it. For example, the cutting of the main axis near an eye or bud would give rise to increased activities in the axillary bud, which would manifest itself in the development of a new shoot. The nearer the cut to the eye or bud, the more marked will be the stimulation, or resultant activities, and the more completely will it assume the characteristics of the primary shoot. The better condition the plants are in, and the more suitable and available plant food with which they are supplied, the more rapid will be the growth of the shoot, and the more marked will be the correlative effects. Such, in fact, are some of the laws governing correlation in plants.

In the case of the bronzing and subsequent death of the axillary rose leaves, the stimulative effect of cutting causes a marked growth of the shoot, and the nutritive substances are thereby utilized by this organ to such an extent that some other portion of the plant is made to suffer. In this instance it is the axillary leaf which finally becomes bronzed, turns more or less yellow and dies. In other words, bronzing is nothing more or less than a physiological disorder, and falls under the domain of plant irritability.

Cucumber Wilt.

The growing of cucumbers under glass is carried on extensively in some places in this State, and a disease known as the wilt has been reported to the station a number of different times. Complaints in regard to this disease have always come from certain localities where it has, as a rule, been quite universal among the different growers. The symptoms of the disease are a wilting of the plant, or, more strictly speaking, of the foliage, whenever it is subjected to the intense rays of the sun.

We visited several cucumber houses this last spring in which the plants were subject to wilt, and observed a number of houses which contained badly affected plants. In those houses running north and south, the vines in the morning on the east side, which are subject to the sun's rays, would be entirely wilted; while those on the west side, and away from the sun's rays, were not in the least affected. In the afternoon, when the sun had reached the west side of the house, the vines would then become badly wilted, and those on the east side, when no longer exposed to the direct rays of the sun, would commence slowly to recover. The cause of the wilt in every instance was not difficult to understand; but, as a necessary precaution against drawing deductions too hastily, we examined every portion of a number of plants very carefully, to convince ourselves that there was no other cause than that which we had in mind. It is well known that there is a bacterial disease of cucumbers that gives rise to a wilting of the leaves, but careful examination of the tissues shows nothing in the nature of bacteria to be present.

At about the same time we visited several other cucumber growers in other sections of the State, and had an opportunity of examining many vines in about the same stage of development. In some instances the identical varieties of cucumbers were grown, but in the majority of cases another variety was used, namely, the White Spine, and in all cases the methods of cultivation were radically different, and the wilting of the vines was something unknown to them. Long before we visited the region of wilt a number of letters of inquiry had shown us that the disease in question was local, and the majority of growers had never had trouble with it.

The cause is not due to any organism, whether insect or fungous, but to extremely abnormal conditions of the plants, brought about by irrational methods of cultivation that give rise to defective transpiration, or, in other words, to the giving off of water from the leaves. The activity of transpiration is affected by various causes. It is well known that the stomata or breathing pores of the leaf are open during sunshine and closed during darkness, and that the greatest activity in transpiration takes place during sunshine. This fact is frequently demonstrated by young cucumber plants in tolerably good conditions of health, which not infrequently show some indications of wilt in sunshine, though not enough to cause any amount of harm. This is especially so when they are forced too rapidly, and when the texture of the leaf is not sufficiently developed. The temperature of the air affects transpiration. A plant in an atmosphere saturated with moisture will not exhale any watery vapor, provided that the temperature of the plant is not higher than that of the air; but when the temperature of the air is high, and the proportion of moisture small, transpiration is promoted. Transpiration is further affected by the temperature of the soil in which the roots are embedded. When the roots are warmed, transpiration becomes more active, and consequently there exists more root absorptive activity. The nature of liquids which the roots absorb and the kind of soil in which they grow also affect transpiration. Plants transpire more when grown in sandy soil than when grown in clay soil; also when grown in acid soil than when grown in alkaline soil. One per cent. solutions of potassium nitrate and other salts diminish transpiration, and we have been able to produce severe cases of the wilt by watering pots of cucumber plants with a one per cent. solution of potassium nitrate.

The wilt, however, in the houses mentioned before was not due to temperature or constituents of the soil, but was brought about, as we have already inferred, by irrational methods of treatment of the plants, and depends upon other causes. In all probability, the cause of the wilt may be attributed partially to the characteristic peculiarities of the varieties of cucumbers grown, as most of the varieties are Telegraph or Giant Pera. In many cases hybrid forms are obtained by crossing these with the White Spine. These varieties present a different appearance from the White Spine; their stem and leaves appear to be small, and the plants do not appear normally as green and rugged as the White Spine.

The methods of growing cucumbers where the wilt occurs are radically wrong in many ways. The houses are imperfectly supplied with ventilation, consequently little use can be made of this necessary feature. Then, again, they are supplied either wholly or partially with two layers of glass, which are set about two inches apart, thus leaving an air space in between for the purpose of keeping out the cold, but which in reality becomes filled up with dirt, and is an excellent aid in shutting out the light. Plants started in such a house in winter continually suffer from lack of light, — a feature which we have often observed in the greenhouses in this State. Their leaves become pale, and they are attached to the stalk by means of elongated petioles, and present all the phenomena of partial etiolation, or, in other words, they resemble plants grown in the dark. If we add to such plants an enormously high temperature, without any proper ventilation to make them stocky and rugged, then we have a crop that is so tender and abnormally matured that it is incapable of standing strong sunlight. If such a crop is carried over until spring, and subjected to the intense rays of the sun occurring in that season of the year, the tender, etiolated, sickly colored leaves commence to wilt even with the house closed and a considerable degree of moisture.

We observed as many as a dozen houses last spring affected in this way, and not in a single one did we see more than a dozen or so of what might be termed fairly good-colored and healthy plants. Whenever we observed a plant which possessed any color or texture in its leaves, we found plants which showed no indication of the wilt. We examined at the same time in another locality a crop of a similar variety of cucumbers grown in a house provided with a single layer of glass, which had also received sufficient ventilation, and the plants were in an exceedingly vigorous condition.

These facts show what it is always necessary to bear in mind, that some varieties of plants can be grown by different growers with entirely different results, and that it is essential to pay the greatest attention to conditions which are normal to the plants.

While the cause of the cucumber wilt is due, as we have already pointed out, to irrational methods of greenhouse management, the specific cause can be traced directly to the lack of texture in the plants, brought about by too high a temperature and lack of light in the beginning, which does not enable them to stand up under the powerful rays of the spring sun, as the amount of water thrown off from their tender leaves is more than can be supplied by their roots. This irrational method seems to have its origin in a desire to save coal, and starve the plant by utilizing double layers of glass, and to indulge in too much forcing; or, in other words, to get more out of the plant in a certain length of time than its inherent capacity warrants. In these methods of culture, affecting, as they do, a single locality, we see nothing but practice based upon a disregard of the normal functions of the plant, and mistakes due to local conception of greenhouse management. The remedy in such a case is obvious, and consists in giving the plants during their young stage of growth plenty of light and air, and not allowing them to grow too rapidly. Cucumber plants grown in this manner will possess color and texture, and they will be capable of standing the spring rays of the sun without wilting.

Some Difficulties which City Shade Trees have to contend with.

For some years back our larger cities have had park commissions, whose duty consists, among other things, in seeing to the setting out and caring for shade trees. Many of these cities, having seen the necessity of a more general oversight in regard to the care of trees, have gone a step further, and have secured the services of a trained forester, whose business it is to pay special attention to their welfare.

This department frequently has specimens of diseased leaves and branches, especially of trees, sent to it for the purpose of determining what is the matter with them. Sometimes these specimens are from trees in which a single branch has lost its leaves in mid-summer, or they may be specimens from a tree which has died suddenly. An examination of the specimens frequently shows that there is no reason for believing that their abnormal condition is caused by either insect or fungi, although at times there may be observed a few aphids on them, which it is generally supposed are the cause of the trouble. The causes of these troubles, however, are in many instances to be traced to conditions which are peculiar to our times. In this age of electric lights, trolley cars, sewers, pavements, gas, and transmission of steam for heating purposes, it must be confessed that the practice of setting out shade trees along the borders of streets in our cities becomes rather discouraging. The price of enjoying these modern appliances of scientific thought means more than the mere cost of digging up our city streets and lopping off the limbs of trees every few months; in many instances it means the death of many shade trees, and it may eventually lead to the question whether it is worth while to bother at all with trees for our city streets. The sickly, disfigured, mutilated specimens of trees which are now and then seen in our busy city streets have very little to recommend them, and in many cases thoroughfares would become improved without them.

Some of the agencies which more especially affect our trees are electricity, gas and steam. These may affect the tree directly, by escaping and coming in contact with some portion of it, or indirectly as by the lopping of limbs for wires or the digging of trenches for the pipes, which very frequently results in destroying portions of the root system. There are other agencies, however, which are associated with the death of the tree. One of these is the borer that is very troublesome to the rock maple. Trees affected with these can be readily detected by an examination of the bark of the tree for round holes about one-quarter of an inch in diameter, and in autumn the affected limbs can be readily detected by a premature coloration, or hectic flush, as it were, of the leaves. Then, again, there is the work of horses' teeth, which, according to Mr. James Draper, who has had many years' experience as a park commissioner at Worcester, inflicts more damage than any other single thing to city trees. Many of the specimens of diseased shade trees which are sent in to us year after year can be referred to one of the above agencies as a cause of the trouble.

The death of many trees can be referred to illuminating gas. If a leak occurs in the pipe, the gas escapes very readily into the soil, especially if it is porous, and when it comes in contact with the roots they are asphyxiated, and the result to the tree manifests itself very quickly. The symptoms of gas poisoning are most generally a sudden falling of the leaves, a deadened appearance of the bark, due to the collapse of the cambium or living layer, brought about by the asphyxiation of the roots, which results in the rapid death of the tree. In mild instances of poisoning the effect shows only upon one side of the tree, but in general the tree seldom escapes death. We have observed many single trees killed by gas on the private grounds of city residences, without the owner ever surmising what the trouble was; and this last summer we had an opportunity to examine whole rows of native trees which had died by gas asphyxiation. Some of the trees which we observed were at a distance of fifty feet from the nearest gas main, while others succumbed when not nearer than one hundred feet to the leak in the pipes. While it is advantageous to all gas companies to stop these leaks as soon as they are found, it becomes practically impossible to do so in every instance, and the death of trees from this source must constantly be expected. As a matter of fact, the death of some fine shade tree is not infrequently the first indication the gas company has of a leak in its main.

Abnormal respiratory conditions, which usually result in either a sudden or lingering death to trees, occur where they have become submerged in water, or where they have been covered with a foot or more of soil. We have noticed trees growing beside sloping roadsides which had become filled in with earth only on one side of the tree, resulting in that side of the tree becoming dead, while the other side would linger along in an unhealthy condition for years.

Less often does the death of trees result from steam, as the transmission of this is not so common. Occasionally, however, where steam pipes are laid near trees, they are sometimes injured.

The various forms of concrete and pavements and the large surface of the ground covered by them about the city streets are a menace to the health of trees, and the sickly conditions which they present are often due to these. Some of our more modern city streets obviate this matter by leaving a wide space of turf between the sidewalk and road, for the purpose of planting trees. This gives the roots a chance to develop normally, inasmuch as the respiratory functions are not interfered with, as is the case when they are covered with pavements. Many of the streets in Springfield are especially commendable in this direction.

Not a little of the disfiguration of trees is directly due to the linemen in lopping limbs, and more especially to the direct effect of electric currents. We have observed no instance where electricity has killed a tree outright, but there are many cases where the limbs have been killed by burning. This effect is not only caused by the alternating current of the electric lights, but by the direct current of the trolley system; the latter current being probably more injurious, provided the same amount of amperes and voltage is employed. The damage done by grounded wires takes place when trees are moist, as at that time the resistance is reduced, and the current becomes increased and has a better opportunity to become dispersed. We have known of instances where trees and the grass for some distance about them have been charged with the escaping current. The damage to the trees, however, is due to the heating effect of electricity. The wire becomes grounded on a limb, and when moist the current escapes. At first comparatively little current passes through the limb, as the resistance is high; but, as the heat increases the resistance decreases, with the result that a large amount of current passes through, which gives rise to still more heat, and subsequently develops into a blaze. The action of electricity, as we have already stated, is local in its effects. The injury, while sufficient to kill every portion above the limb or trunk, does not, so far as our observation goes, destroy the tissues very far above the point of grounding. There are reasons for believing, however, that the effects of the direct current are more severe than those of the alternating current. In the case of the alternating current the anode and cathode alternate very quickly, while in the direct current no alternation takes place, and this results in an electrolysis of the cells, which in turn produces disintegration and quick death to the protoplasm. In short, we may say that all of the injury to trees by electricity is brought about by heating, and by electrolysis and disintegration of the cell contents. Some observations made by Professor Hartig of Munich upon the effects of lightning on trees are interesting in connection with the subject of electricity. He observed that when a tree is struck by lightning the current usually travels along the cambium zone or living layer of the tree, just under the bark, inasmuch as at this point the current finds the least resistance. Sometimes the burning effect is more marked just inside and outside of the cambium layer, where the resistance is slightly greater, — a feature which is shown by the dead areas in the trees many years after. There are many trees struck by lightning which show scarcely any injury, and others will show only a small dead area which coincides with the path of the current. Professor Hartig has made many observations upon trees struck by lightning, and his practised eye is able to detect trees that have been so affected which to the ordinary observer would appear perfectly sound.

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OF THE

HATCH EXPERIMENT STATION

OF THE

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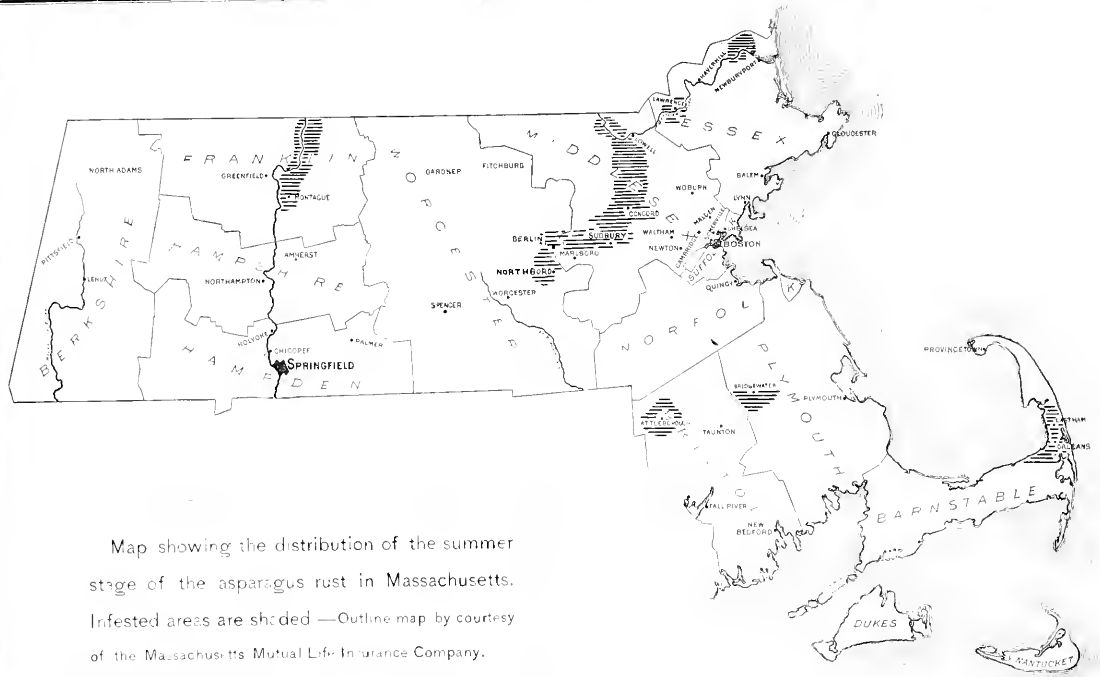

Map showing the distribution of the summer stage of the asparagus rust in Massachusetts. Infested areas are shaded.—Outline map by courtesy of the Massachusetts Mutual Life Insurance Company.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Henry T. Fernald, Ph.D.,	*Associate Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

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

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

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 60. Insecticides; fungicides; spraying calendar.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

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

The usual variety of problems have presented themselves for solution. In the agricultural division some interesting data have been collected on the use of sulfate and muriate of potash as fertilizers. With the sugar beet the larger yield was secured from the muriate, but the percentage of sugar was greater and the juice was of a higher degree of purity, presenting less difficulties in manufacture, from the sulfate. In sweet and field corn there was no perceptible difference in product, quality or food value, but with cabbages the yield was much greater from the use of the sulfate. In the tests of potatoes the Beauty of Hebron and Early Rose still rank in 94 varieties among the most productive sorts, either for early or late harvests. In feeding poultry a narrow *v.* a wide ration for egg-production, the results seemed to be largely in favor of the wide ration, richer in corn meal and corn, in the following particulars: (*a*) lower cost of feed, (*b*) a gain of 23 to 91 per cent. more eggs, (*c*) a lower cost per egg, (*d*) a greater increase in weight and (*e*) a much earlier moult.

In the meteorological division, besides the usual observation of weather phenomena, the means of the various weather elements for the last ten years have been tabulated, and normal conditions for the period deduced. Observations relating to soil temperature and moisture by electrical methods have been continued, and results from the corn-growing season of the current year have been worked out to serve as basis for comparison in succeeding years.

In the horticultural division, experiments have been carried on in the use of hydrocyanic acid gas under glass as an insecticide, but definite results have not yet been secured.

In the entomological division, the card catalogue to the literature of North American insects now numbers over forty thousand. The inspection of nurseries for the San José scale and the granting of authorized certificates has been added to the work of the division; bulletins on the coccid genera Chionaspis and Hemichionaspis and the grass thrips have been issued, and one on the clover-head beetle and a monograph of the Pyralidæ are ready for publication. The composition of Raupenleim, formerly imported at a high price, has been determined, and it can now be made at a trifling cost.

In the botanical division, interesting observations have been made on the distribution of the asparagus rust in Massachusetts and the relation existing between its outbreaks and the rainfall, together with the physical properties of the soil. There is a marked susceptibility of plants to this disease when grown in soil possessing little water-retaining properties, and a strong relation appears to exist between dry seasons and the occurrence of the summer or injurious stage of the rust.

The chemical division (foods and feeding) has analyzed during the year 2,045 substances, besides carrying on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

The chemical division (fertilizers) has issued 67 licenses to manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals, 38 of whom had offices of general distribution in Massachusetts; 384 samples of fertilizers were collected in the open markets by experienced assistants of the station, and 362 were analyzed and the results published in bulletins.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

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

For the Year ending June 30, 1899.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,216 31	
for labor,	5,167 16	
for publications,	1,090 45	
for postage and stationery,	242 31	
for freight and express,	122 39	
for heat, light and water,	164 77	
for chemical supplies,	3 45	
for seeds, plants and sundry supplies,	484 58	
for fertilizers,	1,076 40	
for feeding stuffs,	208 55	
for library,	411 65	
for tools, implements and machinery,	718 80	
for furniture and fixtures,	61 45	
for scientific apparatus,	201 90	
for live stock,	95 00	
for traveling expenses,	105 21	
for contingent expenses,	139 25	
for building and repairs,	490 37	
		$15,000 00

Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,585 00	
from farm products,	1,641 78	
from miscellaneous sources,	1,906 71	
		$18,333 49
Cash paid for salaries,	$8,127 13	
for labor,	4,275 18	
for publications,	201 00	
for postage and stationery,	211 49	
for freight and express,	162 01	
for heat, light and water,	583 59	
Amount carried forward,	$13,563 70	

Amount brought forward,	$13,563 70	
Cash paid for chemical supplies,	842 90	
for seeds, plants and sundry supplies,	752 76	
for fertilizers,	302 21	
for feeding stuffs,	443 36	
for library,	33 97	
for tools, implements and machinery,	32 75	
for furniture and fixtures,	227 68	
for scientific apparatus,	108 27	
for live stock,	87 22	
for traveling expenses,	272 70	
for contingent expenses,	180 00	
for building and repairs,	1,485 97	
		$18,333 49

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1899; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,333.49, and the corresponding disbursements $33,333.49. All the proper vouchers are on file, and have by me been examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1899.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 11, 1899.

REPORT OF THE AGRICULTURIST.

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

The work of the agricultural department of the station has been more extensive during the past year than ever before during its history. Besides the investigations selected for full discussion later in this report, we have carried on a large number of other out-door experiments, among which may be mentioned those having the following objects in view: with potatoes, to determine the best distance for planting; with oats, to determine relative value of equal money's worth of five different phosphates; with corn, to determine relative value of ten leading phosphates when used in quantities furnishing equal amounts of phosphoric acid; with orchard trees, to test the effects of five different systems of manuring; to test the value of employing nitragin for several of the crops of the clover family; to determine the adaptation and value of different grasses, forage and food crops.

We have put up a glass house for use in connection with pot experiments, and have installed a very complete equipment of iron tracks, trucks, pots, etc., for use in such experiments. The house is 23 by 60 feet, and contains six tracks. The track yard adjoining, which is enclosed by fine wire netting, is 28 by 80 feet. It contains seven tracks, on which the trucks carrying the pots stand during good weather, being quickly run into the house in case of rain or storm. It has transfer track, turn-table and an iron water tank. We have partitioned off a room (12 by 30 feet) in the old barn, cemented the floor, and connected the same with the glass house by iron track about 100 feet in length.

This serves as a work room in connection with pot experiments. We have this year carried on experiments with potatoes, onions, soy beans, corn and millet as crops, in which we have used 286 pots. The results are of much value, having assisted toward the solution of a number of important problems; but, as there remains much chemical work to be finished in connection therewith, these experiments cannot be reported at this time. Of the value of this method of experiment, which has so approved itself with European investigators, there can not be the slightest doubt; it will prove a most important adjunct to field work.

We have further carried out a number of experiments in cylinders 4 feet deep and 2 feet in diameter (without bottom), plunged to the rim in the open air and filled with equal amounts of carefully mixed earth. In these experiments we have employed sixty-three such cylinders, dealing with some important problems. This too proves a valuable method of work. Results are not yet sufficiently worked out for publication.

The report will touch in detail only upon experiments the results of which are sufficiently definite to permit practical deductions of value. The report on such experiments follows.

Soil Tests.

Two soil tests have been carried out upon our home grounds during the past season, both in continuation of previous work upon the same ground. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. In addition, each plot in the first test received an application of slaked lime, at the rate of one ton per acre; in the second test, one-half of each plot received an application of lime at the same rate. The lime was spread evenly early this spring, and harrowed in, both fields having been ploughed the previous fall.

Soil Test with Corn. Amherst.

The past is the eleventh season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three having but a single important manurial element, nitrogen, phosphoric acid and potash, — every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produced this year an average of 4.6 bushels of shelled corn per acre and 767.5 pounds stover; and even this figure is somewhat misrepresentative, owing to the fact that after this long period two of the nothing plots which adjoin plots which have been yearly well manured begin to feel the effect of the high fertility of their neighbors, although separated from them by strips three and one-half feet wide.

The Effect of the Fertilizers.

The table shows clearly the marked differences undoubtedly due to the variation now eleven years continued in the fertilizer treatment. The fertilizers wherever employed are applied at the following rates per acre; nitrate of soda, 160 pounds (furnishing nitrogen); dissolved bone-black, 320 pounds (furnishing phosphoric acid); muriate of potash, 160 pounds (furnishing potash); land plaster, 160 pounds; lime, 160 pounds; and cow manure, 5 cords. All plots, it must be remembered, received also an application of lime at the rate of 1 ton per acre, in addition to the materials named in the table.

*South Acre Soil Test, 1899.**

Plot.	FERTILIZERS.	Yield per Acre.		Gain or Loss compared with Nothing Plots, per Acre.	
		Shelled Corn † (Bushels).	Stover † (Pounds).	Shelled Corn (Bushels).	Stover (Pounds).
1	Nitrate of soda,	13.75	1,160	9.87	430
2	Dissolved bone-black,	3.50	620	—.38	—110
3	Nothing,	3.88	730	-	-
4	Muriate of potash,	49.75	2,760	45.50	2,000
5	Lime,	7.25	1,100	2.62	310
6	Nothing,	5.00	820	-	-
7	Manure,	75.88	5,350	70.88	4,530
8	Nitrate of soda and dissolved bone-black.	21.38	1,220	15.50	380
9	Nothing,	5.88	840	-	-
10	Nitrate of soda and muriate of potash.	47.88	2,360	42.75	1,573
11	Dissolved bone-black and muriate of potash.	59.88	3,160	55.50	2,427
12	Nothing,	3.63	680	-	-
13	Plaster,	6.63	990	3.00	310
14	Nitrate of soda, dissolved bone-black and muriate of potash.	72.88	4,450	69.25	3,770

* All plots limed at rate of one ton per acre.

† Both stover and ears were driest upon the plots giving the larger yields, viz., 4, 7, 10, 11 and 12, for only on these was growth sufficiently normal to allow natural ripening.

The Results in 1898.

[No lime had been used except on the lime plot.]

For purposes of comparison I here present a statement covering the results of last year (1898), when also the crop, as has been pointed out, was corn. I quote from my last annual report : —

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season, and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulfate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other soil test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulfate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study. . . .

The problems suggested by the results of the year must be

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* For example, Plot 6, Field A. See report State Experiment Station for 1896.

regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

Conclusions (based upon Results in 1899).

1. By reference now to the table showing the yields for 1899, it will be seen that what last year was merely a suspicion, supported, it is true, by incidental observations in connection with other experiments, is apparently confirmed by the results of this year after liming, viz.: *that last year the application of potash failed to prove beneficial as in the earlier years when corn was grown, because its continued use in the form of muriate had resulted in depleting the soil of its lime.*

It should be noticed that I say "*apparently* confirmed." I would point out that the results of this experiment by themselves do not furnish absolute proof, for its plan is such that it does not enable us to decide that the superior results of the past season may not have been due to the fact that the lime proved beneficial through indirect effects which might have been exerted equally well by some other alkali, such as an alkaline salt of soda or of magnesia. To determine this point, two series of pot experiments with soil from two plots in this field have been carried out. In these, besides slaked lime, we have employed land plaster (sulfate of lime), carbonate and sulfate of magnesia, and bicarbonate and sulfate of soda. The results are not fully worked up, but they decisively indicate: (*a*) *That the benefit from the use of lime was not due to the fact that it corrected soil acidity.* (Sulfate of lime, a neutral salt, produced a better growth than slaked lime, while neither the carbonate of magnesia nor the carbonate of soda proved distinctly beneficial; the latter, indeed, was highly injurious.) (*b*) That it was not due to indirect action of any other sort. (Substances exercising similar chemical and physical influence upon the soil did not prove equally beneficial with the plaster or the slaked lime.)

2. The yield of each of the plots which has been manured with muriate of potash is largely increased. Alone and in

every combination it proves highly beneficial. *That this soil after eleven years' continuous application of muriate of potash at the rate of 160 pounds per acre annually should be capable after liming of producing corn at the rate of 49.75 bushels of shelled grain per acre, is astonishing.*

3. The crop, amounting to almost 60 bushels shelled corn per acre, on the plot which now for eleven years has yearly received only dissolved bone-black and muriate of potash (lime this year of course excepted) and which in this long period of time has received no addition of nitrogen in the form of manure or fertilizers, illustrates the remarkable extent to which, in our climate, the corn plant can thrive upon the natural stores of this element in the soil and that which it accumulates as a result of the introduction of clover into the rotation.

4. It will be noticed that where the elements nitrogen, phosphoric acid and potash have been yearly supplied, the crop this year, amounting to about 73 bushels per acre, is within three bushels of that produced where manure at the rate of 5 cords per acre has been annually applied. The fertilizers used (nitrate of soda, 160 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 160 pounds per acre) cost about $10; while the manure, if purchased, would cost $25 at least in most parts of the State. It should be pointed out, however, that this soil has almost perfect physical characteristics. On the one hand, its perfect drainage insures freedom from excessive moisture even in wet seasons; and, on the other, the happy mean existing in the proportion of fine and coarse particles insures good water-conducting power (capillarity), and thus prevents injury from drought and injurious crust formation. In such a soil the organic matter furnished by manure is far less necessary than in those which are either more sandy or more clayey. For these reasons, fertilizers have doubtless made a more favorable showing as compared with manure than would usually be the case. The table shows the relative standing of the two plots, 7 (manure) and 14 (complete fertilizer), for the entire period of eleven years. It will be seen that the financial outcome where the fertilizer has been used is much better than for the plot receiving manure.

Increases as compared with Plot receiving no Manure.

Produced by Complete Fertilizer, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	198.05	stover, 12,475	$107 29	$48 00
Oats,	1	15.63	straw, 1,720	14 70	9 60
Rye,	1	15.36	straw, 2,480	12 10	9 60
Soy beans,	1	–	beans, 880; straw, 840	4 61	9 60
Grass,	2	–	hay, 3,420; rowen, 1,360	37 56	19 20
Mustard,	1	–	5,100	–	19 20*
				$176 20	$115 20

Produced by Manure, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	216.08	stover, 13,990	$117 79	$125 00
Oats,	1	18.13	straw, 3,260	22 11	25 00
Rye,	1	21.07	straw, 3,200	31 84	25 00
Soy beans,	1	–	beans, 1,520; straw, 3,880	77 26	25 00
Grass,	2	–	hay, 4,860; rowen, 3,460	64 27	50 00
Mustard,	1	–	8,500	–	50 00*
				$313 27	$300 00

* Double application of fertilizers and manure for mustard.

Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for ten years, the several plots having been every year manured alike, as described under the "Soil test with corn." The previous crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes and onions. The land was ploughed in the fall of 1898 and reploughed early this past spring. Fertilizers were employed this year in the same quantities as last, viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together. The west half of each plot was limed, as has been stated, at the rate of 1 ton per acre.

The seed was sown in the customary manner, but more thickly, on April 28. Germination was prompt and perfect.

The development upon the several plots and upon the unlimed and limed sections of all the plots exhibited the most remarkable differences.

1. Many of the plants upon the nothing plots soon died, and those remaining made practically no growth. The limed halves of these plots throughout the first half of the season were even worse in these respects than the unlimed.

2. The application of no single element without lime gave a good growth; but the plants upon the dissolved bone-black (without lime) did best. With lime the growth was more feeble than without it on the dissolved bone-black plot. On the plot on which muriate of potash was used without lime most of the plants soon died, while on this fertilizer alone and lime there was a rank growth, though few ripe bulbs were harvested. Nitrate of soda with lime gave better growth than without, but both with and without growth was very feeble.

3. On nitrate of soda and muriate of potash without lime almost all plants died; with lime there was a rank growth; but the bulbs did not ripen well.

4. On nitrate of soda and dissolved bone-black without lime was the best growth on the unlimed portion of the field. As last year, the development upon these two fertilizers alone was much better than on the plot where they were employed in the same amounts with muriate of potash. The growth upon the limed portion of the plot receiving the nitrate and bone-black was not materially improved, while where the muriate of potash was used with these fertilizers liming influenced the growth most favorably.

5. Liming proved highly favorable on the plot where dissolved bone-black and muriate of potash were used, this portion of that plot ranking third in the field in appearance throughout the season, while there was little growth upon the unlimed portion.

The Effect of the Fertilizers.

The tables give the results of the harvest: —

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Pounds, including Tops.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing, ...	2,950	3,180	-	-
Plot 2,	Nitrate of soda, ...	4,470	9,700	356.67	5,046.67
Plot 3,	Dissolved bone-black, . .	2,950	2,570	—2,323.33	—2,836.67
Plot 4,	Nothing, ...	6,440	6,520	-	-
Plot 5,	Muriate of potash, . . .	3,270	24,740	—2,510	18,467.50
Plot 6,	Nitrate of soda and dissolved bone-black.	17,410	17,380	12,290	11,355
Plot 7,	Nitrate of soda and muriate of potash.	1,440	25,030	—3,020	19,252.50
Plot 8,	Nothing, ...	3,800	5,530	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	11,090	19,510	7,680	13,815
Plot 10,	Nitrate of soda, dissolved bone-black and muriate of potash.	13,770	22,730	10,750	16,870
Plot 11,	Plaster, ...	1,550	1,610	—1,080	—4,415
Plot 12,	Nothing, ...	2,240	6,190	-	-

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Bushels of 52 Pounds of fairly cured Onions.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing, ...	2.69	4.42	-	-
Plot 2,	Nitrate of soda, ...	18.65	91.43	15.13	79.77
Plot 3,	Dissolved bone-black, . .	6.53	12.31	2.17	—6.60
Plot 4,	Nothing, ...	5.19	26.15	-	-
Plot 5,	Muriate of potash, . . .	3.07	161.75	—1.54	137.90
Plot 6,	Nitrate of soda and dissolved bone-black.	143.10	200.00	139.06	178.46
Plot 7,	Nitrate of soda and muriate of potash.	3.07	145.40	—.39	121.55
Plot 8,	Nothing, ...	2.88	16.93	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	40.38	183.88	37.21	163.50
Plot 10,	Nitrate of soda, dissolved bone black and muriate of potash.	46.15	224.60	42.69	200.94
Plot 11,	Plaster, ...	4.04	6.35	.29	—20.68
Plot 12,	Nothing, ...	4.04	30.39	-	-

The Results and Conclusions based thereon in 1898.

In 1898 also the crop upon this field was onions, and it is desirable to present the leading statements and conclusions published that year for the purpose of comparison. The manuring was the same as this year, save that no lime was used. I quote from my last annual report: —

The results show that this [phosphoric acid, — dissolved bone-black] more than either the nitrogen or the potash supply controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

Conclusions (based upon Results in 1899).

1. A study of the tables giving the results of this year affords convincing presumptive evidence that the continued use of muriate of potash has so depleted this soil of lime that its use for the onion crop is a necessity. The suspicion of last year, just quoted, is apparently confirmed. The results obtained in two series of pot experiments (not yet fully worked up), in which soil from two plots in this field was used, force me, however, to look upon this conclusion as in a measure tentative; for in the pot experiments other alkalies proved almost, if not quite, as beneficial as lime, indicating that the presence of free acid in the soil may have been the cause of the poor growth upon most of the plots of this field. Even this conclusion cannot, however, be looked upon as final, for the substitution of sulfate for the muriate of potash in the pots resulted in good growth without the addition of any alkali. A full discussion of the subject is reserved for some future article.

2. We are meanwhile justified in the statement that both field and pot experiments show that the muriate is an undesirable form in which to apply potash for this crop, though the bad influence of the chlorine which it contains may possibly be neutralized by application of lime.*

3. The remarks of last year may in conclusion be appropriately quoted: —

The Proper Course as regards Potash Supply.

What, then, in view of our results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions, viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulfate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulfate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, sup-

* It is believed that the influence of the lime will be even more marked another year. It was applied, it will be remembered, this spring. Its action, as was anticipated, was not sufficiently prompt to prevent much injury to the onions, because of faulty soil conditions in the early part of the season. We have accordingly failed to produce a good yield on any plot this year.

ply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Manure Alone *v.* Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–96, and in 1895 a general summary of the results up to that date was given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field was kept in grass two years, and was manured as usual in 1898. It includes four plots, of one-fourth an acre each. The average results while in grass are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): per acre, hay, 5,662 pounds; rowen, 3,218 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): per acre, hay, 4,540 pounds; rowen, 2,633 pounds.

The sod was turned in the autumn of 1898 and was manured this spring, as shown below: —

Plot 1, manure, 1½ cord; weight, 8,825 pounds.

Plot 2, { manure, 1 cord; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds. }

Plot 3, manure, 1½ cord; weight, 8,840 pounds.

Plot 4, { manure, 1 cord; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds. }

The crop this year has been corn (Sibley's Pride of the North), and its development appears to have been normal in all respects. The crop was a heavy one on all plots.

Yield per Plot.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1,	1,331	1,260
Plot 2,	1,331	1,160
Plot 3,	1,341	1,170
Plot 4,	1,355	1,110

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	66.8	4,860
Plots 2 and 4 (manure and potash),	67.2	4,540

It will be noticed that the crops are of practically equal value, — a little more grain on the manure and potash and a little more stover on the larger quantity of manure alone. The manure and potash used cost per acre nearly $7 less than the larger amount of manure used alone.

We have now grown seven corn crops on this field, and the average yields are at the rate per acre for the two manurings : —

Average of Seven Crops.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone,	61.5	4,562
Lesser manure and potash,	56.7	4,168

At prices which have prevailed during the period covered by this experiment the total manurial application where the manure and potash have been used has cost at the rate of $75 per acre less than on the other plots. The manure alone, however, has produced yields excelling the lesser manure and potash for the entire period at rates per acre amounting to: shelled corn, 33.6 bushels; corn stover, 2,758 pounds; hay, 2,244 pounds; and rowen, 1,170 pounds. These products would have been worth $46.50. In using the large amount of manure alone, then, one would in effect, allowing the manure to cost $5 per cord on the land, have expended $75 for products worth but little more than one-half that sum.

When, further, we note that at present the lesser manure and potash is producing the larger crop of grain, the superior economy of the system is evident.

"Special" Corn Fertilizer *v.* Fertilizer richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average *"special" corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots, if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash,	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

The field was kept in grass for two years, the average yields being at the rates per acre: "Special" fertilizer: hay, 2,730 pounds; rowen, 1,122; fertilizer richer in potash: hay, 2,557.5 pounds; rowen, 1,149 pounds. The "special," it will be seen, gave yearly 172.5 pounds more hay but 27 pounds less rowen than the other fertilizer. The larger nitrogen application accounts for the excess in hay; the larger potash application to the other plot produces the more rowen. The stand of clover in the field was poor. It is believed that, had it been good, the differences in yield of rowen in favor of the fertilizer richer in potash would have been larger.

The sod was ploughed in the autumn of last year, fertilizers as usual applied and wheel-harrowed in this spring. The crop this year was corn, which made perfectly normal and good growth on all plots and gave a good yield.

Yield of Corn, 1899.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,257.5	1,090
Plot 2 (richer in potash),	1,141.0	1,140
Plot 3 (lesser potash),	1,168.5	1,120
Plot 4 (richer in potash),	1,200.5	1,120

Average Rates per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	60.7	4,420
Plots 2 and 4,	58.5	4,520

The crops this year are almost equal, — the "special" giving a little more than 2 bushels more grain; the fertilizer, richer in potash, 100 pounds more stover. The former gives somewhat the more valuable and the more profitable crop. The advantage, however, is insignificant, amounting to only 25 cents per acre.

The experiment has now been in progress nine years, and during seven of these years corn has been grown; on all plots five years and on two only of the plots two years. The averages for the seven years are given in the table: —

Average Yield Corn, Seven Years.

	Shelled Grain (Bushels per Acre).	Stover (Pounds per Acre).
"Special" fertilizer,	57.95	3,760
Fertilizer richer in potash,	50.41	4,033

During two years one-half this field was occupied by Japanese millet (*Panicum Italicum*). The average yields per year are shown in the table: —

Averages, Millet, Two Years.

	Millet Seed (Bushels per Acre).	Straw (Pounds per Acre).
"Special" fertilizer,	63.15	3,522
Fertilizer richer in potash,	66.55	3,735

It will be seen, then, that thus far the two systems of manuring stand nearly upon an equality. The fertilizer poorer in potash ("special") has given the more corn and the more hay. The other fertilizer, richer in potash, has given the more corn stover, rowen, millet seed and millet straw. At present the two stand practically equal, as shown by the corn crop of the past season, It is believed that by the frequent introduction of clover (of which we have not yet had a good catch) the fertilizer richer in potash will prove superior to the other.

Sulfate compared with Muriate of Potash for Various Crops. (Field B.)

This experiment has been in progress in its present essential features since 1893. From 1884 to 1889 the odd numbered plots, 11 to 21, were manured yearly at the rate of 200 pounds per acre of muriate of potash, while the even numbered plots received no potash. From 1889 to 1892 all plots were manured alike. Since 1892 each plot has received yearly bone meal at the rate of 600 pounds per acre, the odd numbered plots muriate of potash at the rate of 400 pounds, and the even numbered plots high-grade sulfate of potash at the same rate per acre. There are eleven plots, numbered 11 to 21. These plots have been used for a wide variety of crops during the seven years that the experiment has been continued. The crops during the past year have been sugar beets, sweet corn, cabbages, field corn and soy beans.

Sugar Beets (Sulfate v. Muriate of Potash).

Sugar beets of four varieties occupied plots 15 and 16. The yield on 15 (muriate of potash) amounted to 3,815 pounds (14.3 tons) per acre; the yield on 16 (sulfate of potash) amounted to 3,708 pounds (13.9 tons) per acre. Each variety was sampled and the value of the beets for sugar manufacture determined. With one exception the beets grown on the sulfate of potash showed considerably higher percentages of sugar and a juice of a higher degree of purity than those grown on the muriate. Though the latter gave a slightly higher yield, the sulfate produced more sugar and a juice offering less difficulties in manufacture. In the case of the one variety where the muriate gave the richer beet, it is believed that this was due to the fact that the sulfate beets selected for analysis were considerably larger than the others. The differences in quality between the beets grown on the two salts were not sufficiently great to materially affect their value for stock feeding.

Sweet Corn (Sulfate v. Muriate of Potash).

This crop (Moore's Concord) occupied plots 11 and 12. Our objects were: first, to study the effect of the two forms of potash on yield; second, to determine whether there was any difference in quality between the product of the two plots which would affect its value for the table; and, third, to determine whether there was any well-defined difference in composition of the entire plant (stalk and ear) which would affect the value for stock feeding.

1. *Product.* — The details concerning product are shown in the table : —

Sweet Corn.

	Weight of Entire Crop (Pounds).	Number of Ears.		Total Ears (Pounds).	Weight of Stover (Pounds).
		Large.	Small.		
Muriate of potash, . .	4,965	1,411	335	929.69	4,035.31
Sulfate of potash, . .	4,965	1,574	377	1,034.36	3,930.64

In the judgment of the men handling the crop, the plants stood slightly thicker on plot 12 than on plot 11, and it is likely that this accounts in large measure, if not entirely, for the greater number of ears on plot 12. It will be noticed that the total product was the same on the two plots.

2. *Quality for Table Use.* — Chemical examination of kernels of corn from the two plots showed no difference which can be regarded as significant ; in fact, the differences are probably within the limits of error. It therefore appears that the chlorine of muriate did not exert the depressing effect on sugar formation that is often noticed with other crops.

3. *The Food Value of the Entire Plant.* — Analyses of the product of the two plots revealed no differences in composition which would materially affect the feeding value.

Field Corn (Eureka for the Silo) (Sulfate v. Muriate of Potash).

This crop occupied plots 19 and 20, and on both made a fine growth, averaging 15 feet in height. The ears were small and in the milk when the crop was ensiled, September 28. The yields (obtained by weighing after partial wilting) were : —

Muriate plot, 6,145 pounds, at rate of 23 tons per acre.
Sulfate plot, 5,675 pounds, at rate of 21.2 tons per acre.

Feeding Value. — The crop from both plots was sampled for analysis. The results showed no important differences in the feeding value of the product on the two salts.

Maercker* has quoted Moser to the effect that corn raised on muriate of potash contains more protein, and therefore has a higher food value, than when grown on sulfate. Three experiments here, one in 1898 and the two this year, have not shown this to be the case. It would appear that the muriate of potash is equally as good for the corn crop as the sulfate.

Soy Beans (Sulfate v. Muriate of Potash).

Through accident the product of the soy bean plots was mixed; and I can only report that during the early part of the season the beans on the sulfate appeared much better than the others. Later this apparent superiority was lost in large measure, as judged after careful examination.

Cabbages (Sulfate v. Muriate of Potash).

This crop (Warren cabbage) occupied plots 13 and 14. The growth on the sulfate of potash was from the start much better than on the muriate, and this superiority was maintained throughout the season. The yield is shown in the table: —

	Number of Hard Heads, November 2.	Total Weight (Pounds).		Loose Leaves (Pounds).
		Hard Heads.	Soft Heads.	
Muriate of potash,	393	4,105	720	750
Sulfate of potash,	502	5,475	255	1,060

It will be noticed that the sulfate of potash plot gave much the larger and more valuable crop. It should be pointed out that, on account of difference of growth due to accidental conditions, the above table has been made to include the yield for only about one-ninth of an acre. The product of plot 14 sold at a price (5 cents per head) which would have made the product of one acre of such cabbages worth about $250, while the product of the other plot was worth only at the rate of about $200 per acre.

* Die Kalidungung, p. 252.

Comparison of Different Potash Salts. (Field G.)

The object in this experiment is to determine the relative manurial value for our various crops of the different prominent potash salts. The experiment was begun in 1898, the crop that year being the soy bean. The results were indecisive and unsatisfactory, the crop where no potash was used in numerous instances being as great as where potash manures were applied. The potash resources of the soil were clearly too large to allow satisfactory deductions to be made. This had, however, been anticipated. From the nature of the problem it was recognized that the experiment must continue for a series of years. We must study not simply the immediate effect upon the crop, but the effect upon the soil of long-continued use of the different salts, — and as well the effect upon the crop of such continued use.

In this experiment the plots are one-fortieth of an acre each, duly separated by dividing strips. There are forty plots, each manuring being five times duplicated. Every plot receives yearly materials estimated to furnish nitrogen and phosphoric acid in liberal amounts. All receive the same materials, save plots 6, 14, 22, 30 and 38, on which the potash salt used is the nitrate, so that the amount of nitrate of soda for these is made only sufficient (.5 pounds) to furnish to these plots the same amount of nitrate nitrogen as to the others. With this exception, the materials applied as sources of nitrogen and phosphoric acid are, per plot: —

	Pounds.
Nitrate of soda,	7.0
Tankage,	7.5
Acid phosphate,	10.0

In order to make certain that there should be no failure through deficiency of lime, the entire field received an application at the rate of one ton to the acre of lime freshly slacked, which was wheel-harrowed in early in the spring of 1898.

The various potash salts where used were applied in amounts intended to furnish an equal quantity of actual potash (K_2O) to each plot, as follows: —

		Pounds.
Plot 1.	No potash.	
Plot 2.	Kainite,	27.75
Plot 3.	High-grade sulfate of potash,	7.50
Plot 4.	Low-grade sulfate of potash,	15.00
Plot 5.	Muriate of potash,	7.50
Plot 6.	Nitrate of potash,	8.25
Plot 7.	Carbonate of potash-magnesia,	20.00
Plot 8.	Silicate of potash,	17.00

Plots 9–16, 17–24, 25–32 and 33–40 are duplicates respectively of plots 1–8.

The crop this year (the second of the experiment) was potatoes, Beauty of Hebron, seed from Maine. It was planted in drills, one set (2–3 eyes) in 14 inches. The tubers were subjected to the formalin treatment, to prevent scab, being soaked two hours in a solution of eight ounces to 15 gallons of water. They were budded in a light room after treatment, before being planted on May 8–9. The crop was well cared for, and sprayed repeatedly with Bordeaux mixture, to prevent blight, of which there was little. The yield was heavy, varying from 297 to 380 bushels of merchantable potatoes per acre on the different potash salts. The results are not entirely conclusive, for the reason that in duplicate plots the yields of the different salts do not occupy the same relative rank. Thus, for example, the various salts made the following relative yields in merchantable tubers : —

Kainite stands : —
1st, once ; 3d, once ; 6th, twice ; and 7th, once.
High-grade sulfate of potash stands : —
1st, twice ; 2d, twice ; and 3d, once.
Low-grade sulfate of potash stands : —
2d, twice ; 3d, once ; 6th, once ; and 7th, once.
Muriate of potash stands : —
1st, once ; 4th, twice ; 5th, once ; and 6th, once.
Nitrate of potash stands : —
Once each : 3d, 4th, 5th, 6th and 7th.
Carbonate of potash-magnesia stands : —
1st, twice ; 3d, twice ; and 5th, once.
Silicate of potash stands : —
4th, twice ; 6th, twice ; and 7th, once.

With such variations in relative standing, it will be agreed we must interpret results with caution. Still, it is believed that the average yield of the different salts should be published as a matter of record : —

Average Yield of Plots.

PLOTS.	Pounds per Plot.		Bushels per Acre.	
	Large.*	Small.	Large.*	Small.
No potash, ...	430.70	61.00	287.13	40.66
Kainite, ...	488.45	52.60	326.83	33.86
High-grade sulfate, ...	525.70	52.95	350.46	35.49
Low-grade sulfate, ...	508.20	55.70	338.79	37.13
Muriate, ...	506.30	61.40	337.53	40.93
Nitrate, ...	498.20	64.75	332.13	43.16
Carbonate, ...	518.00	64.80	345.33	43.39
Silicate, ...	492.40	56.00	328.26	38.39

* Two ounces or over.

Conclusions.

1. It will be noticed that the soil is potash hungry, for every one of the salts used increases the yield.

2. The high-grade sulfate of potash stands first. It has with rare exceptions been found more effective in increasing the yield than the muriate, with which it has been frequently compared, and it gives better quality. We are justified in the conclusion that the application of potash in this form for the potato will give good results. It should be pointed out that our soil is moderately heavy and retentive. On drier sorts the muriate may compare with the sulfate more favorably.

3. The comparatively new carbonate of potash-magnesia ranks second. It is as carbonate that potash exists in wood ashes, which, however, are believed to favor some forms of scab. The fertilizer did not have that effect. This appears to be, then, a very useful form of potash. In mechanical condition it leaves nothing to be desired, being fine and remaining dry under all conditions of weather. The price is at present too high to allow its general use.

4. The low-grade sulfate of potash ranks third; but, as freights cost more per unit of potash for this salt than for the high grade, the latter is generally to be preferred. It is not impossible that in some localities the magnesia of the low-grade sulfate may prove useful; but we have no evidence that such is the case here.

5. The kainite ranks lowest among all the salts employed. Since this, containing only about 13 per cent. of actual potash, can be purchased at a much lower ton price than the purer salts, such as the high-grade sulfate and the muriate, it is sometimes selected by farmers. It should be remembered that the unit of potash on the farm usually costs more in the kainite than in the others. In view of our results, then, I can see no reason for selecting this potash fertilizer.

6. The silicate of potash gives the next lowest crop. It is apparently slowly available. The present cost is high, and it can be kept from caking only by admixture with powdered peat or similar material. It is prepared especially for use on tobacco, for which crop it is under trial in Germany and in this country. I judge it will have no application for ordinary crops; and its usefulness for tobacco is not fully demonstrated, though some favorable results have been obtained.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulfate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have re-

* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

ceived no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6 and 8), sulfate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past four seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulfate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulfate of ammonia. The entire field received at the rate of 1 ton per acre of partially air-slacked lime in the spring of 1898, in addition to the usual fertilizers.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the average in the following order: nitrate of soda, farm-yard manure, dried blood and sulfate of ammonia.

The crop in 1898 was oats. After harvesting them, the land was ploughed and sown to what was supposed to be mammoth red clover in August. The variety appears to be the common red. This went into the winter in excellent condition, but was somewhat winter-killed on all plots, apparently for reasons unconnected with the manures which had been employed. The injury was most severe on plots 0, 5 and 8, and least on plot 5. Between the other plots there was little difference in the degree of injury, if we except plot 6, on which it was greater than on the others. Seed was sown on the surface this spring where needed. This germinated well, but the young plants made little growth, on account of the dry weather. Two crops were cut, the first on July 3. The plants at this time had ceased growth, on account of drought. Not all had blossomed, yet the condition must be classed as mature. The yield was seriously decreased by the dry weather. The second crop was cut August 21, being somewhat mixed with annual grasses, but apparently to equal degree in all plots. The hay was secured in good condition, being cured mostly in the cock. The table shows the fertilizer treatment and the yields of the several plots: —

Nitrogen Experiment, — Fertilizers used and Yield of Clover.

Plots.	FERTILIZERS.	Pounds.	Clover Hay (Pounds).	Clover Rowen (Pounds).	Total (Pounds).
Plot 0,	Barn-yard manure, Potash-magnesia sulfate, Dissolved bone-black,	800.0 32.0 18.0	220.0	288.3	508.3
Plot 1,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	200.0	243.8	443.8
Plot 2,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	220.0	202.6	422.6
Plot 3,	Dried blood, Muriate of potash, Dissolved bone-black,	43.0 25.0 50.0	120.0	225.8	345.8
Plot 4,	Muriate of potash, Dissolved bone-black,	25.0 50.0	140.0	196.8	336.8
Plot 5,	Ammonium sulfate, Potash-magnesia sulfate, Dissolved bone-black,	22.5 48.5 50.0	140.0	202.1	342.1
Plot 6,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	140.0	235.6	375.6
Plot 7,	Muriate of potash, Dissolved bone-black,	25.0 50.0	180.0	162.9	342.9
Plot 8,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	200.0	207.5	407.5
Plot 9,	Muriate of potash, Dissolved bone-black,	25.0 50.0	215.0	206.5	421.5
Plot 10,	Dried blood, Potash-magnesia sulfate, Dissolved bone-black,	43.0 48.5 40.0	215.0	241.5	456.5

It is perhaps questionable whether much weight should be attached to the yields at the first cutting, since full development was not reached on account of drought. The rowen gives a better basis for comparison. Studying these figures, we find the following points bearing upon the problem on which the experiment seeks to shed light: —

1. *The various materials furnishing nitrogen rank in the following order: manure, dried blood, nitrate of soda and sulfate of ammonia.*

2. *The plots receiving no nitrogen approach in average yield much more closely to those getting this element than has been the case with any previous crop on this land. This must be regarded as highly significant, for it will be remembered that this field has been under experiment for eleven years, and in all that time these plots have received no nitrogenous manure or fertilizer of any kind. The clover must, it seems evident, have drawn from the air for this element, in which, as is well known, it is especially rich.*

Fertilizers for Garden Crops. (Field C.)

This series of experiments was begun in 1891, and has for its objects to test the relative value for garden crops: (1) of sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen; and (2) of muriate and sulfate as sources of potash. For full details concerning the methods followed and earlier results, reference is made to my eleventh annual report. It should, however, be pointed out here that partially rotted stable manure has been applied in equal amounts to all the plots for the last two years. The amount of such manure used this year was 7,200 pounds per plot. The fertilizers used were as follows: —

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulfate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulfate of ammonia,	38
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulfate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre : phosphoric acid, 50.4 pounds ; nitrogen, 60 pounds ; potash, 120 pounds. For purposes of comparison, I quote from my last annual report : —

Conclusions based on Results up to 1897. (Fertilizers Alone.)

The chief conclusions which seemed justified by the results with fertilizers alone are the following : —

1. Sulfate of potash in connection with nitrate of soda (plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with the muriate or the sulfate of potash.

3. The combination of sulfate of ammonia and muriate of potash (plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1899.

The crops on each plot this year included the following : fruiting strawberries, celery (following the strawberries), cabbages, squashes, spinach, lettuce, table beets, onions and freshly set strawberries. Both manure and fertilizers were spread on after ploughing this spring and harrowed in.

Strawberries : — The vines of the fruiting beds were set in the spring of 1898. They all made good growth, but were somewhat winter-killed, apparently because covered rather too heavily. The injury was not very materially different on the different plots, but was judged to have been somewhat most serious on plots 0 and 2 and least on plot 4. Picking began on June 15 and ended on July 12. Plot 0 (manure alone) much exceeded the others in yield of ripe fruit at first, and in aggregate yield was excelled by but two of the plots. The total yields in pounds per plot were as follows : plot 0, 126.6 pounds ; plot 1, 94.7 pounds ; plot

2, 96.6 pounds; plot 3, 155.1 pounds; plot 4, 172.3 pounds; plot 5, 108.1 pounds; plot 6, 103.3 pounds.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (plot 0),	126.6
Average of manure and muriate of potash (plots 1, 2 and 3),	115.4
Average of manure and sulfate of potash (plots, 4, 5 and 6),	128.8
Average of manure and sulfate of ammonia (plots 1 and 4),	161.9
Average of manure and nitrate of soda (plots 2 and 5),	102.3
Average of manure and dried blood (plots 3 and 6),	129.2

It will be noticed that but two of the combinations of fertilizers used with the manure excel the manure alone, viz., sulfate of ammonia and sulfate of potash, and dried blood and muriate of potash. Nitrate of soda, which we have found the best source of nitrogen for most crops, makes the poorest showing. Between the muriate and sulfate of potash there seems to be no clearly defined difference. These results were doubtless in part determined by the degree of winter injury.

Celery. — This crop followed the strawberries without extra manuring. The share of the stable manure belonging to the fruiting strawberry area was, however, applied when the strawberry vines were turned in. The yields of the several plots in pounds were as follows: plot 0, 720.8; plot 1, 250; plot 2, 550; plot 3, 510; plot 4, 190; plot 5, 585; plot 6, 550.

The average yields in pounds produced by the different fertilizers were: —

Manure alone,	720.8
Manure and muriate of potash (plots 1, 2 and 3),	436.7
Manure and sulfate of potash (plots 4, 5 and 6),.	441.7
Manure and sulfate of ammonia (plots 1 and 4),	220.0
Manure and nitrate of soda (plots 2 and 5),	567.5
Manure and dried blood (plots 3 and 6),	530.0

* To enable the reader to better make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulfate of potash," etc. It should be remembered that dissolved bone-black was applied to all except plot 0, and that every plot except plot 0 received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 35.

It will be noted that the manure alone gave much the largest crop.* Discussion as to the effect of the fertilizers, then, hardly seems called for. It is not without interest, however, to note that the crops where sulfate of ammonia was employed were much the smallest in the field. The result last year was similar in this respect.

Hanson Lettuce. — In harvesting this crop the heads of market size were cut from day to day. The total yields per plot in pounds were: plot 0, 83.1; plot 1, 54.75; plot 2, 129.25; plot 3, 150.50; plot 4, 88.5; plot 5, 148; plot 6, 122.25.

The average yields in pounds on the different fertilizers were: —

Manure alone (plot 0),	83.1
Manure and muriate of potash (plots 1, 2 and 3),	111.5
Manure and sulfate of potash (plots 4, 5 and 6),	119.6
Manure and sulfate of ammonia (plots 1 and 4),	71.6
Manure and nitrate of soda (plots 2 and 5),	138.6
Manure and dried blood (plots 3 and 6),	136.4

The sulfate of potash proves somewhat superior to the muriate; but the most marked result is the highly unfavorable influence of the sulfate of ammonia. This, as in previous years, in combination with the muriate of potash acts as a plant poison.

Spinach. — This, like the lettuce, was cut from time to time as it became ready for market. The yields in pounds of the several plots were: plot 0, 83.8; plot 1, 3; plot 2, 36.8; plot 3, 46.5; plot 4, 42; plot 5, 75.25; plot 6, 56.5.

The averages on the several fertilizers in pounds were: —

Manure alone (plot 0),	83.8
Manure and muriate of potash (plots 1, 2 and 3),	28.8
Manure and sulfate of potash (plots 4, 5 and 6),	57.9
Manure and sulfate of ammonia (plots 1 and 4),	22.5
Manure and nitrate of soda (plots 2 and 5),	56.0
Manure and dried blood (plots 3 and 6),	51.5

It is noticeable that manure alone produces a considerably larger crop than manure with any combination of fertilizers.

* In explanation of this fact, it should be pointed out that plot 0 previous to 1898 had entirely different manuring and cropping from the other plots. See last annual report. It is not believed that the fertilizers were injurious, as a rule.

The most marked effect is the injurious influence of the sulfate of ammonia.

Onions. — The yields of the several plots are shown in the table: —

PLOTS.	Well-cured Onions (Pounds).	Well-formed Onions, but not cured (Pounds).	Scallions (Pounds).
Plot 0,	1,334.5	26.5	13.0
Plot 1,	214.8	108.5	108.3
Plot 2,	1,174.0	75.0	24.0
Plot 3,	761.5	184.0	157.0
Plot 4,	632.7	248.5	93.0
Plot 5,	1,415.8	81.0	17.0
Plot 6,	929.3	243.8	79.8

The averages on the several fertilizers were: —

	Merchantable (Pounds).	Green (Pounds).	Scallions (Pounds).
Manure alone (plot 0),	1,334.5	26.5	13.0
Manure and muriate of potash (plots 1, 2 and 3),	716.8	122.5	96.4
Manure and sulfate of potash (plots 4, 5 and 6),	992.6	191.1	63.3
Manure and sulfate of ammonia (plots 1 and 4),	423.7	178.5	100.6
Manure and nitrate of soda (plots 2 and 5),	1,294.9	78.0	20.5
Manure and dried blood (plots 3 and 6),	845.4	213.9	118.9

It becomes evident from these figures (1) that none of the fertilizer combinations except one (nitrate of soda and sulfate of potash) benefited the crop, (2) that the sulfate is much superior to the muriate as a source of potash, and (3) that the nitrate of soda is much the best source of nitrogen.

Table Beets. — With this crop the manure alone gave much the best yields, and the several fertilizer combinations failed to produce effects sufficiently marked to warrant discussion. The details, therefore, will not be given.

Cabbages. — But one plot in this crop gave a yield excelling the manure alone, and that was the one receiving, in addition to manure, sulfate of ammonia and muriate of potash. The yields in hard heads in pounds were as follows:

plot 0, 375.1; plot 1, 420; plot 2, 377.5; plot 3, 337.5; plot 4, 347.5; plot 5, 207.5; plot 6, 320.

The averages on the several fertilizers in pounds were: —

	Hard Heads.	Soft Heads.
Manure alone (plot 0),	375.1	223.9
Manure and muriate of potash (plots 1, 2 and 3),	378.3	29.2
Manure and sulfate of potash (plots 4, 5 and 6),	291.7	29.2
Manure and sulfate of ammonia (plots 1 and 4),	383.7	12.5
Manure and nitrate of soda (plots 2 and 5),	292.5	52.5
Manure and dried blood (plots 3 and 6),	328.6	22.5

So far as results justify conclusions, it would seem (1) that the muriate shows itself superior to the sulfate of potash for this crop *when used with stable manure*, and (2) that the sulfate of ammonia is the best source of nitrogen for it. That the sulfate of ammonia should prove the most useful form of nitrogen supply with a crop making most of its growth in the latter part of the season we have before observed.*

In other experiments with cabbages this year, where fertilizers alone were used, the sulfate of potash gave much larger yields than the muriate.† Here this is reversed. I have at present no explanation to offer for this difference.

Squashes. — This crop gave much the best yield on manure alone, and the differences apparently produced by the several fertilizers are not significant. The sulfate gives larger yields than the muriate of potash in every case, while the sulfate of ammonia makes the lowest showing among the fertilizers supplying nitrogen. The details will not be given.

Variety Tests with Potatoes.

The number of varieties tested this year was 94. The seed used was all of our own raising. It was produced under conditions similar in every respect and had been similarly preserved. Of each variety, with a few exceptions later noted, 80 sets were planted at the distance of 1 foot

* See eleventh annual report. † See page 28.

in drills 3 feet apart. One-half of these were harvested at early market maturity (August 1), the balance at full maturity (September 22–23).

The soil was a medium loam, in mixed grass and clover for the two preceding years. It received an application of farm manure at the rate of about 5 cords per acre on the sod early this spring, and was then ploughed. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulfate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were thoroughly mixed and scattered widely in the open furrow before dropping the seed. The seed potatoes were first washed and then treated in formalin solution (8 ounces to 15 gallons water) for two hours. The tubers were budded in a light room after treatment. The planting was done May 4 and 5. The crop was well cared for, and sprayed six times with Bordeaux mixture, to prevent blight, of which, however, there was considerable. The development was normal, save for the blight; and the yields and quality for the most part good. There was practically no scab.

The tables give data for the earlier and the latter diggings: —

Variety Test Potatoes. Record to Aug. 1, 1899.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.*	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Abundance,	June 23,	July 22,	1/16	148.5	24.3
Acme,	June 23,	July 19,	1/2	244.0	24.3
Algoma,	June 28,	July 22,	1/4	154.5	40.9
American Beauty,	June 17,	July 22,	1/4	200.0	10.6
Arizona,	June 17,	July 18,	1/4	224.3	51.5
Bartlett,	June 28,	July 24,	1/16	181.8	36.4
Beauty of Hebron,	June 19,	July 24,	1/8	260.6	40.9

* Fractions indicate proportion of foliage destroyed.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Burpee's Superior,	June 23,	July 22,	⅛	236.4	39.4
Burr's No. 1,	June 19,	July 22,	¼	262.1	45.5
Cambridge Russet,	June 23,	July 18,	¼	166.7	24.3
Carmen No. 1,	June 19,	July 22,	⅝	295.5	30.3
Champion of the World,	June 19,	July 22,	⅛	206.1	31.8
Clay Rose,	June 17,	July 18,	¼	239.4	39.4
Commercial,	June 28,	July 22,	¼	209.1	12.1
Country Gentleman,	June 19,	July 22,	⅛	251.5	33.3
Dakota Red,	June 30,	July 18,	½	184.9	27.3
Dreer's Standard,	June 23,	July 22,	¼	272.8	21.2
Dutton's Seedling,	June 19,	July 22,	⅛	298.5	36.4
Early Kansas,	June 19,	July 22,	⅛	298.5	33.3
Beauty of Hebron,	June 19,	July 24,	Trace.	287.9	31.8
Early Minnesota,	June 28,	July 18,	⅜	190.9	27.3
Early Roberts,	June 19,	July 22,	⅜	300.0	63.6
Early Rochester,	June 19,	July 22,	⅜	230.3	15.2
Early Rose,	June 19,	July 18,	½	263.6	51.5
Early Sunrise,	June 19,	July 18,	¼	221.2	51.5
Extra Early Vermont,	June 19,	July 15,	⅜	266.7	42.4
Empire State,	June 28,	July 22,	¼	148.5	24.3
Enormous,	June 19,	July 22,	⅛	275.8	9.1
Everett,	June 19,	July 15,	½	207.6	45.5
Fillbasket,	June 17,	July 20,	1/16	223.0	51.5
Garfield,	June 19,	July 22,	⅛	193.9	33.3
German Queen,	June 19,	July 22,	¼	213.7	24.3
Good Times,	July 6,	July 29,	Trace.	151.5	21.2
Governor Rusk,	June 28,	July 20,	⅜	236.4	9.1
Green Mountain,	June 23,	July 24,	⅛	127.3	18.2
Howard,	June 19,	July 24,	⅛	275.8	33.3
Hurst,	June 28,	July 15,	¾	–	–
Mill's Longkeeper,	June 23,	July 20,	¼	–	–
Irish Cobbler,	June 17,	July 20,	⅜	260.6	30.3
Joseph,	July 6,	July 24,	¼*	169.7	28.8
King of the Earliest,	–	July 22,	⅜	265.2	24.3
King of Roses,	June 19,	July 22,	¼	209.1	54.6
Lakeside Champion,	June 19,	July 20,	⅜	245.5	39.4

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Late Puritan,	June 23,	July 24,	1/8	224.3	48.5
Lee's Favorite,	June 19,	July 22,	1/4	278.8	47.0
Leonard Rose,	June 19,	July 20,	1/4	239.4	42.4
Lincoln,	June 19,	July 29,	1/8	212.1	37.9
Maule's Thoroughbred,	June 19,	July 22,	3/16	260.6	48.5
Mayflower,	-	July 22,	1/4	124.3	42.4
Mill's Banner,	June 23,	July 29,	Trace.	112.1	15.2
Mill's Prize,	June 28,	July 22,	Trace.	154.5	18.2
Mouey Maker,	June 23,	July 22,	1/8	145.5	12.1
Montana Wonder,	June 17,	July 22,	3/8	260.6	33.3
New Satisfaction,	June 19,	July 22,	1/4	190.9	18.2
Parker's Market,	June 23,	July 22,	1/2	218.2	30.3
Penn Manor,	June 19,	July 22,	3/8	284.9	39.4
Pingree,	June 23,	July 22,	1/4	190.9	37.3
Prince Bismark,	June 19,	July 22,	3/8	269.7	21.2
Prize Taker,	June 23,	July 22,	1/2	244.0	25.8
Early Potentate,	-	July 20,	1/2	187.9	30.3
Pride of Michigan,	June 19,	July 22,	1/4	209.1	50.0
Prolific Rose,	June 19,	July 22,	1/8	257.6	51.5
Quick Crop,	June 19,	July 22,	1/8	221.2	54.6
Reeve's Rose,	June 19,	July 22,	1/8	187.9	36.4
Restaurant,	June 23,	July 24,	1/16	212.1	36.4
Rochester Rose,	June 19,	July 22,	1/8	212.1	48.5
Rose of Erin,	June 28,	July 22,	1/4	221.2	9.1
Rose No. 9,	June 28,	July 22,	1/8	106.1	53.0
Secretary Wilson,	June 19,	July 22,	3/8*	266.7	60.6
Seneca Beauty,	June 19,	July 24,	1/8	209.1	24.3
Sir Walter Raleigh,	July 6,	July 29,	Trace.	148.5	21.2
Sir William,	June 19,	July 22,	3/8	181.8	21.2
Signal,	June 19,	July 22,	3/8	251.5	45.5
Somerset,	-	July 22,	1/8	169.7	18.2
State of Maine,	June 19,	July 24,	1/8	221.2	24.3
State of Wisconsin,	June 19,	July 22,	1/8	121.2	37.3
Table King,	June 23,	July 22,	3/8	230.3	25.8
Thorburn,	June 19,	July 24,	1/8	218.2	48.5
Tonhocks,	June 23,	July 22,	1/8	218.5	37.9

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre. Large, Two Ounces (Bushels).	Small (Bushels).
Uncle Sam,	June 19,	July 22,	1/4	293.9	12.1
Vanguard,	June 19,	July 22,	1/8	277.6	34.9
Vick's Perfection,	June 19,	July 22,	1/8	284.9	39.4
Victory, P. and W.,	June 19,	July 22,	1/16	278.8	36.4
Vigorosa,	June 19,	July 24,	1/8	294.0	40.9
Washington,	June 23,	July 24,	1/16	240.9	28.8
White Elephant,	June 19,	July 29,	1/16	218.2	31.4
White Ohio,	June 23,	July 22,	1/4	230.3	24.3
White Peachblow,	June 23,	July 24,	1/16	125.9	42.4
Wisconsin Beauty,	June 19,	July 22,	1/4	251.5	25.8
Woodbury's White,	June 23,	July 22,	1/16	133.3	31.8
Early Andees,	June 23,	July 22,	1/4	–	–
Early Dawn,	June 28,	July 20,	1/4	–	–
Salzer's Earliest,	June 28,	July 15,	7/8	–	–
Triumph,	June 28,	July 15,	15/16	–	–

Variety Test Potatoes. Final Records.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23. Large, Two Ounces or Above (Bushels).	Small (Bushels).
Abundance,	–	Sept. 6,	230.3	21.2
Acme,	Aug. 12,	Aug. 14,	230.3	18.2
Algoma,	Aug. 12,	Aug. 24,	200.0	42.4
American Beauty,	Aug. 12,	Aug. 24,	266.7	12.1
Arizona,	Aug. 14,	Aug. 24,	236.4	30.3
Bartlett,	–	Sept. 5,	330.0	28.8
Beauty of Hebron,	Aug. 24,	Sept. 5,	342.5	48.5
Burpee's Superior,	–	Sept. 5,	266.7	30.3
Burr's No. 1,	Aug. 12,	Aug. 29,	351.5	36.4
Cambridge Russet,	Aug. 12,	Aug. 24,	233.4	22.7
Carmen No. 1,	Aug. 12,	Aug. 24,	287.9	36.4
Champion of the World,	Aug. 24,	Sept. 5,	269.7	42.4
Clay Rose,	Aug. 20,	Aug. 30,	281.8	33.3

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Commercial,	Aug. 14,	Aug. 30,	197.0	3.0
Country Gentleman,	Aug. 20,	Aug. 30,	315.2	51.5
Dakota Red,	Aug. 19,	Aug. 24,	206.1	18.2
Dreer's Standard,	Aug. 20,	Aug. 30,	312.1	18.2
Dutton's Seedling,	Aug. 20,	Aug. 30,	363.7	60.6
Early Kansas,	Aug. 20,	Aug. 30,	330.3	30.3
Beauty of Hebron,	Aug. 24,	Sept. 5,	393.9	39.4
Early Minnesota,	Aug. 20,	Aug. 30,	278.8	12.1
Early Roberts,	Aug. 12,	Aug. 23,	315.2	54.5
Early Rochester,	Aug. 28,	Aug. 30,	278.8	21.2
Early Rose,	Aug. 20,	Aug. 30,	351.5	66.7
Early Sunrise,	Aug. 20,	Aug. 23,	309.1	75.8
Extra Early Vermont,	Aug. 12,	Aug. 23,	327.3	60.6
Empire State,	Aug. 12,	Aug. 30,	206.1	24.3
Enormous,	Aug. 12,	Aug. 30,	397.0	15.2
Everett,	Aug. 23,	Aug. 30,	215.2	66.7
Fillbasket,	Aug 20,	-	416.2	45.5
Garfield,	Aug. 20,	Aug. 30,	236.4	30.3
German Queen,	-	Aug. 30,	275.8	36.4
Good Times,	-	-	229.1	27.3
Governor Rusk,	Aug. 14,	Aug. 23,	275.8	9.1
Green Mountain,	-	-	242.5	24.3
Howard,	Aug. 12,	Aug. 30,	403.1	51.5
Hurst,*	-	Aug. 8,	193.7	38.2
Mill's Longkeeper,†	-	Sept. 5,	177.6	46.7
Irish Cobbler,	Aug. 12,	-	297.0	45.5
Joseph,	Aug. 12,	Aug. 30,	260.6	30.0
King of the Earliest,	Aug. 12,	Aug. 14,	263.6	51.5
King of the Roses,	-	-	327.3	54.5
Lakeside Champion,	-	Aug. 30,	254.6	45.5
Late Puritan,	Aug. 23,	-	336.4	39.4
Lee's Favorite,	Aug. 14,	Aug. 24,	290.9	66.7
Leonard Rose,	Aug. 22,	Sept. 5,	345.6	57.6
Lincoln,	-	Sept. 5,	357.6	30.3
Maule's Thoroughbred,	Aug. 14,	Sept. 5,	321.2	48.5

* Forty-one hills. † Thirty-nine hills.

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	YIELD AT RATE PER ACRE, SEPTEMBER 22 AND 23. Large, Two Ounces or Above (Bushels).	YIELD AT RATE PER ACRE, SEPTEMBER 22 AND 23. Small (Bushels).
Mayflower,	–	Sept. 5,	218.2	18.3
Mill's Banner,	–	Sept. 5,	272.8	10.6
Mill's Prize,	–	Sept. 5,	290.9	12.1
Money Maker,	–	Sept. 5,	287.9	21.2
Montana Wonder,	Aug. 12,	Aug. 23,	347.0	66.7
New Satisfaction,	Aug. 22,	Sept. 5,	297.0	30.3
Parker's Market,	Aug. 12,	Aug. 23,	234.9	30.3
Penn Manor,	Aug. 12,	Aug. 23,	339.4	60.6
Pingree,	Aug. 20,	Aug. 30,	303.0	24.3
Prince Bismark,	Aug. 12,	Aug. 23,	275.8	60.6
Prize Taker,	Aug. 14,	Sept. 5,	275.8	13.6
Early Potentate,	–	Aug. 23,	230.3	36.4
Pride of Michigan,	Aug. 12,	Aug. 23,	303.0	60.6
Prolific Rose,	Aug. 14,	Aug. 30,	351.5	97.0
Quick Crop,	Aug. 23,	Aug. 30,	309.1	66.7
Reeve's Rose,	Aug. 23,	Sept. 5,	345.5	54.6
Restaurant,	–	Sept. 5,	339.4	78.8
Rochester Rose,	Aug. 14,	Sept. 5,	303.0	72.7
Rose of Erin,	Aug. 14,	Aug. 20,	254.6	6.1
Rose No. 9,	Aug. 23,	Aug. 30,	236.4	34.9
Secretary Wilson,	Aug. 12,	Aug. 23,	290.9	54.6
Seneca Beauty,	–	Sept. 5,	345.5	60.6
Sir Walter Raleigh,	Aug. 23,	Sept. 5,	260.6	18.2
Sir William,	Aug. 14,	Sept. 5,	309.1	30.3
Signal,	–	Aug. 23,	284.9	54.6
Somerset,	–	Sept. 5,	278.8	18.2
State of Maine,	Aug. 23,	Sept. 5,	333.4	27.3
State of Wisconsin,	–	Sept. 5,	272.8	15.2
Table King,	Aug. 23,	Sept. 5,	300.0	27.3
Thorburn,	Aug. 12,	Aug. 24,	357.6	48.5
Tonhocks,	Aug. 23,	Sept. 5,	327.3	57.6
Uncle Sam,	Aug. 23,	Sept. 5,	330.3	36.4
Vanguard,	–	–	381.8	69.7
Vick's Perfection,	Aug. 12,	Aug. 30,	306.1	63.6
Victory, P. and W.,	Aug. 23,	Aug. 30,	321.2	48.5

Variety Test Potatoes, etc. — Concluded.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Vigorosa,	Aug. 23,	Aug. 30,	336.4	48.5
Washington,	Aug. 23,	Sept. 5,	404.6	22.7
White Elephant,	Aug. 23,	Sept. 5,	406.1	63.6
White Ohio,	Aug. 12,	Aug. 14,	272.8	48.5
White Peachblow,	Aug. 14,	Aug. 30,	321.2	60.6
Wisconsin Beauty,	Aug. 12,	Aug. 23,	257.6	48.5
Woodbury's White,	Aug. 23,	Sept. 5,	318.2	33.3
Early Andees,*	Aug. 10,	Aug. 14,	509.1	84.9
Early Dawn,*	Aug. 8,	Aug. 12,	509.1	72.7
Salzers' Earliest,*	–	Aug. 8,	434.4	36.4
Triumph,*	–	Aug. 5,	460.7	72.7

* 20 hills only grown.

Thirty-six varieties produce a yield of 55 pounds or over of large potatoes from forty hills when mature, this yield being at the rate of about 333 bushels per acre. These varieties are the following: Burr's No. 1, 351.5; Dutton's Seedling, 363.7; Beauty of Hebron, 393.9; Early Rose, 351.5; Enormous, 397; Fillbasket, 416.2; Howard, 403.1; Late Puritan, 336.4; Leonard Rose, 345.6; Lincoln, 357.6; Montana Wonder, 347; Penn Manor, 339.4; Prolific Rose, 351.5; Reeve's Rose, 345.5; Restaurant, 339.4; Seneca Beauty, 345.5; State of Maine, 333.4; Thorburn, 357.6; Vanguard, 381.8; Vigorosa, 339.4; Washington, 404.6; White Elephant, 406.1; Early Andees,* 509.1; Early Dawn,* 509.1; Salzer's Earliest,* 434.4; Triumph,* 460.7.

Eleven of these varieties gave at the earlier digging 40 pounds or over of large potatoes, which is at the rate of about 240 bushels per acre. These varieties are: Burr's No. 1, 262.1; Dutton's Seedling, 298.5; Beauty of Hebron, 287.9; Early Rose, 263.6; Enormous, 275.8; Howard, 275.8; Montana Wonder, 260.6; Penn Manor, 284.9; Prolific Rose, 257.6; Vanguard, 277.6; Vigorosa, 294.

* Quantity grown less than 40 sets

There were besides 19 other varieties giving the same or higher yield at the earlier digging. These varieties are: Carmen No. 1, 295.5; Country Gentleman, 251.5; Dreer's Standard, 272.8; Early Kansas, 298.5; Early Roberts, 300; Early Vermont, 266.7; Irish Cobbler, 260.6; King of the Earliest, 265.2; Lakeside Champion, 245.5; Lee's Favorite, 278.8; Maule's Thoroughbred, 260.6; Prince Bismarck, 269.7; Prize Taker, 244; Secretary Wilson, 266.7; Signal, 251.5; Tonhocks, 248.5; Vick's Perfection, 284.9; Victory, P. and W., 278.8; Wisconsin Beauty, 251.5.

It will be noticed that the old Beauty of Hebron and Early Rose are found in both lists, thus ranking still among the most productive sorts, whether for early or late harvest.

There is surely no lack of good varieties of potatoes to choose from, and between many there can be but little difference in value. A single test does not warrant general conclusions. Good northern-grown seed is in my opinion of more importance than name. It is, however, evident that there are a few varieties on our list which seem unworthy of further trial. Among varieties which have made good yields three or more years may be mentioned: Beauty of Hebron, Dutton's Seedling, Early Rose, Enormous, Fillbasket, Prolific Rose, Restaurant, State of Maine, Thorburn, Vanguard and White Elephant.

Experiments in manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and one-half and four acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring, — this year April 21 and 22.

Plot 1, which this year received barn-yard manure, applied Nov. 16, 1898, gave a yield at the rate of 2.095 tons of hay and 0.5 ton of rowen per acre; plot 2, which received bone and potash, yielded 2.289 tons of hay and 0.479 ton of rowen; plot 3, which received ashes this year, yielded 1.58 tons of hay and 0.33 ton of rowen per acre. The field has now been eleven years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,630 pounds per acre. The plots when dressed with manure have averaged 7,027 pounds per acre; when receiving bone and potash, 6,568 pounds per acre; and when receiving wood ashes, 6,294 pounds per acre.

Poultry Experiments.

In experiments completed since our last annual report our attention has been confined exclusively to one point, viz., the comparison of a wide nutritive ration with a narrow ration for egg-production; or, in other words, of a ration in which corn meal and corn were prominent with one in which these feeds were replaced with more nitrogenous foods, such as wheat middlings, wheat and oats. So much greater is the cost of wheat than that of corn, that it seemed desirable to obtain as much evidence bearing upon their relative value for egg-production as possible at an early day. If the latter grain should, on further trial, prove so much superior to wheat as our experiments in 1898 indicated, the knowledge of the fact must prove of enormous value. Accordingly, we reared on the scattered colony plan well-bred pullets of the White Wyandotte, Black Minorca and Barred Plymouth Rock breeds, planning to have two houses (one on each feed) with twenty fowls each of each breed. In introducing purchased cockerels for breeding purposes late in the winter we unfortunately carried contagion, and an obscure form of what is commonly called roup broke out in such aggravated form among the Black Minorcas, that, fearing infection of the fowls in other houses, we killed all the Minorcas. The test with this breed was not, therefore, at all conclusive, and details will not be published. Up to the time the test was closed, however, the corn-fed Minorcas had laid about fifty per cent. more eggs than the others.

General Conditions.

The pullets were first evenly divided into lots of twenty each, being matched in sets of two as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began October 15 and ended April 22. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. At noon a little millet was scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed at intervals of about two months. Sitters were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below : —

Wheat,	$1 60
Oats,	1 00
Millet,	1 00
Wheat bran,	85
Wheat middlings,	85
Gluten feed,	90
Animal meal,	1 75
Cut clover rowen,	1 50
Cabbage,	25
Corn meal,	90
Corn,	90

Narrow v. Wide Ration for Egg-production.

The experiments were in one sense continuous, as the same fowls were used throughout; but it is deemed best to report the results obtained during the cooler months and those of the warmer months separately, one being denominated the *winter experiment*, the other the *summer experiment*. These experiments have for their object testing the correctness of the generally accepted view that the laying fowl should receive feeds very rich in nitrogenous constituents (*i.e.*, should have rations with a narrow nutritive ratio). During the tests of the past year corn has been much more largely used than in 1898. Then it replaced about one-half of the oats and wheat usually fed at night; this year the fowls on the wide ration received at night only corn. The fowls on both rations have received cut clover and animal meal in equal proportions.

The health of the fowls on both rations has been uniformly good through both the winter and summer experiments. As last year, however, it is found to require the exercise of more care to avoid overfeeding and loss of appetite among the corn-fed hens.

Winter Experiment.

This experiment, as has been earlier stated, began October 25. This was much too early to make possible the showing of a good record for total eggs, since the pullets did not begin to lay to any extent until January. The facts that they had been at large until the experiment began, after which they were closely confined, and that, as will be remembered, November and December were very cold and stormy, perhaps in large measure account for this. All details necessary to a full understanding of the experiments and the results, it is believed, will be found in the tables: —

Foods consumed, Narrow v. Wide Ration, October 25 to April 27.

KIND OF FOOD.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds).
Wheat,	333.00	-	333.00	-
Oats,	55.00	-	60.00	-
Millet,	57.00	56.00	57.50	58.00
Wheat bran,	42.11	42.00	41.30	42.00
Wheat middlings,	42.11	-	41.30	-
Gluten feed,	42.11	-	41.30	-
Animal meal,	42.11	42.00	41.30	42.00
Cut clover rowen,	40.07	40.00	37.80	40.00
Corn meal,	-	111.00	-	111.00
Corn,	-	408.50	-	436.00
Cabbage,	152.38	145.63	152.63	190.75

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte. Narrow Ration.	White Wyandotte. Wide Ration.	Barred Plymouth Rock. Narrow Ration.	Barred Plymouth Rock. Wide Ration.
October 25,	4.3	4.3	4.9+	4.9
January 3,	4.6+	5.0+	5.1	5.6—
March 17,	4.6—	4.7+	5.4—	5.4+
April 27,	4.5—	4.3—	4.9—	4.9+

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

MONTHS.	White Wyandotte. Narrow Ration.	White Wyandotte. Wide Ration.	Barred Plymouth Rock. Narrow Ration.	Barred Plymouth Rock. Wide Ration.
October,	-	6	11	7
November,	1	7	18	44
December,	9	33	38	44
January,	50	193	27	83
February,	159	228	57	194
March,	213	177	121	216
April,	179	199	112	168
	611	843	384	755

Narrow v. Wide Ration for Egg-production, Winter Test.

	White Wyandotte. Narrow Ration.	White Wyandotte. Wide Ration.	Barred Plymouth Rock. Narrow Ration.	Barred Plymouth Rock. Wide Ration.
Total dry matter in foods (pounds),	604.47	635.97	603.13	661.52
Number of hen days, not including males,	3,560	3,560	3,424	3,554
Number of hen days, including males,	3,622	3,622	3,548	3,678
Gross cost of food,	$9 26	$7 30	$9 25	$7 68
Gross cost of food per egg (cents),	1.50	.90—	2.41	1.02
Gross cost of food per hen day (cents),	.26—	.20+	.26	.21
Number of eggs per hen day,	.17+	.24—	.11+	.21+
Average weight per egg (ounces),	1.91—	1.82+	1.76	2.09
Total weight of eggs (pounds),	72.90	95.90—	48.24	98.62
Dry matter consumed per egg (pounds),	.99—	.75+	1.57	.88
Nutritive ratio,*	1:4.80—	1:6.30	1:4.80	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment remained the same as in the winter, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week to the hens in all the houses the same, and (2) the feeding of cabbages was discontinued. The yards, twelve hundred square feet in area for each house, were kept fresh by frequent use of the cultivator and spade. The health of all the fowls was good throughout this experiment. The tables give all details: —

Foods consumed, Narrow v. Wide Ration, May 1 to September 27.

KIND OF FOOD.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds.)
Wheat,	273	-	237	-
Oats,	59	-	52.5	-
Millet,	10	10	8	11
Wheat bran,	56	49	40	42
Wheat middlings,	56	-	40	-
Gluten feed,	56	-	40	-
Meat meal,	56	49	40	42
Corn meal,	-	129.5	-	111
Corn,	-	368	-	300

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
April 27,	4.50	4.30 —	4.90 —	4.90
June 2,	4.14 —	4.41 +	4.86	4.80
August 11,	4.28	4.68 +	4.88	4.88
September 27,	4.53	4.79	4.70	4.91

Number of Eggs per Month, Narrow v. Wide Ration, Summer Test.

MONTHS.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
May,	162	181	124	177
June,	140	198	156	217
July,	164	213	140	215
August,	158	213	112	128
September (27 days),	107	110	87	76
	731	915	619	813

Narrow v. Wide Ration for Egg-production, Summer Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (per cent.),	510.41	534.22	412.44	446.35
Number of hen days, not including males,	2,945	2,913	2,400	2,555
Number of hen days, including males,	3,245	3,213	2,573	2,735
Gross cost of food,	$7 50	$5 86	$6 14	$4 91
Gross cost of food per egg (cents),	1.03	.64	1.00	.60
Gross cost of food per hen day (cents),	.23	.18+	.24	.18
Number of eggs per hen day,	.25—	.31+	.26—	.32—
Average weight per egg (ounces),	1.88	1.90	1.82	1.77
Total weight of eggs (pounds),	85.89	108.70	70.40	89.94
Dry matter consumed per egg (pounds),	.70	.58	.67	.55
Nutritive ratio,*	1:4.20	1:6.30	1:4.40	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that the results of this year's experiments are in every particular similar to those of the experiments carried out in 1898.

The following are the most essential facts: —

1. The wide (rich in corn) ration appears to be much superior to the narrower ration. In all experiments, both summer and winter, the hens receiving corn have laid many more eggs than those receiving wheat.

2. The differences this year in favor of the wide ration, upon the basis of an equal number of hen days, are as follows: —

White Wyandotte, winter test,	41 per cent.
White Wyandotte, summer test,	24 per cent.
Barred Plymouth Rock, winter test,	91 per cent.
Barred Plymouth Rock, summer test,	23 per cent.
Last year the winter difference was	25 per cent.
Last year the summer difference was	$33\frac{1}{3}$ per cent.

3. The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one dozen eggs the saving amounted to from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents.

4. The fowls on the wide ration gained more in weight than the others. Although laying many more eggs, they averaged at the end of the summer test nearly one-quarter of a pound each more than the others.

At the close of the summer experiment the fowls were most critically examined by a number of different parties, working independently, and all were unanimous in the conclusion that the corn-fed hens were farther advanced in the moult than the others. In my own opinion, the difference amounted to some two or three weeks in time. The corn-fed hens had shed all their old tail feathers, the others but few; the corn-fed hens had a large share of their new body feathers, the others had not shed the old. It was evident that the corn-fed hens were sure to begin laying again before the cold weather, while it seemed that the others were unlikely to do so. This judgment has been verified, for a small number of the corn-fed hens which were purchased by the writer have already laid one litter of eggs since October 1 and are beginning to lay a second, their plumage having been perfect for many weeks (December 20).

The great importance of an early moult in case hens are to be kept over is recognized by all. It makes all the difference between profit and a probable loss.

Our results with both breeds, both summer and winter, are thus greatly in favor of the ration richer in corn meal and corn. On its side we have: (1) lower cost of feed; (2) from 23 to 91 per cent. more eggs; (3) a far lower cost per egg, making possible a saving of from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents per dozen in the food cost of their production; (4) a greater increase in weight; and (5) a much earlier moult.

It may here be remarked, using the words employed by the writer in a recent article, "that nature is generally a safe guide; 'Biddy,' kept healthy and vigorous, will take corn always in preference to wheat. Man conceived the idea that wheat is better for large egg-production. He has been endeavoring to convince the hen that she doesn't know what is good for her; and now it seems that, after all, her instinct and not his supposedly scientific reasoning has been right."

The writer is aware that under different conditions other results might follow. It is here particularly pointed out that our fowls are given plenty of space and fresh air, and that they are made to scratch vigorously for their whole grain.

REPORT OF THE BOTANISTS.

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

The work of this division has gone on steadily during the past year, having been almost entirely along the line of vegetable physiology and pathology. A large amount of correspondence has been carried on, along with the work of investigation. A considerable part of the work has been in connection with the growing of green-house crops, as in past years, lettuce, cucumbers and tomatoes receiving especial attention. The investigations outlined in our last report have been continued, and results obtained which in several cases are nearly ready for publication. The only entirely new subject of importance which has been taken up is that of aster diseases, which is referred to more fully later in this report. A bulletin on "The asparagus rust in Massachusetts" has been issued, containing the results of the investigation of this subject up to 1899. A further consideration of the same subject will be found in the present report.

Aster Diseases.

General complaint has been made of late years in all parts of the country of the trouble in growing asters, and at present more or less complete failure is almost universal. We have therefore commenced an investigation of this subject, with a view to ascertaining the exact nature of the trouble, and what may be done to prevent it. A large number of asters were grown during the past season, and, with the experience already gained, it is planned to grow many more next year, under various conditions which have suggested themselves as bearing on the trouble. Some valuable information has already been obtained, and it is hoped that another season's experience will afford considerable insight into the difficulties which now bid fair to prevent the raising of this popular and valuable flower.

Some Prevalent Diseases of the Year.

The following are some rather uncommon diseases which have been unusually prevalent during the past season: —

The Bacterial Cucumber Wilt.

In our last report we gave an account of a wilting of cucumber leaves, due to purely physiological causes. A disease of the same plant, and having a very similar effect, but caused by bacteria, is well known, and appeared in this vicinity in out-of-door cucumbers this year. In this case the bacteria which cause the trouble develop mostly in the ducts of the stem and leaf petioles, multiplying rapidly, and causing a stoppage of the flow of sap and hence a wilting of the leaves. The organisms can be readily seen, oozing out in little drops from the cut ends of affected parts. Pure cultures may be easily obtained from these drops.

No remedy can be given as yet for this disease, other than the removal and burning of affected plants.

A Geranium Disease.

In our annual report for 1897 we described a leaf-spot disease of the cultivated geranium (Pelargonium), which was thought to be caused by bacteria. It appeared at that time in a very wet season, and seemed more a result of the abnormal conditions than a true disease. The same trouble has been abundant during the past season, however, and appears to be a dangerous enemy to the growth of this plant. It causes small yellow and dead spots in the leaves, so that they fall off, and the plant becomes nearly denuded in the worst cases. Examination showed, as before, that the dead spots are full of bacteria, and no other organisms could be found, the former appearing to be the cause of the disease. Attempts were made to isolate the organisms, but thus far without success; apparently it does not flourish under ordinary culture methods and conditions. Nevertheless, we have here, to all appearances, a genuine bacterial disease.

No remedy can be given for this trouble, beyond good cultivation and the production of vigorous plants. Cases have been seen where affected plants lost most of their leaves and produced a new crop, the latter more or less diseased, but still sufficient to present a fairly good appearance. The use of fungicides has no apparent value in such a case as this.

Muskmelon Failures.

Much complaint has been heard during the past season in this and other States of trouble with muskmelons. In our last report we described a disease of this plant caused by a fungus (*Alternaria*). The disease appeared again this year in the same and other places, and some weeks earlier than before, so that spraying experiments which we had planned were begun too late to be of value. Besides this disease, the common anthracnose (*Colletotrichum lagenarium* (Pass.) E. & H.) has been abundant, and very destructive both on muskmelons and watermelons. We saw one field of watermelons of unusually fine appearance completely ruined by this disease within a week. The stems and fruit were the parts most affected. There is every reason to believe that the Bordeaux mixture can be used with profit in these cases; but our experience this year has shown that if the treatment is not begun by July 1 or earlier, before any sign of disease has appeared, it will be entirely useless.

The Maple Leaf Blight. (*Phyllosticta acericola C. & E.*)

This disease, which affects several species of maple, has been known for some time, but has been much more abundant than usual during the past season. We have received it on sugar maple from several different parties. Large dead spots are produced in the leaves, which become curled and distorted, losing all beauty. Beyond this the actual injury to the tree is probably in most cases very slight.

The Chrysanthemum Rust.

This disease, which we first reported in 1897, appears to be on the decline in Massachusetts. It has been quite common the past season in various places, but in most cases has caused no apparent damage.

Some Experiments in growing Violets in Sterilized Soil.

Some experiments have been made this last year with violets, for the purpose of determining the relation between the production of flowers and the occurrence of leaf spots in sterilized and unsterilized soil respectively. For this purpose cuttings were made in the spring from mature plants and put into sterilized sand, after which they were transplanted into sterilized soil and removed out of doors, where they remained during the summer. In the fall they were transferred to the house and planted in a bed divided equally into two sections, each of which consisted of garden soil of good quality. One section of the bed was sterilized and the other section was not, and, in addition to this, the latter was inoculated with the parasitic nematode *Heterodera*. It should be stated, however, that the nematodes were not abundant enough in the inoculated soil to do any harm, as the bed was inoculated some time previous to setting out the violet plants, and, as no host plants were present, they died, or at least they did not gain any foothold upon the violets. The experiment is therefore largely one between sterilized and unsterilized soils.

Sterilizing the soil alone gives rise to beneficial results in the growth of a crop, a fact which we have already called attention to in Bulletin 55, issued from this station, and various experiments on different crops since has demonstrated the same thing.

Both of the beds were under tolerably equal conditions, at least so far as light and moisture were concerned; but a ventilator made some difference in the growth of a few plants in each section. The total number of plants employed in this experiment was fifty-four, and were of the variety known as the Schœnbrun, which is not especially noted as a flower producer.

The following table shows the results of the experiment: —

Table showing the Monthly Production of Violets in Sterilized and Unsterilized Soil.

DATE.	NUMBER OF BLOSSOMS PICKED.		Percentage of Gain.
	Unsterilized Soil.	Sterilized Soil.	
November,	19	38	100
December,	62	101	63
January,	55	125	127
February,	39	72	84
March,	144	250	73
April,	482	510	5
Total,	801	1,096	-
Average,	133	182	36

The results in the preceding table show a considerable increase in the production of blossoms as a result of sterilizing the soil. The percentage of gain of the sterilized plat over that in the unsterilized was 36. It will be observed also that the gain in flower production in general was most marked during the first half of the experiment, and the flower production falls off in the sterilized earths in the succeeding months, until in April, when the experiment was discontinued, the gain was only 5 per cent. over that of the unsterilized. The maximum occurred during the third month (January), although this might not occur in every instance, as a large number of experiments would probably modify these results.

Observations were made in regard to the number of leaf spots in the two plats, with the result that the sterilized plats gave the smallest number, hence showing that vigorous plants are less susceptible to fungi.

The methods employed in sterilizing the soil were the same as those described on page 54 in Bulletin 55, from this station.

In regard to the practice of sterilizing soil for the purpose of growing plants, we will state that, while there is no doubt as to the beneficial results obtained by sterilizing the same soil for two or three crops, it does not necessarily follow that soil will repeatedly stand this treatment and give good crops.

Within the last year sterilized soil has been recommended for home culture purposes, and those who use it claim to have obtained superior results.

The Relationship existing between the Asparagus Rust and the Physical Properties of the Soil.

The past season has been most favorable to the outbreak of the asparagus rust, which has manifested itself in a severe manner in the same localities where it has occurred during the last few years. The unusually dry spring enabled us to predict to asparagus growers the probable occurrence of the rust for last summer; and, as the rust has usually shown itself the season following an outbreak, regardless of the weather conditions, we may expect to encounter the same next summer (1900), at least in those beds which were badly affected and weakened from the attacks of 1899. We have endeavored to point out in Bulletin 61, issued from this station, the relationship existing between dry seasons and the occurrence of the summer or injurious stage of the rust, and also the susceptibility of plants growing in localities possessing soil with little water-retaining properties. Our observations and experiments during the past season have not led us to reverse any of the conclusions set forth in this bulletin, but, on the other hand, we are more strongly convinced of their validity. These conclusions are based upon an extensive study of the localities affected, and the object of the present article is to call attention to additional data relating to the distribution of the rust in Massachusetts, and the relationship existing between the outbreak of the rust and the rainfall, together with the physical properties of the soil. For the past three seasons we have paid attention to the distribution of the rust in Massachusetts, although the regions infected during the past summer (1899) scarcely differ from those infected during previous years.

Attention was first called to the asparagus rust in the fall of 1896. During 1897, although an extremely wet season, the damage by the rust was severe. Its occurrence during this season, however, was merely an after-effect, the primary cause being due to the injury caused by the preceding dry seasons. In 1898 the summer stage of the rust was scarcely perceptible; while in 1899 (the past season) the rust was severe, on account of the want of soil moisture.* The fall stage of the rust (black or teleuto spore stage), which is, according to our estimation, a harmless stage, and not worth paying much attention to, has been universally distributed over the State since 1896. There has, however, been some tendency for it to become less common during the last two years. This stage usually occurs during September and October, about the time when the asparagus plants first commence to lose their green color and turn yellow, the appearance of this stage being associated with the disintegration and death of the plant. The summer stage of the rust (red or uredo stage), which is in every instance an injurious stage, occurs during July and August. It occurs about July 11, or later, on beds from which a crop has been marketed, and spreads very rapidly with the wind, as is evident by those sides of the asparagus plant being first infected which correspond with the prevailing direction of the wind. We have no data as to any earlier appearance of the rust on young plants which have not been cut for the market, and it would not be at all improbable that they become infected earlier than July 11. The summer stage of the rust, however, is limited in its distribution in Massachusetts, and is found only on those soils which are sandy, and possess little water-retaining properties. The sand increases as we approach the sea-coast, and the soils which support asparagus plants affected with the red rust are found with some local exceptions in the eastern part of the State.

The summer stage of the rust has never been observed by us, nor has it been reported (with one exception, which we will refer to later, and which is local) any further west than the towns of Berlin and Northborough, which are east of the

* The amount of rainfall from April 1 to September 1 in 1899, at Amherst, was 14.09 inches; that for the same period in 1898 was 23.97 inches.

meridian 71° 40′. (See map.) These towns would appear to be on the border zone of the uredo spore outbreak, and the occurrence of the rust here is by no means so universal as it is in the sandier region of Cape Cod. Some of the growers situated upon the border zones of infection may have the summer stage badly one season and the next season be free from it. The soil of this region offers sufficient differences in texture from the more sandy coast soils, so that sound, vigorous plants might be expected to be proof against the rust in any season, and the outbreak here might be largely prevented by careful cultivation and feeding of the plants.

An examination of the map (fig. 1) will show those portions of Massachusetts in which the summer stage of asparagus rust has appeared up to the present time. The only region infested with this stage of the rust in Massachusetts west of the meridian 71° 40′ is in the Connecticut valley, in the vicinity of Montague, where the soil is remarkably sandy and dry, while other portions of the Connecticut valley which possess more or less heavier soil have been entirely free from this stage. The affected area shown on the map is characterized by a loose sandy soil, which possesses less water-retaining properties in most instances than the soils of their immediate vicinity. In order, however, to show more definitely the differences existing between the texture of the soils of the eastern part of the State and those of the central and western parts, we have made a number of mechanical analyses of the soils of various regions, which include many from the infected asparagus fields. Any one who has paid special attention to our Massachusetts soils and their influence upon the development of plants would not require a mechanical analysis in order to become convinced of the differences existing between them, as a glance at the soils in the field would be sufficient. Nevertheless, a mechanical analysis will show us the exact differences existing between the textures of the soil of the various regions, and we will moreover be able to demonstrate the amount of difference exhibited in their water-retaining capacity. The following table gives the data of the mechanical analysis*

* The methods of analysis employed are those of Prof. Milton Whitney.

of ten typical surface soils from various parts of the State between the Cape and the New York State line: —

TABLE I. — *Showing the Mechanical Analyses* * *of Ten Massachusetts Soils, extending from Cape Cod to Western Massachusetts. — Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in 20 Grams of Soil.*

[Diameter of the grains in millimetres (1 millimetre equals about 1/25 inch): gravel, 2-1; coarse sand, 1-.5; medium sand, .5-.25; fine sand, .25-.1; very fine sand, .1-.05; silt, .05-.01; fine silt, .01-.005; clay, .005-.0001.]

SAMPLE.	Water.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Orleans,	1.82	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
Bridgewater,	1.86	2.10	17.92	28.80	18.85	5.80	19.15	2.85	1.34	.66
Eastham,	1.66	2.00	9.38	27.91	25.09	21.43	8.70	1.40	.77	1.43
Concord,	1.66	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.73	1.08
Attleborough,	8.13	7.64	9.26	11.15	7.87	11.53	29.50	10.95	2.51	1.42
Worcester,	3.00	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
Spencer,	3.40	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
Montague,	.90	1.86	.27	4.39	19.85	43.88	25.75	2.63	.36	.27
Amherst,	2.98	7.31	.95	1.25	1.72	7.28	66.19	6.96	1.33	4.13
Pittsfield,	9.50	11.25	5.50	5.95	5.02	13.87	36.15	6.45	.87	5.40

* Analyzed by A. A. Harmon and Asa S. Kinney.

The first six soils represent typical samples taken from affected fields in locations where the summer stage of the rust has always been present since its occurrence in Massachusetts, and in most instances where it has been severe. The other samples are from towns which have not shown the summer stage of the rust, but in which the fall stage has occurred. All of the samples are so-called surface soils, and represent single analyses. Except in the Amherst soils they represent an average of four analyses, while in the Pittsfield there is an average of two. A careful examination of the table will show considerable difference in the texture of the soils of the various regions. It will be observed that the coarse elements are much more common in the coast soils than in the inland soils, and conversely that the fine elements are greatly increased in the inland soils.

In order to obtain a better idea of the relative amounts of the various constituents found in the different soils, we can arrange them as in Table II., in which the average constituents contained in the four coast soils are shown alongside of four inland soils which are characteristic of the central and western regions of Massachusetts. The four coast soils represent badly infested regions, while the four inland soils represent those in which only the fall stage has occurred.

TABLE II. — *Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in Orleans, Eastham, Concord and Bridgewater (Coast Soils), and Worcester, Spencer, Amherst and Pittsfield (Inland Soils).*

SAMPLE	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Four coast soils, ...	2.62	13.12	24.48	19.11	16.85	16.80	2.21	1.32	1.13
Four inland soils, ...	9.44	2.70	2.63	4.57	15.83	18.72	6.14	1.90	3.88

The largest amount of gravel as shown by the table is in the Orleans soil from Cape Cod, which is 20.97 per cent.; the average for the whole is 13.12 per cent., against 2.70 per cent. for the inland soils. What holds true in regard to the gravel is also true when we consider the coarse sand, where the proportion is 24.48 per cent. in the coast soil, to 2.63 per cent. in the inland soils; while in the medium sand it is 19.11 per cent. to 4.57 per cent. Only slight differences are shown in the proportion of fine and very fine sand between the two regions, although the coast soils are ahead in the former and the inland in the latter; whereas in both of the silts and clay the largest amounts are found in the inland soils. If we turn to the organic matter, we find that it is also more abundant in the inland soil than it is in the coast soil. This difference is partly accounted for by the fact that some of the samples of inland soil represent highly manured soils, adapted to intensive cultivation. Even making allowances for this fact, the organic matter would seem higher in the inland soils than in the coast soils, inasmuch as various samples of soil taken from inland localities which were not manured gave an average of about 6 per cent., or about three times as much as that shown by the coast soils. This is not true, however, of the coast soils such as are used for general truck farming, — as in the case of Arlington, for example, — in which instance we would find the percentage of organic matter quite large. The amount of water in the soils differs also, which is caused by the analyses of some of the samples being taken at different times, and from not being subject to the same air-drying conditions. It will also be noticed that the Attleborough soil contains an unusually large amount of silt, — a feature which seems to be peculiar to that soil alone. As a rule, the inland soils contain a very large amount of very fine sand, and this appears to be especially characteristic of the Connecticut valley soils. Some analyses which we have made show that this soil sometimes possesses as much as 75 per cent. of this constituent. It is the excessive amounts of this constituent of the soil which renders the Amherst soil compact, and which gives to it an increased water-retaining capacity. The clay, however, shows a gradual increase as we pass inward, and in a less uniform manner is this exhibited by the silt, which can be seen by examining Table III.

TABLE III. — *Showing the Percentage of Gravel-Sand, Silt and Clay in the Soils shown in Table I.*

SAMPLE.	Gravel-Sand.	Silt.	Clay.
Orleans,	90.22	4.23	1.37
Bridgewater,	90.52	4.16	1.13
Eastham,	92.51	2.17	1.43
Concord,	89.35	3.57	1.08
Attleborough,	69.39	13.46	1.42
Worcester,	71.50	7.45	2.75
Spencer,	66.50	9.10	3.25
Montague,	94.15	2.99	.27
Amherst,	77.39	8.29	4.13
Pittsfield,	66.49	7.32	5.40

There are inland soils which contain considerable amounts of sand, such as the Connecticut valley soils, for example, thus offering exception in this respect to the surrounding localities. The Montague soil is one of these, and it will be noticed by examining Table III. that the percentage of sand is very high in this. It is not, however, the coarser varieties but the finer which predominate, thus differing widely from the sandy soil of Cape Cod. Notwithstanding this variation, a large number of analyses show that the clay appears to follow, as a rule, what might be termed a normal amount for each particular region. It is therefore interesting to note in this connection that the increase of clay as we pass inward is fully as characteristic and uniform in the Massachusetts soils as is the decrease of the sand. The differences existing between the texture of the coast and inland soils are sufficient to exert considerable influence upon the growth of plants. This difference is equally perceptible, whether we see the soils in the field or in a table showing their analyses.

Having paid some attention to the physical properties of a few of our State soils, and their effect upon plant development, we are able to ascertain approximately from a mechanical analysis the characteristic properties of the constituents, and what effect they exert upon the development of certain crops. As a rule, we can divide the various constituents directly in the middle; that is, we can consider the four coarser elements and the four finer constituents by themselves. Such an arrangement of the soils is shown in Table IV.

TABLE IV. — *Showing Soils as in Table I., arranged according to the Percentages of Gravel and Coarse, Medium and Fine Sand, the Very Fine Sand, Silt and Clay being omitted.*

Orleans,	83.96	Attleborough,	39.81
Eastham,	83.81	Spencer,	36.90
Bridgewater,	71.37	Pittsfield,	30.34
Montague,	68.39	Worcester,	28.55
Concord,	55.18	Amherst,	11.20

If, for example, a soil is rather low in the constituents represented by the gravel and coarse, medium and fine sand,

and correspondingly high in the remaining constituents, then we possess a soil which is characteristic of the inland types, and will pack down very closely when wet. If, however, the reverse of this is true, we find a loose, pliable soil, such as is found on the coast, which is easily worked and especially adapted for truck farming. The latter soil will not retain much water, it quickly dries out; while the former or inland soil will retain considerable water for a long time, inasmuch as the resistance and relative amount of water maintained by different soils depends upon the volume of space in the soil for the water to enter, which in turn depends upon the number of grains of sand, silt and clay. In sandy soils the space is not divided up as much as in a clay soil; the grains of sand being larger, the spaces between the grains are also larger, there is less friction, and the water moves downward more quickly. The order of arrangement of the soils in Table IV. (which is that relative to the coarse material they contain) follows very closely the water-retaining capacity of the soils, as we shall see when we come to Table V.

These are in part the principal differences existing between the coast and inland soil, with now and then an exception; and the outbreak of the summer or injurious stage of the asparagus rust is always characteristic of those soils which are sandy and porous, and consequently possess little water-retaining capacity, whether they are located near the coast or inland. It should, however, be borne in mind that it is not the percentage of coarse and fine material alone which is responsible for the character of a soil, but the shape and arrangement of its particles exert an influence upon it. Then, again, the organic matter, the depth of the soil and the nature of the sub-soil, as is well known, are important when the question of moisture and dryness is concerned. We have already pointed out that the four soils from the coast contain less organic matter than those from inland soils, and this fact holds good for the Montague sample also. If these soils were richer in organic matter, their water-retaining properties would be increased, and they would become less susceptible to the rust.

In order to test the water-retaining properties of some of these samples of soil, we subjected them to the following treatment. Three hundred grams of the air-dried soils were taken and put into a cylinder three inches wide and six inches high, with a perforated bottom, over which there was placed a layer of filter paper. The cans containing the soil were then weighed, after which the samples were liberally treated with water until they contained all that was possible for them to hold. The cylinders were then set aside, and after the water had stopped dripping they were again weighed, and the additional weight which was due to the amount of water applied was noted. This represented the amount of water which the soils could retain. Other air-dried samples of the same soil were heated in an oven to perfect dryness, and by this means the amount of hygroscopic water was obtained for each. This, being added to the amount of water retained, gave the total water capacity of the soil; and, dividing this sum by the weight of water-free soil, which was obtained by subtracting the hygroscopic water from the original three hundred grams, we obtain the percentage of water which each soil is capable of retaining; or, in other words,

$$\frac{\text{Water retained} + \text{Hygroscopic water}}{\text{Water-free soil}} = \% \text{ of water-retaining capacity.}$$

The following table gives the results of these experiments in the order of water-retaining capacity: —

TABLE V. — *Showing the Retentivity of Soil Moistures in Order of Retaining Capacity.*

SAMPLE.	Water retained (Grams).	Hygroscopic Water (Grams).	Weight of Water-free Soil (Grams).	Percentage of Water retained.
Orleans, ...	103.0	2.10	297.90	35.28
Bridgewater, ...	99.5	.66	299.34	37.13
Eastham, ...	115.9	.78	299.22	38.99
Montague, ...	144.8	.90	299.10	48.71
Concord, ...	145.3	2.76	297.24	49.81
Attleborough, ...	168.9	4.20	295.80	58.52
Amherst, ...	200.6	2.82	297.18	68.45

As might be expected, the coast soils show the smallest percentage of water-retaining capacity, and this percentage increases as we pass inland to the heavier soils, as would naturally follow. The smallest percentage is shown by the soils from Cape Cod, where there is a considerable amount of coarse material and small amounts of fine material; while the largest percentage is given by the Amherst soil, which contains a larger amount of fine material and a less amount of coarse material than the coast soils. The Amherst soils show 68.45 per cent. water-retaining capacity, against 35.28 per cent. for the Orleans; or, in other words, the Amherst soil possesses nearly twice the water-retaining capacity of the Orleans soil. Only two determinations were made of the water-retaining properties of the soil west of Worcester, one being at Montague, where the summer stage of the rust is present, and the other at Amherst, where it has never occurred. These two determinations are, however, sufficient for our purpose; inasmuch as the preceding table shows that the water-retaining properties of the soil decrease in loose, sandy soil, and increase in fine, compact soil; and, as the mechanical constituents of such soils as the Worcester, Spencer and Pittsfield are larger in fine material and more closely resemble the Amherst soil than those of the coast, we would therefore find similar water-retaining properties.

The cans containing the soils were left in a room of even temperature, and after five days had elapsed they were weighed again, with the following result: —

TABLE VI. — *Percentage of Water lost by the Following Soils after Five Days.*

Bridgewater,	75.07	Attleborough,	46.95
Orleans,	73.78	Montague,	40.33
Eastham,	66.17	Amherst,	23.33
Concord,	51.75		

These results follow in a general way those shown in Table V. The Bridgewater, however, lost slightly more than the Orleans. As most of these soils were gathered within a few days of each other, it may be of some interest to note the amount of water found in each at the time the samples reached the laboratory. Amherst gave 33.60 per cent. of water; Montague, 11.26 per cent.; Orleans, 12.50 per cent.; Attleborough, 15.40 per cent.; Concord, 8.65 per cent.; Eastham, 5.69 per cent.; Bridgewater, 3.74 per cent. These figures do not possess any great value, but in a general way they correspond with those in the preceding table. The variation in the amount of rainfall in different parts of the State of course comes into account here. We will state, however, that the Amherst soil referred to was taken from an asparagus bed which has never had the rust in any stage, — a fact which is not only due to its characteristic texture and the nature of the subsoil, but to the fact that the plants have been thoroughly cultivated and properly fed, and consequently are in a very vigorous condition. According to Professor Brooks, this bed has at times received a heavy dressing of cow manure in the fall, which has been forked in in the spring, and then fertilizer has been put on at the following rate per acre: muriate of potash, 600 pounds; nitrate of soda, 200 pounds; and acid phosphate, 900 pounds.

Asparagus growers have stated that there is a difference as to infection in different parts of a field. Many have stated that the drier places were the most badly infested, while others could notice no difference, or in some instances those parts which they considered the least dry showed the rust the worst. This latter condition does not in any way affect our conclusions that the rust (summer stage) is peculiar alone to those regions that possess sandy soil which has little water-retaining capacity, inasmuch as our conclusions are general, and refer to the State as a whole. That exceptions do occur even in a single bed is not at all strange, so long as plants are endowed with a tendency to vary. There are other factors which have a bearing on the susceptibility of plants to rust other than those of soil and water conditions, among which is the general health condition or vigor of the plant. We have repeatedly observed in the same bed numerous plants that were badly infected, while directly beside them were some which were perfectly healthy. We do not maintain, however, that, in a bed where the plants possess the same amount of vigor and where they are under exactly similar conditions except in regard to moisture, those in the dry place will succumb to the rust quickest and become more severely affected than those located in dry places. The principal feature which we wish to emphasize in connection with these experiments is that the summer stage of the asparagus rust is due to a weakened condition of those plants growing on dry soil during seasons of extreme drought. In other words, the plants suffer for water; and, since this is the case, the rational method of prevention must take the amount of soil moisture into consideration. It will not be out of place here to reflect upon the present status of the rust problem, and consider the methods which should be employed in our endeavors to control it.

The practice of spraying, it would seem, is not likely to give promise of any remarkable results, because the asparagus plants offer difficulties in this respect, and all of the rusts are hard to control. Stewart found, in his experiments on spraying for the carnation rust, which attacks a host largely confined to greenhouses and therefore much better under control, that the best results obtained by spraying were not very promising. Then, again, it is possible that the asparagus rust mycelium may be confined to the plant throughout the year, in which case the value of spraying would be practically useless. We have observed a fungous mycelium in the roots and stems of the asparagus plants below the ground long before any occurrence of the rust showed upon the aerial stems; but whether the mycelium was identical with that of the rust, or of other parasitic fungi frequently found upon the asparagus, we were not able to ascertain. We must therefore turn our attention to other methods of control, — to methods which will enable us to keep the plants under more normal conditions during seasons of drought. These methods will consist, first, of securing the most vigorous plants, — a feature which is dependent upon cultivation and the proper kinds and amounts of plant food with which the plants are supplied. There is considerable difference in the plants of various growers in this respect; the most vigorous and largest plants which we have observed were situated in a dry region, subject to uredo infection, but they have never suffered from the rust till this season. The amount of rainfall between April 1 and September 1 of this year has been the lowest for many years, and many beds have shown the summer stage for the first time this year. It is interesting to note, however, that cultivation and skilful plant feeding alone have enabled some beds to suppress the outbreak of the summer stage.

Then, again, the question of soil moisture during dry seasons must be considered. There are different ways of securing this, such as by irrigation, by increasing the organic matter in the soil, or by mulching. In selecting a site for new beds, they should be started on soil possessing some degree of water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. We are convinced, however, that soils such as the Montague and Attleborough, which appear to be good asparagus soils, possess enough fine material and sufficient water-retaining capacity to prevent the summer outbreak, provided robust plants are secured. In fact, we are informed that the summer stage of the rust has not appeared on the beds at Attleborough from which this sample was taken previous to this year. It is these extremely light, sandy soils that have been selected for the largest asparagus beds, because they appear to be best adapted for its growth. Numerous inquiries from towns adjoining many of these badly infected regions have failed to show any evidence of injuries from the rust, as the texture of the soil is slightly different.

If the asparagus rust continues to cause as much injury in the future as it has in the past, it may become necessary to resort to those soils of a finer texture for the cultivation of this crop. The matter of irrigation would be expensive and not readily resorted to on many beds, while others that we know of could be very easily irrigated by damming a small stream and properly diverting the course of the water. Since the asparagus rust is brought about by drought, and is therefore not likely to cause much injury except during such seasons, the occurrence of the disease can be anticipated. In this respect it differs from other common plant diseases, inasmuch as we have to spray for them every season, whether we know they are going to make their appearance or not. An annual treatment would therefore not be required. It is hoped that some preventive measures, based upon the retentivity or the supplying of soil moisture, will be employed by those growers who are favorably situated and who have suffered from the rust.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of this division the past year has been principally devoted to the observation of the various weather phenomena, together with the reduction of the records and their arrangement in form for preservation.

The usual monthly bulletins, giving the more important daily records and a review of the character of the weather, have been issued, and the annual summary will be published as soon as the records for the year are complete.

Throughout the year the New England section of the United States Weather Bureau has furnished us daily, except Sunday, with the local forecasts of the weather, and the signals have been displayed from the top of the tower. Arrangements have been made to furnish them the weekly snow reports, as heretofore.

The observations relating to soil temperature and moisture by the electrical method, begun two years ago, have been continued this year. Owing to the unsatisfactory results of the previous years, the temperature cells and moisture electrodes were tested and standardized before using them in the field. The temperature cells were placed in water and the resistances observed. After the resistances became constant for each cell, the temperature of the water was taken by a standard thermometer. The resistance of each cell was thus determined, for temperatures varying by about 10° F., for a range exceeding that which it would be subjected to in the field. The cells were afterward placed in soil in a box, and the resistances observed and the temperature computed by the tables in Bulletin No. 7 of the United States Department of Agriculture, Division of Soils, and checked by using a standard thermometer. The standardization of the moisture electrodes was effected by placing them in soil in boxes so arranged as to provide for a proper diffusion throughout the soil of water as added, taking the resistances and computing the percentage of moisture from the weight. When afterward used in the field these electrodes gave more satisfactory results than had before been attained. The results for the corn-growing season of the current year have been worked out. The observations will be continued next year, for purposes of comparison.

The means of the various weather elements for each month and year, for the ten years from 1889 to 1898 inclusive, have been tabulated, and normal conditions for the period deduced. These results are of especial interest for the purpose of noting departures from normal conditions. The tabulations, together with other data of interest, will be found on the following pages.

Meteorological Observatory of the Hatch Experiment Station, Massachusetts Agricultural College, Amherst.

General Summary, 1889–98.

Latitude of observatory, 42° 23′ 48.5″ N.; longitude, 72° 31′ 10″ W. Elevation of ground at base of observatory above mean low water, Boston harbor, 223 feet, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is 50.5 feet above the ground and 273.5 feet above sea level. The Draper self-recording barometer is 51.5 feet above ground. The cup anemometer, pressure anemometer, anemoscope and sun thermometer are located on top of the tower, 72 feet above the ground. All temperatures are taken in the thermometer shelter on the campus, about 4 feet above ground and 220 feet above sea level. The standard rain gauge is on the campus, about 2 feet above the ground and 218 feet above sea level.

Mean Barometer.

[Readings are reduced to freezing and sea-level.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889,	30.113	30.238	29.843	29.795	29.916	29.960	29.909	30.008	29.999	30.050	30.040	30.139	30.001
1890,	30.191	30.097	29.993	30.098	29.959	29.975	30.019	30.001	30.124	29.880	30.007	30.013	30.030
1891,	29.958	30.041	30.099	29.923	29.983	29.919	29.986	29.965	30.114	30.028	30.117	30.081	30.018
1892,	29.965	30.106	29.895	29.972	29.943	29.923	29.988	30.017	30.103	29.896	29.988	30.010	29.983
1893,	29.951	30.111	30.065	30.086	29.895	30.056	29.968	30.001	30.065	30.126	30.124	30.120	30.047
1894,	30.175	30.160	30.088	30.054	30.000	29.997	30.012	30.033	30.143	30.016	30.081	30.148	30.085
1895,	30.047	29.918	29.998	30.119	30.097	30.172	30.031	30.016	30.097	30.082	30.187	30.151	30.076
1896,	30.158	29.860	29.990	30.143	29.984	29.949	29.974	29.989	30.004	30.011	30.145	30.135	30.028
1897,	30.041	30.056	30.036	30.042	29.924	29.901	29.943	29.943	30.091	30.122	30.034	30.036	30.014
1898,	29.976	30.052	30.203	29.927	29.937	29.947	30.017	29.959	30.012	30.089	30.010	29.963	30.008
Mean,	30.057	30.064	30.021	30.016	29.964	29.980	29.985	29.993	30.075	30.030	30.073	30.080	30.029

Range of Barometer (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890,	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891,	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892,	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893,	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894,	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895,	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896,	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897,	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898,	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
Mean,	1.53	1.58	1.30	1.11	.85	.73	.71	.66	.84	1.12	1.27	1.41	1.92

Maximum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890,	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891,	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892,	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893,	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894,	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895,	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896,	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897,	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898,	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
Mean maximum,	30.70	30.71	30.62	30.56	30.41	30.37	30.36	30.29	30.44	30.55	30.63	30.70	30.86

Minimum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889, ...	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.20
1890, ...	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891, ...	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892, ...	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893, ...	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894, ...	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895, ...	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896, ...	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897, ...	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898, ...	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
Mean minimum, .	29.17	29.13	29.32	29.45	29.56	29.62	29.65	29.63	29.60	29.43	29.37	29.19	28.94

Mean Temperature (in Degrees F.).

[Completed from daily maximum and minimum readings.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	29.2	32.0	31.0	45.8	56.3	65.3	68.4	67.2	60.4	48.2	37.2	21.8	46.9
1891,	26.4	27.6	32.7	47.5	55.6	65.2	66.3	69.0	64.9	48.7	38.1	36.9	48.2
1892,	23.6	26.1	31.4	45.2	56.0	69.3	69.3	68.9	59.3	48.6	37.8	26.3	46.8
1893,	16.1	22.9	30.4	43.0	55.8	66.9	68.1	69.2	55.8	52.6	38.2	25.5	45.4
1894,	26.4	21.6	39.6	46.7	57.3	67.8	72.9	68.0	65.5	51.5	34.8	26.9	47.9
1895,	23.2	19.5	31.2	45.6	59.7	69.1	67.6	69.7	64.1	45.6	40.7	30.5	47.2
1896,	20.7	25.0	29.2	48.3	61.1	65.0	71.3	68.8	59.5	47.0	42.2	25.6	47.0
1897,	24.7	25.4	33.1	47.1	56.8	62.0	71.6	66.8	60.1	49.8	36.2	28.3	46.8
1898,	21.8	26.1	39.7	42.4	55.3	66.1	70.9	70.2	63.6	51.1	37.5	25.9	47.5
Mean,	23.6	25.1	33.1	45.7	57.1	66.3	69.6	68.6	60.9	49.2	38.1	27.5	47.1

* Records incomplete.

Range of Temperature (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890,	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891,	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892,	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893,	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894,	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895,	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896,	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897,	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898,	65.5	73.0	45.5	54.0	46.0	50.0	56.5	46.5	58.5	59.5	56.0	60.0	115.5
Mean,	56.7	60.3	54.1	58.4	55.4	52.2	48.0	49.6	55.9	55.4	55.2	57.7	107.0

* Records incomplete.

Maximum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890,	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891,	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892,	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893,	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894,	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895,	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896,	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897,	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898,	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
Mean maximum,	51.2	50.8	58.8	78.3	85.3	91.6	92.8	91.7	88.2	79.2	65.3	53.1	95.4

* Records incomplete.

Minimum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890,	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891,	—0.5	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892,	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893,	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894,	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895,	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896,	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897,	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898,	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
Mean minimum,	—5.5	—9.5	4.7	19.9	29.9	39.4	44.8	42.1	32.3	23.8	10.1	—4.6	—11.8

* Records incomplete.

Mean Dew Point (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890,	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891,	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892,	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893,	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894,	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895,	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896,	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897,	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898,	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
Mean,	19.5	20.3	26.5	35.6	49.2	58.1	61.6	60.6	54.7	41.4	32.4	22.7	40.2

Mean Relative Humidity.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890,	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891,	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892,	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893,	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894,	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895,	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896,	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.1	82.3	79.8	76.9
1897,	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898,	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
Mean.	77.0	78.9	73.6	65.3	67.0	71.0	71.8	75.5	76.6	73.2	75.2	76.1	73.5

Mean Per Cent. of Cloudiness, from Tri-daily Observations.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	55	40	63	55	42	53	54	43	65	60	68	61	55
1890,	52	66	66	50	59	50	56	57	59	64	47	53	57
1891,	61	59	55	49	54	47	54	58	50	54	50	51	53
1892,	63	55	45	42	66	50	35	53	29	46	58	45	49
1893,	52	57	46	55	55	58	44	45	46	40	49	54	50
1894,	53	53	55	53	52	54	50	44	53	44	50	44	50
1895,	51	39	55	54	46	48	58	44	42	42	61	45	49
1896,	43	63	54	39	40	47	50	40	52	63	59	42	49
1897,	46	51	56	46	47	47	64	42	39	39	71	68	51
1898,	66	64	53	68	65	57	53	60	48	62	60	66	60
Mean,	54.2	54.7	54.8	51.1	52.6	51.1	51.8	48.6	48.3	51.4	57.3	52.9	52.4

Hours of Bright Sunshine by Sun Thermometer.

YEAR.	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours,	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889,	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890,	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891,	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892,	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893,	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894,	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895,	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896,	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897,	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898,	132	138	200	168	200	270	236	201	218	157	105	113	2,159
Mean,	134	145	178	211	228	242	238	224	199	161	114	136	2,212
Mean per cent.,	45.7	49.0	48.0	52.5	50.3	53.0	51.5	52.2	53.4	47.2	39.0	48.1	49.7

Precipitation (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	3.50*	1.46*	1.02*	3.22*	4.18*	5.40*	10.52	2.72	3.17	4.58	6.04	3.57	49.38
1890, ...	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, ...	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, ...	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, ...	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, ...	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, ...	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, ...	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, ...	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, ...	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
Mean, ...	3.93	3.13	3.12	2.76	4.15	3.73	5.74	4.05	3.73	4.00	4.10	3.56	46.00

* Kindly furnished by Miss S. C. Snell.

Departures from Monthly Normals.

YEAR.	January.	February.	March	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	—.43	—1.67	—2.10	.46	.03	1.67	4.78	—1.33	—.56	.58	1.94	.01	3.38
1890, . .	—1.32	1.07	2.25	—1.03	1.24	—2.20	—.11	.83	2.12	3.13	—2.78	—.70	2.50
1891, . .	2.82	1.10	—.13	—.10	—2.18	1.02	—.46	.13	—1.07	—1.06	—1.11	1.84	.80
1892, . .	1.92	—1.23	—.72	—2.00	2.13	—.27	—1.33	2.42	—1.57	—3.34	.88	—2.55	—5.66
1893, . .	—.60	2.62	.54	1.65	.87	—.41	—3.15	—.56	—.91	.88	—1.29	1.30	.94
1894, . .	—1.77	—1.39	—1.35	—.93	—.15	—.60	—4.19	—3.74	.90	.85	—.96	—.03	—13.36
1895, . .	—.06	—2.08	—.41	2.80	—2.08	—.97	—1.87	—.59	1.31	.77	1.26	.38	—1.54
1896, . .	—2.86	1.54	2.99	—1.44	—1.57	—1.16	—.78	—.21	1.68	—.77	—1.07	—2.69	—6.34
1897, . .	—.93	—.61	.41	—.34	.23	2.92	8.77	.24	—1.79	—3.27	1.75	3.67	11.05
1898, . .	3.22	.67	—1.49	.97	1.46	—.04	—1.65	2.05	—.08	2.27	1.38	—1.26	8.25

Wind Movement (in Miles).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, ...	4,914	4,616	5,395	5,020	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, ...	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, ...	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, ...	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, ...	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, ...	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	5,029	4,156	5,506	46,861
1896, ...	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, ...	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, ...	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
Mean, . . .	4,511	4,630	5,770	5,078	4,530	3,680	3,439	3,262	3,404	4,154	4,385	4,722	51,566

Maximum Wind Pressure (in Pounds per Square Foot).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,	26.00	24.0	16.75	15.50	9.00	11.50	10.00	6.5	9.75	12.25	14.50	29.0	29.00
1890,	27.75	17.5	13.50	11.50	16.50	10.00	9.25	13.0	5.00	11.00	9.50	24.5	27.75
1891,	16.25	13.5	10.50	14.00	10.75	10.50	4.50	2.5	4.00	9.50	15.75	14.0	16.25
1892,	10.50	11.5	20.50	16.75	15.75	20.50	11.50	7.5	15.50	12.50	16.00	13.5	20.50
1893,	12.00	20.0	18.50	24.50	24.75	9.00	13.00	37.5	14.50	23.00	14.00	18.5	37.50
1894,	20.00	22.5	11.50	15.50	14.50	14.00	9.50	9.5	13.00	10.00	18.00	15.0	22.50
1895,	13.00	25.0	20.00	10.00	7.00	8.00	8.00	5.5	43.00	14.00	22.00	24.0	43.00
1896,	15.00	24.5	19.00	18.00	25.00	7.75	8.50	12.5	19.00	12.00	15.00	12.0	25.00
1897,	18.50	10.0	13.50	14.00	22.00	7.00	12.00	14.0	20.00	11.50	20.00	12.0	22.00
1898,	22.50	15.5	15.50	10.00	18.00	8.50	17.50	13.0	30.50	12.00	19.00	28.0	30.50
Maximum,	27.75	25.0	20.50	24.50	25.00	20.50	17.50	37.5	43.00	23.00	22.00	29.0	43.00

Maximum Velocity of Wind (in Miles per Hour).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, ...	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, ...	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, ...	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, ...	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, ...	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, ...	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, ...	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, ...	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, ...	67	56	56	45	60	41	59	51	78	49	62	75	78

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days .01 Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889,	April 2,	Oct. 13,	26.0	May 26,	Sept. 21,	119	94	110	161
1890,	April 8,	Oct. 19,	43.5	May 12,	Sept. 25,	141	137	105	123
1891,	May 5,	Nov. 26,	54.2	May 19,	Oct. 12,	112	145	103	117
1892,	April 10,	Nov. 5,	42.5	May 10,	Sept. 30,	108	123	109	134
1893,	April 21,	Nov. 4,	74.3	May 8,	Sept. 3,	143	101	96	168
1894,	April 12,	Nov. 5,	71.5	May 22,	Aug. 22,	125	107	83	175
1895,	April 3,	Oct. 20,	61.0	May 17,	Aug. 22,	119	118	110	137
1896,	April 7,	Nov. 14,	44.0	May 1,	Sept. 24,	108	132	102	132
1897,	April 27,	Nov. 12,	52.8	May 8,	Sept. 22,	127	108	109	148
1898,	April 6,	Nov. 24,	69.5	April 27,	Sept. 21,	135	78	138	149

Summary for the Ten Years 1889–98.

Barometer (Pressure in Inches).

Maximum, reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum, reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum, reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum, reduced to freezing and sea level, Feb. 8, 1895, 7 A.M.,	28.560
Mean,	30.029
Total range,	2.410
Greatest annual range, 1895,	2.270
Least annual range, 1892,	1.650
Mean annual range,	1.920
Greatest monthly range, January, 1891,	1.930
Least monthly range, July, 1895,	.510
Mean monthly range,	1.090

Air Temperature (in Degrees F.).

Highest, July 20, 1894, 5 P.M.,	98.000
Lowest, Feb. 3, 1898, 6 A.M.,	—19.000
Mean,	47.100
Total range,	117.000
Greatest annual range, 1898,	115.500
Least annual range, 1891,	100.000
Mean annual range,	107.000
Greatest monthly range, February, 1898,	73.000
Least monthly range, July, 1897,	36.000
Mean monthly range,	54.900
Greatest daily range, Feb. 18, 1892,	52.500
Least daily range, April 5, 1898,	2.500
Mean daily range,	22.100

Humidity.

Mean dew point,	40.200
Mean force of vapor,	.430
Mean relative humidity,	73.500

Precipitation (in Inches).

Total rain or melted snow,	460.000
Total snowfall,	539.300
Greatest annual precipitation, 1897,	57.050
Least annual precipitation, 1894,	32.640
Mean annual precipitation,	46.000
Greatest monthly precipitation, July, 1897,	14.510
Least monthly precipitation, October, 1892,	.660
Mean monthly precipitation,	3.830

Greatest in twenty-four hours, July 12-13, 1897,	5.650
Greatest in one hour, July 30, 1898,	1.500
Unusual rains: 1889, June 15, 2.10 inches in four hours; 1896, July 7, 1.10 inches in thirty minutes; 1897, June 9, 4.08 inches in twenty hours; July 13-14, 8 inches in forty-four hours; 1898, July 30, 2.65 inches in two hours; September 10, .95 inch in twenty minutes. Number of days on which .01 inch or more rain or melted snow fell,	1,241.000

Wind (in Miles).

Total movement,	515,638
Greatest annual movement, 1896,	59,198
Least annual movement, 1894,	36,257
Mean annual movement,	51,566
Greatest monthly movement, March, 1896,	8,182
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,297
Greatest daily movement, Nov. 27, 1898,	675
Least daily movement, Sept. 29, 1894, and March 7, 1895,	–
Mean daily movement,	141

Maximum pressure per square foot, 43 pounds, = 93 inches per hour, Sept. 11, 1895, 3 P.M.

Weather.

Mean cloudiness observed,		52.40 per cent.
Total cloudiness by the sun thermometer,	22,400 =	50.30 per cent.
Number hours bright sunshine recorded.	22,120 =	49.70 per cent.
Number of clear days,		1,143
Number of fair days,		1,065
Number of cloudy days,		1,444

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of experimentation carried on by this division have been kept strictly within the limits of practical horticulture, devoting especial attention to the growth of common fruit and garden crops, and their protection from insect and fungous pests.

New varieties of fruits, vegetables, ornamental trees, shrubs and plants of promise have been obtained and tested under varying conditions, and many new seedlings produced. For the work of testing varieties a large collection of standard varieties from different sections of the country have been obtained, that, when a new variety is to be tested, careful comparison may be made under conditions where the exact value of standard varieties is known. As far as possible, new varieties are grown under many varying conditions, and very careful inquiry is made of their behavior in many localities.

Previous reports have given the number of varieties of the different kinds of fruits, vegetables, flowers, etc., under experiment, to which have been added the following number of new varieties the past season: apples, four; pears, five; plums (domestic), three; plums (Japanese), seven; plums (American), seven; peaches, five; quinces, two; cherries, four; grapes, four, besides numerous seedlings; blackberries, three; red raspberries, two, and a large collection of seedlings; strawberries, twenty, and many seedlings; chestnuts (Japanese, Spanish and native varieties), eight; walnuts (species and varieties), six; several new hardy ornamental trees, shrubs and plants, and many new varieties of ornamental plants for the greenhouse and summer outdoor decoration.

Immediate results are constantly called for in the case of widely advertised new varieties, but such results can be obtained only under a series of seasons and varying conditions of growth. This work of testing varieties is begun at once upon introduction, and is hastened by all possible means.

The experiments under way, in addition to the testing of varieties, are as follows: —

1. The girdling of the grape vine for profit.
2. Spraying fruit trees when in bloom, to change the bearing year.
3. Spraying peach trees during the winter with lime, to protect the flower buds from winter-killing.
4. The use of dilute copper sulfate in place of the ammoniacal carbonate of copper.
5. The testing of insecticides and fungicides.
6. The testing of spraying apparatus.
7. The use of clear kerosene and kerosene and water for the destruction of scale insects and aphides.
8. The protection of young fruit trees from mice.
9. Various kinds of grafting wax.
10. Various methods of grafting.
11. Whole roots and piece roots in apple root-grafting.
12. Different kinds of stocks for the pear.
13. Growing seedling fruit-tree stocks.
14. The use of hydrocyanic acid gas for the destruction of insects under glass.
15. Turf culture *v.* cultivation in growing apples.
16. Amount and kinds of fertilizers needed for best growth of fruits.
17. Green manuring for orchards.
18. Comparative hardiness of varieties of Japanese plums.
19. Growth of lettuce under glass.
20. Growth of tomatoes under glass.

Assistance has been given many horticulturists by visiting their places or answering inquiries by letter, which takes a large share of the time of the head of the division. Assistance has also been given in many places in planning ornamental planting of home and public grounds.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Since my last report the entomological work of the station has proceeded along its usual lines. A large amount of correspondence has been carried on, and many letters of inquiry from residents of this State have been answered. Believing, however, that the opportunities afforded by this division of the experiment station were either not known of by many, or that the way in which to make use of them was not understood, the following note on the work was prepared: —

Free Aid for the People.

Prevention of Loss by Injurious Insects.

The attacks of injurious insects probably cause the loss of several millions of dollars in Massachusetts alone each year. This has not always been the case, but insects are becoming more abundant and consequently more destructive. Much of this destruction, however, could be either in part or wholly prevented if the proper methods of treatment were made use of, and that this is not more frequently done is very unfortunate. It is probable that the reason for the apparent negligence in this regard is due to ignorance as to what the insect is in each particular case, and what to do to prevent its ravages. It is this very uncertainty which results in nothing being done in most cases.

In order to provide this information for residents of the State, the entomological division of the Hatch Experiment Station at Amherst offers its services without charge to all who may desire them. To obtain this assistance, write to the entomologist, Hatch Experiment Station at Amherst, Mass., describing the trouble, and also, if possible, send samples of the injury and the insect causing it, and attention will at once be given to the matter.

As the Hatch Experiment Station of Massachusetts is supported in part by State appropriation, such a use of its facilities by the people of the State is not only justifiable but most desirable, for it was established for just that purpose; and no one who incurs loss by insect ravages can excuse himself for that loss except on the ground of ignorance that such assistance can be obtained.

Over eight hundred of these circulars were sent out to the newspapers, granges and other organizations of the State, with the request that the facts contained therein be given the greatest publicity. As these slips were not circulated till December, 1899, it is not possible to ascertain the results, but a considerable increase in the already large correspondence is anticipated during the coming year.

Last June my assistant, Mr. R. A. Cooley, was appointed professor of zoölogy and entomology at the Montana State College. Mr. Cooley is a careful and thorough investigator, and proved himself a very efficient and valuable assistant to me. The loss of his services rendered necessary the appointment of some one to take his place. As it was advisable for many reasons to obtain a man of large experience, Dr. H. T. Fernald of Pennsylvania, for nine years professor of zoölogy and entomology at the Pennsylvania State College, and for the past two years State entomologist of Pennsylvania, was elected associate entomologist, to take the place made vacant by the resignation of Mr. Cooley.

The San José Scale.

The San José scale is now known to occur in injurious abundance at more than thirty different places in Massachusetts, — in fact, it may be said to be generally distributed over the State. It has probably been introduced from several other States, as there is nothing except the objections of purchasers to prevent its being brought in on every plant purchased. Its presence, however, and the serious destruction it causes, have led a number of States to pass laws excluding all stock from outside their borders unless accompanied by an authorized certificate that the stock had been inspected and no scale found. This action was most inconvenient for Massachusetts nurserymen, who were often thus prevented from filling orders to go to States having such laws. To meet this difficulty, the committee of the trustees of the college, in charge of the experiment station, authorized the entomological division of the station to inspect nurseries when requested to do so by their owners, and to give authorized certificates where no scale is found, charging for this work only the actual expenses incurred. This action was not a required one, and was taken solely for the purpose of accommodating nurserymen, many of whom have already shown their appreciation of the arrangement and have availed themselves of the opportunity thus afforded them.

Bulletin on Chionaspis.

On the 10th of August, 1899, the work of Mr. R. A. Cooley on the different species of *Chionaspis* and *Hemichionaspis* was published in a special bulletin of the station. This bulletin, treating of many of the important scale insects which have recently attracted so much attention because of the injury they do to fruit and other trees, was fully illustrated, and has received high commendation not only in this country but also in Europe.

The Grass Thrips.

Studies on the grass thrips have been continued during the year by Mr. W. E. Hinds, one of the senior students, with most satisfactory results, and are published as an appendix to the college catalogue. As these studies are largely technical, such of the facts as have an economic bearing will also be published in a bulletin for the use of the farmers of the State.

The Clover-head Beetle.

Work on the clover-head beetle (*Phytonomus nigrirostris*) has been continued during the year by Mr. C. M. Walker, and the results are nearly ready for publication. Its life history has been nearly completed, and the best methods of treatment are being investigated. This work will be published as soon as completed.

Raupenleim.

This substance, which is of such value for banding trees liable to the attacks of the canker worms, tussock moth, etc., has heretofore been manufactured by a secret process in Germany. During the past year the chemist of the Gypsy Moth Commission, Mr. F. J. Smith, made experiments at the chemical laboratory of the insectary, to determine its composition. These experiments proved very successful, and in consequence raupenleim can now be manufactured in this country at a low cost. This one discovery has been estimated as worth half a million of dollars to the farmers and fruit growers of the United States.

The Gypsy Moth.

The work of exterminating the gypsy moth, with which I have been connected since 1891, has been carried on during the past year with marked success, and the insect has been reduced to such an extent over almost the entire territory that one who has kept in close touch with the field work for several years past cannot fail to be impressed by the great gain that has been made towards the extermination of this pest.

There is no longer any question, in the minds of those who have made a careful personal investigation of the work throughout the infested territory, that the gypsy moth can be exterminated. Nearly all of the prominent economic entomologists of this country have inspected the work with great care, and have become fully convinced that extermination is possible, if the Legislature each year promptly grants the full appropriation asked for this purpose by the gypsy moth committee. The entire responsibility now rests with the Legislature.

The Brown-tail Moth.

This insect has now become widely distributed in the eastern part of this State, and even extends into New Hampshire; it is therefore believed to be impossible to exterminate this pest with any appropriations that the two States in which it now occurs would be likely to make. When attention was first called to this insect, in the spring of 1897, the matter was laid before Governor Wolcott, who sent a message to the Legislature recommending an appropriation of $10,000 for the extermination of the pest, which then occurred only in a very limited area. It was believed that this amount would be sufficient to stamp out the insect. The Legislature, however, refused to make any appropriation for this purpose, and the inevitable results followed.

In consideration of the failure of the Legislature to prevent the spread of the brown-tail moth over the country, the gypsy moth committee have authorized me, with the assistance of those associated with me, to "collect such information, both in this country and Europe, in regard to the brown-tail moth, and make such experiments with the insect as may be useful to the committee in future dealing with the creature and necessary for the proper enlightenment of the public on the subject, with a view to publish the said information, if it may appear desirable."

In accordance with this action of the gypsy moth committee a large amount of time has already been spent on this work, but it is far from being completed, and it is impossible at present to say just when the work will be ready for publication.

Monograph of the Pyralidæ.

I have been engaged for many years in a critical study of the microlepidoptera of North America, and have already published several monographs on certain families of these insects. I am now at work on a monograph of the Pyralidæ, which will probably be ready for publication some time this year.

The Card Catalogue.

The card catalogue of insects now contains over forty thousand cards, and is continually growing in size, as constant additions are made to it from the new journals and other entomological publications as they are received. Only those insects occurring in North America have been catalogued in the past, but the literature of the scale insects (Coccidæ) of all countries is now being added. This is rendered necessary, as these insects are being imported into our country from different parts of the world without restriction in any State except California.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, F. W. MOSSMAN, B. K. JONES, P. H. SMITH, JR.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

PART I.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has materially increased during the past year, notwithstanding the prolonged illness of Dr. Lindsey, which necessitated a temporary rearrangement of the staff, leaving the bulk of the analytical work to be carried on by two assistants.

There have been sent in for examination 167 samples of water, 144 of milk, 193 of cream, 36 of pure and process butter, 25 of oleomargarine, 147 of feed stuffs and 52 of miscellaneous substances.

In connection with experiments by this and other divisions of the station there have been analyzed 62 samples of milk, 54 of butter and 429 of fodders and feed stuffs.

In addition to the above, 748 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, of which 736 samples have been tested, either individually or in composite. This makes a total of 2,045 substances analyzed during the year, as against 1,875 last year and 1,147 in the year previous. There have also been carried on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

Character of Chemical Work.

Water. — Sanitary examinations of water have been carried out, as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for the use of live stock.

Persons whose water supply is other than that of a city or town system should use every possible means to guard it against pollution arising from sinks, vaults and stables, or from the entrance of surface water and animal and vegetable matter. The latter, while not in itself highly injurious to health, is objectionable, as it favors the rapid propagation of bacteria and other micro-organisms. The detection of specific disease germs in water is, however, not a function of the chemist, but of the bacteriologist.

Frequent cases of poisoning result from conducting drinking water through lead pipe, and such a practice cannot be too severely condemned, for the poison, once assimilated, is very difficult to remove from the system. At least five samples examined during the past year have shown its presence. Soft waters as a rule have a much greater solvent action upon lead than hard waters. Wells and springs ought to be thoroughly cleaned at regular intervals.

It is of great importance that the utmost care be exercised in taking the sample for analysis, otherwise the chemical examination, conducted under the most careful and exacting conditions, is of little or no value. The quantity necessary is two to three quarts, collected in a thoroughly cleaned and well-rinsed glass bottle, stoppered with a new cork, over which is to be tied a clean piece of cotton cloth. An air space of about one inch should be left between cork and liquid, to allow for expansion. In case of pond water, the sample should be taken from below the surface, being careful to avoid the surface scum and the sediment at the bottom. The chemist's report upon the character of the water must necessarily be a matter of judgment, based on the analysis and the information furnished by the party sending the sample. Accurate replies to the following questions are necessary to a complete understanding of each case, and are for the interest of the person sending the water: —

1. Sources, whether from spring, stream, pond, reservoir or well.
2. Character of soil in which located.
3. Distance from any possible source of pollution, and character of the same.
4. Kind of pipe used for conducting the water.

Ship samples at once by express, charges prepaid. In making the report of an analysis a printed form is used, which explains the results so as to be readily understood by any one.

The examination of mineral or spring waters for which medicinal properties are claimed, or those intended for commercial purposes, does not fall within the scope of our duties.

Milk. — The samples sent in show a wide variation both in solids and fat, a considerable number falling below the Massachusetts legal standard,* indicating a need on the part of certain milkmen and others of introducing better stock and disposing of inferior animals.

In taking a sample for analysis, mix the entire milking by pouring three or four times from one vessel to another, and immediately fill a pint bottle. Mark each sample, stating kind of milk (whole, skim or buttermilk) and the tests desired, together with the name and address of the shipper; the package to be marked "*Immediate Delivery*," and sent by express, prepaid. Samples sent from a considerable distance should be treated with four drops of forty per cent. formaldehyde (obtained at any apothecary's), to insure the preservation of the sample.

Cream. — Everything said in regard to the sampling and shipping of milk applies equally well to cream.

* In the months of October, November, December, January, February and March, 13 per cent. solids and 3.7 per cent. fat are required, but during the remainder of the year only 12 per cent. solids and 3 per cent. fat.

Butter. — In connection with the feeding experiments conducted at the barn last season many samples of butter were analyzed, and very thorough examinations of the butter fat, both in regard to its chemical composition and physical properties, were made.

"Renovated" or "process" butter having become of considerable prominence in the market, a law was passed by the last Legislature forbidding its sale except when plainly marked, in one-half inch type, "Renovated butter." Several samples have been identified in this laboratory by means of a microscopical examination, general characteristics of the melted fat and curd, together with the Reichert number; and a much larger number of oleomargarines have been identified by the same methods.

Cattle Feeds. — The feed law passed by the State Legislature, which took effect in July, 1897, is apparently meeting with good success. The work is carried out by this department, the assistants making a semi-annual canvass of the State, taking samples of all the prominent concentrated feed stuffs. The samples so collected are carefully analyzed, and the results published in bulletins from time to time. The purpose of this work is to exclude poor and adulterated feeds, and to maintain products of a uniform grade.

The effect of the law on the quality of cotton seed meal has been very marked. In the earlier collections inferior meals were common, but during the present season but few were found, and the average protein content is many per cent. higher. Low-grade wheat feeds and oat feeds of unknown manufacture still remain in the market, and probably will to some extent until a guarantee is required on all feeds and power given to enforce the same.

Part II.

Feeding Experiments and Dairy Studies.

An investigation was instituted last season to ascertain the effect produced on the quantity and quality of butter fat by feeding ground flax-seed meal containing thirty-six per cent. of oil, as compared with a normal linseed ration.

Following this, a long series of feeding experiments was begun, the object being to demonstrate, if possible, the effect of each of the food components, protein, fat and carbohydrates, as found in different feed stuffs, — linseed meal, gluten meal, cotton seed meal, etc., — upon the composition and physical characteristics of the resulting butter fat. In each case the experiment was compared with a standard ration supposed to be without special effect on the butter fat. It is evident that such a task involves a large amount of careful and long-continued work, but as soon as positive results are obtained they will be published.

Digestion Experiments.

Digestion experiments were conducted last winter and spring in the same careful manner as in previous years, using two or three sheep in each trial. The grains fed were oat feed, Parson's $6 feed, four lots of "Bourbon" distillers' grains (brands X., XX., XXX. and XXXX.), rye distillers' grains, Cleveland flax meal and Chicago gluten meal.

The digestion coefficients, together with complete data, will be reported at a later date.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

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

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

Part I. — Report on Official Inspection of Commercial Fertilizers and Agricultural Chemicals during the Season of 1899.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 67; of these, 38 have offices for the general distribution of their goods in Massachusetts, 10 in New York, 5 in Connecticut, 3 in Vermont, 3 in Rhode Island, 3 in Canada, 2 in Pennsylvania, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and ninety-one distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Three hundred and eighty-four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and sixty-two samples were analyzed at the close of November, 1899, representing 289 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 59, March; No. 62, July; and No. 63, November, 1899.

The samples not already analyzed, together with others that may be collected before the first of May, 1900, will be examined with a view of being published in our spring bulletin.

During the season the inspector has caused samples to be taken in the towns and villages distributed throughout the State, and representing each county within the Commonwealth. Wherever more than one sample of a given brand has been collected in different parts of the State, a composite sample has been made up of equal weights of the several samples, and an analysis made of the homogeneous mixture. It is believed that an analysis of this nature more fairly represents the composition of the fertilizer than the analysis of any one sample.

It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses are here inserted: —

	1898.	1899.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	5	16
Number with two elements above the highest guarantee,	17	27
Number with one element above the highest guarantee,	77	73
Number with three elements between the lowest and highest guarantee,	85	88
Number with two elements between the lowest and highest guarantee,	93	84
Number with one element between the lowest and highest guarantee,	54	58
Number with two elements below the lowest guarantee,	19	19
Number with one element below the lowest guarantee,	90	68
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	5	7
Number with one element above the highest guarantee,	24	32
Number with two elements between the lowest and highest guarantee,	25	20
Number with one element between the lowest and highest guarantee,	17	27
Number with two elements below the lowest guarantee,	2	2
Number with one element below the lowest guarantee,	8	18
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	18	10
Number between lowest and highest guarantee,	23	16
Number below lowest guarantee,	15	10

A comparison of the above-stated results of our inspection with the results of 1898 shows, on the whole, a marked superiority in favor of the samples analyzed in 1899.

Wherever a discrepancy has arisen between the results of our analyses and the manufacturer's guarantee, it has been evident that imperfect mixing has been the cause, and not a desire of the manufacturer to place inferior goods on the market. It should be remembered, when purchasing fertilizers, that the responsibility of the manufacturer or dealer ends with furnishing an article corresponding in its composition with the lowest stated guarantee of each of the three essential elements of plant food.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1898 and 1899 (Cents per Pound).

	1898.	1899.
Nitrogen in ammonia salts,	14.00	15.00
Nitrogen in nitrates,	13.00	12.50
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade fertilizers.	14.00	14.00
Organic nitrogen in fine bone and tankage,	13.50	14.00
Organic nitrogen in medium bone and tankage,	10.00	10.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.50	2.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows an increase, as compared with the preceding year, 1898.

The above trade values are based on the market cost, during the six months preceding March, 1899, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

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

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

Analysis of Fertilizer (Pounds in One Hundred Pounds of Fertilizer).

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

	Value per One Hundred Pounds.	Value per Two Thousand Pounds.
Four pounds nitrogen, at 14 cents,	$0.56×20	=$11.20
Eight pounds soluble phosphoric acid, at 4½ cents,	.36×20	= 7.20
Four pounds reverted phosphoric acid, at 4 cents,	.16×20	= 3.20
Two pounds insoluble phosphoric acid, at 2 cents,	.04×20	= .80
Ten pounds potassium oxide, at 5 cents,	.50×20	= 10.00
Value per ton,		$32.40

The following table gives the average analysis of officially collected fertilizers for 1899: —

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.86	2.96	2.82	4.65	3.29	3.19	11.13	8.77	7.94	6.67	5.16	4.92
Ground bones,	5.23	2.99	2.63	-	5.58	18.61	24.19	22.53	5.58	6.67	-	-
Tankage,	5.75	4.88	4.41	-	4.99	14.49	18.66	16.33	5.83	-	-	-
Dissolved bone-black,	14.02	-	-	13.62	2.82	-	16.76	16.00	16.44	15.00	-	-
Wood ashes,	9.50	-	-	-	-	-	1.57	1.00	-	-	6.37	4.50
Cotton-hull ashes,	10.44	-	-	-	6.88	1.28	8.16	8.00	6.88	-	27.74	25.00
Cotton-seed meal,	7.79	7.09	6.96	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.65	15.71	15.36	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	1.94	21.00	20.60	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.17	-	-	-	-	-	-	-	-	-	48.42	48.95
Sulfate of potash and magnesia,	3.93	-	-	-	-	-	-	-	-	-	26.70	25.28
Muriate of potash,	1.43	-	-	-	-	-	-	-	-	-	49.68	50.27

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1899, to May 1, 1900), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.
- Fruit and Root Crop Special.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

The American Jadoo Co., Philadelphia, Pa.: —
- Jadoo Liquid.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

The East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Special Complete Strawberry Manure.
- Special Complete Potato Manure.
- Special Complete Cabbage Manure.
- Special Complete Grass and Lawn.
- Complete Manure for General Use.
- Pure Ground Raw Bone.
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn.: —
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, ◇H◇ B.
- Fish Scrap No. 2, ◇H◇ B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Special Fertilizers.
- Bowker's Potatoes and Vegetables.
- Bowker's Fish and Potash, Square Brand.
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Essex County Fertilizer.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.

William E. Brightman, Tiverton, R. I.: —
- Brightman's Potato and Root Manure.
- Brightman's Phosphate.
- Brightman's Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's Dry Ground Fish.
- Bradley's Strawberry Manure.
- Bradley's English Lawn Fertilizer.
- Bradley's New Method Fertilizer.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's Columbian Fish and Potash.

Bradley Fertilizer Co. — *Con.*
- Bradley's Circle Brand Extra Fine-ground Bone with Potash.
- Bradley's X. L. Phosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Complete Manures.
- Bradley's Fish and Potash.
- Bradley's Corn Phosphate.
- Bradley's Fine-ground Bone.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Dissolved Bone-black.
- Sulfate of Potash.
- Muriate of Potash.
- Nitrate of Soda.
- Kainite.

Joseph Breck & Sons., Boston, Mass.: —
- Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B. Special Fertilizer.
- Church's C. Standard Fertilizer.
- Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove King Philip Guano.
- Clark's Cove White Oak Pure Ground Bone.
- Clark's Cove Bay State Potato Manure.
- Clark's Cove Great Planet Manure.
- Clark's Cove Bay State Fertilizer.
- Fish and Potash.
- Potato Fertilizer
- High-grade Sulfate of Potash.
- Muriate of Potash.
- Nitrate of Soda.

Cleveland Dryer Co., Boston, Mass.: —
- Cleveland Fertilizer
- Cleveland Potato Phosphate.
- Cleveland Superphosphate.
- Cleveland Grass Fertilizer.
- Cleveland Corn and Grain Phosphate.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's High-grade Potato Fertilizer.

E. Frank Coe Co. — *Con.*
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's Fish Guano and Potash.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Crocker's Vegetable Bone Superphosphate.
- Crocker's Special Potato Manure.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Ammoniated Wheat and Corn Phosphate.
- Crocker's New Rival Ammoniated Superphosphate.
- Crocker's New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.:—
- Cumberland Phosphate.
- Cumberland Potato Fertilizer.
- Cumberland Concentrated Phosphate.
- Cumberland Fertilizer.

Chas. M. Cox & Co , Boston, Mass.: —
- Cotton-seed Meal.

L B. Darling Fertilizer Co., Pawtucket, R. I.: —
- Potato and Root Crop.
- Animal Fertilizer.
- Blood, Bone and Potash.
- Fine Bone,
- Tobacco Grower.
- Special Formula.
- Nitrate of Soda.
- Muriate of Potash.
- Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
- Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Elbert & Gardner, New York, N. Y.: —
Cotton-seed Meal.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Wood Ashes.

T. H. Frowley, Brookline, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Garden Special.
Vegetable, Vine and Tobacco.
Northern Corn Special.
General Fertilizer.
Grass and Oats.

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

F. E. Hancock, Walkerton, Ont., Can.: —
Canada Unleached Hardwood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Animal Brand.
Swift's Lowell Potato Phosphate.
Swift's Lowell Market Garden Manure.
Swift's Lowell Fruit and Vine.
Swift's Lowell Lawn Dressing.
Swift's Lowell Tobacco Manure.
Swift's Lowell Ground Bone.
Swift's Dissolved Bone and Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Celebrated Onion Fertilizer.
Lister's Special Tobacco Fertilizer.
Lister's High-grade Special for Spring Crops.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunnville, Ontario, Can.: —
Canada Hardwood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Mapes Bone Manures.
Mapes Superphosphates.
Mapes Special Crop Manures.
Economical Potato Manure.
Tobacco Ash Constituents.
Sulfate of Potash.
Sulfate of Ammonia.
Nitrate of Soda.
Double Manure Salt.

Geo. L. Munroe, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
Fine-ground Bone.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hardwood Ashes.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Niagara Wheat and Corn Producer.
Niagara Potato, Tobacco and Hop Fertilizer.

Pacific Guano Co., Boston, Mass.: —
High-grade General Fertilizer.
Soluble Pacific Guano.
Potato Special.
Nobsque Guano.
Grass and Grain Fertilizer.
Pacific Guano with ten per cent. Potash.
Fish and Potash.
Special Potato Manure.

Packers Union Fertilizer Co., New York, N. Y.: —
Animal Corn Fertilizer.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover.
Gardeners' Complete Manure.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Special Strawberry Brand Fertilizer.
Plymouth Rock Brand.
Special Potato Fertilizer.

Parmenter & Polsey Fertilizer Co. — *Con.*
- P. & P. Potato Fertilizer.
- Star Brand Superphosphate.
- A. A. Brand.
- Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Superphosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

Quinnipiac Co., Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Dry Ground Fish.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Fish and Potash.
- Quinuipiac Grass Fertilizer.
- Quinnipiac Corn Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Climax Phosphate.
- Quinnipiac Pure Bone Meal.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

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

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Complete Manure for Potato, Roots and Vegetables.
- Essex Odorless Lawn Dressing.
- Essex Dry Ground Fish.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
- Read's Standard.
- Practical Potato Special.
- Bone, Fish and Potash.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.
- Sanderson's Sulfate of Potash.
- Sanderson's Muriate of Potash.

Standard Fertilizer Co., Boston, Mass.: —
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.
- Staudard Complete Manure.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
- Swift Sure Superphosphate for General Use.

F. C. Sturtevant, Hartford, Conn.: —
- Sturtevant's Granulated Tobacco and Sulphur.

Edward H. Smith, Northborough, Mass.: —
- Smith's Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

The South Sea Guano Co., Boston, Mass.: —
- South Sea Guano.

E. A. Tompkins, Jamaica Plain, Mass.: —
- Ferti Flora.

Henry F. Tucker Co., Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Imperial Bone Superphosphate.
- Tucker's Special Potato Fertilizer.
- Tucker's Bay State Special.

I. S. Whittemore, Wayland, Mass.: —
- Complete Manure.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- Ammoniated Bone Superphosphate.
- Prolific Crop Producer.
- Potato Phosphate.
- High-grade Special.
- Royal Bone Phosphate.
- Corn Phosphate.

Williams & Clark Fertilizer Co. — *Con.*
- Potato Manure.
- Grass Manure.
- Fish and Potash.
- Onion Manure.
- Bone Meal.
- Dry Ground Fish.
- Muriate of Potash.
- Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
- Superior Truck Fertilizer.
- Havana Tobacco Fertilizer.
- Potato Manure.
- Corn Fertilizer.
- Fruit Fertilizer.
- Royal Wheat Grower.
- Grass and Oats.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

J. M. Woodard & Brother, Greenfield, Mass.: —
- Tankage.

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

CHARLES A. GOESSMANN.

1. Analyses of materials sent on for examination.
2. Notes on wood ashes and condition of the trade.

1. Analyses of Materials sent on for Examination.

During the past season 225 materials have been received, and the results of our examination have been published in detail in bulletins 59, 62 and 63 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality they come from. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of many industries are of such a nature that their value as manurial substances is unlimited and the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value. A frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements will be made, as in previous years, to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a partial list of materials received during the past season, which shows the general nature of the work: —

Wood ashes.
Sulfate of potash.
Muriate of potash.
Nitrate of soda.
Sulfate of ammonia.
Acid phosphates.
Sulfate of potash and magnesia.
Ground bone.
Complete fertilizers.
Minerals.
Liquid fertilizers.
Soils.
Dried pig's blood.
Lime-kiln ashes.
Glucose sugar refuse.
Damaged grain.
Insecticides.
Composts.
Refuse from glass factory.
Cotton-seed meal.
Cotton-hull ashes.
Tankage.
Wool shoddy.
Jadoo fibre.
Plaster.
Forage crops.
Soot.
Spent bone-black.
Brick-yard ashes.
Sludge.

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to those who may desire such information.

2. Notes on Wood Ashes.

This subject has engaged our attention for past seasons and has been discussed at length in previous reports.

During the past year (1899) 24.4 per cent. of the materials sent on for analysis consisted of wood ashes, as against 40.1 per cent. the previous year (1898).

The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article. The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to guarantee the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of those two elements is present. Wood ashes ought to be bought and sold by weight and *not* by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given volume.

	No. of Samples.	
	1898.	1899.
Moisture below 1 per cent.,	–	2
Moisture from 1 to 3 per cent.,	9	6
Moisture from 3 to 6 per cent.,	6	4
Moisture from 6 to 10 per cent.,	20	11
Moisture from 10 to 15 per cent.,	22	28
Moisture from 15 to 20 per cent.,	16	7
Moisture from 20 to 30 per cent.,	6	1
Moisture above 30 per cent.,	–	1
Potassium oxide above 8 per cent.,	4	4
Potassium oxide from 7 to 8 per cent.,	6	9
Potassium oxide from 6 to 7 per cent.,	8	13
Potassium oxide from 5 to 6 per cent.,	22	7
Potassium oxide from 4 to 5 per cent.,	25	19
Potassium oxide from 3 to 4 per cent.,	11	2
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	6	4
Phosphoric acid from 1 to 2 per cent.,	60	43
Phosphoric acid below 1 per cent.,	13	10
Average per cent. of calcium oxide (lime),	33.60	34.10
Per cent. mineral matter insoluble in diluted hydrochloric acid: —		
Below 5,	1	–
5 to 10,	16	16
10 to 15,	31	26
15 to 20,	15	7
20 to 30,	13	5
Above 30,	–	2

Cotton-hull Ashes. — This waste product is receiving increased attention from the farmers, and is an article of great merit. The samples received this year analyze from 21 to 29 per cent. of potash, and are especially adapted to tobacco growing on account of the large proportion of carbonate of potash present, this form of potash being the most valuable one known for that purpose.

Sludge. — At the present time the larger cities are collecting all waste débris in reservoirs, and subjecting it to chemical treatment for recovery of fertilizing ingredients. This source of plant food is often within easy reach of the farmer, and may be turned to good advantage, as is seen from the average analysis: nitrogen, 1.31 per cent.; potash, .16 per cent.; phosphoric acid, .86 per cent.; lime, 1.13 per cent.

Hen Manure. — In this ingredient we have a very rich fertilizer and a material that is worthy of careful treatment. To save the nitrogen that otherwise might pass into the air a "fixer" is a necessity. Two samples received at the laboratory were analyzed, as follows: —

SAMPLES.	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Sample I., ...	.46	1.12	.69
Sample II., ...	.42	.43	.63

No. I. was treated with kainite, a material analyzing on an average 16 per cent. potash, and a substance capable of fixing the ammonia, thereby saving this element and at the same time supplementing the manure in potash, — the ingredient which it is deficient in. This application of an ammonia fixer may be applied to all animal refuse products, and, as is seen, has a twofold action, — the saving of nitrogen and the supplementing of potash.

Cotton-seed Meal. — This material still holds its own and is a recognized standard article, a source of nitrogen sought by tobacco growers. Its high standard has been maintained as in previous seasons.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

THIRTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

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

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

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

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 47. Field experiments with tobacco.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 66. Variety tests of fruits; fertilizers for fruits; thinning fruits, pruning; spraying calendar.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

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

Of the numerous problems presented for solution, a few only of the more important have been selected. From a series of experiments on the effect of food on the composition of milk and butter fat and on the consistency or body of butter, it was found: (*a*) that different amounts of protein do not seem to have any influence on the composition of milk; (*b*) that, in general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed, but after a few weeks the fat percentage gradually returns to normal; (*c*) that it is not practicable to feed large amounts of oil to cows, as it has a tendency to derange the digestive and milk-secreting organs; (*d*) that linseed oil effected 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 iodine coefficient; (*e*) and that cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration.

In experiments to show the feeding value of barnyard millet, it is shown: (*a*) that the millet has less nutritive value than corn, for the reason that it must be cut when in early blossom to secure it in the most desirable condition for feeding, while the corn can partially mature its grain and still be readily eaten by animals; (*b*) that it is not suitable for hay and is inferior to maize as a silage crop; (*c*) that it furnishes quite a desirable green feed, especially during the month of August, and for this purpose can be most satisfactorily utilized.

A study of the effects of different chemical solutions on germination brought out some interesting facts. The solutions formed from those substances known to exist in seeds and seedlings were of two kinds: ferments, as diastase and pepsin; and amides, as asparagin and leucin. In each experiment one hundred seeds were used, the solution varying in strength from one-tenth per cent. to two per cent. The seeds were soaked in the solution for twelve hours, then rinsed in water and placed in Zurich germinaters. With asparagin as the solution on such seeds as vetch, rape, alfalfa, the average percentage of germination for normals was seventy-four and five-tenths per cent.; for the treated was eighty-eight and eight-tenths per cent. and an acceleration of germination in several seeds. With leucin on buckwheat and alfalfa the average of three experiments gave eighty-three per cent. for normal and ninety-two per cent. for treated. With pepsin and diastase there was in like manner a gain of about ten per cent.

Great complaint having been made of the difficulty of growing asters, fifteen thousand were grown under different conditions of fertilizers, varieties, localities, time of planting and methods of handling. A peculiar and obscure disease was made out, not resulting from organisms of any kind, but very destructive in its effects. There was an abnormal development, due to disturbance of the assimilative functions of the plant.

Remedies for the various diseases of lettuce grown under glass have occupied the attention of the division of plant pathology for several years. The "drop," which is characterized by rotting of the stem and sudden and complete collapse of the whole plant, is the most destructive of these diseases. The amount of loss is very commonly twenty-five per cent. of the entire crop. It has been found that by sterilizing the soil, either wholly or in part, the drop and its kindred disease can be wholly eradicated or suppressed. Experiment shows that five-eighths inch or three-fourths inch surface covering of sterilized sand or earth gave an average reduction of forty-seven per cent. in the amount of drop; one inch of sterilized sand or earth gave an average reduction of eighty-seven per cent.; one inch and a half of sterilized soil, an average of ninety-three per cent.; and two, three and four inches secured entire immunity from the disease.

In the entomological division the structure and life history of various insect pests have been worked out and published, and the remedies to be employed. Among those thus treated are the grass thrips; the thrips of the greenhouse, attacking cucumbers; the fall canker worm; the marguerite fly; and greenhouse aleurodes, doing great damage to tomatoes and cucumbers grown under glass. The San José scale continues its ravages in the State. It has already been found in thirty-seven different towns, and it probably exists in as many more. It attacks the fruit as well as the bark, and specimens of currants, pears and apples have been sent in so completely covered with them as to render their sale impossible.

In the agricultural division the results of experiments continued since 1890 with oats, rye, soy beans, clover and potatoes seem to indicate that the various manures supplying nitrogen rank in the following order: (*a*) nitrate of soda, barnyard manure, sulfate of ammonia and dried blood; (*b*) that in crops of the clover family as nitrogen gathers, the crops not being turned under, but improvement sought from roots and stubble, there was no appreciable improvement from soy beans, but marked from clover; (*c*) that potatoes, clovers, cabbages and soy beans did much the best on sulfate of potash, while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate; (*d*) that, if the muriate is used continuously, sooner or later lime must be applied; (*e*) that, with garden crops, both early and late, the sulfate rather than the muriate should be used; (*f*) that none of the natural phosphates appear to be suited to crops belonging to the turnip and cabbage family; (*g*) that, while it is possible to procure profitable crops of most kinds by a liberal use of natural phosphates, the best practice will probably be found to consist in using one of those in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

A detailed account of the operations of the year is herewith submitted.

ANNUAL REPORT

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

For the Year ending June 30, 1900.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,614 58	
for labor,	4,278 90	
for publications,	409 40	
for postage and stationery,	228 53	
for freight and express,	127 48	
for heat, light and water,	254 96	
for chemical supplies,	108 53	
for seeds, plants and sundry supplies,	602 04	
for fertilizers,	1,168 55	
for feeding stuffs,	136 62	
for library,	157 31	
for tools, implements and machinery,	673 63	
for furniture and fixtures,	51 90	
for scientific apparatus,	384 95	
for live stock,	60 30	
for travelling expenses,	22 02	
for contingent expenses,	125 25	
for buildings and repairs,	595 05	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,600 00	
from farm products,	1,720 86	
from miscellaneous sources,	1,979 82	
		$18,500 68
Cash paid for salaries,	$8,158 11	
for labor,	4,696 81	
for publications,	556 56	
for postage and stationery,	313 85	
for freight and express,	123 64	
Amount carried forward,	$13,848 97	

Amount brought forward, ...	$13,848 97	
Cash paid for heat, light and water, . . .	582 04	
for chemical supplies, ...	525 14	
for seeds, plants and sundry supplies,	611 53	
for fertilizers, ...	162 47	
for feeding stuffs, ...	995 78	
for library, ...	96 95	
for tools, implements and machinery,	107 81	
for furniture and fixtures, . . .	50 73	
for scientific apparatus, . . .	546 38	
for live stock, ...	125 66	
for travelling expenses, . . .	216 62	
for contingent expenses, . . .	94 00	
for buildings and repairs, . . .	536 60	
		$18,500 68

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1900; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,500.68 and the corresponding disbursements $33,500.68. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1900.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 9, 1900.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, F. W. MOSSMAN,* B. K. JONES,† P. H. SMITH, JR., J. W. KELLOGG.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

A. Effect of feed on the composition of milk, butter fat, and on the consistency or body of butter.

B. The feeding value of barnyard millet.

C. Dried distillery grains.

D. Digestion experiments with sheep.

E. The composition of purslane.

F. Parsons' "six-dollar" feed.

* Resigned Nov. 1, 1900.

† Resigned Nov. 1, 1900, to accept position in the Utah Experiment Station.

PART I.

LABORATORY WORK.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has materially increased over all previous years. There have been sent in for examination 287 samples of water, 123 of milk, 888 of cream, 20 of pure and process butter, 29 of oleomargarine, 123 of feed stuffs and 10 of vinegar. In connection with experiments by this and other divisions of the station, there have been analyzed 45 samples of milk and cream, 60 of butter and 695 of fodders and feed stuffs.

In addition to the above, 707 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, and tested, either individually or in composite; and 40 tonics, condimental feeds, etc., have been examined. This makes a total of 3,036 substances analyzed during the year, as against 2,045 last year and 1,875 in the previous year.

CHARACTER OF CHEMICAL WORK.

Water, Milk, Cream, Feed Stuffs, etc., sent for Examination. — More than the usual number of samples have been received during the year. Sanitary examinations of water have been carried on as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for live stock. In milk analysis, the percentages of total solids and fat are the usual ones determined. The percentage of fat only is determined in cream, unless the quantity of other ingredients is requested. An estimation of the percentage of protein is usually all that is necessary to determine the genuineness of a feed stuff. In some cases it is wise to determine the percentage of fat; in others, the percentage of ash and fibre.

Full information concerning water, milk and cream, how to take samples, etc., will be found in our report for 1899. Special information will be furnished upon application.

Cattle Feed Inspection. — We have continued the inspection of concentrated feeds during the year, collecting and analyzing over 700 samples. A bulletin is about to be issued, giving the results of the work accomplished. The better class of feeds is practically free from adulteration. Some manufacturers and jobbers are still disposed to put cotton-seed meal mixed with ground hulls upon the market, marked simply cotton-seed meal. Mixed feed, so called, consisting principally of wheat bran together with several hundred pounds of fine or flour middlings to the ton, is beginning to be adulterated with wheat hulls, ground corn cobs, etc. This material ought to be accompanied by a guaranty to assure the purchaser of its purity. Many very inferior oat feeds, containing 50 to 60 per cent. of oat hulls, are still on sale. They are very expensive at the price asked for them. These inferior oat feeds are often used by millers to mix with cracked corn, the resulting product being sold as provender. It is quite inferior to a mixture of genuine ground oats and corn. New feeds are constantly coming into the market, most of them by-products from different industries. The writer is convinced that the time is nearly at hand for a change in the present feed law, making it conform to the laws in the other New England States.

Methods of Analysis. — This department has co-operated with the Association of Official Agricultural Chemists in investigating different methods of analysis, with a view to their improvement. During the present year investigations have been made relative to the best methods of determining starch, pentosans and galactan in feed materials, and of casein and albumin in milk. Work of this character cannot be expressed in figures. It consumes much time, but is very necessary, and likely to be productive of valuable results.

Chemical and Physiological Investigations. — So far as time and resources permit, the chemical staff is engaged in investigating some of the many pressing dairy and feeding problems. The time at present is largely devoted to the examination of butter fat, the manufacture of butter and to the digestibility of feeding stuffs. It is to be regretted that the analysis of the various materials sent to the station — waters, milk, cream, butter and feed stuffs — consumes each year an increasing amount of time, and necessarily limits the extent of experimental work.

PART II.

FEEDING EXPERIMENTS AND DAIRY STUDIES.

A.—EFFECT OF FEED ON THE COMPOSITION OF MILK, BUTTER FAT, AND ON THE CONSISTENCY OR BODY OF BUTTER.

J. B. LINDSEY.*

CONCLUSIONS.

As a result of the experiments which follow, concerning the influence of feeds and feed constituents on the composition of milk, butter fat, and on the character of the butter, the following deductions are made: —

1. Different amounts of protein do not seem to have any influence on the composition of the milk.

2. Linseed oil in flax-seed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage and 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 the fat.

3. In general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed. The fat percentage gradually returns to normal.

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

* Ably assisted by E. B. Holland, F. W. Mossman, B. K. Jones and P. H. Smith, Jr.

5. Linseed oil effected 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 iodine coefficient.

6. All oils do not produce the same effects on butter fat.

7. The melting point of butter fat is not always indicative of the firmness or body of butter.

8. An excess of linseed oil produced a soft, salvy butter, with an inferior flavor.

9. Linseed and corn gluten meals, with a minimum percentage of oil (3 per cent.), produced a normal butter fat. The corn gluten meal produced butter with a desirable flavor and of good body.

10. King gluten meal (corn gluten meal with 13 per cent. oil) increased the iodine coefficient of the butter fat several degrees above standard ration butter fat, and slightly depressed the melting point of the fat. This effect was probably due to the corn oil. The same meal produced butter of a very desirable flavor and body.*

11. Cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration. The butter produced by this meal was rather crumbly when hard, and slightly salvy to the taste.

Further experiments concerning the effects of food and food constituents on butter fat and butter are now in progress.

(*a*) Preliminary Statement.

During the last six years a number of experiments have been made at this station relative to the effect of food, first on the composition of milk and later on the composition of butter fat. It is not the writer's intention at this time to attempt any historical or critical review of the work of others along these lines, nor to present the full data of his own work, but rather to call attention to the progress thus far made in the effort to secure positive knowledge on the subject under investigation. The detailed experiments will be published at a proper time. The writer believes that experimenters have hitherto neglected to note the effect of the several food

* The body of this butter was very satisfactory to Mr. W. A. Gude, the scorer, but might have been considered by some as lacking in firmness.

constituents — protein, fat and carbohydrates — on the milk and butter fat, but have rather attempted to observe the influence of the combinations of these groups as they exist in the different foods. It is believed that the former method would yield more definite information on this perplexing subject.

(b) The Effect of Protein on the Composition of Milk.

In an early experiment * different amounts of protein were fed, and the effect on the composition of the milk was noted. The experiment showed that the fat content of the milk appeared to be increased. Unfortunately, the ration contained, in addition to the protein, an excess of corn and cotton-seed oil, derived from gluten feed and cotton-seed meal, and it was not at all clear whether the protein or the oil was responsible for the fat increase. Again, the periods were of too short duration to make clear whether the increase was temporary or permanent. In the next two experiments† the oil factor was eliminated as far as possible, the protein being derived from corn and gluten meals. The length of the periods were increased so as to cover from four to six weeks, and, because of increased facilities for carrying out the experiments, many outside influences bearing upon the results were eliminated. The results of these two investigations showed no particular influence of the protein upon the several ingredients of the milk, except a very slight increase in the nitrogenous matter of the milk when the largest amount of protein was fed. It therefore seemed probable that the oil in the rations fed in the first experiment above referred to was responsible for the fat increase.

(c) The Effect of Fat on the Composition of Milk.

About this time (1898), Soxhlet, a German investigator, made the statement that, contrary to general teachings, the fat of the food — as found in the different oil cakes fed on the continent — did produce a very noticeable increase in the

* Report of Massachusetts State Experiment Station, 1894.
† Ninth and eleventh reports of Hatch Experiment Station.

relative amount of fat in the milk. The full data proving this statement has not been published. The conclusion of several American experimenters who had previously fed different fats to dairy animals was that no positive increase was to be observed. Soxhlet suggested that the reason the effect of "food fat" had not been more pronounced was because the fat or oil fed had not been digested and assimilated by the animals. Following out the suggestion made by our first experiment, and endeavoring to prove or disprove Soxhlet's statements, several experiments were instituted.

The first two were made with three animals, — the only ones in condition at the time, — in the summer of 1898, and have been designated Experiments I. and II. It was merely a preliminary test. These animals were in rather an advanced stage of lactation, but producing 15 to 20 pounds of milk each per day. The coarse feeds during the several periods consisted of first and second cut hay, or second cut hay and green feed. The grain feed during the "normal oil" periods was wheat bran, or bran and Chicago gluten meal; and in the so-called "excess oil" periods flaxseed meal* was added to the wheat bran, or was substituted for the Chicago gluten meal. In the normal oil periods the amount of oil calculated to be digested was from .4 to .5 pounds, and during the excess oil periods from 1.4 to 1.8 pounds. The normal oil periods lasted seven days, then followed excess oil period of ten days, subsequently normal oil periods of four days. Each period proper was preceded by a preliminary period of seven days. When the excess oil was fed, the fat of the milk increased one-half per cent. in almost every case (that is, from 5 to 5.50, for example), and in some cases even more, and dropped back again when the excess oil was removed to even below what it was in the first or normal oil period. Part of the increase might be attributed to change of feed. The periods were short and the weather warm, and the experiment could be considered of only sufficient importance to warrant still further investigations under more favorable conditions.

* This meal contained about 37 per cent. of linseed oil.

Experiment III.

[New-process linseed meal (Cleveland flax meal) *v.* flaxseed meal.]

The next experiment was begun in October, 1898, and continued until February, 1899. The cows, ten in number, were divided as evenly as possible into Herds I. and II. Both herds received rowen (second cut hay) as the coarse fodder during the entire experiment. The grain ration for each herd consisted of bran, new-process linseed meal* (Cleveland flax meal, so called) and corn meal during the first period of three weeks, one week of which was preliminary. This was designated the "normal oil" ration. In the second period of twelve weeks Herd II. received flaxseed meal in place of the Cleveland flax meal, and corn meal; and the entire ration of Herd I. was continued unchanged. The ration consumed by Herd II. in the second period was designated the "excess oil" ration. The third period proper lasted two weeks, and both herds were fed the same ration as in the first period. Herd I. then received the same (normal oil) ration throughout the entire experiment and Herd II. the excess oil ration in the second period. The normal oil ration consisted of about .5 pounds of digestible oil and the excess oil ration of 1.75 pounds. The amount of protein and carbohydrates were essentially the same, the oil being the varying factor.

Daily Ration (Pounds).

First period: both herds normal oil ration.

HERDS.	Wheat Bran.	Cleveland Flax Meal.	Flaxseed Meal.	Corn Meal.	Rowen.
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	2	-	2 to 3	20 to 24
Second period: Herd I., normal oil ration; Herd II., excess oil ration.					
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	-	4	0 to 1	20 to 24
Third period: both herds normal oil ration.					
Herd I.,	2	2	-	2 to 3	20 to 24
Herd II.,	2	2	-	2 to 3	20 to 24

* This meal contained less than 3 per cent. of oil.

The animals completed the experiment with only slight disturbances. Composite samples of each cow's milk and of the mixed milk of each herd were made for five days of each week, and the milk was tested for total solids, fat, nitrogen and ash. The analyses of the mixed milk only are presented at this time: —

Milk Analyses.

First period: both herds normal oil ration.

SAMPLES.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.		Ash.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Weekly sample,	13.27	13.25	4.23	4.05	9.04	9.20	0.519	0.531	0.69	0.72
Weekly sample,	13.55	13.43	4.62	4.40	8.93	9.03	0.539	0.543	0.70	0.71
Weekly sample,	13.79	13.62	4.59	4.52	9.20	9.10	0.547	0.544	0.72	0.72
Averages, .	**13.54**	**13.43**	**4.48**	**4.32**	**9.06**	**9.11**	**0.535**	**0.539**	**0.70**	**0.72**

Second period: Herd I., normal oil ration; Herd II., excess oil ration.

SAMPLES.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.		Ash.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Weekly sample,	14.00	14.36	5.07	5.56	8.93	8.80	0.550	0.511	0.71	0.72
Weekly sample,	14.12	-	5.05	-	9.07	-	0.581	-	0.71	-
Weekly sample,	14.16	14.25	4.96	5.24	9.20	9.01	0.572	0.529	0.72	0.71
Weekly sample,	14.21	14.19	5.16	5.27	9.05	8.92	0.574	0.532	0.73	0.71
Weekly sample,	14.26	14.02	5.08	5.14	9.18	8.88	-	-	-	-
Weekly sample,	14.21	14.03	5.13	5.19	9.08	8.84	0.575	0.519	0.72	0.71
Weekly sample,	14.07	13.85	4.85	4.96	9.22	8.89	0.575	0.517	0.72	0.70
Weekly sample,	14.07	13.92	4.85	5.00	9.22	8.92	0.572	0.531	0.72	-
Weekly sample,	-	13.96	-	5.05	-	8.91	-	-	-	-
Weekly sample,	14.30	14.06	4.85	4.93	9.45	9.13	0.587	0.536	0.72	0.71
Averages, .	**14.16**	**14.07**	**5.00**	**5.15**	**9.16**	**8.92**	**0.573**	**0.525**	**0.72**	**0.71**

Third period: both herds normal oil ration.

SAMPLES.	Total Solids.		Fat.		Solids not Fat.		Nitrogen.		Ash.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Weekly sample,	14.14	13.54	4.87	4.38	9.27	9.16	-	0.561	-	0.70
Weekly sample,	14.06	13.70	4.68	4.28	9.38	9.42	-	0.566	-	0.71
Averages, .	**14.10**	**13.62**	**4.77**	**4.33**	**9.33**	**9.29**	-	**0.563**	-	**0.71**

In studying the *average results*, one notes that in the first period both herds produced milk of approximately the same quality. The second period of twelve weeks showed an increase in the fat of Herd I. from 4.48 to 5, or .52 per cent.,

— a natural increase, due to the advance in the period of lactation; and in Herd II. from 4.32 to 5.15, or .83 per cent. The percentage increase in Herd I. was 11.6 per cent. and in Herd II. 19.2, showing that Herd II. made the greater average increase. The total solids increased about the same in each herd. The average nitrogen percentage increased for Herd I. from .535 to .573, in about the same proportion as the total solids; while Herd II., instead of showing an increase, had a slight decrease. The ash remained practically unchanged. In the third period there was a slight decrease in the total solids and fat of Herd I., and a very noticeable decrease in the fat of Herd II. The nitrogen percentage of Herd II. in this period increases to about the average produced by Herd I. in the second period. To note, however, the full effect of the excess oil ration, one must observe the weekly analyses of the milk of both herds in the excess oil period. For example, the last fat test in the normal oil period was 4.59 per cent. for Herd I. and 4.52 per cent. for Herd II. The first fat test in the second period was 5.07 for Herd I. (receiving the normal oil ration) and 5.56 for Herd II. (receiving the excess oil ration). During this entire period Herd I. showed little variation in fat, and averaged 5 per cent. Herd II. increased from 4.48 to 5.56 at the beginning of the excess oil period, and then gradually decreased, until at the close of the period it tested 4.93 and averaged 5.15 per cent. of fat. When it is remembered that the figures given represent the mixed milk of five cows, it seems safe to conclude that the excess of oil did increase the percentage of fat in the milk, but the increase was only temporary, the fat percentage gradually dropping back to an amount parallel with Herd I. The nitrogen percentage of Herd II. in the second period did not increase so rapidly as did the fat. At the beginning of the period it was less than at the close of Period I., and did not begin to increase until near the close of the period. In the third period it was apparently normal again.

One might suppose that the fat increase in the case of Herd II. could be accounted for by the shrinkage in milk production. The shrinkage, however, was no more than with Herd I. Again, should this be the case, why should not the nitrogen increase in the same proportion, instead of actually decreasing, etc.?

To summarize briefly, the marked effect of the oil was to produce a quite noticeable increase in the percentage of milk fat when first fed; this increase gradually diminished, until at the end of the fifth week it reached the normal.* When the excess oil ration was removed, the milk fat percentage dropped noticeably below the normal. A second effect of the oil ration was to cause a depression in the percentage of nitrogen in the milk, which began to increase only towards the close of the period, and increased to the normal percentage when the excess oil ceased to be fed. As a result of this experiment, one is led to inquire in what way the oil in the feed caused the temporary increase of fat in the milk. Does the *feed oil* to any extent enter directly into the milk fat, or does it by substitution cause the body fat to be utilized by the animal in the production of milk fat, as Soxhlet suggests; or does the feed oil produce a disturbance in the milk glands, causing an increased fat secretion, by utilizing a portion of the material that would otherwise become nitrogenous matter and milk sugar? These are questions worthy of further investigation.

This experiment is rather more decisive in its teachings than many earlier investigations. The question for further investigation is, whether other oils, derived from cotton-seed, corn, etc., act in a similar way to linseed oil. Investigations touching this and other points are now in progress.†

(*d*) The Effect of Linseed Oil on Butter Fat.

Two samples of butter fat were taken weekly from each herd, in the experiment above described, and upon analyses yielded the following *average* results: —

* By normal is meant the percentage produced by Herd I.

† This experiment was completed during the winter of 1898-99, but has remained unpublished, owing to the prolonged illness of the writer. Since that time Hills (twelfth report, Vermont Experiment Station), Rhodin (Milch Zeitung 27, pp. 306-323, 1898), Bartlett (fourteenth report, Maine Experiment Station) and others have published results of a similar nature, to which more extended reference will be made at another time.

Butter Fat Analyses.

First period: both herds normal oil ration.

HERDS.	Length of Period (Weeks).	Specific Gravity $\left(\frac{100}{100}\right)$.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I., . . .	2	.905	29.79	5.24	31.99	28.93
Herd II., . . .	2	.906	28.62	5.04	32.24	30.02
Second period: Herd II., excess oil ration.						
Herd I., . . .	12	.904	30.28	5.33	32.89	28.16
Herd II., . . .	12	.903	25.17	4.43	36.93	43.19
Third period: both herds normal oil ration.						
Herd I., . . .	2	-	-	-	-	-
Herd II., . . .	2	-	27.96	4.92	33.03	32.15

The averages show that the effect of the oil was to depress the volatile acids and to increase the melting point and iodine number. The change was noted in the case of Herd II. at the beginning of the excess oil period, and continued uninterrupted until its close.

In the third period of two weeks (one week preliminary and two weeks proper), in which both herds received the normal oil ration, the butter fat in case of Herd II. changed in composition nearly to that of Herd I. at the close of the second period. The effect of the change of feed was observed at the close of the first week, but it seemed to require several weeks for the animals to thoroughly readjust themselves. It is evident that the linseed oil caused a butter fat to be produced having lower volatile acids than that produced in the normal oil period. One would also assume that it caused a change in the relative proportions of stearin, palmitin and olein. The question arose as to whether linolic and linolinic acids — the characteristic acids of linseed oil — had been actually transmitted to the butter fat, and an effort was made to detect them, but without positive results. We hope to still further investigate this matter.

(e) The Effect of Linseed Oil on Butter.

When this experiment was begun it was not the intention to convert the cream into butter, but to note particularly the effect of the oil on the composition of the milk and butter fat. The oil, however, effected such a change in the chemical character of the butter fat that it seemed wise to note its effect on the resulting butter product. Accordingly six lots of butter were made from each herd, towards the close of the second or excess oil period. It was not possible at the time to make a first-class article, owing to poor facilities. We were obliged to ripen the cream in cans, to churn with a small hand churn and to work the butter with a small paddle.* Two lots of butter from each herd were submitted to chemical analysis, and found to be of normal character. They contained from about 10 to 12 per cent. of water, 85 to 87 per cent. of butter fat, less than 1 per cent. of curd and a normal amount of salt. The several samples were scored by Mr. W. A. Gude, of the firm of Gude Bros., New York, who stated that both lots were of poor flavor, having a burnt taste, as of rendered butter; and the body from Herd I. was short grained, brittle and crumbly; from Herd II., salvy or very salvy.

Mr. C. H. Eckles, butter maker at the college dairy school, reported as follows concerning the body and flavor of the several butters: "The butter from the normal ration is considerably firmer than that from the excess oil ration, and the grain is shorter. As compared with the product of the best creamery butter, neither is exactly normal in consistency, the normal ration butter being more crumbly and the butter from the excess oil ration more salvy or greasy than normal. From a commercial stand-point, the body of excess oil butter is possibly the more objectionable. The flavor and aroma of normal ration butter is inferior to that of excess oil butter. In case of the former, something of an old flavor, impossible to describe, is noticed. The flavor of excess oil butter, while not very good, is more the flavor

* Since then a small dairy building for experimental purposes has been erected and fully equipped for this department.

of fresh butter." Referring to another lot, Mr. Eckles says: "The same difference in consistency was observed, and in about the same degree, and the difference in flavor was the same, but more marked."

The writer lays no claim to being an expert judge of butter, but his observations, made at the time, were as follows: Butters from normal ration were hard and firm at 15° C., and those from excess oil ration of a softer, lardy nature. It required some effort to force a glass rod into normal ration butter, but the same rod slipped much easier into excess oil butter. One could distinguish the two butters almost with the eye, and easily with the touch. Samples of the two butters were placed in crystallization dishes upon a hot-water radiator. Normal ration butter remained firmer for a time than excess oil butter, but resolved itself into oil more quickly. When normal ration butter was nearly all oil, excess oil butter was soft enough to spread out over the bottom of the dish, but had melted but little. This latter observation is very interesting, and shows, at least in case of this experiment, *that the melting point of the butter fat did not govern the firmness or body of the butter.* Does this hold true in all cases? The average melting point of normal oil butter fat was 32.89 and of excess oil butter fat 36.93. While the excess oil butter fat showed a melting point 4° higher than the normal oil fat, yet the normal oil butter was firmer at ordinary temperature, and kept its body better when a gentle heat was applied. When, however, the heat was increased, the firmer normal oil butter actually resolved itself into oil more quickly than did the salvy excess oil butter. The reason for this cannot be discussed at this time.

It is clear, from the foregoing observations, that the butters from both herds were of quite inferior flavor. It was unfortunate that our facilities for butter making at the time were not better. Just why the flavor of both lots was so poor is not quite clear, as they were made by an experienced butter maker, the stable was clean and the milk carefully handled. How much of this is to be attributed to poor facilities, how much to inferior bacteria and how much to influence of food, cannot be ascertained. The butters were probably rather overworked. One point, however, stands out *very distinctly; namely, the influence of food on the body of the butter.* The linseed oil surely produced a butter of high melting point, yet soft and salvy, and unable to stand up under a gradually rising temperature, as did the butter when the oil was not fed.

The above experiment naturally suggests two questions: First, do the oils in the various feed stuffs tend to produce a salvy butter, lacking in firmness? Second, what is the effect of different forms of protein, as found in linseed, cotton-seed and gluten meals on the body of butter?

(*f*) The Effect of Different Concentrated Feeds on Butter Fat and Butter.

At the close of the above experiment it seemed advisable to note the effect of several concentrated feeds, as they are found in the markets, upon the character of butter fat and butter. Accordingly a "standard" grain ration was adopted, and other rations compared with it. It is not to be inferred that the so-called "standard" ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce a normal butter.

Two experiments, known as Experiments IV. and V.,* were completed in the spring of 1898, with twelve cows, divided into two herds of six cows each. Rations containing 4 pounds of Cleveland flax meal and 4 pounds of Chicago gluten meal, respectively, were compared with the standard ration. Herd II. received the standard ration, and Herd I. the Cleveland flax meal and Chicago gluten meal rations. All these rations contained only a normal amount (.5 to .6 pounds) of digestible oil, while the Cleveland flax or the Chicago gluten meal themselves contained less than 3 per cent. of oil, so that one could note particularly the effect of the protein in the linseed and gluten meals on the butter fat and butter.

* These two experiments were made in connection with the Department of Agriculture.

Daily Ration (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal.	Chicago Gluten Meal.	Cleveland Flax Meal.	First Cut Hay.	Corn Silage.
Standard ration,	3	5	.5	.5	-	12-15	20
Cleveland flax meal ration.	2	2	-	-	4	12 15	20
Chicago gluten meal ration.	2	2	-	4	-	12-15	20

The experiments proper lasted five weeks, preceded by a preliminary period of ten to fourteen days.

Experiment IV.

[Standard ration *v*. Cleveland flax meal ration.]

Five samples of butter fat were analyzed, with the following average results: —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration,	30.92	5.44	88.48	33.80	28.96
Cleveland flax meal ration,	29.50	5.19	88.69	33.23	26.77

The averages show comparatively slight variations, the fats resulting from both rations being normal in character. The Cleveland flax meal ration produced a fat with less volatile acids and a trifle lower melting point and iodine number than did the standard ration. Whether this difference is due to the individuality of the two herds, or to the influence of the linseed meal, cannot be stated.

Ten lots of butter were made from each herd. The ripening, churning, etc., were made in the same way as in the previously described linseed oil experiment (Experiment III.). Five lots of butter made from each ration were analyzed and found to be of normal character. The ten lots were scored by Mr. W. A. Gude of New York, with the following average results: —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration,	35.9	24.2	15	10	5	90.1
Cleveland flax meal ration,	31.4	22.0	15	10	5	82.4
Standard score,	45.0	25.0	15	10	5	100.0

Mr. Gude reported the flavor of the butter from the flax meal ration as "stale, rancid or oily," "strong, oily, seems rancid," "oily," etc. Concerning the flavor of standard ration butter he reported "fair to fine" and in four instances he referred to "oily flavor." With regard to body of flax meal butter he used the terms "brittle, dry, salvy, short," and for standard ration butter "good, but trifle short," and "perfect." In a letter Mr. Gude said: "While trying to pay particular attention to body, I notice that the most objectionable feature is that peculiar oily taste," etc. "This I notice you have apparently overcome in No. 1282" (standard ration butter). Again: "I notice a particular improvement in the quality, particularly of samples 1272 and 1274" (standard ration butter).

The butters were rather dry, having about 12 per cent. of water. It is clear that, while the butter made from both rations did not score high, that made from the flax meal ration was noticeably inferior in flavor and in body to the standard ration butter. This seems to agree with the linseed oil experiment (Experiment III.). In that experiment, even when only two pounds of flax meal were fed, the flavor was inferior; and when flax-seed meal was fed the body and flavor were both bad. It is not desired, however, to be too positive about the flax meal (linseed meal, with a minimum amount of oil) producing an inferior-flavored butter, but we prefer to call attention to the results thus far secured, and to repeat the experiment.

Experiment V.

[Standard ration *v*. Chicago gluten meal ration.]

This experiment was identical with Experiment IV., excepting that 4 pounds of the Chicago gluten meal (corn gluten) were substituted for 4 pounds of flax meal. The average results of the analyses of five samples of butter fat follow: —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acids Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration,	30.07	5.29	88.84	34.76	29.00
Chicago gluten meal ration,	32.07	5.64	88.26	33.04	27.67

No wide variations are noted. The Chicago gluten ration produced rather more volatile acids, a trifle less insoluble acids, a lower melting point and a lower iodine number. The differences are too slight to draw any positive conclusions. In both these experiments (Experiments IV. and V.) one notes that the standard ration produced butter with a little higher melting point and a lower iodine number. All the butter fats, however, were of normal character.

Ten lots of butter were made from each ration, under similar conditions, as previously described. Five samples were analyzed chemically and found to be normal. The butter was quite dry, showing but 11 per cent. of water. Mr. Gude scored the ten samples made from each ration with the following average results: —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration,	35.6	23.8	15	10	5	89.4
Chicago gluten ration,	35.2	24.0	15	10	5	89.2
Standard score,	45.0	25.0	15	10	5	100.0

These butters appear to be practically identical, no particular feed influence being noted. The first four or five lots from each ration were reported as having a "tainted oil flavor," and were marked down. The last five lots were reported as being "good," "clean flavor," etc., and scored 38 and 39 out of a possible 45. The body of each of the two lots was reported a "trifle short," "brittle," "breaks easily," etc., and were marked down one point. The score is not very high, due to rather poor flavor. This is attributed, partly at least, to rather poor facilities in ripening and handling and not to feed. The corn gluten in this case does not appear to have had any bad influence on the body of the butter. It is held by many that gluten products produce a soft, salvy butter. This we are inclined to attribute to the influence of the corn oil, which is now largely removed before the gluten products are put upon the market. Bartlett's recent experiments support this view.*

Both lots of butter were tested for firmness of body by the usual method of allowing a plunge of given weight to drop from a certain height, noting the degree of penetration in millimeters. The average figures were 6.9 millimeters for the standard ration, and 6.7 millimeters for the Chicago gluten meal ration, showing practically no difference.

Experiment VI. 1899–1900.

[Period I., standard ration, both herds; Period II., standard ration *v.* King gluten meal ration; Period III., standard ration *v.* cotton-seed meal ration.]

During the winter of 1899–1900 another experiment was instituted, to note the effect of King gluten meal, with 14 per cent. corn oil, and normal cotton-seed meal, with 12.6 per cent. oil, on the butter fat and butter. Ten cows were divided as evenly as possible into herds of five each. In the first period, lasting two weeks,† both herds were fed the standard ration. In the second period of five weeks † Herd I. received the standard ration and Herd II. the King gluten meal ration. In the third period of five weeks † Herd I. received the standard ration and Herd II. the cotton-seed meal ration. It will thus be seen that both Herds received the same ration in the first period, then Herd II. was changed

* Maine Experiment Station report, 1898, pp. 97–113.

† Preliminary period of two weeks not included.

to the other two rations and Herd I. was used as a check for comparison. The several rations were as follows: —

Daily Rations (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal	Chicago Gluten Meal.	King Gluten Meal.	Corn Silage.	Hay.
Standard ration, ...	3	5	.5	.5	-	20	10–15
King gluten meal, ...	2	2	-	-	4	20	10–15
Cotton-seed meal, ...	2	2	4	-	-	20	10–15

The average results follow: —

Analyses of Butter Fat.

First period: both herds standard ration.

HERDS.	Number Samples.	Saponification Equivalent.	Insoluble Acids.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I., .	4	233.3	88.35	32.18	5.67	34.08	25.84
Herd II.,	4	232.9	87.98	32.64	5.74	33.94	26.78
Second period: Herd I., standard ration; Herd II., King gluten meal ration.							
Herd I., .	10	232.4	88.27	31.48	5.54	34.00	26.44
Herd II.,	10	231.0	88.24	32.62	5.76	32.80	32.75
Third period: Herd I., standard ration; Herd II., cotton-seed meal ration.							
Herd I., .	10	229.6	88.62	30.56	5.38	34.12	26.35
Herd II.,	10	227.9	88.70	31.03	5.46	35.60	29.35

The experiment began December 7 and ended April 15, or 130 days. It is interesting to note the evenness in the composition of the butter fat during this time produced by Herd I. receiving the standard ration. There was a slight decrease in the saponification equivalent and the Reichert-Meissl number, but practically no change in the melting point or iodine number.

In the first period both herds produced butter fat of similar composition. In the second period the fat produced by Herd II., receiving the King gluten meal ration, showed no change in Reichert-Meissl number, a slight depression in melting point and a noticeable increase in the iodine number. The effect would probably have been more marked had more corn oil been fed. In the case of the linseed oil experiment both the melting point and iodine number were increased.

In the third period the fat produced by the cotton-seed meal ration showed but little change in composition from that produced by the standard ration.

It seems evident that different oils — linseed, corn and cotton-seed oils — exert a different influence on butter fat, these oils themselves being of different composition.

In making the butter, the creams, raised by the gravity process, were treated as nearly alike as possible. Our dairy building was completed, and afforded excellent facilities for doing the work. The cream was ripened to approximately .7 acidity in forty-eight hours. A skim-milk starter was used without the aid of any specially prepared ferment. Every sample of butter was analyzed and found to be normal, showing about 12 per cent. of water, 80 to 82 per cent. of butter fat and 1 per cent. casein. The butters were scored by Mr. W. A. Gude, with the following average results: —

Average Butter Score.

First period: both herds standard ration.

HERDS.	Number Samples.	Flavor.	Body.	Color.	Salt.	Style.	Total.
Herd I.,	4	36.2	23.4	15	10	5	89.6
Herd II.,	4	36.2	23.4	15	10	5	89.6
Second period: Herd I., standard ration; Herd II., King gluten meal ration.							
Herd I.,	10	37.8	24.0	15	10	5	91.8
Herd II.,	10	39.7	24.9	15	10	5	94.6
Third period: Herd I., standard ration; Herd II., cotton-seed meal ration.							
Herd I.,	10	36.0	24.1	15	10	5	90 1
Herd II.,	10	35.9	24.4	15	10	5	90.3
Standard score,	–	45.0	25.0	15	10	5	100.0

Mr. Gude's notes concerning the different samples are as follows: First period: flavor, "fair aroma," "fairly clean," "oily taste;" body, "short and breaks easily, seems brittle," "slightly short and brittle." Second period: flavor, Herd I., "fairly clean, lacks aroma," "defective;" Herd II., "clean and fine;" body, Herd I., "brittle, short, seems light and spongy, trifle salvy;" Herd II., "all right." Third period: flavor, Herd I., "fairly clean, but lacks aroma," "slight taints;" body, Herd I., "spongy when soft, short and crumbles when hard;" Herd II., "perfect," "short when soft, crumbles when hard," "salvy to taste."

Average Degree of Penetration (Millimeters).

HERDS.	First Period.	Second Period.	Third Period.
Herd I.,	4.8	4.9	5.4
Herd II.,	4.9	6.7	5.8

Our own deductions, based on the score and remarks of Mr. Gude and the degree of penetration concerning this experiment, are as follows: The tendency of the standard ration was to make butter with a firm body and likely to crumble. It seemed also to produce at times a slight oily or defective flavor. The hardness is probably due to the oats, and possibly the oily flavor to the oil of the oats. The King gluten meal seemed to produce a butter very satisfactory to Mr. Gude. He gave it an average score of 94.6, spoke of its flavor as clean and fine and of its body as perfect. The degree of penetration shows it to be a softer, more yielding butter than that produced by the standard ration. This condition is probably brought about by the corn oil. Butters of this consistency are objected to by some. It is our intention soon to feed corn gluten without oil, and the same with different quantities of oil.

The cotton-seed ration produced butter of about the same quality and condition as the standard ration. Mr. Gude spoke of it as lacking aroma and having a slight taint, and of being rather spongy when soft and crumbling when hard. This butter is firmer than the King gluten butter. It would be of interest to note the influence of the cotton-seed protein and the cotton-seed oil separately on the butter, and we hope to carry out such experiments.

It is clear, from our several experiments, that food does influence to a noticeable degree the composition of the butter fat and the body of the butter. It seems also to influence the flavor; to what extent, as compared with the influence produced by bacteria, is not quite clear. This matter is being given further study.

B. — THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF BARNYARD MILLET (*Panicum crus-galli*).

J. B. LINDSEY.

Conclusions.

1. Barnyard millet is a warm-weather plant, similar in this respect to Indian corn.

2. As harvested in early blossom, the fodder contains less nitrogen-free extract matter, more fibre or woody matter, and rather more ash than corn fodder. The seed resembles the cereals (especially oats) in composition. It contains considerable more fibre, rather more ash and 5 to 6 per cent. less extract matter than maize.

3. Barnyard millet, grown on naturally moist and fertile land, will probably yield as much dry matter per acre as corn.

4. It has less nutritive value than the corn, the principal reason for this being that the corn can partially mature its grain and still be readily eaten by animals, while the millet must be cut when in blossom to secure it in the most desirable condition for feeding.

5. It is not suitable for hay, and, while it makes a fairly satisfactory silage, it is inferior to maize as a silage crop.

6. It furnishes a desirable green feed, especially during the month of August, and *it is for this purpose that it can be most satisfactorily utilized.*

7. The millet can be used for silage in place of corn whenever it is not convenient or possible to grow the latter.

Preliminary Statement.

During the last ten years the attention of farmers has been frequently called to the value of several varieties of Japanese millets.* Experiments have demonstrated the *Panicum crus-galli* — now termed barnyard millet — to be the most useful Japanese variety for fodder purposes; and this department has endeavored to ascertain, by experiment and observation, its relative value, as compared with other materials of similar character, as a food for dairy animals. The term barnyard millet has been adopted as its common name, for the reason that it appears to be a cultivated and improved variety of the common barnyard grass. The information given below is not meant to be an exhaustive treatise on the subject, but rather a bringing together of data already at hand concerning the nutritive value and practical utility of the plant.

(*a*) Character of the Millet.

This variety of millet is a coarse-growing form, with a comparatively heavy leafage and compact beardless heads. When headed out it stands from four to six feet in height, and rarely lodges. It is a warm-weather plant, similar to corn, and makes a very rapid growth when the temperature is high. Sown the middle of May, it begins to head about August 1, the time varying a little, depending on weather conditions. After the heads appear it becomes woody, and proportionately less valuable for fodder purposes. It will not endure dry weather as well as corn, and succeeds best upon moist land in a good state of fertility. If cut when it begins to bloom, a second crop may be frequently secured, but it is apt to be small in quantity and coarse in quality.

(*b*) Composition of Green Millet.

Numerous analyses of this material have been made, the more recent ones by this department being tabulated as follows: —

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* See, in the different reports of the Massachusetts Agricultural College and Hatch Experiment Station, the articles by Prof. W. P. Brooks, to whom we are indebted for the introduction of these fodder plants. See also Farmers' Bulletin, 101, published by the United States Department of Agriculture, on millets.

I. Water-free Material (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
(*a*) First week of blossom,*	-	7.84	8.44	32.06	49.92	1.74
(*b*) Second week of blossom,*	-	8.59	11.00	35.03	43.65	1.73
(*c*) Well headed,†	-	10.18	10.73	34.48	43.05	1.56
(*d*) Beginning to head,†	-	8.36	6.77	36.69	46.78	1.40
Average,	-	8.74	9.23	34.56	45.85	1.62
Corn fodder for comparison,‡	-	5.20	9.70	21.30	60.60	3.20

* (*a*) and (*b*) grown in same year on same plot.
† (*c*) and (*d*) grown in different years.
‡ Flint varieties, average forty analyses, Jenkins' and Winton's tables.

II. Average Results, Natural Moisture (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet,	80.00	1.75	1.85	6.91	9.17	.32
Corn,	79.80	1.10	2.00	4.30	12.10	.70

As is to be expected, the different samples of millet vary somewhat in composition, depending upon the stage of growth, weather conditions, fertility of land and possible errors in sampling. The natural tendency is for the fibre to increase as the plant approaches maturity.

Of the total crude protein in sample (d) (6.77 per cent.), 6.02 per cent. was found to exist as true albuminoids and .75 per cent. in the form of amids. The amids thus represented 12.46 per cent. and the albuminoids 87.54 per cent. of the matter calculated as crude protein. This is what might be expected in immature material of this character. The same sample showed 22.46 per cent. of pentosans, representing about one-half of the non-nitrogenous extract matter. It is quite probable, however, that a small quantity of the total pentosans still remained in the crude fibre and could not be counted as extract.

When the analysis of the millet is compared with that of corn fodder, on the basis of dry matter, one striking difference is noted, namely, that the fibre is much in excess in the millet, and the nitrogen-free extract matter correspondingly less. The millet naturally develops relatively more woody matter than the corn, and for this reason it is necessary to cut the millet for feeding purposes while in blossom. If allowed to grow until the seed is developed, the straw is hard and woody, and quite unsatisfactory for feeding. Corn fodder, the analysis of which is given above, is supposed to be rather thickly seeded corn, with ears more or less developed, and probably cut late in August. It is an advantage to allow the corn fodder when fed green to grow until it has reached the above stage, for the reason that its digestibility and palatability are not appreciably decreased, while the nutritive value is considerably enhanced because of the ear development. The character also of the extract matter in the two fodders is not the same, the corn having a considerable amount of the valuable starch, which is practically lacking in the millet. The principal difference, then, from a chemical stand-point, between these two plants, consists, in case of the corn, in the extra percentage of nitrogen-free extract matter containing considerable quantities of starch, and the smaller percentage of the less valuable woody fibre.

The protein percentage is about the same. The millet shows relatively rather more ash than the corn. This may be due to the fact that it is cut at an earlier stage in its growth. From the comparative chemical analysis of the two plants, as given above, one would naturally expect a greater nutritive effect from the corn than from the millet.

Composition of the Ash (Dry Matter).

Only two analyses of the ash of the millet are on record. One of them was made a number of years ago, and is very incomplete; the other represents a recent analysis of sample (d): —

SAMPLES.	Crude Ash.	Soluble Ash	Insoluble Ash.	Calcium Oxide.	Potassium Oxide.	Phosphoric Acid.	Undetermined.
Sample (d),	8.36	6.33	2.03	.96	3.70	.52	1.15
Earlier sample,	–	–	–	–	1.96	.44	–
Green corn,*	6.12	5.00	1.12	.82	2.18	.60	–

* From Wolff tables, given for comparison; exact stage of growth unknown.

The amount of the several ash constituents will of course vary, depending upon the state of growth, soil moisture and fertility. The above figures are not sufficient to enable one to form any very correct idea of the mineral constituents of the plant; they indicate, however, that the millet takes considerable quantities of mineral constituents from the soil, especially potash, and fully as much as Indian corn at a corresponding stage of growth.

Composition of the Seed.

SAMPLES.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet seed (1898),	11.47	2.81	9.44	7.69	65.20	3.39
Millet seed (earlier),	10.30	3.10	12.30	7.70	60.90	5.70
Average of both samples,	10.88	2.96	10.87	7.69	63.05	4.55
Oats for comparison,*	11.00	3.00	11.80	9.50	59.70	5.00

* Jenkins's and Winton's tables, average 30 samples.

The millet seed resembles oats very closely in composition. The protein and fibre are a trifle higher in the oats, and the nitrogen-free extract correspondingly lower.

Composition of Millet Silage (Natural Moisture).

	Number Analyses.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free-Extract.	Fat.
Millet,	3	74.0	2.40	1.70	7.50	13.60	.80
Millet and soy beans,*	9	79.0	2.80	2.80	7.20	7.20	1.00
Millet and soy beans,†	2	81.0	2.21	2.04	6.66	7.44	.65
Corn and soy beans,*	4	76.0	2.40	2.50	7.20	11.10	.80
Corn and soy beans,†	1	75.0	1.80	2.35	7.06	13.19	.60
Corn silage for comparison,‡	99	79.1	1.40	1.70	6.00	11.00	.80
Dry Matter.							
Millet,	3	–	9.24	6.50	28.80	52.36	3.10
Millet and soy beans,	11	–	13.06	12.91	34.40	35.07	4.56
Corn and soy beans,	5	–	9.12	10.20	29.63	47.59	3.14
Corn silage for comparison,	99	–	6.60	8.00	28.70	53.00	3.70

* Previous to 1897; approximately two-thirds millet or corn and one third bean.
† During 1897. ‡ Jenkins's and Winton's tables.

The millet silage and the corn silage, so far as the above figures are concerned, show no great analytical differences. It must not be forgotten, however, that the non-nitrogenous extract matter of the corn contains a considerable amount of starch, which fails in the millet. The mixtures made from millet and corn, with soy beans, were not perfect. The object was to add one-third beans and two-thirds corn in putting the materials into the silo, but this was done only by loads of material and not by actual weight. The analytical results on the basis of dry matter are about what might be expected; namely, an increase in the protein percentage and a decrease in the extract matter in each case, when compared with millet or corn silage. One notes, however, more extract matter in the corn and bean than in the millet and bean silage. The protein and ash are higher in the millet and bean than in the corn and bean silage. This condition is satisfactorily explained on the ground that the millet and bean, being cut at an earlier stage than the corn and bean, would naturally contain relatively more ash and protein and less extract matter.

The Digestibility of Millet.

The following figures represent the digestibility of the different ingredients of millet, and were obtained by the use of sheep at this station. The numbers mean that, of the total amount of ash, protein, etc., contained in the millet, such and such amounts or percentages were digested. Thus, if green millet contains 6.91 per cent. of fibre, 73 per cent. of it is digestible, or $6.91 \times 73 = 5.04$ per cent.

CHARACTER OF MATERIAL.	Number Different Samples.	Number Single Trials.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet, early to late blossom,	1	3	71	64	69	73	72	63
Dent corn fodder (in milk) for comparison,	3	9	70	-	61	64	76	78
Millet hay, full blossom,*	1	3	57	63	64	61	52	46
Millet hay, full blossom,†	1	2	56	24	31	63	55	50
Timothy hay for comparison,	12	26	57	-	48	52	63	60
Millet silage for comparison,‡	-	-	-	-	-	-	-	-
Millet and soy bean silage,	1	4	59	-	57	69	59	72
Corn and soy bean silage,§	1	3	69	-	65	65	75	82
Corn silage for comparison,‖	-	10	71	30	56	70	76	82

* Same plot as green material previously given.
† *Panicum italicum*, — a different species of Japanese millet.
‡ No digestion tests have been made.
§ Pride of North corn (dent) and medium green soy beans, two-thirds former and one-third latter, in excellent condition.
‖ Average dent and flint.

The green millet appears, from the figures at our disposal, to be as digestible as the fodder corn.

The millet hay shows a very much less degree of digestibility than the same material green. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be the case with young and tender plants and with grains that can be ground fine. In the case of coarse, woody plants the reverse is likely to be true. The hardening of the woody stalks in the curing process, and the less perfect mastication resulting, in all probability are the most important factors in bringing about this apparent result. We hope to make other experiments to still further prove this point. Unfortunately, no figures are on hand for the millet silage. The corn and bean silage shows about 10 per cent. more total digestible matter than the millet and bean silage. The extract matter of the former is noticeably more digestible. The high degree of digestibility of the extract matter of the corn and bean silage is explained when one remembers the considerable amount of corn grains present. Corn and soy bean silage, as shown by this experiment, appears to be nearly as digestible as average corn silage, and the protein even more so.

Multiplying the percentage composition of the millet, as given in a previous page, by the digestion percentages or coefficients as stated above, one obtains the following percentages digestible in one hundred: —

[Figures equal percentages, or pounds in 100 digestible.]

CHARACTER OF MATERIAL.	FRESH OR AIR-DRY MATERIAL.					DRY MATTER.			
	Dry Matter.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet,	14.20	1.28	5.04	6.60	.20	6.37	25.23	33.01	1.02
Green corn, fodder,	14.14	1.22	2.75	9.19	.55	5.91	13.63	46.06	2.50
Millet hay,	48.45	5.02	17.91	20.25	.63	5.90	21.08	23.84	.73
Timothy hay for comparison,	49.00	4.10	14.70	27.20	1.10	4.80	17.10	31.60	1.30
Millet and soy bean silage,	12.15	1.51	4.90	4.27	.68	7.36	23.74	20.69	3.28
Corn and soy bean silage,	16.70	1.60	4.66	8.64	.62	6.63	19.26	35.69	2.57
Corn silage for comparison,	14.84	.95	4.20	8.44	.66	4.48	20.09	40.28	3.12

Millet hay is assumed to contain 15 per cent. of water and timothy hay 14 per cent. It is doubtful if the water content of the millet could be brought as low as 15 per cent.

The above figures tell the same story as those representing the *composition* of the several materials, namely, the excess of fibre and the lack of extract matter in the millet, as compared with the corn. While the green millet appears to be as digestible as the green corn, *there is more digestible fibre in the millet and correspondingly less digestible extract matter.* The corn silage shows rather less digestible protein than the millet and bean silage, and nearly twice as much digestible extract matter. There is not a great deal of difference between the corn and bean silage and the corn silage, excepting the increased amount of protein in the former.

Utility of Barnyard Millet.

Yield per Acre. — The millet is a heavy yielder of green fodder; from 12 to 18 tons per acre have been grown upon the college farm, on naturally moist land in good condition, while as high as 35 tons per acre have been reported by outside parties. Our own experience has shown it to yield from 12 to 14 tons per acre upon medium loam in good state of fertility, but not naturally very retentive of moisture. Such quantities, however, were produced without the millet appearing to suffer from lack of water; and it is believed that this amount is a conservative estimate of its productiveness, unless the land is especially moist, warm and fertile. If the millet is planted in drills 15 inches apart and allowed to mature, it will yield about 60 bushels of seed per acre, of an average weight of 35 pounds per bushel. When sown broadcast, 90 bushels per acre have been reported.

Millet as a Soiling Crop. — For use as a soiling crop, the seed should be sown broadcast and harrowed in May 10 to 15, at the rate of 12 quarts per acre. The fodder will be ready to cut August 1 or a few days earlier. It is wise to begin cutting before the heads appear, and to continue for twelve days. It cannot be cut to advantage for a much longer period, for the reason that after it is well headed it becomes tough and woody, and the animals refuse a portion of it. In order to secure green millet feed during the entire month of August, a second seeding can be made June 1, and a third about June 20. If green feed of this character is desired in September, later seedings are necessary. We have found it advantageous to sow peas with the first seeding of millet, at the rate of one and one-half bushels of Canada peas together with six quarts of millet per acre. The peas are first deeply harrowed in, and the millet covered with a tooth harrow. If the weather should prove cool during May and June, the peas are likely to get ahead of the millet, but the latter catches up as the warm weather comes on. This pea and millet mixture makes a desirable green feed. No experiments have been made to measure the feeding value of green millet for milk production, for the reason that the time in its growth when it is available is too short to secure any very reliable data. We have fed the green millet to the station herd during the first three weeks of August for a number of years. During the first week of the cutting the animals eat it well, but the second week a considerable portion of the stems remain unconsumed. Millet acts as a laxative as well as a diuretic, and it is not advisable to feed it as the entire source of coarse fodder. Fed in this way, we have observed that the bowels become very loose, the animals soon refuse to eat above 60 pounds per day, and they lose in flesh and milk production. When they are fed entirely in the barn or yard, 10 pounds of hay per day, together with what green millet they will eat, is a desirable quantity. This usually amounts to about 50 or 60 pounds of millet daily. When animals run in pastures, a supplementary feeding of green millet at night is quite helpful.

From our observations we prefer corn fodder to millet as a green feed, because more milk is secured and the animals tend to keep in better condition. The corn fodder can be fed for a longer period than the millet, and, being more or less eared, its nutritive value is thereby enhanced. Millet, on the other hand, has the advantage of requiring less labor to grow than corn, as after it is once sown it requires no further attention until ready to cut.

Millet as a Hay Crop. — Brooks,* a number of years since, called attention to the fact that, although the yield of hay was from 3 to 6 tons per acre, the difficulty of properly curing it was such that the millet could not be very satisfactorily utilized as a hay crop. We can simply confirm this. The coarseness of the fodder renders it very difficult to eliminate sufficient of the water to enable the hay to keep well unless several extra hay days follow one another; the hay therefore is likely to become musty and consequently unsatisfactory for feeding, and the farmer cannot depend upon it as a rule to furnish him with any considerable amount of dry fodder.

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* *Loco citato.*

Millet as a Grain Crop. — According to Brooks,* the birds have a great liking for the seed and it is therefore difficult to harvest without loss. The yield of one ton to the acre is small, as compared with an average crop of corn. Brooks and Smith fed millet meal to four dairy cows, comparing it to an equal quantity of ground oats, and noted no difference in the results (experiment not published). The cost of threshing the grain is to be considered, and the straw would be quite inferior to corn stover for fodder purposes. It does not seem probable that the grain could be made an economic feed for farm animals.

Millet for Silage. — Millet makes a very fair silage, but, as a result of the writer's experience, it is not considered equal to maize. So far as known, there are no exact feeding experiments on record comparing these two plants for silage purposes. It lacks the large quantity of digestible starchy matter which the corn contains in the form of the grain. It could not be put into the silo after it had ripened its seed, as is the case with corn, for the straw would then be dry and tough, and the seed is covered with a hard seed-coating. Our observations have convinced us that millet silage has less nutritive effect than corn silage. The digestion experiments with millet and bean silage, as compared with corn and bean silage, confirm this opinion. We have also noticed that animals are inclined to consume a larger quantity of corn than of millet silage, especially when fed for a considerable length of time. While the labor involved in growing a crop of millet is certainly less than in growing a crop of corn, the extra work in harvesting the former for the silo makes up for it, at least to a considerable degree. If for any reason, however, the corn crop should fail, and millet could be advantageously grown, it would certainly make a very desirable substitute for the former. Millet and soy bean silage is preferable to millet silage, from a nutritive stand-point; but the cost of growing and harvesting the same prevents its general use.

The following estimate of the value of millets on the farm is made in Farmer's Bulletin, 101, already referred to, and

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* *Loco citato.*

it so fully expresses the writer's estimate of the utility of barnyard millet that it is quoted in full: —

On the whole, it is doubtful if there are many sections in this country where millets should be made a primary crop. Their place is rather that of a supplementary one, — a "catch-crop," when the corn has been destroyed by hail or otherwise; a substitute for corn, where that crop is not easily grown; a crop to be grown on a piece of land that might otherwise lie idle; a readily available crop for use in short rotations; an excellent thing to grow on foul land, to get rid of weeds, giving practically the same results as fallowing or summer cultivation, and in addition a crop of forage; a supplement to the regular and permanent pastures and meadows. It is in such ways that the millets are most valuable on the average farm, and such is the place they should be given in American agriculture.

C. — DRIED DISTILLERY GRAINS.

What They are. — Dried distillery grains consist of the residue remaining in the process of manufacturing alcohol, spirits and whiskey from the several cereals. Briefly stated, the process consists in grinding the various grains employed and heating them with a solution of malt, thus converting the starch into sugar. The addition of yeast converts the sugar into alcohol, which is then distilled, and the residue or distillery slop is filtered, dried in especially constructed driers and put upon the market as a cattle food. It consists chiefly of the hulls, germ and protein of the grains. It has a more or less sour taste and smell, because of the fermentation. If the slop remains undried too long, this sour condition is increased. Well-informed parties state that the quality of the dried grains depends, in the first place, upon the composition of the distillers' mashes (*e.g.*, the kinds and proportions of the grains employed); secondly, upon the distillers' mode of mashing and fermenting; and, thirdly, somewhat upon the process of drying.

How They may be classified. — The dried grains may be classified as follows, depending upon the source from which they are derived: —

A. Alcohol and spirits grains.
B. Bourbon whiskey grains.
C. Rye whiskey grains.

The grains produced from *alcohol and spirits distilleries* are the highest in quality, and of the most uniform grade. Corn is practically the only grain used.

The grains produced by *whiskey distilleries* vary according to the proportion of corn, rye and malt contained in their mashes. The larger the proportion of corn and the smaller that of rye and malt (small grain, so called), the higher the grade of dry grains produced. Some bourbon whiskey distillers use very little "small grains," and their product stands near that of Class A. Many make bourbon, half rye and pure rye whiskey alternately in one season, and their product of dried grains varies in quality accordingly. Others, especially in Pennsylvania and Maryland, produce rye grains only.

Their Average Composition. — A large number of analyses of Class A grains are said to show an average of 35.33 per cent. of protein and 11.25 per cent. of fat.

Class B, or bourbon whiskey grains, run from 23.9 to 38.06 per cent. of protein and from 6.3 to 15 per cent. of fat.

Class C, or rye grains, show from 17.85 to 24.28 per cent. of protein and from 5.04 to 7.5 per cent. of fat, averaging 20.87 per cent. protein and 6.32 per cent. fat.

Where manufactured. — The grains derived from spirits and alcohol are manufactured chiefly in Illinois and Indiana, those from bourbon whiskey in Kentucky, and those from rye whiskey in Pennsylvania and Maryland. All grades are produced in Ohio and Wisconsin.

The Yearly Product. — According to the last annual report of the commissioner of internal revenue (page 104), there were used in the distilleries of the United States during the fiscal year ending June 30, 1900: —

Bushels corn,	16,277,034
Bushels rye,	4,070,861
Bushels malt,	2,721,124
Bushels wheat,	27,225
Bushels oats,	15,414
Bushels barley,	1,328
Bushels mill feed and other materials,	1,276
Bushels grain of 60 pounds,	23,114,262

At present the annual output of distillers' dried grains in this country is less than 40,000 tons; but, if all the distillery slop were dried by perfect machinery, the country would produce about 170,000 tons yearly. The output of single distilleries varies from 1½ to 40 tons per day. Alcohol and spirits grains are produced in the largest establishments, which are generally operated throughout the year. Bourbon and rye whiskey grains are produced in smaller distilleries, rarely turning out more than 5 tons per day, and they are in operation only between November and July.

Where Distillers' Grains are consumed. — Very few grains have been thus far used in the United States, they being mostly exported and consumed in Germany. Statistics of the quantity exported have been lacking until recently, because of the classification employed. The export of distillers' dried grains, brewers' dried grains and malt sprouts, from July 1 to Oct. 31, 1900, was 22,347 tons, or about 5,600 tons per month. How much of this is distillers' dried grains is a trifle uncertain. It is estimated that the exports from July to October consisted of about 50 per cent. brewers' dried grains, 35 per cent. distillers' dried grains and 15 per cent. malt sprouts; that from January 1 to June 30 distillers' grains will predominate, and that the total export of the latter will amount to about 28,000 tons during the present fiscal year.*

* For the larger part of the above information we are indebted to the J. W. Biles Company, Cincinnati, O.

We understand it is the intention to introduce this material in our eastern markets. Our inspectors have already noticed it occasionally. For convenience in distinguishing the different qualities, the sellers have divided the various products into five grades, namely, "R," "X," "XX," "XXX" and "XXXX." Those marked "R" are lowest in protein and fat, and those marked "XXXX" highest. Some two years since, this department secured several tons of these grains. They were analyzed, tested for digestibility and fed to milch cows.

Composition of Distillers' Grains.

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."
Water,	7.00	7.00	7.00	7.00	7.00
Protein,	16.67	29.76	26.20	30.01	35.46
Fat,	5.68	10.88	9.77	11.90	10.04
Extract matter,	55.87	40.89	43.00	38.69	34.14
Fibre,	12.74	9.77	11.53	10.33	11.63
Ash,	2.04	1.70	2.50	2.07	1.73
Total,	100.00	100.00	100.00	100.00	100.00

The several grades showed between 7 and 8 per cent. of water; for the sake of uniformity, they were all calculated to a 7 per cent. basis.

The sellers state that the markings on "X" and "XX" must have been reversed, as the "XX" grains should show a higher percentage of protein than those marked "X." The "R" grains, as the sellers claim, are the poorest in composition, showing in this particular lot 16.67 per cent. of protein and 5.68 per cent. of fat, — about equal to the amounts found in wheat bran. The others gradually increase in these two ingredients, the "XXXX" showing 35.46 per cent. of protein and 10.04 per cent. of fat. The fibre is not excessive, being from 2 to 4 per cent. more than in bran. The analyses show these materials to be valuable feeding stuffs and worthy of the attention of feeders, providing they are sold on a guaranty. The sellers state that a guaranty will always accompany the different grades.

Digestibility of Distillers' Grains.

Digestion tests were made with sheep, and the following co-efficients obtained:—

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Average, excepting Brand "R."
Total dry matter, .	58	87	81	76	77	81
Protein, ...	59	73	77	74	71	74
Fat, ...	84	93	95	93	96	94
Extract matter, . .	67	89	84	75	79	82

Excepting the "R" brand, these materials show relatively high digestibilities, with comparatively small variations. In the last column is given an average of the four "X" brands, which may represent the average digestibility of distillery grains made largely from corn.

Multiplying the composition by the percentages digestible, one obtains the *percentage or pounds in 100 digestible:* —

CONSTITUENTS.	Brand "R."	Wheat Bran for Comparison.
Dry matter, ...	53.94	54.29
Dry matter contains: —		
Protein, ...	9.84	12.60
Fat, ...	4.77	3.20
Extract matter, ...	37.43	35.40
Organic nutrients (excluding fibre) digestible, ...	52.04	51.20

The "R" brand appears to contain about the same quantity of digestible nutrients as does wheat bran. The latter contains rather more protein, and a trifle less fat and extract matter digestible than the former.

Constituents.	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Gluten Feed for Comparison.*
Dry matter,	80.91	78.12	70.68	71.61	77.28
Dry matter contains: —					
Protein,	21.72	20.17	22.21	27.30	22.50
Fat,	10.12	9.28	11.07	9.64	3.30
Extract matter,	36.39	36.12	29.02	26.96	43.80
Organic nutrients, excluding fibre digestible.	68.23	65.57	62.30	63.90	69.60

* We refer to such well-known brands as Buffalo, Davenport, Rockford, being the residue from the glucose factories.

These several brands are quite similar in digestible ingredients to gluten feed, and for the present they can be considered as having approximately an equal value. They have noticeably more digestible fat and less digestible extract matter than the latter. They are likely to vary more in composition from time to time than the regular gluten feeds. The highest grade would probably contain rather more protein.

Tests with Milch Cows.

We were not in a position at the time to carry on any exact experiments with dairy animals. The several lots of grain were, however, fed to a number of cows, and the results were as good as one would naturally expect. The animals ate them well, receiving 3 or 4 pounds daily, mixed with wheat bran; the milk yield was satisfactory. We see no reason why the quality of the milk and butter should not be equal to that derived from animals fed upon corn silage, dried brewers' grains, etc. It would probably be wise not to feed such materials to animals when the milk was intended for infant feeding. Should these grains be generally introduced, it would be advisable to note particularly their influence, if any, on the flavor of milk and butter.

Several years since, a considerable quantity of so-called Atlas gluten meal was sold in Massachusetts and Vermont. This was dry distillery grains, sold by a distilling company in Peoria, Ill. It was not accompanied by a guaranty, and varied from 22 to 36 per cent. of protein. It has not been in the market of late. Hills* fed this material (testing 35 per cent. of protein) to milch cows, and secured very satisfactory results. Its effect on the flavor of milk and butter was not mentioned, and we can assume it was satisfactory. He considered it the cheapest source of protein in Vermont markets at the time.

D. — DIGESTION EXPERIMENTS WITH SHEEP.

These experiments were made during the winter of 1898–99. The method employed was the usual one, as described in the eleventh report of the Massachusetts State Experiment Station for 1893. The full data will be published at another time. By digestion coefficients is meant the percentages of protein, fat, etc., that the animal is capable of digesting. Thus, if wheat bran contains 16 per cent. of protein, or 16 pounds in 100, and the percentage digestible or digestion coefficient is 78, it means that the animal can digest 78 per cent. of the 16 pounds, or 12.46 pounds.

Description of Feed Stuffs.

Hay. — This hay was used in connection with the several concentrated feeds. It was largely Kentucky blue grass, with a small admixture of red clover. It was cut in bloom.

Meadow Fescue. — This was grown on an experimental plot, on land in an average state of fertility. It was free from weeds or other grasses.

Kentucky Blue Grass. — Same conditions as for meadow fescue.

Tall Oat Grass. — Same conditions as for meadow fescue.

Distillery Grains. — Fully described on pages 44–50. The digestibility of the fibre varied to such an extent with the different sheep that no digestion coefficient is presented. It seems to be very digestible in the various "X" brands, possibly 75 or more per cent.

Oat Feed. — This food consisted of the refuse from the oatmeal mills. It was quite an inferior sample of its kind,

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* Vermont Experiment Station report, 1895, p. 222.

containing a large quantity of hulls. The sheep digested only one-third of it.

Rye Feed. — This material is a mixture of rye bran, with a considerable quantity of fine middlings.

Chop Feed. — This consists of the hull, bran and broken germs of Indian corn, and is one of the residues remaining in the manufacture of starch and glucose. The sheep digested this material very unevenly, and the digestion coefficients given represent the average results from six sheep. They are not as satisfactory as could be desired.

Cleveland Flax Meal. — Linseed meal, with the oil quite thoroughly extracted by the naphtha process.

Parsons' "Six Dollar" Feed. — Fully described on pages 53, 54.

Digestion Coefficients resulting from Digestion Experiments.

KIND OF FEED STUFF.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fat (Per Cent.).	Extract (Per Cent.).	Fibre (Per Cent.).	Ash (Per Cent.).
Hay, largely June grass in bloom (*poa pratensis*).	1	6	59	61	47	62	57	48
Meadow fescue, full bloom (*Festuca elatior pratensis*).	1	2	61	52	54	59	67	46
Kentucky blue grass, full bloom (*poa pratensis*).	1	1	56	57	42	53	63	42
Tall oat grass, late bloom (*Arrhenatherum elatius*).	1	2	55	51	56	58	55	41
Distillery grains, Brand "R,"	1	2	58	59	84	67	?	–
Distillery grains, Brand "X,"	1	2	87	73	93	89	?	–
Distillery grains, Brand "XX,"	1	2	84	77	94	81	?	–
Distillery grains, Brand "XXX,"	1	2	76	74	93	75	?	–
Distillery grains, Brand "XXXX,"	1	2	77	71	96	79	?	–
Oat feed (large amount hulls),	1	3	34	62	92	33	27	13
Rye feed,	1	3	82	80	90	88	?	35
Chop feed,	2	6	80	67	82	84	82	–
Cleveland flax meal,	1	2	87	83	76	94	?	21
Parsons' "six dollar" feed,	1	2	56	57	81	64	47	12

E. — THE COMPOSITION OF PURSLANE (*Portulaca oleracea*).

During the present summer this department received a letter from a Massachusetts farmer inquiring concerning the feeding value of purslane. He stated that he had been feeding it to his cows, and had noticed a decided increase in the quantity of milk; and that, while the animals at first refused to eat it, they soon became accustomed to it, and consumed considerable quantities daily. At the time we had no analysis of the material on hand, consequently a sample was procured and examined. Since making the analysis, we have found a similar analysis made by the Indiana station.* The results are presented below: —

	Green Material.						Water-free Material.				
	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Massachusetts station, .	90.90	1.55	2.28	1.61	3.42	.24	17.08	25.11	17.71	37.44	2.66
Indiana station, . . .	86.56	2.23	1.81	2.12	6.49	.50	-	-	-	-	-
Corn fodder for comparison,	79.80	1.10	2.00	4.30	12.10	.70	5.20	9.70	21.30	60.60	3.20

The analyses show that the plant contains a very large percentage of water, mineral constituents and nitrogenous matter (protein).

The Missouri station* found .29 per cent. of nitrogen, .85 per cent. of potash and .045 per cent. of phosphoric acid in the green matter, equivalent to approximately 2 per cent. of nitrogen, 6 per cent. of potash and .3 per cent. of phosphoric acid in dry matter. We have found .37 per cent. of nitrogen, equivalent to 4.1 per cent. of nitrogen in dry matter. The percentage of potash present in the Missouri sample is exceptionally large. The plants selected by us must have been in an earlier stage of growth than those of the Indiana and Missouri stations, for both the water and the protein content are very high.

* Farmers' Bulletin, 119, Department of Agriculture.

The above results show that purslane takes large quantities of water, nitrogen and potash from the land, and must be considered a great soil exhauster.

Plumb* has fed purslane to pigs with quite satisfactory results. If dairy animals can be induced to eat it, it would quite naturally increase the flow of milk, because of its high protein content. Whether it would produce any undesirable flavor in the milk, has not been observed.

It being a most objectionable weed where clean cultivation is desired, growing and spreading with wonderful rapidity, and being at the same time a large consumer of plant food, it would hardly be considered a desirable fodder crop on most farms. Whether it has any special ability to dissolve and utilize ordinarily insoluble plant food, has never been determined.

Purslane has been frequently used in many sections as a pot herb, being cooked in a similar way to spinach, etc. It is thus highly esteemed by many.

F. — PARSONS' "SIX DOLLAR" FEED.

The station frequently receives letters requesting information relative to the value of this material. We think Mr. Parsons himself quite fairly states in his circular what this feed is. He says: "It is composed principally of the hulls of different kinds of grains and other low-grade stuff from grain mills and elevators." A sample lot was procured for us by an outside party. In appearance it seemed to consist of the chaff of different grains. It analyzed as follows: —

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Parsons' feed, ...	11.00	7.90	9.99	17.89	51.10	2.12
Oat hulls for comparison, . .	11.30	10.00	4.00	34.00	36.20	1.50

It is quite evident from the above analysis that this sample of the feed contained a considerable quantity of hulls, chaff,

* Bulletin, 82, Indiana Experiment Station.

etc., because of the presence of so large an amount of fibre. It contained, however, in addition, other grain refuse and sweepings, for there is considerable more protein and extract matter than would be found in clear hulls.

The material was fed to sheep, to ascertain its digestibility. These animals were induced to eat it after a little effort. The figures following represent the *percentages digestible* of the total amounts of the several ingredients contained in the feed, and are termed digestion coefficients: —

	Dry Matter.	Ash.	Protein.	Fibre	Nitrogen-free Extract.	Fat.
Parsons' "six dollar" feed, .	56	12	57	47	64	81
Oat hulls for comparison, . .	–	–	35	57	45	35

This lot showed a degree of digestibility approaching average late-cut English hay, and superior to oat hulls. How much different lots are likely to vary in quality, we cannot state. Considerable difference in quality would naturally be expected.

We endeavored to feed this material to cows, as a partial hay substitute, but the animals could not be induced to eat it. This was in the spring of the year. It is possible that in the winter some of it might have been consumed with satisfactory results. It is dry, possesses considerable fertilizing value, having 1.60 per cent. of nitrogen, and is chiefly useful as an absorbent. We have not determined its content of phosphoric acid and potash. Oat hulls show .45 per cent. of potash and .13 per cent. of phosphoric acid. A conservative estimate of its fertilizing value would be $3 per ton.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

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

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1900.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 55; of these, 33 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 6 in Connecticut, 2 in Vermont, 2 in Rhode Island, 1 in Canada, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and forty-four distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

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

Three hundred and seventy-two samples were analyzed at the close of November, 1900, representing 251 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 65, March; No. 68, July; and No. 70, November, 1900.

The samples not already analyzed, together with others that may be collected before the first of May, 1901, will be examined with a view of being published in our spring bulletin. It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

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

	1899.	1900.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	16	15
Number with two elements above the highest guarantee,	27	24
Number with one element above the highest guarantee,	73	85
Number with three elements between the lowest and highest guarantee,	88	118
Number with two elements between the lowest and highest guarantee,	84	92
Number with one element between the lowest and highest guarantee,	58	43
Number with three elements below the lowest guarantee,	–	1
Number with two elements below the lowest guarantee,	19	11
Number with one element below the lowest guarantee,	68	50
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	7	5
Number with one element above the highest guarantee,	32	20
Number with two elements between the lowest and highest guarantee,	20	19
Number with one element between the lowest and highest guarantee,	27	6
Number with two elements below the lowest guarantee,	2	–
Number with one element below the lowest guarantee,	18	20
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	15
Number between the lowest and highest guarantee,	16	9
Number below lowest guarantee,	10	10

A comparison of the above-stated results of our inspection with the results of 1899 shows, with the exception of those fertilizers which are classed under (*b*) (where two essential elements of plant food are guaranteed), a marked superiority in favor of the samples analyzed in 1900.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1899 and 1900 (Cents per Pound).

	1899.	1900.
Nitrogen in ammonia salts,	15.0	17.0
Nitrogen in nitrates,	12.5	13.5
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade fertilizers.	14.0	15.5
Organic nitrogen in fine bone and tankage,	14.0	15.5
Organic nitrogen in medium bone and tankage,	10.0	11.0
Phosphoric acid soluble in water,	4.5	4.5
Phosphoric acid soluble in ammonium citrate,	4.0	4.0
Phosphoric acid in fine-ground fish, bone and tankage,	4.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.0	4.0
Phosphoric acid in coarse fish, bone and tankage,	2.0	3.0
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.0	2.0
Potash as sulfate (free from chlorides),	5.0	5.0
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows a marked increase, as compared with the preceding year, 1899.

The above trade values are based on the market cost, during the six months preceding March, 1900, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.

Dissolved bones.
Acid phosphate.
Refuse bone-black.
Ground phosphate rock.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Muriate of potash.
Kainit.
Sylvinite.
Crude saltpetre.

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

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

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

	Value per Hundred Pounds.	Value per Ton (Two Thousand Pounds).
Four pounds nitrogen, at 15.5 cents,	$0 62×20	=$12 40
Eight pounds soluble phosphoric acid, at 4.5 cents,	36×20	= 7 20
Four pounds reverted phosphoric acid, at 4 cents,	16×20	= 3 20
Two pounds insoluble phosphoric acid, at 2 cents,	04×20	= 80
Ten pounds potassium oxide, at 5 cents,	50×20	= 10 00
Value per ton,		$33 60

The following table gives the average analysis of officially collected fertilizers for 1900: —

Average Analysis of Officially Collected Fertilizers for 1900.

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.29	2.95	2.53	4.53	3.79	2.81	10.52	9.02	7.96	7.31	5.40	5.02
Ground bones,	5.06	3.30	2.79	.58	8.29	15.73	24.11	11.31	8.46	6.46	-	-
Tankage,	6.57	4.18	4.02	-	9.68	10.65	19.76	17.67	9.68	-	-	-
Dissolved bone black,	11.33	-	-	14.75	3.00	.53	18.25	16.00	16.32	15.54	-	-
Wood ashes,	4.59	-	-	-	-	-	1.84	1.00	-	-	6.59	4.75
Kainit,	1.35	-	-	-	-	-	-	-	-	-	12.90	12.00
Nitrate of soda,	1.17	15.75	15.22	-	-	-	-	-	-	-	-	-
Muriate of potash,	1.77	-	-	-	-	-	-	-	-	-	49.55	50.27
High-grade sulfate of potash,	.44	-	-	-	-	-	-	-	-	-	50.78	48.00
Sulfate of ammonia,	.47	21.15	19.00	-	-	-	-	-	-	-	-	-
Acid phosphate,	16.22	-	-	13.82	2.06	.12	16.00	15.00	15.88	13.15	-	-
Cotton-seed meal,	5.70	7.64	7.00	-	-	-	-	-	-	-	-	-
Cotton-hull ashes,	8.05	-	-	-	-	-	10.38	10.00	-	-	24.48	20.00
Sulfate of potash and magnesia,	2.25	-	-	-	-	-	-	-	-	-	24.04	25.93

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1900, to May 1, 1901), and the Brands licensed by Each.

Armour Fertilizer Works, Chicago, Ill.: —
- All Soluble.
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- High-grade Potato.
- Cape Cod Asparagus Mixture.
- Armour's Grain Grower.
- Bone Meal.
- White Bone Flour.
- Armour's Flower Food.

Wm. H. Abbott, Holyoke, Mass: —
- Animal Fertilizer.
- Eagle Brand for Grass and Grain.
- Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Castor Pomace.
- A. A. Ammoniated Superphosphate.
- Complete Potato Manure.
- Strawberry Manure.
- Complete Tobacco Manure

C. A. Bartlett, Worcester, Mass.: —
- Pure Ground Bone.

Berkshire Mills Co., Bridgeport, Conn.: —
- Complete Fertilizer.
- Potato Phosphate.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Farm and Garden Phosphate.
- Bowker's Hill and Drill Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.
- Ground Bone.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's X. L. Phosphate.
- Potato Manure.
- Potato Fertilizer.
- Complete Manure for Potatoes and Vegetables.
- Corn Phosphate.
- Breck's Lawn and Garden Dressing.
- Eclipse Phoshate.
- Niagara Phosphate.
- Fine-ground Bone.
- Muriate of Potash.
- Kainit.
- Double Manure Salts.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Brightman's Fish and Potash.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer, G. G.
- Potato Manure.
- Potato Fertilizer.
- Great Planet Manure.
- King Philip Guano.

Cleveland Dryer Co., Boston, Mass.: —
- Cleveland Superphosphate.
- Cleveland Potato Phosphate.
- Cleveland High-grade Complete Manure.

E. Frank Coe Co., New York, N. Y.: —
- High-grade Ammoniated Bone Superphosphate.
- Special Potato Fertilizer.
- Fish and Potash, F. P.
- Gold Brand Excelsior Guano.
- Tobacco and Onion Fertilizer.
- Vegetable and Vine.
- Bay State Phosphate.
- Market-garden Special Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Crocker's Ammoniated Corn Phosphate.
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's New Rival Ammoniated Superphosphate.
- Crocker's General Crop Phosphate.
- Crocker's Superior Fertilizer.
- Crocker's Grass and Oats Fertilizer.

Cumberland Bone Phosphate Co., Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
- Potato and Root Crop.
- Blood, Bone and Potash.
- Fine Bone.
- Potato Manure.
- Animal Fertilizer.
- Complete Ten Per Cent. Manure.
- Nitrate of Soda.
- Muriate of Potash.

John C. Dow & Co., Boston, Mass.: —
- Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Wood Ashes.

Farmers' Union Fertilizer Co., Peabody, Mass.: —
- Corn King.
- Market-garden Special.
- Complete Potato Fertilizer.
- Ammoniated Bone Fertilizer.

Great Eastern Fertilizer Co., Rutland, Vt.: —
- Northern Corn Special.
- Vegetable, Vine and Tobacco.
- General Fertilizer.
- Grass and Oats Fertilizer.
- Garden Special.

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

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Canada Hardwood Ashes.

Charles W. Hastings, Jamaica Plain, Mass.: —
- Ferti Flora.

Thomas Kirley, South Hadley Falls, Mass.: —
- Pride of the Valley.
- Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Animal Brand.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market Garden.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Potato Manure.
- Swift's Lowell Ground Bone.
- Swift's Lowell Nitrate of Soda.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Celebrated Onion Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Special Tobacco Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

The Mapes Formula & Peruvian Guano Co., New York, N. Y.: —
- The Mapes Bone Manures.
- The Mapes Superphosphates.
- The Mapes Special Crop Manures.
- Sulfate of Potash.
- Nitrate of Soda.
- Tobacco Ash Constituents.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Pure Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Market Garden.
- Chittenden's Complete Fertilizer.
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.

Pacific Guano Co., Boston, Mass.: —
- High-grade General.
- Soluble Pacific Guano.
- Potato Special.
- Nobsque Guano.

Packer's Union Fertilizer Co., New York, N. Y.: —
- Gardener's Complete Manure.
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato Fertilizer.
- Special Strawberry Manure.
- A. A. Brand.
- Star Brand Superphosphate.
- Pure Ground Bone.
- P. & P. Potato Fertilizer.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Corn Manure.
- Market-garden Manure.
- Grass Fertilizer.
- Pequot Fish and Potash.
- Havana Tobacco Fertilizer.
- Climax Phosphate.

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

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex XXX Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Potatoes and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Fertilizer.
- Essex Tobacco Starter.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable Fertilizer.
- Complete Corn Fertilizer.
- Fish and Potash.
- High-grade Soluble Tobacco and Potato.
- High-grade Oats and Top Dressing.
- High-grade Grass and Grain.
- High-grade Tobacco Fertilizer.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
- Read's Standard.
- High-grade Farmer's Friend.
- Practical Potato Special.
- Bone, Fish and Potash.
- Samson.
- Potato Manure.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.

Standard Fertilizer Co., Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.
- Standard A Brand.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

Henry F. Tucker Co., Boston, Mass.: —
- Original Bay State Bone Superphosphate.
- Special Potato Fertilizer.

Darius Whithed, Lowell, Mass.: —
- Ground Bone.
- Champion Animal Fertilizer.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- High-grade Special.
- Ammoniated Bone Superphosphate.
- Potato Phosphate.
- Corn Phosphate.
- Potato Manure.
- Special with ten per cent. Potash.
- Royal Bone Phosphate.
- Prolific Crop Producer.
- Fine Wrapper Tobacco Grower.
- Bone Meal.

M. E. Wheeler & Co., Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Havana Tobacco Grower.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Electrical Dissolved Bone.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

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

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

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.
3. Notes on sludge, its agricultural value.
4. Notes on phosphatic slag, as a source of phosphoric acid for manurial purposes.

1. Analyses of Materials sent on for Examination.

During the past season 237 materials have been received and the results of our examination have been published in detail in bulletins 65, 68 and 70 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality from which they come. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of our industries are becoming from year to year more numerous and important. As the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value, frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements are made to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a list of materials received during the past season, which shows the general nature of the work: —

Wood ashes,	73	Acid phosphate,	1
Cotton-hull ashes,	8	Dissolved bone-black,	2
Brickyard ashes,	1	Dissolved bone,	2
Leather-scrap ashes,	1	Cotton-seed meal,	4
Lime-kiln ashes,	2	Castor pomace,	1
Lime refuse,	1	Cotton waste,	7
Muriate of potash,	3	Tobacco stems,	3
High-grade sulfate of potash,	2	Tobacco dust,	1
Sulfate of potash and magnesia,	3	Muck,	2
Kainit,	1	Peat,	1
Silicate of potash,	1	Soot,	1
Sulfate of ammonia,	1	Bat guano,	1
Nitrate of soda,	3	Cork dust,	1
Ground bone,	7	Kiln dust,	1
Raw bone flour,	1	Complete fertilizers,	13
Steamed bone meal,	1	Refuse from garbage plant,	1
Tankage,	5	Stable manures,	14
Dry fish meat,	2	Stable refuse material,	1
Florida rock phosphate,	1	Sludge,	7
Phosphatic slag,	1	Soils,	29
South Carolina rock phosphate,	2	Bug death,	1
Apatite,	1	Miscellaneous materials,	22

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to the farmers of the State. As our resources are limited, we have to request all farmers sending material for examination to prepay express charges.

2. Notes on Wood Ashes.

During the past year (1900) 30.8 per cent. of the materials sent on for analysis consisted of wood ashes, as against 24.4 per cent. the previous year (1899). The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article.

The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to furnish a guarantee of the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of these two elements is present.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and general character of the foreign matters are apt to seriously affect the weight of a given volume. The following table shows the general character of the wood ashes, so far as their chemical composition is concerned, that have appeared in the general markets during the season of 1900: —

Analysis of Wood Ashes.

CONSTITUENTS.	NUMBER OF SAMPLES.	
	1899.	1900.
Moisture below 1 per cent.,	2	1
Moisture from 1 to 10 per cent.,	21	25
Moisture from 10 to 20 per cent.,	35	32
Moisture from 20 to 30 per cent.,	1	13
Moisture above 30 per cent.,	1	1
Potassium oxide above 8 per cent.,	4	1
Potassium oxide from 7 to 8 per cent.,	9	6
Potassium oxide from 6 to 7 per cent.,	13	12
Potassium oxide from 5 to 6 per cent.,	7	25
Potassium oxide from 4 to 5 per cent ,	19	14
Potassium oxide from 3 to 4 per cent.,	2	7
Potassium oxide below 3 per cent.,	2	7
Phosphoric acid above 2 per cent.,	4	6
Phosphoric acid from 1 to 2 per cent.,	43	62
Phosphoric acid below 1 per cent.,	10	4
Average per cent. of calcium oxide (lime),	34.10	32.51
Per cent. of mineral matter insoluble in diluted hydrochloric acid: —		
Below 10 per cent.,	16	15
Between 10 and 15 per cent.,	26	35
Between 15 and 20 per cent.,	7	12
Above 20 per cent.,	7	11

To assist our farmers in selecting the best quality of wood ashes in our market, it is desirable that those sending samples for analysis will state the name of the party of whom the goods were purchased and price per ton paid.

3. Notes on Sludge, its Agricultural Value.

The interest in the character of this class of materials and their value for manurial purposes is deservedly steadily increasing, judging from inquiries received at this office. As the source of the article as well as the mode of collecting the same may differ widely, it is but natural that no definite advice can be furnished without a special examination into the existing circumstances. The subsequent compilation of analyses of sludge, made at the request of farmers of the State, are published to increase a more general interest in the matter: —

Analyses of Samples of Sludge (Per Cent.).

[The five samples were received from Worcester, Mass. I., taken from bottom of basin, unpressed; II., taken from top of basin, unpressed; III., pressed sample, yellowish in color; IV., pressed sample, black color; V., pressed sample, reddish color.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	65.99	63.59	54.98	68.15	53.11
Nitrogen,	.44	.38	.49	.36	.62

Analyses of Samples of Sludge (Per Cent.).

[I., Average complete analysis of the above five samples; II., sludge received from Worcester, Mass.; III., sludge received from Brockton filter beds (1899); IV., sludge received from Brockton filter beds (1900).]

CONSTITUENTS.	I.	II.	III.	IV.
Moisture at 100° C.,	61.16	65.61	21.44	2.77
Phosphoric acid,	.39	.47	.86	.72
Potassium oxide,	.13	.07	.16	.66
Nitrogen,	.46	.58	1.31	1.27
Calcium oxide,	5.08	–	1.13	trace.
Ferric oxide,	6.50	–	–	–
Aluminum oxide,	2.05	–	–	–
Magnesium oxide,	2.19	–	–	–
Sulfuric acid (SO_3),	.44	–	–	–
Carbonic acid,	4.86	–	–	–
Chlorine,	trace.	–	–	–
Insoluble matter,	10.57	5.63	–	–

It will be seen from the above analyses that there is a great difference in the percentage of the fertilizing constituents present in the different samples. There remains, however, no doubt that these materials when properly studied furnish a valuable source of plant food, when they can be conveniently obtained, and supplemented by such ingredients as potash and phosphoric acid compounds, to render them more suitable for manurial purposes in case of different crops.

4. Notes on Phosphatic Slag as a Source of Phosphoric Acid for Manurial Purposes.

The phosphatic slag, sometimes called Thomas basic phosphatic slag, or odorless phosphate, in advertisements of dealers of commercial fertilizers, is obtained as a by-product in the conversion of phosphorus containing iron ores into phosphorus free metallic iron. Investigations regarding its fitness as an economical source of phosphoric acid for manurial purposes have received, from the date of its first production, the special attention of agricultural chemists and agriculturists of Germany and other European countries. Field observations in the United States date back, as far as the writer is informed, to the year 1888. Summing up the results of the past, it will be admitted that a genuine phosphatic slag, judiciously applied, has proved a valuable addition to our phosphoric-acid-containing manurial resources, and that its use is only limited by its supply at a reasonable cost.

The subsequent tabular statement may convey some more definite idea regarding the general character of the phosphatic slag tested at Amherst, Mass. : —

Analyses of Phosphatic Slag (Per Cent.).

[I., German phosphatic slag (sent on), 1887; II., English phosphatic slag (sent on), 1887; III., German phosphatic slag (imported for station use), 1888; IV., phosphatic slag received from England, 1888.]

CONSTITUENTS.	I.	II.	III.	IV.
Moisture at 100° C.,	.10	.37	5.08	.37
Ferric and aluminum oxides,	4.26	-	15.98	8.55
Total phosphoric acid,	31.51	18.91	21.05	18.91
Available phosphoric acid,	.19	5.93	-	-
Insoluble phosphoric acid,	30.32	12.98	-	-
Calcium oxide,	41.87	49.82	53.97	49.22
Magnesium oxide,	-	-	3.83	-
Insoluble matter,	13.74	5.06	-	5.06

Analyses of Phosphatic Slag (Per Cent.).

[I., bought for field experiments, 1894; II., sent on from Hatfield, Mass., 1893; III., sent on from Marshfield, Mass., 1893; IV., sent on from Amherst, Mass., 1893; V., sent on from Mansfield, Mass., 1900.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	.47	1.12	.60	.63	.25
Ferric and aluminum oxides,	14.35	-	-	-	-
Total phosphoric acid,	19.04	18.40	19.45	18.42	19.80
Available phosphoric acid,	-	-	-	-	6.04
Insoluble phosphoric acid,	-	-	-	-	13.76
Calcium oxide,	46.47	49.00	61.30	48.27	52.93
Magnesium oxide,	5.05	-	-	-	-
Carbonic acid,	-	2.67	2.25	-	-
Potassium oxide,	-	.32	.52	-	.50
Insoluble matter,	4.39	7.20	5.12	5.53	-

The analyses of phosphatic slag in earlier years, as a rule, show lower percentages of ammonium citrate soluble phosphoric acid when subjected to the same current mode of treatment as other phosphatic fertilizers, — a circumstance due to the presence of a varying quantity of caustic lime, which caused a decomposition of the citrate of ammonia, and thus affected more or less seriously its power to dissolve the available phosphoric acid present. The recognition of this fact on the part of chemists has caused the adoption of a modification in the character and the concentration of the citrate of ammonia solution proposed by Dr. P. Wagner, which aims at a neutralization of the free lime. The determination of available phosphoric acid in phosphatic slag, by Wagner's method, for trade purposes is to-day generally adopted. As our above-stated analyses of phosphatic slag extend over a period of more than twelve years, the main interest in our results consists in the statement of the amount of total phosphoric acid found present.

Aside from these recent changes in the current modes of analyzing these phosphates, there has been introduced an important change in the manufacture of phosphatic slag for manurial purposes. As in the fertilizer trade, the valuation of the phosphoric acid is based, as a rule, on the amount of available phosphoric acid present. Manufacturers of phosphatic slag have aimed at the production of a material which, by chemical analysis, will show the largest amount of available phosphoric acid; this result is obtained by fusing the slag at about 900° C. with sufficient quartz sand to change the free lime present into silicate of lime. The inventor of this process (G. Hoyermann) has published as an illustration the following results: —

Analyses of Thomas Phosphatic Slag (Per Cent.).

[I., analysis of Thomas phosphatic slag before smelting with quartz sand; II., analysis of the same material after fusing with quartz sand.]

CONSTITUENTS.	I.	II.
Calcium oxide (free lime),	11.00	.70
Silicic acid,	2 to 3	12.00
Available phosphoric acid (percentage of whole),	58.00	84.00

The general introduction of Hoyermann's process has changed the character of the phosphatic slag of earlier years materially. The phosphatic slag of to-day contains, in exceptional cases only, some free lime, not sufficient to charge any beneficial effect of the phosphatic slag on the crop raised to free lime present.

An imitation of phosphatic slag is reported as having been introduced in Sweden. It is obtained by fusing apatite with soda ash at from 700° to 800° C. No representative sample of this material has yet come to the writer's notice.

REPORT OF THE BOTANISTS.

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

The work of this division during the past year has consisted as usual in the investigation of various forms of plant disease, together with a large amount of correspondence, the preparation of results for publication, and miscellaneous botanical work. Bulletin No. 69, on "The rotting of greenhouse lettuce," was issued during the year, giving an account of the work on this subject, to which reference has been made in several recent annual reports of this station. The extent of the lettuce-forcing industry in this State makes the subject of this bulletin one of great importance, as the financial loss from this source has been a large and increasing one. Notably in the case of the disease known as the "drop," the least understood and the most destructive of these troubles, results have been obtained which show hitherto entirely unknown characteristics in the development of the organism which causes the trouble, on the basis of which knowledge a practical and efficacious treatment can be applied. Another result of no small importance has been the demonstration of the worthlessness of many so-called remedies.

Our greenhouses used for purposes of experiment have as usual been devoted to the study of problems connected with the forcing of vegetables, principally cucumbers, in addition to lettuce.

Aster Diseases.

During the past summer, work on the diseases of the China aster has been continued, upon a much more extensive scale than heretofore. Altogether some 15,000 plants were grown, and a great variety of experiments were conducted upon fertilizers, varieties, localities, time of planting, methods of handling, etc. In one bed, 600 feet in length, were grown all the varieties of this plant obtainable from the leading seedsmen of the country, over 300 in all. This plant is very generally affected by a number of serious troubles, most prominent of which is a disease of a peculiarly obscure nature. No organism of any kind appears to be the cause of it, yet it has a very characteristic as well as destructive effect. Our most recent results indicate that the abnormal development is due to a disturbance of the assimilative (metabolic) functions of the plant. The conditions, however, which bring about this disturbance, seem, as shown by our results thus far, contradictory and obscure. At least three other diseases, all of a fungous nature, also attack the aster, with serious effects. These can be more readily understood, if not prevented. Complaint is made from all parts of the country of trouble in growing this popular flower.

Nematode Worms.

A peculiar disease on potted cuttings of perennial phlox was sent in during the past winter, which proved to be caused by a species of nematode, but quite different from that attacking the roots of many plants, to which this division has devoted considerable attention. This new form attacks the stem of the plant, causing there an abnormal enlargement, while the leaves are stunted or reduced to mere rudiments, and the plant generally dies. The worm causing the mischief is a slender creature of microscopic size, which embeds itself in the tissues of the stem, where it multiplies rapidly and produces the abnormal growth. The species is an undescribed one, though it appears to be the same as that mentioned by several writers as attacking the stems and leaves of plants. This is the only occurrence of the sort which we have known in this State, and from its nature it does not appear to be anything which will become generally prevalent or destructive.

Cucumber Mildew (*Plasmopara Cubensis*, B. and C.).

This mildew made its appearance in Massachusetts during the past autumn for the first time, so far as we are aware, since 1889, when it was reported by Dr. Humphrey * as found in two distinct localities in the State. This time it is again reported as occurring upon greenhouse cucumbers in two entirely distinct and remote localities, namely, Beverly and Leominster, but we are not aware of its presence during the summer on out-door cucumbers, squashes or melons. The fungus occurs more commonly in the south, and even no further remote than Ohio and Long Island it has proved exceedingly disastrous to out-door crops. It is surmised by Professor Selby of Ohio that it persists in the south and works its way northward as the season advances. The notable results in Long Island, obtained by Stewart,† in spraying with the Bordeaux mixture cucumbers affected with this mildew, show that the disease can be practically controlled.

The fungus appears largely upon the under side of the leaf, as a downy mass, greatly resembling the downy mildew of the grape. It must not, however, be confounded with the common powdery mildew found so frequently upon the upper surface of cucumber leaves. It is, moreover, more disastrous than the powdery mildew, and on this account should not be neglected when found.

Russian Thistle in Massachusetts.

The first report of the finding of the Russian thistle in Massachusetts which has come to our notice is made by Mr. Wm. P. Rich.‡ Two plants were first observed by him on a railroad bank at Dedham, Aug. 22, 1897, and since that time the plants have shown a tendency to increase slightly. Mr. Rich states that on Aug. 4, 1900, he found in the same locality twenty plants. A few of them had spread three hundred feet from where first observed in 1897. The Russian thistle has been previously reported in New York and Rhode Island.

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* Eighth annual report, Massachusetts Agricultural Experiment Station, p. 210.

† New York Agricultural Experiment Station Bulletin, No. 119, Geneva, N. Y.

‡ Rhodora, Vol. II., p. 204.

Influence of Chemical Solutions upon the Germination of Seeds.

It is well known that there are many chemical solutions which accelerate and retard the germination of seeds; it is also known that germinating seeds are very susceptible to changes in temperature and moisture, to variations in the degree and kinds of light, to the amount of oxygen they receive, to the influence of electricity, etc. It was our idea, in inaugurating these experiments, to determine to what degree seeds could be accelerated in their germination, and also to what extent their germinating capacity could be increased. Experiments in this direction have been carried on in this department since 1895, but they have been interrupted a number of times. These experiments have been directed along two lines, namely, a study of the influence of physical factors upon germination, and a study of the effects of different chemical solutions upon germination. The results of the former experiments have already been published, in a bulletin entitled "Electro germination;" while some of the results of the latter, which have been carried on by Mr. E. H. Sharpe, at one time a student in the college, constitute the subject of this article.

Any form of treatment capable of accelerating the germination of seeds possesses perhaps more scientific than practical value; but there are, nevertheless, some high-priced seeds which do not retain their germinating capacity very long, and, if the percentage of germination can be materially increased at a small expense, such a treatment would be worthy of practical consideration. It is not our purpose, however, to maintain, from the results shown in the following tables, that they warrant practical application.

The solutions selected for these experiments are those which are frequently found in seeds and seedlings; and it was thought that, by applying these solutions to the seeds for a certain number of hours, they might supply the deficiency in some essential constituent, and thus enable poorer and exhausted seeds to germinate. There are many seeds which do not retain the power of germinating very long; and it might be supposed that one cause of this had some connection with the normal condition of the enzymes or ferments, which are essential for the conversion of certain seed products into available forms for germination. It is with this idea in mind that our experiments with solutions have been conducted; and the solutions selected have been those which are known to exist in many seeds and seedlings as ferments or enzymes, termed diatase, pepsin, trypsin and others, and amides, such as asparagin, leucin, etc. With the exception of diatase, all of the chemicals used in making these solutions were obtained from Mercks, the diatase being made up from malt. These experiments are by no means as complete as desired, but circumstances did not permit of their continuation at the time they were made.

Experiments with Asparagin Solutions.

Asparagin is a typical amide, found in connection with many seedlings and storage organs. During germination the amides increase in some instances to a considerable extent. Asparagin is especially abundant in leguminous seedlings, and is believed to play an important part in metabolism. The following tables, I. to V., represent the effects of asparagin solution upon different seeds which display considerable variation in their germinating capacity. One hundred seeds were used in all instances for each strength of solution, and the strength of solution varied in each experiment from .1 to 2 per cent. The seeds were soaked in asparagin twelve hours, after which they were rinsed with water and placed in Zurich germinators excluded from the light in a room with fairly even temperature. The number of seed germinating each day were taken out and recorded, no observations being made previous to twenty-four hours after placing them in the germinator. In many instances the number of observations have been omitted in the tables, to save space, and the percentages in the last columns give the final results. The relative gain, however, during this period, is practically the same as that preceding it. The seeds were in every instance left a few days or a week longer, in order to see if any more would germinate. We endeavored to select seed which did not show a high percentage of germination, but in every case this was not accomplished.

TABLE I. — *Showing the Effects of Asparagin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa L.).*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).			
	1 (24 Hours).	2.	3.	4.
Normal,	65	85	87	88
2 per cent.,	81	92	97	97
1 per cent.,	85	96	98	99
.5 per cent.,	64	88	97	98
.25 per cent.,	73	93	98	99
.1 per cent.,	75	97	99	100

Normal average (per cent.), ... 88.0
Asparagin average (per cent.), ... 98.6

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).	
	1 (24 Hours).	2.
Normal,	53	90
2 per cent.,	93	100
1 per cent.,	88	99
.5 per cent.,	95	100
.25 per cent.,	89	98
.1 per cent.,	88	100

Normal average (per cent.), ... 90.0
Asparagin average (per cent.), ... 99.4

Experiments *A* and *B* in the table show an acceleration in germination as well as a gain in the germinating capacity. Experiment *B* is a repetition of *A*. Both experiments lasted three days longer than indicated by the table, but no further germination occurred in either.

TABLE II. — *Showing the Effects of Asparagin Solutions upon the Germination of Rape Seeds (Brassica napus L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION.									
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	19.
Normal,	–	–	–	–	–	2	8	16	25	68
2 per cent.,	1	1	2	2	4	11	23	39	47	97
1 per cent.,	5	5	5	6	10	10	14	17	28	85
.5 per cent.,	5	5	6	6	10	16	22	31	41	86
.25 per cent.,	6	7	10	12	17	28	40	51	58	90
.1 per cent.,	1	1	1	1	3	7	25	36	49	86

Normal average (per cent.), ... 68.0
Asparagin average (per cent.), ... 88.8

This experiment lasted three days longer than indicated in the table, and, as no further germination occurred, the experiment was discontinued.

TABLE III. — *Showing the Effects of Asparagin Solutions upon the Germination of Canadian Field Pea (Experiment A) and Vetch (Experiment B) Seeds.*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	2.	3.
Normal,	3	98	100
2 per cent.,	12	98	100
1 per cent,	18	100	100
.5 per cent.,	27	100	100
.25 per cent.,	12	100	100
.1 per cent.,	17	99	100

Normal average (per cent.), ... 100
Asparagin average (per cent.), ... 100

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	3.	3.
Normal,	35	97	99
2 per cent.,	78	100	100
1 per cent,	84	100	100
.5 per cent.,	71	100	100
.25 per cent.,	83	100	100
.1 per cent.,	89	100	100

Normal average (per cent.), ... 99
Asparagin average (per cent.), ... 100

On account of the especially good seed used in these experiments, the results merely show an acceleration, due to the asparagin.

TABLE IV. — *Showing the Effects of Asparagin Solutions upon the Germination of Buckwheat Seeds (Fagopyrum esculentum* Moench).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.
Normal,	1	36	60	65	71	71	71	71	71
2 per cent.,	1	42	71	76	77	77	77	77	77
1 per cent,	–	30	67	71	77	80	80	80	80
.5 per cent.,	–	47	80	86	91	92	92	92	92
.25 per cent.,	–	32	64	68	72	75	75	75	75
.1 per cent.,	–	43	75	79	80	83	84	84	85

Normal average (per cent.), ... 71.0
Asparagin average (per cent.), ... 81.6

No change in the results were shown when experiment was allowed to remain two days longer.

TABLE V. — *Showing the Effects of Asparagin Solutions upon the Germination of Serradella Seeds (Ornithopus sativus).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).									
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	17.
Normal,	–	2	7	10	16	28	34	40	42	55
2 per cent.,	–	2	7	16	25	28	34	41	46	76
1 per cent.,	–	3	16	24	34	39	44	47	53	74
.5 per cent,	–	4	13	23	26	32	39	48	52	68
.25 per cent.,	1	6	16	22	31	34	38	44	51	74
.1 per cent.,	1	4	10	21	29	35	41	47	52	82

Normal average (per cent.), ... 55.0
Asparagin average (per cent.), ... 74.8

The seeds in this experiment failed to germinate further than shown in the table. Another experiment showed a corresponding acceleration, and at the end of fifteen days, when no more seed would germinate, the normal gave 54 per cent. and the treated averaged 79 per cent. One experiment with asparagus seed showed an acceleration throughout, and gave for the normal 40 per cent., while the treated was 45 per cent., — a gain of little consequence.

In considering the results of asparagin experiments as a whole, we find that the average percentage of germination for the normals in five experiments was 74.5 per cent.; that for the treated, 88.6 per cent. When the average percentage of the normal is compared with the .5 per cent. asparagin solution, we obtain 88.8 per cent. for asparagin and 74.5 per cent. for the normal.

In experiments dealing with seeds showing a small germinating capacity, some allowance must be made for individual variation, and it is better to use a large number of seeds in such cases, or, what is better, to have the experiment repeated a number of times with each species. Four experiments, however, of one hundred seeds, possess more value than one where four hundred seeds are used. After due allowance has been made for individual variation, it will be observed that the asparagin exerts an acceleration upon the germination of certain seeds, and also increases their germinating capacity. The various solutions of asparagin used show no detrimental effect upon the seeds.

Experiments with Leucin Solutions.

Leucin, like asparagin, is an amide, and is found frequently in connection with the latter in germinating seeds and seedlings. The seeds were soaked twelve hours in different strengths of solutions, and then rinsed before placing them in Zurich germinators, as in the asparagin experiments. Tables VI. and VII. give the result of two experiments with leucin.

TABLE VI. — *Showing the Effects of Leucin Solutions upon the Germination of Buckwheat Seeds (Fagopyrum esculentum Moench).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	11.
Normal,	–	20	56	68	72	72	72	72	72
1 per cent.,	–	20	61	68	70	72	73	73	74
.5 per cent.,	–	20	59	71	76	77	78	80	80
.25 per cent.,	–	11	51	64	71	74	74	75	80
.1 per cent.,	–	22	66	81	89	90	92	92	92
.05 per cent.,	–	21	61	74	76	78	78	79	80

Normal average (per cent.), ... 72.0
Leucin average (per cent.), ... 81.2

No further germination took place in the untreated seeds after the fifth day.

TABLE VII. — *Showing the Effects of Leucin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).				
	1 (24 Hours).	2.	3.	4.	5.
Normal,	43	87	90	90	90
1 per cent.,	43	90	93	95	96
.5 per cent.,	43	89	94	96	96
.25 per cent.,	46	95	98	98	98
.1 per cent.,	47	94	96	97	97
.05 per cent.,	51	95	98	98	98

Normal average (per cent.), ... 90.0
Leucin average (per cent.), ... 97.0

No further germination took place in the untreated seeds after the third day. Another experiment with alfalfa gave 89 per cent. for the normal and 98 per cent. for the treated seeds. The average of the three leucin experiments gave 83 per cent. for the normal and 92 per cent. for the treated. The various solutions of leucin had no injurious effect on the seeds.

Experiments with Pepsin Solutions.

Pepsin is a proteolytic ferment (enzyme), found in some seeds during germination, and is capable of converting non-diffusible proteids into diffusible ones. The seeds in the experiments shown in the two tables. VIII. and IX., were treated as in the preceding ones.

TABLE VIII. — *Showing the Effects of Pepsin Solutions upon the Germination of Crimson Clover Seeds (Trifolium incarnatum* L.).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).						
	1 (24 Hours).	2.	3.	4.	5.	6.	7.
Normal,	9	21	25	27	27	28	28
5 per cent.,	9	22	29	31	33	36	36
2.5 per cent.,	10	19	26	30	35	39	43
1 per cent.,	17	26	31	37	39	40	42
.5 per cent.,	19	27	33	36	39	40	42
.25 per cent.,	16	23	31	36	39	41	43
.1 per cent.,	17	25	31	35	37	39	42

Normal average (per cent.), ... 28.00
Pepsin average (per cent.), ... 41 33

None of the seeds showed any further germination when left five days longer. Two other experiments with crimson clover were made: in one the normal seeds gave 22 per cent., the average of the treated seeds 38.6 per cent.; in the other, the normals were 22 per cent., while the average treated ones gave 33.8 per cent. The average of the three crimson clover experiments is: normal average, 24 per cent.; pepsin average, 34 per cent. The best results were obtained by the .25 per cent. solution in each experiment, and by comparing the results of this treatment we have for the normal averages 24 per cent. and pepsin averages 41 per cent.

Table IX. — *Showing the Effects of Pepsin Solutions upon the Germination of Cucumber Seeds* (*Cucumis sativus* L.).

Strength of Solution.	Percentage of Germination (in Days).											
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Normal,	-	47	51	52	53	53	53	53	53	58	58	58
5 per cent.,	-	63	67	70	71	71	73	76	76	76	77	77
2.5 per cent.,	-	54	67	68	70	70	71	71	71	71	71	73
1 per cent.,	-	62	67	70	70	70	75	75	75	77	77	77
.5 per cent.,	-	53	56	58	58	58	63	63	66	70	70	70
.25 per cent.,	-	48	57	58	60	60	63	65	67	70	70	70
.1 per cent.,	-	53	56	58	60	63	69	71	72	75	75	75

Normal average (per cent.), ... 58.00
Pepsin average (per cent.), ... 73.66

None of the seeds showed any further germination. Another pepsin experiment with cucumber seeds gave for the normal 51 per cent. and an average of the treated was 68 per cent. Two pepsin experiments with vetch (*Vicia sativa*) gave precisely the same percentages of germination for both the normal and treated seeds, and all of the solutions except the .1 per cent. (which accelerated germination) resulted in a retardation. Yellow lupine seeds (*Lupinus luteus*) treated with the various pepsin solutions were also retarded, and alfalfa seeds responded to pepsin but slightly. It is known that pepsin does not exist, or at least has not been detected, in some germinating seeds. Among these is the lupine, and, from the results of the foregoing experiments, it would appear not to be present, or at any rate play a very unimportant role, in such seeds as vetch and alfalfa.

Waugh* obtained favorable results with pepsin on tomatoes and watermelon seeds, but not with radish seeds. In our experiments the seeds showed a slight tendency to mould by the use of pepsin.

Experiments with Diastase Solutions.

Diastase, the starch-converting ferment, is probably the most widely distributed enzyme in the vegetable kingdom, it being found in seeds and mature parts of plants, and usually increasing during the mobilization of reserved food materials. The official solution used by chemists was prepared for this experiment, and consisted of 10 grams of fresh, finely ground malt, mixed with 200 cubic centimeters of water. This we have roughly designated, for convenience, as a 5 per cent. solution, from which the other percentages were obtained. The methods of treatment follow those in the preceding experiments.

TABLE X. — *Showing the Effects of Diastase Solutions upon the Germination of Black Barley Seeds (Hordeum sativum Jessen).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).					
	1 (24 Hours).	2.	3.	4.	5.	6.
Normal,	75	84	88	88	88	88
5 per cent.,	14	39	63	74	85	89
2.5 per cent.,	71	92	95	96	97	97
1 per cent.,	80	91	94	94	94	98
.5 per cent.,	82	95	96	97	98	98
.25 per cent.,	82	93	94	96	98	98
.1 per cent.,	81	96	96	96	96	97
.05 per cent.,	85	93	94	94	94	94

Normal average (per cent.),	88
Diastase average (per cent.),	95

* Tenth annual report, Vermont Experiment Station, pp. 106-111; also eleventh annual report, Vermont Experiment Station, pp. 290-295.

TABLE XI. — *Showing the Effects of Diastase Solutions upon the Germination of Upland Rice Seeds (Oryza sativa L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).			
	1 (24 Hours).	2.	3.	4.
Normal,	-	-	-	28
5 per cent.,	-	-	1	32
2.5 per cent.,	-	-	2	32
1 per cent.,	-	-	5	43
.5 per cent.,	-	-	5	41
.25 per cent.,	-	-	6	39
.1 per cent.,	-	-	5	42
.05 per cent.,	-	-	2	48

Normal average (per cent.), ... 28.0
Diastase average (per cent.), ... 39.5

Two other experiments were made, with black barley and with wheat seeds; the results, however, are of no consequence, inasmuch as the treated seeds became mouldy. This troublesome feature constituted the worst drawback in all of the diastase experiments. Waugh experienced the same trouble in the use of many of his solutions. This difficulty does not lie in the sterilization of the germinating appliances, but in the use of the solutions, which constitute excellent media for mould development. We therefore made the practice of rinsing all of the treated seeds with water before placing them in the germinators, which process helps keep down the moulds, but in some cases the moulds would appear even after the seeds had been rinsed. The results obtained from the foregoing experiments have already been sufficiently explained, and no further comment upon them is necessary here. In conclusion, it may be stated, however, that the study of the effects of amides and ferments and other accelerated factors upon seeds still offers a field for investigation worthy of a much more serious consideration than that given here.

REPORT OF THE ENTOMOLOGISTS.

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

During the year which has elapsed since the last report the entomological work of the station has been conducted as usual, and with satisfactory results. An increasing amount of correspondence shows that the people of Massachusetts appreciate the opportunities afforded them for assistance more than formerly, and are availing themselves freely of that assistance.

The addition of a very complete set of apparatus for the photography of insects and their work has already been of much advantage to the division, as photographs from life are now being made, for use in the entomological publications of the station. The equipment in this line includes an enlarging, reducing and copying camera, a Premo camera for field work and another for use in photomicrography, all of which, with the necessary accessories, are in constant use.

Last spring a bulletin on the grass thrips was issued from this division, being a presentation of the practical and economic portions of the paper on the same subject by Mr. W. E. Hinds, which was published as an appendix to the last annual report of the college; and other bulletins on various important subjects are now being prepared. A catalogue of the Coccidæ of the world is also in preparation, and will probably be ready for publication during the coming year. Several papers on injurious insects have been written by Dr. H. T. Fernald, and published by the secretary of the Board of Agriculture of Massachusetts.

Many of the entomological bulletins from different stations have been bound for preservation and more convenient reference, and a number of valuable recent publications have been added to the insectary library.

Insects of the Year.

The past year has witnessed few serious insect attacks in Massachusetts. Why this was the case is difficult to determine, though it is possible that weather conditions last spring were in a measure responsible. An early warm period, continuing long enough to produce some of the earlier changes in insects from their winter conditions toward those of spring was followed by a colder period, which, coming after the initial changes had been taken, caught the insects in a state where they were unprepared for it, and may have caused the death of so many as to reduce their numbers. How far this explanation holds, however, cannot be determined.

The San José Scale.

This most serious pest to fruit growers has been present in Massachusetts a number of years. When it first made its appearance in the State it was believed by many that it had reached about its northern limit of distribution, and that its injuries would not be likely to be serious on that account. Time has shown, however, that this is not the case, and that the scale can not only become a very serious pest here, but that it can survive a temperature of thirty degrees below zero. The past summer, perhaps because of its dryness, has been distinctly favorable to the rapid increase of the scale and to a correspondingly increased destructiveness. As early as July 19 currants were received at the station so thoroughly covered by the young scales as to make them unsalable, and during the fall apples and pears were received in a similar condition. Up to the present year it was not known that fruit in Massachusetts could be so injured by the scale as to prevent its sale, though fruit trees killed by it were met with frequently. Now, however, the scale has demonstrated its ability to attack the fruit itself in this latitude, and this must call the attention of fruit raisers to the necessity of giving the most careful attention to their trees, if they desire to sell their products.

The scale has now been received from thirty-seven different towns in the State, and in all probability it occurs in as many more. It is believed to have been exterminated in three places and in several others to be under control, but, as it is being sent in from other States on nursery stock each year, it is but a question of time when it will be present in almost every orchard, and destroy many of our ornamental trees and shrubs as well. That this is more than a mere fear is shown by the remark of a nurseryman in another State recently, when refused a certificate of inspection because of the presence of this scale: "Well, I can fill my Massachusetts orders with this stock, any way."

Much of the correspondence of the division of entomology has been about this and the other common scales, and, as little literature on the subject has recently been published in this State, a bulletin is being prepared upon these insects and the best methods of treatment for them.

Seventeen-year Locust.

This interesting insect appeared last June on Martha's Vineyard in considerable abundance. As this is the only place east of Pennsylvania where the brood due in 1900 has been found, it seemed desirable to make investigations as to the accuracy of previous observations, and to ascertain, if possible, whether this isolated colony was holding its own. Through the kindness of Mr. George Hunt Luce of West Tisbury, the necessary information and specimens were obtained, from which it appears that the brood is a well-known one on the island, and was as much in evidence as ever this year.

Birch Bucculatrix.

During September the birches were seriously attacked by the caterpillars of this insect, causing the leaves to become brown and noticeable, even at some distance. The injury was most apparent in the southern half of the State, except in the Connecticut valley, where it extended northward nearly to the State line. In 1887, 1890 and 1892 this insect was very abundant and destructive in Massachusetts, and has been present in smaller numbers every year. As it does not attract particular attention generally, it is not improbable that little will be seen of it in 1901, or, if abundant, that it will appear in the northern portions of the State, which escaped this year.

Marguerite Fly.

This little pest was sent to the station in February, 1900, with the statement that it was destroying the marguerites in the greenhouses of the sender. Careful studies upon its life history and methods for its destruction were at once commenced, and are now nearly completed. A successful, easy and inexpensive treatment for it has been discovered, and it is hoped that the results of the work will soon be in readiness for publication.

Greenhouse Aleurodes.

This insect has also caused much destruction in greenhouses in the State during the past year, a loss of four thousand dollars having been reported in one case, the damage being to early tomatoes and cucumbers, which were completely destroyed. Thorough investigations of the structure and life history of this insect are now being carried on at the insectary, together with a search for methods which will ensure its control.

Fall Canker Worm.

Little has been published upon the life history of the fall canker worm. During the year this insect has been raised from the egg, and its various stages fully described, much being added to our previous knowledge of the subject.

Pea-vine Louse.

Less has been heard about this insect than in 1899, though it has caused considerable loss in several places in the State. Whether it will increase in importance during 1901 is at least doubtful.

FAUNAL DISTRIBUTION.

The distribution of insects is one of great interest and importance. Many of our worst pests will in all probability never extend as far north as Massachusetts, where the climatic conditions are unfit for their continued existence. Certain portions of the State, however, appear to be so different from others in these regards that some insects may thrive there while unable to live elsewhere. It is of the utmost importance, therefore, to be able to locate these regions and their approximate limits, that we may know what the range of new insect foes will probably be. To this task the entomological division is giving much attention, already with many interesting and valuable results.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the work of this division has been mainly that of taking observations of the various features of the weather, and transcribing the records in convenient form for reference and preservation. With the report of last year were published the means of many of the records for a period of ten years. These results are now assumed to indicate normal conditions at this station, and the monthly means are compared with them, for the purpose of determining variation from the normal.

Bulletins of four pages each have been regularly issued at the beginning of each month, giving the more important daily records, together with mean monthly conditions and remarks on any unusual features of the month. The usual annual summary will be prepared and published with the December bulletin.

The New England section of the United States Weather Bureau has furnished daily, except Sunday, throughout the year the local forecasts for the weather of the following day, and the signals have been displayed from the flag staff on the tower. At the request of the section director, the weekly snow reports are being sent to the Boston office this season, as has been done the past few years.

The observations for the determination of the amount of soil moisture by the electrical method were started, but, owing to the failure of the apparatus to give any concordant results, the work was abandoned after an unsuccessful attempt to remedy the defects. The electrodes tried were those that last year gave fairly satisfactory results; the reason for their failure this year is not apparent. It is evident to the division that further work with our present equipment would be unprofitable.

The true meridian established here two years ago has enabled the division to begin a series of observations on the declination of the needle. These observations are taken monthly, and the readings entered in the yearly record book. The results will be of value in deducing a formula for variation in declination for this locality, and also in making surveys with the compass.

The only addition to the equipment during the year consists of an "adder," for facilitating the computation of mean daily temperatures from the hourly readings on the Draper temperature chart.

At the opening of the college, in September, Mr. A. C. Monahan, the observer, retired from the division, and was succeeded by the assistant observer, Mr. C. S. Rice.

REPORT OF THE AGRICULTURIST.

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

The work of the agricultural division of the experiment station has been carried on during the past year upon the same general lines as those which have been followed in recent years. The usual variety of problems has presented itself for experimental inquiry, and the work has been more extensive than in any previous year. As in previous years, a very large share of our attention has been directed to solving some of the many problems connected with the use of manures and fertilizers. Our experiments in this line employ three distinct methods, viz., plot experiments in the open field, experiments in cylinders plunged to the rim in the ground, and pot experiments. The results of the last two will not be discussed in this report.

Plot Experiments.

A considerable number of these has been carried out upon our own grounds. On these, we have used one hundred and sixty-five plots, varying in size from about one-fortieth of an acre in case of some experiments to two or three acres in others, the average size of the plots being perhaps about one-tenth of an acre. Fifty-five plots have been used in such experiments upon land hired for the purpose. The nature of the experiments carried out upon these plots will be made plain by the following statement: —

To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and the extent to which the introduction of a crop of the clover family can make the use of nitrogen unnecessary, — eleven plots.

To determine the relative value of muriate and of sulfate of potash used in connection with bone meal, — eleven plots.

To determine the relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and of muriate of potash and sulfate of potash as sources of potash for garden crops, — seven plots.

To determine the relative value of kainite, and of the muriate, high-grade sulfate, low-grade sulfate, carbonate, silicate and nitrate as sources of potash, — forty plots.

To determine the relative efficiency of equal money's worth of dissolved bone-black, ground South Carolina rock, ground Florida phosphate, Mona guano and phosphatic slag as sources of phosphoric acid, — six plots.

To determine the relative efficiency of equal quantities of phosphoric acid, furnished in the following materials: acid phosphate, dissolved bone-black, dissolved bone, fine-ground raw bone, fine-ground steamed bone, fine-ground South Carolina phosphate, fine-ground Florida phosphate, phosphatic slag, apatite, Navassa phosphate, — thirteen plots.

To determine the relative value of manure alone, as compared with a smaller quantity of manure and a moderate amount of potash, for the corn crop, — four plots.

To determine the relative value of mixtures of fertilizer materials, furnishing, on the one hand, nitrogen, phosphoric acid and potash in the same proportions as in average corn fertilizers, and a mixture of similar materials containing more potash, — four plots.

Soil test with mixed grass and clover, — fourteen plots.

Soil test and experiment to determine the effect of liming for onions, — twenty-four plots.

Experiment in manuring grass lands, — three plots.

Experiment to determine the value of nitrate of soda for the rowen crop, — twelve plots.

Experiment in the use of fertilizers for orchard trees, — five plots.

Experiment to determine the relative efficiency of manure hauled and spread as fast as made, compared with manure put into large piles and spread in the spring, — ten plots.

Alfalfa, on which the effect of liming the soil is being studied, occupies four plots.

One of the plot experiments upon hired land has for its object the determination of the value of nitragin, or germ fertilizer, for various legumes, and includes forty plots; while fifteen plots in another locality have been used in a soil test with grass as the crop.

Most of the problems upon which we hope to obtain light by means of these experiments have engaged our attention for a number of years. As might naturally be expected, the results are somewhat affected by season, as well as by numerous other causes which are not fully under control. Results in some cases have varied to some extent from year to year, and such variation must always be looked for in experiments of this character. This variation, of course, renders interpretation of the results a matter of much difficulty. Moreover, from the very nature of the questions engaging our attention, it is necessary that the work should continue over a considerable series of years before conclusions of general interest and importance can be drawn. It does not, therefore, seem best to publish in full the details concerning any considerable number of these experiments. Attention, however, will be called to some of the conclusions which it is believed are fully warranted by the results, not of the past year alone, but of a continuous line of investigations touching these points, many of which have continued for ten or more years.

I. — The Relative Value of Manures furnishing Nitrogen.

The experiments on which the conclusions now to be stated are based have been carried out on Field A, and a detailed description of the plan of experiment followed will be found in our twelfth annual report. These experiments were begun in 1890, and the crops grown have been oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover and potatoes. As the result of these experiments, we have found, taking into account all experiments from the beginning of the work up to date, that the various manures supplying nitrogen rank in the following order: nitrate of soda, barnyard manure, sulfate of ammonia and dried blood. If we allow numbers to express the relative efficiency of these materials, their standing is as follows: nitrate of soda, 100; barnyard manure, 90; sulfate of ammonia, 89; dried blood, 86; the plots receiving no nitrogen, 68.

It should be pointed out: (*a*) That the figure for barnyard manure is probably not a correct indication of the relative efficiency of the nitrogen it contains, because barnyard manure supplies humus and considerable quantities of lime, magnesia and other minerals which are not supplied by the fertilizers used on the other plots. These constituents of the barnyard manure are in almost all cases useful. The crops where manure is used, therefore, stand relatively higher than the availability of the nitrogen alone would warrant. (*b*) It is important to point out, further, that the relative standing of the sulfate of ammonia is lower than it undoubtedly would have been had lime been more largely used. Before these plots were limed the crops in some years were almost an absolute failure. Comparing the yields on the sulfate of ammonia with those on the nitrate plots for the years only which immediately follow the application of lime, we find, representing the yield on the nitrate of soda as 100, that the yield of the sulfate of ammonia is 101. The conclusion is inevitable, that, if we are to depend upon sulfate of ammonia as a source of nitrogen, we shall be obliged upon many of our soils to occasionally use considerable quantities of lime in connection with it. Since, however, a given quantity of nitrogen in the form of sulfate of ammonia costs more than the same quantity in the form of nitrate of soda, it is evident that the latter should usually be preferred. The nitrate of soda, however, is not so readily used in mixture with other fertilizers, on account of its tendency to become moist. Such materials as sulfate of ammonia and dried blood are far more likely to remain dry, and can therefore be more readily incorporated with other materials in manufacturing fertilizers or in making home mixtures.

II. — Crops of the Clover Family (Legumes) as Nitrogen Gatherers.

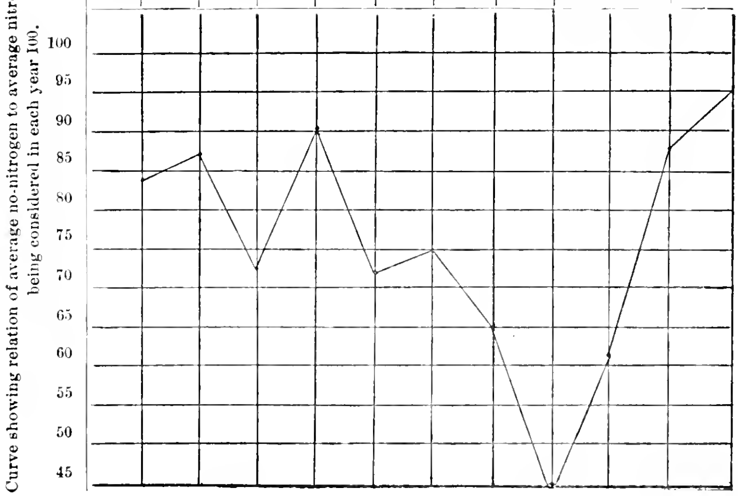
This experiment is carried out in connection with the experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and clover have been used, the former during three years, the latter one year; but it should be understood that the crops of both are harvested. We have aimed to test, not the effect of ploughing under these crops, but simply the improvement, if any, derived from their roots and stubble. The results indicate little or no improvement in the condition of the soil following culture of the soy bean, while a great improvement followed the turning under of the clover sod. The following table, with the curve below it, will, it is believed, make these facts clear: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS.	1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean.	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.
Nitrogen plots, .	343	484	1,965	598	620	494	1,740	445	254	413	1,316
No-nitrogen plots, .	290	421	1,443	540	452	370	1,143	197	158	367	1,254

[Per cent. average no-nitrogen to average nitrogen.]

1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.
84.5	87.0	73.5	90.5	72.9	75.0	65.7	44.3	62.2	88.9	95.3



The plots, three in number, from which the average of the so-called no-nitrogen plots was obtained, have received no nitrogen-containing manure or fertilizer since 1884. The past season, therefore, is the sixteenth since these plots have been manured with anything containing nitrogen. The fact that after this long period potatoes on a clover sod give a crop amounting to 95.3 per cent. of that on plots which have yearly received a fair amount of manure or fertilizer containing nitrogen is certainly one of much significance, and strikingly illustrates the advantage which may be derived from the growth of clover under appropriate conditions. The actual yields of potatoes this year, although not large, were good; the no-nitrogen plots giving a yield at the rate of 209 bushels to the acre, and the nitrogen plots an average yield at the rate of 219.3 bushels per acre.

III. — The Relative Value of Muriate and High-grade Sulfate of Potash.

The experiments on which the following statements concerning relative value are based have been carried out on Field B, and have been in progress since 1892. The potash salts named are used in equal quantities, each continuously upon one-half of the plots, while all the plots have received a yearly application of fine-ground bone at the rate of 600 pounds per acre throughout the entire period. The potash salts were used yearly, at the rate of 400 pounds per acre, from 1892 to 1899. During the past year they have been applied at the rate of 250 pounds per acre. Full details concerning these experiments will be found in recent annual reports.

During the time that this experiment has continued the following crops have been grown on the field: potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Crops have generally been good. Among these crops the potatoes,* clovers, cabbages and soy beans

* Potatoes have been grown upon our grounds under conditions making it possible to compare the yield of sulfate of potash with that of muriate of potash in fourteen different experiments; and as the average of all these experiments, if we represent the yield of sulfate of potash by 100, that of muriate is represented by the number 94.1, and in almost all instances the potatoes on the sulfate have been richer in starch and of better eating quality than those raised on the muriate.

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

Further, in estimating the significance of our results, it should be kept in mind that the continued use of muriate of potash causes the loss with drainage waters of large amounts of lime. In the experiments on which the conclusions above stated are based we have yearly supplied a large amount of lime in the bone meal used, and accordingly the productiveness of the field even where the muriate of potash has been used has been fairly well maintained. Results on other fields on our farm indicate that when not used in connection with lime the muriate of potash stands much lower than the sulfate within comparatively few years. Whoever under ordinary conditions uses muriate of potash continuously, must sooner or later lime his land; and this is equally true, whether the farmer purchases muriate of potash and applies it by itself or in a home-made mixture, or if it is the source of the potash in a mixed fertilizer which he purchases. In deciding upon the purchase of any of the ordinary fertilizers upon the market, it is important to inquire whether the potash found in the fertilizer is present in the form of muriate or in the form of sulfate; and, other things being equal, the fertilizer containing its potash in the form of sulfate should be selected, unless the soil on which the material is to be used is exceptionally light. The soil in the experiments on which the conclusions here presented are based is a medium loam. On a lighter soil the results would possibly be more favorable to the muriate.

As has been stated, the yield of the clovers has not been taken into account in making the calculations upon which the statements concerning the relative efficiency of the two potash salts are based. The reason why they have not been so taken into account is because there have always been more or less weeds produced among the clovers, and these have not been separated. The amount of weeds has naturally been greater in proportion as the clovers have been thinner and poorer. The figures, therefore, showing yields on the several plots in the form of hay, including the weight of the dried weeds as well as the weights of the dried clovers, do not correctly represent the effect of the fertilizers; accordingly, these figures have been discarded. There is, however, not the slightest doubt that in its effects upon the growth of the clovers the sulfate of potash stands distinctly ahead of the muriate. In some years and upon some plots the difference has been very large, at other times it has been smaller, and in a few instances the weight of the harvested product grown on muriate of potash has slightly exceeded that grown on the sulfate. It is without hesitation, however, that farmers are advised to employ sulfate of potash rather than the muriate, where good clover crops are desired, particularly unless prepared to use lime as well as potash salts liberally. If lime be liberally used, as indicated by our experiments on other fields, good clover can be grown on muriate of potash; but the combined cost of the lime and muriate will in most cases exceed the cost of the sulfate.

IV.—Field C.

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

The experiments upon which the conclusions now presented are based have been in progress since 1891, each of the several sources of nitrogen being applied yearly throughout the entire period upon the same plot. The crops grown during this series of years have included spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn and celery, and each of these as a rule has been grown a number of years. Up to 1898, chemical fertilizers alone were employed in these experiments. During the past three years stable manure has been applied in equal quantities to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. Taking into account the period when chemical fertilizers only were used, and the crops (spinach, lettuce, onions, table beets, garden peas and early cabbages) whose period of growth is the comparatively early part of the season, we find the relative efficiency of the different materials used as the source of nitrogen: —

Nitrate of soda,	100.0
Dried blood,	86.6
Sulfate of ammonia,	83.6

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

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	103.5

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

Nitrate of soda,	100.0
Dried blood,	88.8
Sulfate of ammonia,	61.7

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

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	91.9

With one exception, it will be seen that the nitrate of soda here, as in the case of the field crops, proves the most efficient source of nitrogen. Its superiority is, however, much more marked, as should be expected, because it is immediately available, for the early crops. For the late crops in one instance during the earlier years of the experiment the sulfate of ammonia exceeded the nitrate of soda in efficiency, but during the later years of the experiment it has stood behind, even for these crops. It should be stated, further, in comment upon these results, that on one-half the plots in these experiments muriate of potash is used in connection with the various nitrogen manures. The combination of sulfate of ammonia and muriate of potash, as has been repeatedly pointed out in former reports, is a bad one, owing to the possible formation and poisonous influence of chloride of ammonia. It should be further pointed out that this field has not received the application of any lime throughout the years during which it has been under experiment. The availability of the sulfate of ammonia would undoubtedly be increased by giving this soil a heavy dressing of lime, since the presence of lime promotes those changes which are essential to convert the nitrogen of the sulfate of ammonia into nitrates, which are the most readily available nitrogen compounds.

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

The period during which the experiments upon which the conclusions now to be stated are based and the crops grown are the same as in the case of the nitrogen fertilizers above discussed, and the relative standing of the two potash salts is shown for the same periods and crops.

Before Manure was used, — 1891–97.

	Early Crops.	Late Crops.
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	91.3	91.5

After Manure was used, — 1898–1900.

	Early Crops.	Late Crops.
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	86.1	98.8

It should be noted that the muriate of potash stands much below the sulfate for all the periods, its inferiority being particularly marked in the case of the early crops. This marked inferiority in the latter years of the experiment for the early crops is doubtless in considerable measure due to the fact that the yields of such crops on the one plot where the muriate of potash and sulfate of ammonia are used together, which has always been exceedingly small, with the progress of time appear to be growing relatively worse. This is doubtless due in some measure to the fact that the continued use of muriate of potash has caused the loss of considerable lime, — an effect which had been noted and reported in a number of previous years.

The yields on the muriate, it may be said in conclusion, could undoubtedly be brought much nearer those on the sulfate by heavily liming the field.

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

The phosphates under comparison in this experiment (which was begun in 1890) have been applied on the basis of equal money's worth, the idea being to determine whether it is more profitable to employ cheaper natural phosphates or one of the higher-priced dissolved phosphates. The plan of the experiment has been outlined in previous reports. It is necessary to state here, for clearness only, the following points: —

The phosphates compared on the basis of equal money's worth are dissolved bone-black, ground South Carolina rock, ground Florida rock, Mona guano and phosphatic slag. These phosphates were liberally applied during four years

(1890 to 1893, inclusive). Since 1893 no phosphate has been applied to any part of the field. All plots from the beginning were liberally manured with materials furnishing nitrogen and potash, and this manuring has continued on an even more liberal scale since 1893. The amounts of phosphoric acid supplied the several plots, the basis being equal money's worth, have of course varied widely. They are as follows: —

	Pounds.
Plot 1, phosphatic slag,	96.72
Plot 2, Mona guano,	72.04
Plot 3, ground Florida rock phosphate,	165.70
Plot 4, ground South Carolina rock phosphate,	144.48
Plot 5, dissolved bone-black,	49.36

The crop this year was cabbages, variety, Solid Emperor. The yield is shown in the following table: —

Comparison of Different Phosphates — Yield of Cabbages.

PLOTS.	Number over 2.25 Pounds.	Weight (Pounds).	Weight of Balance * (Pounds).
Plot 0,	3	8	95
Plot 1,	115	330	570
Plot 2,	73	250	580
Plot 3,	5	10	210
Plot 4,	111	550	950
Plot 5,	65	260	835

* Balance includes many small, hard heads, but too small for market.

The differences are very large, the ground South Carolina rock standing first, the phosphatic slag second, the Mona guano third, the dissolved bone-black fourth and the Florida phosphate last. The no-phosphate plot produced practically nothing. The plots are about one-seventh of an acre in area, and no plot has given what could be called a good crop. Last year the field was in oats, and there was but little difference between the yields of the different plots. The yield on all, even on the no-phosphate plot, was good.

In 1898 the crop on this field was corn, and the yield was good upon all plots except the no-phosphate plot and the

Florida phosphate plot, and there was no great difference between these yields. In 1897 the crop was Swedish turnips, and the relative growth on the different plots was about the same as this year in cabbages, the no-phosphate, the Florida phosphate and the dissolved bone-black giving the smallest yields, although the latter was not very much behind the balance of the plots.

Since the third year of the experiment the yields on the plots to which phosphatic slag, Mona guano and South Carolina rock phosphate have been applied have been substantially the same as on the dissolved bone-black plot, with the exception of the turnips and the cabbages, where the yields of these plots have been considerably greater than on the dissolved bone-black. All the crops grown upon the field, with the exception of the turnips and the cabbages, have given fairly good yields. The oat crop of last year was at the rate of about 40 bushels per acre; but even the no-phosphate plot gave practically the same yield as any of the others, so that the results with that crop really afford no light upon the particular question touched by this experiment. Taking into account all the crops which have been grown upon this field, except the Swedish turnips, which were affected by disease not apparently due to the fertilizer which had been used on a portion of the plots, and the yields of which, therefore, as expressed in figures, would be misleading, and representing the aggregate yield which stands highest by 100, the efficiency of the different phosphates is as follows: —

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

There was at first no no-phosphate plot used in this experiment, but we have had a no-phosphate plot since 1895. Taking into account the yields of the several plots since 1895, and excepting the Swedish turnips, which were grown in 1897, for reasons above stated, the phosphates have the following relative rank: —

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

The crops which have been raised on the field in the order of their succession are as follows: potatoes, wheat, serradella, corn, barley, rye, soy beans, Swedish turnips, corn, oats and cabbages. All the plots in the field received an application of lime at the rate of one ton to the acre of quick-lime, slaked, spread after ploughing and deeply worked in with a harrow in the spring of 1898.

This statement of the conditions of the experiment and of the relative yields on the different plots should perhaps be further supplemented by the statement that, supposing the crops harvested to have been of average composition and that there has been no waste, there would remain of the total phosphoric acid applied to the several plots the following amounts in each: —

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

The following conclusions appear to be justified by the results which we have obtained: —

1. It is possible to produce profitable crops of most kinds by liberal use of natural phosphates, and in a long series of years there might be a considerable money saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates.

2. None of these natural phosphates appear to be suited to crops belonging to the turnip or cabbage family; but whether it is because these crops require the presence of an unusually large amount of soluble phosphoric acid, or whether it is because of some other effect of the dissolved phosphates, our experiments do not enable us to say. While we have obtained much the largest crops of turnips and cab-

bages on the natural phosphates, the yields have not been what could be considered good.

3. Between ground South Carolina rock, Mona guano and the phosphatic slag there is no considerable difference in the economic result.

4. The Florida phosphate, though used in amounts furnishing much more phosphoric acid than is furnished by either of the others, stands far behind them in yield, and would appear, therefore, to be rendered available only with extreme slowness.

In conclusion, it may be doubted whether, under the conditions prevailing in ordinary farm or garden practice, it would be wise to depend exclusively upon the natural phosphates. The best practice will probably be found to consist in using one of these in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

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

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

During the past year two crops have been grown upon this field: oats, which were cut and made into hay; and Hungarian grass, also made into hay. The yields have been large on all plots, varying from a little less than 4 tons per acre for the two crops on the poorest no-phosphate plot to rather over 5 tons per acre for the two crops on the dissolved bone-black which gave the largest yield. The only points to which it seems desirable to call attention are the following: —

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

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

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

Soil Tests.

During the past season two soil tests have been carried out upon our own grounds, both in continuation of previous work upon the same grounds. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. The fertilizers in these experiments are used in accordance with the co-operative plan for soil tests adopted in Washington in 1899. Each fertilizer wherever employed is always applied at the following rates per acre: —

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

Soil Test with Grass (South Acre).

The past is the twelfth season that the experiment on this field has been in progress. The field has been cropped in successive years as follows: corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, corn, and this year grass and clover seeded in early spring. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer. Three plots have yearly received a single important manurial element, nitrogen, phosphoric acid or potash, every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received, yearly, lime, plaster or manure. The larger part of the field accordingly has remained either entirely unmanured or has had but a partial manuring, and the degree of exhaustion of most of the plots is considerable. The four nothing plots this year produced an average at the rate of 930 pounds of hay per acre. The following table shows the rate of yield of the several plots: —

Effect of the Fertilizers.

Hay (South Acre Soil Test, 1900).

FERTILIZERS USED.	Yield per Acre (Pounds).	Gain or Loss per Acre, compared with Nothing Plots (Pounds).
Plot 1, nitrate of soda,	2,460	1,660.00
Plot 2, dissolved bone-black,	1,000	200.00
Plot 3, nothing,	800	-
Plot 4, muriate of potash,	1,140	366.67
Plot 5, lime,	880	133.33
Plot 6, nothing,	720	-
Plot 7, manure,	4,160	3,440.00
Plot 8, nitrate of soda and dissolved bone-black,	2,540	1,440.00
Plot 9, nothing,	1,100	-
Plot 10, nitrate of soda and muriate of potash,	3,000	1,900.00
Plot 11, dissolved bone-black and muriate of potash,	1,600	500.00
Plot 12, nothing,	1,100	-
Plot 13, plaster,	900	—200.00
Plot 14, nitrate of soda, dissolved bone-black and muriate of potash.	2,300	1,200.00

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

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Hay (pounds per acre),	1,660	1,240	1,533.33	700	1,283.33

Value of net average increment, ... $10 27
Financial result (gain), ... 7 07

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Potash.	Average Result.
Hay (pounds per acre),	200	—220	133.33	—700	—146.67

Value of net average decrease, ... $1 17
Financial result (loss), ... 4 37

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Hay (pounds per acre),	366.67	240	300	—240	166.67

Value of net average increment, ... $1 33
Financial result (loss), ... 1 87

	Results of the Addition to Nothing of —			
	Complete Fertilizer.	Manure.	Plaster.	Lime.
Hay (pounds per acre),	1,200	3,440	−200	133.33
Value of increment,	$9 60	$27 52	–	$1 07
Value of decrease,	–	–	$1 60	–
Financial result,	No gain or loss.	2 52 gain.	3 40 loss.	0.13 loss.

These results require little comment. A study of the figures shows that it is the nitrate of soda chiefly which causes an increase in the crop. Alone and in every combination it gives a large increase. It should be remembered, in estimating the significance of these figures, that the field was seeded last spring, and that accordingly the crop was comparatively small. The effect of the fertilizers will undoubtedly become more pronounced another season, when both grass and clover are fully established. *It is especially noteworthy that nitrate of soda alone applied to a plot which has now received no other fertilizer for twelve years gives a crop of hay amounting to almost* 1¼ *tons. This plot last year gave a crop of corn at the rate of something less than* 14 *bushels per acre. The plot to which muriate of potash alone has been applied during the past twelve years gave us last year a yield of corn at the rate of nearly* 50 *bushels per acre. The hay crop this year is* 1,140 *pounds.* These comparisons, bringing out the differing effects of the same fertilizer on the same field for different crops, and still other comparisons which might be made, illustrate in a striking manner the fact that the selection of fertilizers for our average soils should be made chiefly with reference to the crop.

All plots in this field were evenly seeded with a mixture of grass and clover seeds, sown crosswise, to insure even seeding of all plots. Both grass and clover seeds came up well, and the clover was thick at the start on all plots. At the present time there is practically no clover on any of the plots except the four to which potash has been applied and the one to which manure has been yearly applied.

Soil Test with Onions (North Acre).

This experiment is upon the land occupied last year in a similar soil test with onions. The field has been employed in soil test work for eleven years, the several plots having been every year manured alike, as described under soil test with grass. The previous crops in the order of rotation have been potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions, and onions. It will be remembered that the west half of each plot was limed in the spring of 1899 at the rate of 1 ton per acre of quicklime, slaked, and immediately spread and harrowed in. The fertilizers were employed this year in the same quantities as last, viz. : —

	Pounds.
Nitrate of soda (per acre),	320
Dissolved bone-black (per acre),	640
Muriate of potash (per acre),	320

The seed was sown at the rate of 5 pounds per acre. The variety was Danvers' Yellow Globe. Germination was prompt and perfect, but many of the plants upon the nothing plots and upon the unlimed portion of the plots receiving respectively muriate of potash, nitrate of soda, nitrate of soda and muriate of potash, and dissolved bone-black and muriate of potash, soon died; while such plants as survived upon these plots made but very little growth. The following tables give the results of the harvest : —

Effect of the Fertilizers.

Onions (North Acre Soil Test, 1900).

Plot.	FERTILIZERS USED.	Yield per Acre of Scallions and Tops (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing,	460	1,600	-	-
2	Nitrate of soda,	3,100	1,780	1,640	20
3	Dissolved bone-black,	1,160	880	—1,300	—1,040
4	Nothing,	3,460	2,080	-	-
5	Muriate of potash,	3,200	3,400	—455	1,050
6	Nitrate of soda and dissolved bone-black.	1,720	760	—2,130	—1,860
7	Nitrate of soda and muriate of potash.	1,100	4,520	—2,945	1,630
8	Nothing,	4,240	3,160	-	-
9	Dissolved bone-black and muriate of potash.	5,320	1,720	1,500	—1,980
10	Nitrate of soda, dissolved bone-black and muriate of potash.	5,600	1,520	2,200	—2,220
11	Plaster,	1,760	1,960	—1,220	—2,070
12	Nothing,	2,560	4,320	-	-

Onions (North Acre Soil Test, 1900).

Plot.	Fertilizers Used.	Yield per Acre of Well-cured Onions (Bushels). Unlimed.	Limed.	Gain or Loss per Acre, compared with Nothing Plots (Bushels). Unlimed.	Limed.
1	Nothing,	6.15	41.54	-	-
2	Nitrate of soda,	50.00	155.00	21.67	83.21
3	Dissolved bone-black,	17.31	37.69	—33.20	—64.36
4	Nothing,	72.69	132.31	-	-
5	Muriate of potash,	37.69	383.46	—26.45	257.31
6	Nitrate of soda and dissolved bone-black.	225.77	202.31	170.20	82.31
7	Nitrate of soda and muriate of potash.	9.23	310.77	—37.80	196.93
8	Nothing,	38.46	107.69	-	-
9	Dissolved bone-black and muriate of potash.	159.62	380.00	124.91	273.66
10	Nitrate of soda, dissolved bone-black and muriate of potash.	136.92	488.46	105.96	383.46
11	Plaster,	4.62	23.08	—22.59	—80.57
12	Nothing,	23.46	102.31	-	-

	Results of the Addition of Nitrogen to— Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Scallions, unlimed (pounds),	1,640	—830	—2,490	700	—245
Scallions, limed (pounds),	20	—820	580	—240	—115
Onions, unlimed (bushels),	21.67	203.40	—11.35	—18.95	48.69
Onions, limed (bushels),	83.21	146.67	—60.38	109.80	69.83

Value of net average increment: unlimed, $12.66; limed, $18.16.
Financial result: unlimed, $6.26 gain; limed, $11.76 gain.

	Results of the Addition of Phosphoric Acid to— Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Muriate of Potash.	Average Result.
Scallions, unlimed (pounds),	—1,300	—3,770	1,955	5,145	507.50
Scallions, limed (pounds)	—1,040	—1,880	—3,030	—3,850	—2,450.00
Onions, unlimed (bushels),	—33.20	148.53	151.36	143.76	102.61
Onions, limed (bushels),	—64.36	—.90	16.35	186.53	34.41

Value of net average increment: unlimed, $26.68; limed, $8.95.
Financial result: unlimed, $20.28 gain; limed, $2.55 gain.

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Scallions, unlimed (pounds), .	—455	—4,585	2,800	4,330	522.50
Scallions, limed (pounds), . .	1,050	1,610	—940	—360	340.00
Onions, unlimed (bushels), .	—26.45	—59.47	158.11	—61.24	1.99
Onions, limed (bushels), . .	257.31	113.72	338.02	301.15	252.55

Value of net average increment: unlimed, $0.52; limed, $65.66.
Financial result: unlimed, $5.88 loss; limed, $59.26 gain.

	Results of the Addition to Nothing of —			
	complete fertilizer.		land plaster.	
	Unlimed.	Limed.	Unlimed.	Limed.
Onions (bushels per acre), . . .	105.96	383.46	—22.59	—80.57
Value of net increment, ...	$27 55	$99 70	-	-
Value of decrease, ...	-	-	$5 87	$20 95
Financial result, ...	8 35 gain.	80 10 gain.	9 47 loss.	24 55 loss.

The yield upon the limed portion of many of the plots this year is, as was anticipated, much better than last year, although the tops on all parts of the field were somewhat prematurely killed by blight. The heavy application of lime made in that year appears to have corrected in large measure the faulty soil conditions. *We have this year a crop at the rate of nearly 500 bushels to the acre of well-cured onions upon the limed half of the plot, which has been yearly manured with nitrate of soda, dissolved bone-black and muriate of potash; while on the unlimed portion of the same plot we have a yield of 136.9 bushels to the acre. The lime has evidently proved highly beneficial.*

Particular attention is called to the fact that we nowhere obtained a fairly good crop except upon those plots to which potash has been yearly supplied. The limed portion of the plot, which has yearly been manured with muriate of potash alone, gives a yield at the rate of 383 bushels to the acre; the nitrate of soda and the potash give a yield at the rate of about 311 bushels; the dissolved bone-black and potash, a yield at the rate of 380 bushels. These figures make it perfectly evident that potash is an exceedingly important manure *for the onion crop. Its effects far exceed those of either of the other elements.*

Our results make it equally evident that the continuous use of muriate of potash makes the employment of lime an absolute necessity. The combined cost of the muriate of potash and the lime necessarily used with it is likely to be greater than would be the cost of some other source of potash.

That the nitrate of soda as well as the muriate of potash has proven in some degree injurious when used without lime is made equally evident by our results, for the yield on the combined nitrate of soda and muriate of potash without lime is much inferior to the yield on the muriate alone without lime. It is, indeed, almost the poorest in the field.

Especial attention is called to the fact, which was very evident on all the plots where it was used, that dissolved bone-black greatly promoted the perfect ripening of the crop. By far the best ripened crop on the unlimed portion of the field was the crop produced by nitrate of soda and dissolved bone-black. Any other dissolved phosphate would undoubtedly have a similar effect.

Attention is called, further, to the fact that the dissolved bone-black in large measure corrects the injurious effects following the use of muriate of potash. This is made especially evident by the comparison between the yields where dissolved bone-black was used together with nitrate of soda and muriate of potash and where the last two fertilizers were used alone. Where they were used alone, the crop, as has already been pointed out, was almost the poorest in the field, a large share of the plants dying at a very early stage in their growth; while where the dissolved bone-black was used together with these fertilizers a moderate crop was the result. It becomes evident, therefore, that where fertilizers containing a liberal amount of some dissolved phosphate are employed, liming is less necessary than where such phosphates are not employed. That this should be so is not strange, since all dissolved phosphates contain a large amount of sulfate of lime (land plaster), which, if used in large quantities, produces many of the effects ordinarily following the use of lime.

Practical Advice on Fertilizers for Onions.

Although further investigations are called for concerning the many questions connected with using fertilizers for onions, it is believed that the results thus far obtained justify the following advice: —

1. Mixed fertilizers which are to be used for the culture of onions where nothing else is employed should contain about 3 to 4 per cent. nitrogen, 5 to 6 per cent. available phosphoric acid and 8 to 10 per cent. potash. It is believed that the nitrogen of such fertilizers should be derived in about equal proportions from nitrate of soda, dried blood and dry ground fish or tankage. It is further believed that the source of potash should be either the sulfate or carbonate. Such a fertilizer might be required in amounts varying from 1 to 1½ tons.

2. If a home mixture of materials is to be made, it is believed that it should supply 60 pounds of nitrogen, from 90 to 100 pounds of phosphoric acid and 160 to 200 pounds of potash per acre. It is believed, further, that the nitrogen, as stated above, should be derived in part from nitrate of soda and in part from animal materials. It is believed that the phosphoric acid should be derived mainly from acid phosphate or dissolved bone-black, and that for potash either the high or low grade sulphate or the carbonate of potash-magnesia should be employed. As an illustration of a mixture which it is believed will suit average conditions, the following list of materials is given: —

	Pounds.
Nitrate of soda,	200
Dried blood,	250
Dry ground fish or tankage,	200
Acid phosphate,	700
For potash, either of the following: —	
High-grade sulfate,	350
Low-grade sulfate,	700
Carbonate of potash-magnesia,	950

These materials should be mixed just before use, spread after ploughing and harrowed in.

3. It is suggested, the suggestion being based upon our observations, that in case the onions do not ripen well, and where the proportion of scallions is large, the application of lime be tried, or the proportion of acid phosphate increased. If lime is to be used, it is recommended that about 1 ton of quicklime per acre be applied. This should be slaked with water, spread after ploughing, and deeply worked in with wheel harrow. The best season is autumn or very early spring.

"Special" Corn Fertilizer *v.* Fertilizer richer in Potash.

The experiments upon which it is now proposed to comment have for their object the effort to determine the most profitable combination of fertilizers to be used for the growth of corn. The plan of the experiment and the results up to the close of last season are given in full in our last annual report.

Results in recent years had led to the conclusion that this field might be benefited by liming. It accordingly received an application at the rate of 1 ton of air-slaked lime, applied May 14 and thoroughly worked in. The kinds and amounts of fertilizers used during the past season have been somewhat changed. To two of the plots (1 and 3) in the field we have applied materials supplying the same quantity of nitrogen, phosphoric acid and potash as would be furnished by the use of 1,800 pounds of fertilizer, having the average composition of the "special" corn fertilizers analyzed at this experiment station in 1899. This average is as follows: —

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

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

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

The other plots in the field received an application of materials practically the same in kind and quantity as have been recommended in Bulletin No. 58 for corn on soils poor in organic matter. The principal difference between the manuring of these plots and the others is that they receive slightly more nitrogen, much less phosphoric acid and considerably more potash. The materials supplied to the several plots are shown in the following table: —

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

The variety of corn grown this year was Sibley's Pride of the North. The growth was vigorous and healthy, and unaffected, so far as could be seen, by any abnormal conditions. The yields were as follows: —

Yield of Corn, 1900.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,510	1,460
Plot 2 (richer in potash),	1,435	1,540
Plot 3 (lesser potash),	1,590	1,675
Plot 4 (richer in potash),	1,515	1,600

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	77.50	6,270
Plots 2 and 4,	73.75	6,280

It will be noticed that the yield of grain on the "special" fertilizer exceeds that on the fertilizer richer in potash, the difference being at the rate of 3.8 bushels per acre; the fertilizer richer in potash gave slightly more stover. The difference in cost of the fertilizers applied on the two sets of plots is at the rate of a little more than $4 per acre. This is the apparent cost of the 3.8 bushels of corn. I say apparent, for the following reason: the field was seeded to mixed grass and clover the latter part of July, and at the present time the condition of plots 2 and 4, which received the fertilizer richer in potash, indicates a much heavier growth of clover next season than on the other plots.

It is believed that when this field is once more broken up and put into corn the yields of plots 2 and 4 will stand relatively better.

In conclusion, attention is called to the fact that the results on this field furnish important light upon the problem as to whether corn can be successfully grown on fertilizers alone. The present is the tenth year since this field has been under experiment, and throughout this time fertilizers only, and in very moderate quantities, have been employed. The result this year on the plots richer in potash is a crop at the rate of about 74 bushels of sound corn and of 3 tons of stover per acre, and a magnificent catch of grass and clover. The cost of the fertilizers employed this year on these plots is at the rate of $13.50 per acre, not including the lime. One ton of the latter was put on this year, but such application will not be required oftener than once in six or seven years.

Manure alone *v.* Manure and Potash.

This experiment, which was intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure used in connection with some form of potash, was begun in 1890. Full accounts of the results in the different years will be found in preceding annual reports, and summaries are found in the reports for 1895 and 1900. The field contains one acre and is divided into four plots of one-fourth acre each. Corn was the crop in 1899. The field was ploughed last fall and seeded to rye for winter protection. After ploughing this spring the field received a dressing of air-slaked lime at the rate of 1 ton to the acre; this was thoroughly worked in with a wheel harrow; the field was then manured as shown below: —

Plot 1, manure, 1½ cord; weight, 6,805 pounds.
Plot 2, manure, 1 cord; weight, 4,610 pounds; high-grade sulfate of potash, 40 pounds.
Plot 3, manure, 1½ cord; weight, 6,717 pounds.
Plot 4, manure, 1 cord; weight, 4,067 pounds; high-grade sulfate of potash, 40 pounds.

Samples of the manure used were analyzed, and the sulfate of potash was analyzed. The calculated amounts of plant food applied to the several plots are as follows: —

PLOTS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1,	22.64	19.65	38.43
Plot 2,	14.21	13.70	40.67
Plot 3,	20.15	20.15	27.54
Plot 4,	12.20	12.20	36.67

The variety of corn grown this year was Sibley's Pride of the North. The growth was good and the crop large on all plots. The yield on the several plots is at the rate per acre shown in the following table: —

Yield of Corn (Rate per Acre).

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plot 1,	72.5	6,740
Plot 2,	72.0	7,020
Plot 3,	74.5	6,540
Plot 4,	72.8	6,580

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3, manure alone,	73.5	6,640
Plots 2 and 4, manure and potash,	72.4	6,800

The crops, as in previous years, are of substantially equal value, the manure alone giving 1.1 bushels more grain than manure and potash, while the latter gave 160 pounds more stover. The combination, 4 cords of manure and 160 pounds sulfate of potash per acre, will cost about $6.40 less than 6 cords of manure alone. We have now grown eight corn crops on this field, and the average yields are at the rate per acre for the two manurings: —

Average of Eight Crops.

	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone,	63.0	4,822
Less manure and potash,	58.7	4,497

The money cost of the materials applied to the plots receiving manure and potash for the ten years during which the experiment has continued is at the rate of about $81 less than on the other plots. The manure alone, however, has produced yields exceeding the combination of a smaller amount of manure and potash, at rates per acre amounting to shelled corn 34.4 bushels and stover 2,600 pounds. During two years since the experiment began the field has been in grass, and the yields on manure alone exceed those on manure and potash at rates per acre amounting to hay 2,244 pounds and rowen 1,170 pounds. Such an amount of corn and hay at average prevailing market prices would have been worth about $44.18. In using the large amount of manure alone, then, one would, in effect, allowing the manure to cost $5 to the cord on the land, have expended about $81 for products worth but little more than one-half that sum.

This field has now been seeded to mixed grass and clover seeds. The stand on all plots is good, but the clover is proportionally more abundant on the plots receiving the manure and potash.

It is believed that these experiments conclusively indicate that corn may be more cheaply grown on a combination of manure and potash than on manure alone.

The Relative Value for Green Manuring of the Soy Bean and Cow Peas.

So much has been said concerning the value of cow peas for green manuring purposes that it has seemed desirable to compare this crop with the soy bean for that purpose. Accordingly, two varieties of cow peas, the Wonderful and the Black, the former a late and the latter an early variety, have been grown under conditions allowing comparison with the medium green soy bean. The growth of all the crops was good and each occupied about one-fifth of an acre. The Wonderful cow pea when cut had only just begun to blossom, the Black had but a small proportion of its pods ripe, while all the pods on the soy bean were practically mature. The following table shows the results: —

Cow Peas and Soy Beans for Green Manuring.

Variety.	Pounds per Acre.		
	Green Weight.	Dry Matter.	Nitrogen.
Wonderful cow pea,	19,600	3,622	80.4
Black cow pea,	20,035	3,389	62.1
Medium green soy bean,	19,685	5,386	167.3

It will be noticed that the soy bean furnished much larger quantities both of dry matter and of nitrogen than either of the varieties of cow peas. It gave practically three-fifths more dry matter and more than double the nitrogen furnished by the better of the two varieties of cow peas. The roots of the bean were thickly studded with nodules, as also were the roots of the cow peas; and both must, therefore, have possessed the ability to draw upon the atmosphere for a considerable part of their nitrogen. It appears impossible to doubt that the manurial value of the soy beans must have been far greater than that of either of the varieties of cow peas.

In estimating the significance of these results, it should be kept in mind that the soil was a medium loam, retentive of moisture, and that the season had a fairly well-distributed rainfall. It is not impossible that on lighter and less retentive soils, or with deficient rainfall, the cow pea may compare more favorably with the soy bean as a green manuring crop, for the latter is somewhat impatient of drought and of soils deficient in moisture.

It may be of interest to state in this connection that a portion of the area in soy beans was allowed to ripen, and that the yield was about 36 bushels per acre of thoroughly ripened seed.

Nitrate of Soda for Rowen.

Many experiments both here and elsewhere have convincingly shown the great value of nitrate of soda for application to mowings in early spring. Not many experiments appear to have been tried to determine the effect of such applications for the second crop. Accordingly plots were laid out in July in two of our mowing fields, for the purpose of carrying out an experiment to test this question. There were two sets of these plots. One set included four plots, laid out in a permanent mowing which was seeded twelve years ago, the principal species at the present time being Kentucky blue grass. The first crop was cut June 25. The nitrate of soda was applied July 1 to two plots at the rate of 150 pounds per acre. The first crop of hay on this land was at the rate of 2.16 tons per acre. The rowen was cut on these plots on September 7. The results are shown in the following table: —

Nitrate of Soda for Rowen.

Plots.	Pounds per Acre.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	2,082
Plot 2,	150	3,117
Plot 3,	Nothing.	2,438
Plot 4,	150	3,035

The average of plots 1 and 3 is at the rate of 2,260 pounds of rowen per acre; of plots 2 and 4 it is 3,076 pounds per acre. The application, then, of 150 pounds of nitrate of soda, costing $3, gave an apparent increase of 816 pounds of rowen, at a cost for the fertilizer of .37 cents per pound.

The second set of plots occupied a portion of a field seeded to timothy in 1898. There were eight plots in this series. The first crop of timothy had been cut July 10, and the yield was at the rate of 2.6 tons per acre. The nitrate of soda was applied July 16. The following table shows the nature of the experiment and the results: —

Nitrate of Soda for Rowen.

PLOTS.	POUNDS PER ACRE.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	587
Plot 2,	150	1,394
Plot 3,	Nothing.	514
Plot 4,	150	679
Plot 5,	Nothing.	202
Plot 6,	200	1,137
Plot 7,	Nothing.	440
Plot 8,	250	1,816

The average yield of all the nothing plots was at the rate of 436 pounds per acre. The average of plots 2 and 4 was 1,036 pounds per acre, a gain of 600 pounds of rowen following the application of 150 pounds of nitrate, costing $3, the cost of the gain per pound being .5 cents. The application at the rate of 200 pounds produced an apparent gain of 701 pounds, at a cost of .57 cents per pound; the application at the rate of 250 pounds produced an apparent gain of 1,380 pounds, at a cost of .36 cents per pound; but we have some evidence indicating that this plot is naturally better than the average of the nothings.

In commenting upon these results, it should be stated at the outset that the season was not favorable for the production of a maximum effect from the application of the nitrate, as the rainfall was deficient, amounting, for the entire period during which the rowen upon the old mowing was growing, to 7.26 inches;* during the period that the timothy was growing, to 6.66 inches.† The application of the nitrate produced an effect both upon color and growth almost imme-

* The average for this period for the ten years 1889-98 is 8.59 inches.

† The average for this period for the ten years 1889-98 is 8.39 inches.

diately following the first rain which fell after it had been made. It is believed that the gain in crop would have been much greater had the rainfall been larger.

Further experiment is needed to determine what amount of nitrate, if any, it will pay to use; but the opinion is here advanced that probably the most profitable application will be found not to exceed about 150 pounds per acre.

Experiment in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued, with two slight modifications. We have three large plots (between two and one-half and four acres each) under this treatment. According to the system followed, each plot receives wood ashes at the rate of 1 ton per acre one year, the next year ground bone 600 pounds and muriate of potash 200 pounds per acre, and the third year manure at the rate of 8 tons. The changes in manuring introduced this year consist, first, in the use of a small quantity of nitrate of soda in connection with the ashes on one plot and with the ground bone and muriate of potash on another. The experiment is further modified to a slight extent by the fact that a little more than one acre on plot 1, which contains about four acres, was used for experiment in the application of nitrate of soda for rowen, elsewhere described in this report, the nitrate being used at the rate of 150 pounds per acre. Our system of manuring is so planned that each year we have one plot under each of the three manurings. The manure is always applied in the fall, the other materials early in the spring. The ashes were put on this year April 5, the bone and potash April 16. The nitrate of soda was used with the ashes at the rate of 64 pounds to the acre, and was put on April 17. Nitrate of soda was used on plot 3, with bone and potash in the quantities above named, at the rate of 83 pounds per acre. It was applied April 19.

Plot 1, which this year received wood ashes and nitrate of soda, gave a yield at the rate of 2.164 tons of hay and 1.326 tons of rowen per acre. Plot 2, which was top-dressed in the fall of 1899 with manure, yielded hay 1.525 tons and rowen 1.150 tons per acre. Plot 3, which was manured with a combination of bone and potash in amounts named, and nitrate, gave yields of hay 2.228 tons and rowen (two crops on a part of the plot) 1.219 tons per acre. The average yield of the entire area for this year is 6,510 pounds, hay and rowen both included. The field has now been twelve years in grass, and during the continuance of the present system of manuring, since 1893, has produced an average product, hay and rowen both included, of 6,615 pounds per acre. The plots, when dressed with manure, have averaged 6,817 pounds per acre; when receiving bone and potash, 6,626 pounds; and when receiving ashes, 6,371 pounds. It will be noticed that, while the general average for this year, including all the plots, falls below the general average for the entire period, the average for this year of the two plots receiving bone and potash and ashes is above the general average for the entire period. It will be remembered, however, that these plots have this year, in addition to the usual amounts of bone and potash and ashes respectively, received a light dressing of nitrate of soda. It is possibly this difference in treatment which has produced the results just pointed out.

Poultry Experiments.

The experiments of the past season have, as in previous years, been devoted to the study of methods of feeding, as affecting egg-production. The only experiment the results of which it is proposed to report at the present time is one having for its object the determination of the relative merits of the system of giving a mash in the morning, as compared with the system of giving it late in the afternoon.

General Conditions.

Barred Plymouth Rock pullets, raised on the scattered colony plan, divided into two lots as equally matched in weight and development as possible at the beginning of the experiment, were employed. Twenty such pullets with two cockerels were put into each house. Our houses are detached, and include a closed room for nests and roosts, 10 by 12 feet, with two windows about 3 by 6 feet on the south, scratching shed, 8 by 12 feet, which is left either entirely open in fine weather or closed by folding doors with large glass windows in stormy weather, while the fowls are allowed the run of large yards whenever the weather permits.

Two tests were made: a so-called winter test, December 7 to May 20; and a summer test, May 29 to September 16. The feeds used in the two coops were of the same kinds, the intention being to give each lot of fowls as much food as would be readily consumed. The mash used in these experiments was commonly mixed with boiling water about twelve hours before use, but in some instances was given hot immediately after mixing. The morning mash was always given as soon after light as possible, the evening mash just before dark. The whole grain given to both lots of fowls was scattered in the straw in the scratching shed, for the fowls in one coop early in the morning, for those in the other coop about an hour before dark. Both lots of fowls were given a little millet seed scattered in the straw at noon, the object in view being to keep them industriously searching for food in the straw a considerable share of the time. About twice a week a small cabbage was given to each lot of fowls. The eggs were weighed weekly; all the fowls were weighed at intervals of about one month. Sitters were confined in a coop until broken up, being meanwhile fed like their mates. The prices per hundred weight for feeds upon which financial calculations are based are shown below: —

	Per Cwt.
Wheat,	$1 65
Corn and corn meal,	90
Millet,	1 00
Bran and middlings,	90
Gluten feed,	1 00
Gluten meal,	1 25
Animal scraps,	2 25
Clover,	1 50
Cabbage,	25
Oats,	1 12.5

The health of the fowls under both systems of feeding has been in general good, although, as is usually the case, there have been a few losses. Two fowls on the morning mash died in April, and post-mortem examination showed a catarrhal condition of the throat and intestines. Three fowls in the evening mash coop died; post-mortem examination of one showing enlarged liver and spleen and ulcerated alimentary canal, and in another case enlarged liver and intestinal parasites.

Winter Experiment.

All details necessary to a full understanding of the experiment will, it is believed, be found in the following tables: —

Foods consumed, Morning v. Evening Mash, December 7 to May 20.

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Corn,	261.00	239.50
Wheat,	130.50	120.00
Millet,	39.50	37.75
Bran,	46.00	45.00
Meat scraps,	45.00	43.00
Clover,	22.00	21.50
Corn meal,	112.00	107.00
Cabbage,	62.50	77.75

Average Weights of Fowls (Pounds).

DATES.	MORNING MASH.		EVENING MASH.	
	Hens.	Cocks.	Hens.	Cocks.
December 7,	4.61	7.75	4.33	7.13
February 6,	5.38	7.38	4.78	6.88
March 17,	5.69	7.38	5.28	8.88
May 21,	5.24	7.88	5.13	6.88

Number of Eggs per Month, Morning v. Evening Mash, Winter Test.

DATES.	Morning Mash.	Evening Mash.
December,	1	1
January,	19	27
February,	76	52
March,	283	229
April,	271	292
May,	143	157
Totals,	793	758

Morning v. Evening Mash for Egg-production, Winter Test.

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	593.28	556.11
Number of hen days, not including males,	3,228	3,158
Number of hen days, including males,	3,558	3,488
Gross cost of food,	$7 78	$7 36
Gross cost of food per egg (cents),	.97	.97
Gross cost of food per hen day (cents),	.22	.21
Number of eggs per hen day,	.25	.24+
Average weight per egg (ounces),	1.84	1.85
Total weight of eggs (pounds),	91.19	87.64
Dry matter consumed per egg (pounds),	.75	.73+
Nutritive ratio,*	1:6.3+	1:6.1+

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment was the same as in the winter, save in two particulars: first, in place of cut clover rowen in the mash, lawn clippings in such quantities as the fowls would eat before wilting were fed three times a week, to the hens in all the houses the same; and, second, the feeding of cabbages was discontinued. The yards, 1,200 square feet in area for each house, were kept fresh by frequent turning over of the soil. The tables give all details: —

Foods consumed, Morning Mash v. Evening Mash, May 29 to September 16.

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Bran,	41.80	40.70
Middlings,	41.80	40.70
Meat scraps,	32.00	32.00
Oats,	47.80	49.20
Corn meal,	41.80	40.70
Corn,	171.70	174.80

Average Weight of Fowls (Pounds).

DATES.	Morning Mash.		Evening Mash.	
	Hens.	Cocks.	Hens.	Cocks.
May 29,	5.69	8.00	4.94	6.75
July 30,	5.53	7.75	5.00	6.75
August 16,	5.11	8.00	4.74	7.00

Number of Eggs per Month, Morning v. Evening Mash, Summer Test.

DATES.	Morning Mash.	Evening Mash.
May,	28	24
June,	174	186
July,	163	181
August,	164	128
September,	54	51
Totals,	583	570

Morning v. Evening Mash for Egg-production, Summer Test.

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	337.02	338.11
Number of hen days, not including males,	1,719	1,722
Number of hen days, including males,	1,941	1,944
Gross cost of food,	$3 94	$3 95
Gross cost of food per egg (cents),	.68—	.69+
Gross cost of food per hen day (cents),	.20+	.20+
Number of eggs per hen day,	.34—	.33+
Average weight per egg (ounces),	1.83	1.90
Total weight of eggs (pounds),	66.68	67.69
Dry matter consumed per egg (pounds),	.51—	.59+
Nutritive ratio,*	1:5.5+	1:5.6

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that neither in the winter nor summer experiment was there any very considerable difference in the number of eggs produced. It is, however, possibly significant, and this fact is made evident by the tables showing monthly egg yields, that during the period of shortest days the fowls receiving the evening mash laid less eggs than the others.

The most striking result of the experiments is the great difference in the relative amounts of droppings voided during the night by the fowls under the two systems of feeding. It was noticed from the beginning, and the same remained true throughout the entire period, that the amount of droppings voided during the night by the fowls receiving the evening mash was very much greater than the amount voided by the other lot of fowls. Weights were taken on a number of different occasions, with the results shown below: —

Morning v. *Evening Mash.*

DATES.	Number of Days Droppings.	Morning Mash.		Evening Mash.	
		Number of Hen Nights.	Weight of Droppings (Pounds).	Number of Hen Nights.	Weight of Droppings (Pounds).
March 3, ...	1	22	3.00	21	6.00
March 5, ...	2	44	5.25	42	11.00
March 7, ...	2	44	5.25	42	10.50
March 10, ...	1	22	2.50	21	6.25
March 21, ...	1	22	2.50	19	4.50

It will be noticed that the weight of the droppings voided during the night by the fowls receiving the evening mash during the period of nearly even days and nights during which these weights were taken is practically double the weight of the droppings of the other lot of fowls. The fact thus brought out is doubtless of much significance. It furnishes conclusive evidence that the digestive process in the case of a soft food like a mash is very rapid. The fact that digestion among birds is relatively much more rapid than with most classes of animals has been already many times pointed out. Forbush, in his paper in the report of the secretary of the State Board of Agriculture for 1899, gives valuable data bearing upon this subject concerning a number of the smaller birds and crows. Our experiments indicate that the ordinary domestic fowl, as might have been supposed would be the case, is also able to digest soft foods with a degree of rapidity which seems astonishing. There has long been a general impression, and the usual practice in feeding fowls is evidence of this, that it is better to give the more solid food at night, especially during the winter, since it will "stay by" the fowls better. Our experiments indicate that this impression is well founded, and that the usual practice is correct, although they cannot be considered to prove it, because, of course, it may be that a period of comparative rest for the digestive organs during the night is better than the condition of more continuous work for these organs which would follow the use of solid food at night.

We have not obtained a sufficient difference in egg-production to be considered significant, but it is believed that the experiment, so far as it goes, indicates that it is better that the mash should be fed in the morning. It is conceivable, however, that, if the mash be given in too large quantities, the fowls will gorge themselves, will then as a consequence become inactive, and remain comparatively inactive during a considerable part of the morning; whereas, if they be given whole grain, for which they are required to scratch, they are of necessity more active. The relative weights of the fowls, particularly during the winter, afford some indication that we to some extent experienced this difficulty; for it will be noticed that the fowls receiving the morning mash, especially during the period of shortest days, weighed considerably more than the fowls receiving the evening mash.

It must, however, be further pointed out that the average difference in weight during the summer months was also considerable, amounting to about one-half pound at the time of each of the weighings. During the earlier part of this period, however, the fowls receiving the evening mash were producing the greater number of eggs, which difference may perhaps account for their decreased relative weight.

It is concluded that, so far as the results of this experiment enable one to judge, the morning mash is preferable to the evening; but it is evident that additional investigation is required in order to throw further light upon the subject.

INDEX.

PUBLIC DOCUMENT . . . . No. 33

FOURTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1902.

BOSTON:
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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ANNUAL REPORT

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

For the Year ending June 30, 1901.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$8,157 57	
for labor,	2,941 04	
for publications,	1,436 30	
for postage and stationery,	269 33	
for freight and express,	99 82	
for heat, light, water and power,	259 63	
for seeds, plants and sundry supplies,	621 30	
for fertilizers,	182 21	
for feed stuffs,	135 08	
for library,	221 31	
for tools, implements and machinery,	52 58	
for furniture and fixtures,	75 59	
for scientific apparatus,	5 49	
for live stock,	20 25	
for travelling expenses,	84 39	
for contingent expenses,	147 52	
for building and repairs,	290 59	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,490 25	
from farm products,	2,091 08	
from miscellaneous sources,	2,050 50	
		$18,831 83
Cash paid for salaries,	$11,099 76	
for labor,	1,620 38	
for publications,	681 28	
for postage and stationery,	318 65	
for freight and express,	102 49	
for heat, light, water and power,	434 12	
Amount carried forward,	$14,256 68	

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

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

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 1, 1901.

REPORT OF THE AGRICULTURISTS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Yield of Soy Beans per Acre.

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

The average results are as follows: —

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

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

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

In yield of straw the rank is: —

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B. — Cabbages.

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

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

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

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

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

These two points will be separately discussed: —

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Before Manure was used, — 1891–97.

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

After Manure was used, — 1898–1900.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Comparison of Phosphates. — Yield of Oats per Acre.

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

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

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

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

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

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

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

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

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

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

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

Onions on Plots manured with Equal Amounts of Phosphoric Acid.

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

The conclusions stated last year were as follows: —

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

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

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

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

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

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

A. — Wheat.

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

Wheat. — Yield per Acre.

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

B. — Corn.

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

Corn. — Average Yield of Four Varieties.

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

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

VII. — Varieties of Ensilage Corn compared.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VIII. — Soil Tests.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

* Gain. † Loss.

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

The analysis of the manure used is shown below: —

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

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

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

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

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

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

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

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

Onions. — North Acre Soil Test, 1901.

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

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

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

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

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

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

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

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

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

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

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

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

IX. — Manure Alone *v.* Manure and Potash.

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

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

Yield of Hay and Rowen (Pounds).

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

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

1. The corn crops have been substantially equal in value.

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

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

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

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

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

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

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

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

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

Yield of Hay and Rowen, 1901 (Pounds).

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

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

Average Yields per Acre (Pounds).

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

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

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

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

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

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

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

XI. — Experiment in manuring Grass Lands.

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

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

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

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

XII. — Nitrate of Soda for Rowen.

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

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

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

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

The average rates of yield per acre are: —

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

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

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

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

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

The average rates of yield per acre were: —

	Pounds.
No nitrate, ...	449
Nitrate, ...	709

The average increase is therefore 259 pounds, which, at the current price for nitrate of soda, costs about $1\frac{1}{6}$ cents a pound. The use of nitrate for rowen is therefore profitable in the case of the Kentucky blue grass sod, unprofitable in the case of the timothy. Neither the blue grass nor the timothy, however, are varieties characterized by a free or abundant second growth. The results of the application of nitrate of soda for rowen are likely to be better for other varieties, such as orchard grass, the fescues and rye grasses.

XIII. — Experiment in Application of Manure.

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

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

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

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

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

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

Yield of Corn and Millet, in Pounds per Plot.

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

Relative Yield of Corn and Millet, in Percentages.

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

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

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

XIV. — Alfalfa as a Forage Crop.

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

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

A. — Alfalfa on Campus Slope.

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

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

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

Yield of Alfalfa (Pounds).

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

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

B.—Alfalfa on Field B.

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

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

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

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

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

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

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

XV. — An Old Crop under New Names.

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

REPORT OF THE BOTANISTS.

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

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

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

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

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

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

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

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

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

The Dying of Cut-leaved Birches.

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

The Present Status of Chrysanthemum Rust in Massachusetts.

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

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

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

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

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

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

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

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

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

The Effects of Desiccation on Soil.

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

Melon Failures.

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

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

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

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

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

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

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

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

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

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

Stem Rots and Wilt Diseases.

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

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

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

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

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

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

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

The Present Status of Asparagus Rust in Massachusetts.

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

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

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

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

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

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

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

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

Sterilization of Soil in Greenhouses for Fungous Diseases.

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

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

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

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

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

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

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

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

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

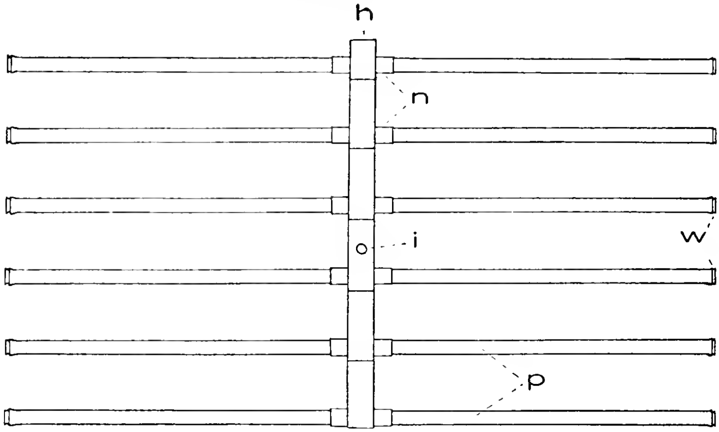
A house of this description was sterilized during the past winter at a cost of $100, and in examining this crop, which was one of the most perfect we have ever seen, there was only one case of disease in the whole house. This one diseased plant occurred near an iron post that supported the house, and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

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

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

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

The heating by steam is now done largely by the aid of perforated pipe, and in some cases use is made of 2 inch porous tile, though this method is not so applicable. If finely perforated tiles could be obtained in the market at a reasonable cost, their use would be much more valuable for this purpose than at present. The various contrivances are made out of perforated pipe, varying from 1 inch to 3 inches in diameter, usually placed from 7 to 12 inches apart, and made up into frames from 10 to 20 feet or more in length and into any desired width. The size and number of the perforations vary much in different appliances. When they are rather large (¼ inch in diameter) they are frequently covered with burlap. In some appliances the perforations are ¼ inch in diameter and are only 1½ inches apart each way. In others the perforations may be only ⅛ inch in diameter and from 3 to 6 inches apart, with two or three rows of such holes extending around the circumference of the pipe. Some of these appliances are not made up into



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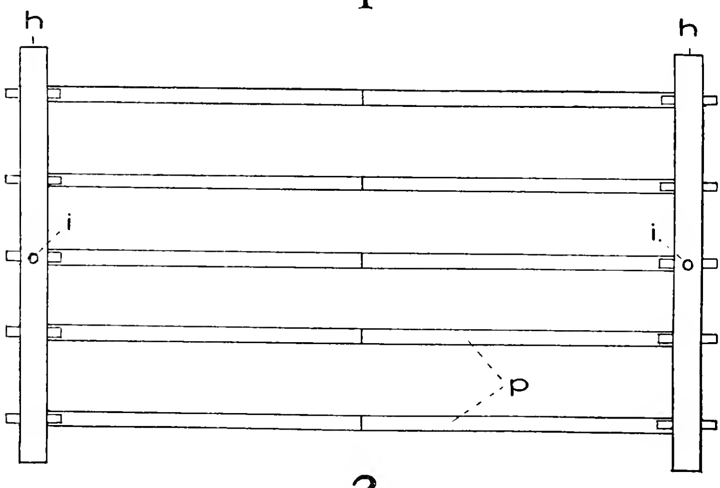

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FIGS. 1 AND 2. — Showing types of sterilization apparatus: *h*, header; *n*, nipple; *w*, wooden plug; *i*, steam inlet; *p*, pipes. Both appliances are 20 feet long and about 8 feet wide.

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

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

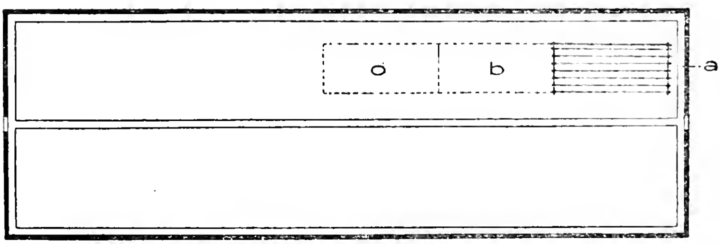

Fig. 3. — Plan of house, showing methods of sterilization: *b*, *c*, successive positions of the apparatus.

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

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

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

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

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

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

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

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

REPORT OF THE ENTOMOLOGISTS.

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

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

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

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

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

Insects of the Year.

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

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

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

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

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

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

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

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

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

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

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

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

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

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

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

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

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

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

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

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

CHARLES A. GOESSMANN.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Average Analysis of Cranberries.

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

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

Phosphoric acid,	1.00
Potassium oxide,	3.33
Nitrogen,	2.66

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

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

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

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

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

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

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

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

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

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

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

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

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Grass Fertilizer.
- Quinnipiac Havanna Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Special with Ten Per Cent. Potash.

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

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker, branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Potato Fertilizer.
- Tucker's Imperial Bone Superphosphate.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.

The American Agricultural Chemical Co. — *Con.*
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

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

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

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

Armour Fertilizer Works, Baltimore, Md.: —
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- Grain Grower.
- All Soluble.
- High-grade Potato.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.

Bartlett & Holmes, Springfield, Mass.: —
- Animal Fertilizer.
- Pure Ground Bone.
- Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash, "Square Brand."
- Bowker's Potato Phosphate.
- Bowker's Sure Crop Phosphate.
- Bowker's Market-garden Manure.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Potash or Staple Phosphate.
- Bowker's Ammoniated Dissolved Bone.
- Bowker's Superphosphate.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash-magnesia.
- Sulfate of Potash.
- Dried Blood.
- Tankage.
- Wood Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
- Tankage.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Bay State Phosphate
- E. Frank Coe's F.P. Fish and Potash.
- American Farmers' Market-garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.
- Farmers' Grass and Grain Fertilizer.
- Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
- Dow's Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Unleached Hard-wood Ashes.

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

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Canada Unleached Hard-wood Ashes.

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

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

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
- Pride of the Valley.

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

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Market Garden.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Potato Manure.
- Swift's Lowell Animal Brand.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.
- Acid Phosphate.
- Tankage.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- The Mapes' Bone Manures.
- The Mapes' Superphosphates.
- The Mapes' Special Crop Manures.
- Tobacco Ash Constituents.
- Tobacco Manure, Wrapper Brand.
- Complete Manure with Ten Per Cent. Potash.
- Economical Potato Manure.
- Fruit and Vine Manure.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulfate of Potash.

McQuade Bros., West Auburn, Mass.: —
- Ground Bone.

Mitchell Fertilizer Co., Tremley, N. J.: —
- Mitchell's Special Fertilizer.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Complete Fertilizer.

New England Fertilizer Co., Boston, Mass.: —
- Corn Fertilizer.
- Potato Fertilizer.
- High-grade Truck Fertilizer.

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

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.

Parmenter & Polsey Fertilizer Co. — *Con.*
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

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

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Tobacco.
- Fine-ground Bone.

N. Roy & Son, South Attleborough, Mass.: —
- Animal Fertilizer No 1.
- Animal Fertilizer No. 2.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X.X.X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Sanderson Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Special Strawberry.
- Sanderson's Formula A.
- Sanderson's Formula B.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

James P. Trainor, Jamesville, Mass.: —
- Ground Bone.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

E. J. Whitman, Dracut, Mass.: —
- Whitman's Potato Fertilizer, "Plowman's."
- Whitman's Corn Fertilizer, "Success."
- Whitman's Pure Ground Bone.
- Whitman's Pure Ground Meat.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- Complete Bone Superphosphate.
- Potato Manure.
- Fish and Potash.
- Nitrate of Soda.
- Muriate of Potash.

Sanford Winter, Brockton, Mass.: —
- Pure Fine-ground Bone.

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

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

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. Analysis of Materials sent on for Examination.

During the season of 1901, 217 samples of fertilizing materials of various description have been received from farmers within our State. The results of our examination of these substances have been published in three bulletins: No. 74, March; No. 75, July; and No. 77, November, 1901, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Next in importance to the analysis of licensed commercial fertilizers for inspection purposes is the examination of waste and by-products from different manufacturing industries. It has been the aim of the chemical division to encourage the use of different refuse and by-products for manurial purposes wherever the chemical analysis of such material proves them to be of sufficient value to merit their use.

The value of our work in this direction may be seen from year to year by the increased number of all kinds of waste products that are being forwarded to this department for investigation. The increased consumption of this class of materials for manurial purposes cannot but exert an important influence in favor of the agriculturalist on the consumption of commercial fertilizers. The examination of general fertilizing material is carried on free of charge to the farmers in the State, the material being taken up for analysis in the order of arrival of samples at this office.

Following is a list of materials received during the past season, which shows the great variety of substances which are used and valued for manurial purposes, as well as the great variety of work necessarily employed to keep in close touch with the critical examination of this class of materials: —

Wood ashes,	72	Sulfate of ammonia,	1
Complete fertilizers,	27	Acid phosphate,	1
Cotton-seed meal,	17	Tennessee phosphate,	1
Soils,	15	Superphosphate,	1
Muriate of potash,	8	Plain superphosphate,	1
Onions,	8	Marl,	1
Muck,	7	Sewage,	1
Nitrate of soda,	6	Lime-kiln ashes,	1
Tankage,	4	Carbonate of lime,	1
Cotton-hull ashes,	4	Waste from gas house,	1
Ground bone,	3	Pulverized sheep manure,	1
Dissolved bone-black,	3	Hair waste,	1
Blood, bone and meat,	2	Jadoo fibre,	1
Ground fish,	2	Tobacco stems,	1
Concentrated phosphate,	2	Tobacco dust,	1
Mud,	2	Walnut ashes,	1
Hen manure,	2	Pine-wood ashes,	1
Barnyard manure,	2	Ashes from soft coal and saw-dust,	1
Wool waste,	2	Linseed meal,	1
Raw bone meal,	1	Sal-ammoniac,	1
Steamed bone meal,	1	Salt,	1
Condensed bone steam,	1	Asparagus tops,	1
Fresh-cut bone,	1	Milk casein,	1
Burned bone,	1		
Fleshings,	1		

Under the division of general work in the chemical laboratory may also be classed investigations along various lines which are constantly being carried on, such as: a study of the physical and chemical conditions of soil, and their relation to the solubility of different substances applied for fertilizing purposes; investigations of the availability of the different elements of plant food in the soil; new and improved methods for the ash analysis of plants; critical examination of methods of analysis of insecticides and fungicides found in our market; ammonia absorption tests, to determine the most efficient chemical to be used as a fixer or absorber of ammonia in manure composting; investigation work for the Association of Official Agricultural Chemists, for the establishment of new and improved methods of analyses of agricultural products, etc. The results of the above-stated investigations will be published later, as in the past, whenever the results prove of general interest to the public.

2. Notes on Wood Ashes.

During the season of 1901, 33.1 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 30.8 per cent. the previous year.

The following table shows the general chemical character of wood ashes that have been forwarded for investigation during the season of 1901: —

Analysis of Wood Ashes.

Constituents.	Number of Samples.	
	1900.	1901.
Moisture below 1 per cent.,	1	2
Moisture from 1 to 10 per cent.,	25	28
Moisture from 10 to 20 per cent.,	32	31
Moisture from 20 to 30 per cent.,	13	7
Moisture above 30 per cent.,	1	-
Potassium oxide above 8 per cent.,	1	4
Potassium oxide from 7 to 8 per cent.,	6	5
Potassium oxide from 6 to 7 per cent.,	12	17
Potassium oxide from 5 to 6 per cent.,	25	24
Potassium oxide from 4 to 5 per cent.,	14	10
Potassium oxide from 3 to 4 per cent.,	7	7
Potassium oxide below 3 per cent.,	7	1
Phosphoric acid above 2 per cent.,	6	5
Phosphoric acid from 1 to 2 per cent.,	62	61
Phosphoric acid below 1 per cent.,	4	2
Average per cent. of calcium oxide (lime),	32.51	33.20
Per cent. of mineral matter insoluble in diluted hydrochloric acid: —		
Below 10 per cent.,	15	22
Between 10 and 15 per cent.,	35	24
Between 15 and 20 per cent.,	12	17
Above 20 per cent.,	11	4

From a comparison of the above-stated results of analyses of wood ashes with the results of the previous year, it will be seen that the average standard of composition is somewhat higher than in 1900.

To assist our farmers in selecting the best quality of wood ashes which the market affords, it is imperative that those sending samples for analysis should give us all the general information they possess in regard to the source from which the ashes were obtained, etc. With this idea in view, we caused to be published in our March bulletin, No. 74, a copy of a blank application for free analysis of fertilizing materials, which will hereafter be sent from this office to every applicant for an analysis free of charge. We believe the result of this course will be to impart a more general and intelligent interest in this department of work at the institution, and it will surely make known the names of the licensed as well as the unlicensed dealers in our State. We take this occasion to urge the farmers to patronize the dealers who are on record at our institution, as having complied with our State laws for the regulation of the trade in commercial fertilizers, which includes wood ashes, which are sold in our State for manurial purposes, rather than those who have failed to secure such a license.

In deciding the commercial value of wood ashes, it is well to consider the large quantity of calcium oxide (lime) that is present in a most superior form.

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

H. D. HASKINS.

1. Chemicals, refuse salts, etc.
2. Ashes, marls, lime compounds, etc.
3. Refuse substances.
4. Guanos, phosphates, etc.
5. Animal excrements, etc.
6. Average per cents. of the different ingredients found in the preceding compilation of analyses, calculated to pounds per ton of 2,000 pounds.

1868 to 1901.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1895, contained in the reports of the secretary of the Massachusetts State Board of Agriculture for these years, and in the bulletins of the department of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

No valuation is stated in this compilation, as the basis of valuation changes from year to year.

In the following compilation of agricultural chemicals, refuse materials, manurial substances, etc., the signification of the star (*) prefixed to the name of the substance is that the compilation is made up of analyses subsequent to the year 1897. It was believed that a compilation made up of more recent analyses would more nearly represent the present general chemical character of the substances, and would therefore be of more practical value.

It must be understood that the chemical character of many of the refuse substances used for manurial purposes is constantly undergoing changes, due to frequent variations in the parent industry.

As a rule, in all succeeding analyses the essential constituents are determined and stated: blanks do not imply the absence of the non-essentials.

1. *Chemicals, Refuse Salts, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Carbonate of potash,	1	26.88	-	-	-	-	-	-	18.48	-	-	-	-	-	-	-	-	19.52	-	-	-	-	.39
Carnalite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	-	.56	-	41.56	-
* Kainit,	5	1.85	-	-	-	-	13.65	10.90	12.74	-	-	-	-	-	-	18.97	2.37	6.37	-	20.25	-	20.64	2.13
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	-	31.94	-	6.63	14.96
* Muriate of potash,	40	1.41	-	-	-	-	54.80	45.40	49.91	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Nitrate of potash,	4	1.30	-	14.58	11.60	12.71	45.62	44.76	45.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	41	1.36	-	16.42	14.14	15.50	-	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50
Nitre salt cake,	2	6.03	-	-	-	2.29	-	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92
Phosphate of potash,	1	3.76	-	-	-	-	-	-	32.55	-	-	37.50	-	37.50	-	-	-	-	-	13.43	-	-	.92
Phosphate of ammonia,	1	6.05	-	-	-	10.37	-	-	-	-	-	43.86	-	-	-	-	-	-	-	12.46	-	-	.82
* Potash refuse from manufacture of cyanide of potash.	1	39.23	-	-	-	.96	-	-	7.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	13	1.10	-	21.44	19.44	20.65	-	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-
* Sulfate of potash,	20	.89	-	-	-	-	53.15	45.70	49.51	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
* Sulfate of potash-magnesia,	13	4.83	-	-	-	-	31.45	19.55	24.91	-	-	-	-	-	-	6.25	2.57	-	-	44.25	-	2.60	1.41
* Silicate of potash,	2	2.07	-	-	-	-	27.62	21.48	24.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Sulfate of magnesia,	10	23.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.40	-	36.10	-	-	5.73
* Sulfate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste,	12	2.54	-	3.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-

2. *Ashes, Marls, Lime Compounds, etc.*

Ashes of spent tan bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Ashes from cremation of swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
* Ashes from cremation of garbage,	3	3.01	-	-	-	-	6.01	3.72	5.13	10.21	7.16	8.77	-	-	-	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42
* Ashes from hay and straw,	1	.40	-	-	-	-	-	-	1.55	-	-	1.02	-	-	-	-	5.22	-	-	-	-	-	66.35
* Ashes from jute waste,	1	.19	-	-	-	-	-	-	.51	-	-	.54	-	-	-	3.84	6.04	.39	7.60	-	-	.57	81.02
* Ashes from peach tree trimmings,	1	.54	-	-	-	-	-	-	4.92	-	-	2.44	-	-	-	7.53	18.74	-	10.50	2.20	-	-	13.54
Ammoniated marl,	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
* Bleachery refuse,	2	4.19	-	-	-	-	1.24	.35	.79	-	-	-	-	-	-	11.69	35.79	-	-	-	-	-	23.09
Bituminous coal ashes,	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	-	1.88	-	-	-	-	-	74.17
* Brick yard ashes,	1	.40	-	-	-	-	-	-	3.59	-	-	1.61	-	-	-	-	23.44	-	-	-	-	-	53.32
* Cotton-seed hull ashes,	21	7.97	-	-	-	-	32.80	15.20	23.93	11.00	6.26	8.70	-	6.88	1.28	-	7.20	12.64	-	-	-	-	18.30
Corn-cob ashes,	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
* Carbonate of lime,	1	.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.98	-	-	-	-	-	-
Gypse,	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
* Gas house lime,	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05

2. *Ashes, Marls, Lime Compounds, etc.* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
* Lime refuse from soda factory,	1	24.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.86	-	1.36	23.14	-	-	1.63
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
* Lime-kiln ashes,	8	10.83	-	-	-	-	4.73	.43	2.09	1.56	.26	.76	-	-	-	-	38.86	1.30	-	-	-	-	5.68
* Leather scrap ashes,	1	.70	-	-	-	-	-	-	3.36	-	-	3.96	-	-	-	-	2.56	-	-	-	-	-	40.00
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Magnolia ashes (Florida),	1	1.58	-	-	-	-	-	-	2.56	-	-	.45	-	-	-	-	-	-	-	-	-	-	6.12
Massachusetts marls,	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marl (North Carolina),	1	.70	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
* Nova Scotia plaster (gypsum),	17	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.74	.75	-	44.87	-	-	5.79
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
* Picker waste ashes,	1	.28	-	-	-	-	-	-	6.56	-	-	1.18	-	-	-	-	-	-	-	-	-	-	63.43

Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Railroad tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
* Wood ashes,	340	11.17	-	-	-	-	8.86	1.12	5.63	2.82	.06	1.32	-	-	-	-	34.54	3.31	7.43	-	-	-	18.28
* Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Virginia marls,	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23

3. *Refuse Substances.*

Ammoniate,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
* Blood and bone,	5	5.97	-	7.19	5.70	6.23	-	-	-	12.86	11.38	12.14	-	4.41	7.73	-	-	-	-	-	-	-	-
Bone soup,	1	82.92	7.07	-	-	1.14	-	-	-	-	-	1.26	-	-	-	-	-	-	-	-	-	-	-
* Bone from fish,	1	8.78	-	-	-	4.82	-	-	-	-	-	23.54	-	8.04	15.50	-	-	-	-	-	-	-	-
* Broom-corn seed,	1	7.40	-	-	-	1.51	-	-	.50	-	-	.57	-	-	-	-	-	-	-	-	-	-	-
* Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia Majasculas*),	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
* Concentrated wool washings,	1	41.13	-	-	-	1.09	-	-	10.15	-	-	.10	-	-	-	-	-	-	-	-	-	-	-
* Condensed bone steam,	1	81.75	-	-	-	1.94	-	-	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-
* Castor-bean pomace,	3	7.87	5.70	5.85	4.98	5.47	3.40	.64	1.20	2.26	1.57	2.12	-	-	-	-	.87	.29	-	-	-	-	1.75
* Cotton-seed meal,	67	6.88	-	7.99	3.24	7.04	1.92	1.41	1.64	3.30	1.71	2.56	-	-	-	-	-	-	-	-	-	-	.28
* Cork dust,	1	.74	-	-	-	.59	-	-	.33	-	-	.10	-	-	-	-	.74	.08	-	-	-	-	.21
* Cotton waste, wet,	3	26.35	-	1.21	.84	1.08	.61	.43	.53	.74	.69	.75	-	-	-	-	2.12	-	-	-	-	-	41.90

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
* Cotton waste, dry,	7	6.45	-	1.60	.91	1.20	1.40	.88	1.21	.66	.17	.39	-	-	-	-	1.12	-	-	-	-	-	20.78
Cotton dust,	2	32.68	50.93	-	-	.78	-	-	.45	-	-	.32	-	-	-	-	-	-	-	-	-	-	42.22
* Dried blood,	22	9.01	6.37	13.55	8.10	9.84	-	-	-	8.70	1.30	2.07	-	-	-	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
* Dry ground fish,	21	9.07	-	10.48	7.44	8.56	-	-	-	16.07	5.70	8.98	-	4.21	4.73	-	-	-	-	-	-	-	-
* Damaged grain,	3	42.15	-	1.97	.84	1.44	.43	.16	.28	.83	.35	.55	-	-	-	-	-	-	-	-	-	-	-
* Deposit from Charles River,	1	21.46	-	-	-	.95	-	-	.59	-	-	.74	-	-	-	-	1.81	-	-	-	-	-	44.27
* Dredgings from Cape Cod,	1	18.99	-	-	-	.99	-	-	.13	-	-	.07	-	-	-	-	-	-	2.06	-	-	.54	-
* Deposit from pond,	1	4.01	-	-	-	.41	-	-	.26	-	-	.32	-	-	-	-	.62	-	-	-	-	-	-
Eel grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Fleshings,	1	6.96	43.14	-	-	7.55	-	-	-	-	-	.31	-	-	-	-	-	-	-	-	-	-	-
* Fresh-cut bone,	1	24.98	-	-	-	3.00	-	-	-	-	-	16.85	-	5.26	11.59	-	-	-	-	-	-	-	-
Fish with 20 to 40 per cent. water,	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than 40 per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35

Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
* Ground tobacco stems,	8	8.84	20.20	2.72	.99	2.02	8.18	3.88	6.15	1.15	.32	.62	-	-	-	-	6.75	-	-	-	-	-	1.30
* Ground bones,	135	5.51	66.14	4.99	1.17	3.10	-	-	-	31.42	16.18	24.30	-	7.55	16.73	-	-	-	-	-	-	-	1.08
Glucose refuse,	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-
* Hoof meal,	1	4.10	-	-	-	15.19	-	-	-	-	-	.77	-	-	-	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	3	10.17	7.63	15.49	11.84	13.25	-	-	-	2.30	1.36	1.83	-	-	-	-	-	-	-	-	-	-	.24
* Hair waste,	1	6.52	22.77	-	-	9.22	-	-	.14	-	-	.51	-	-	-	4.10	-	-	-	-	-	-	-
* Hop refuse,	2	84.56	1.71	.69	.49	.59	.06	.05	.05	.11	.10	.10	-	-	-	-	-	-	-	-	-	-	.83
Ivory dust,	1	11.50	52.63	-	-	6.64	-	-	-	-	-	24.56	.97	17.97	5.62	-	-	-	-	-	-	-	-
* Jadoo fibre,	1	11.53	11.60	-	-	.97	-	-	.48	-	-	1.24	-	-	-	-	3.50	-	-	-	-	-	4.05
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
* Kiln dust from brewery,	1	9.72	-	-	-	4.32	-	-	2.16	-	-	.96	-	-	-	-	.78	-	-	-	-	-	7.11
* Linseed meal,	3	8.23	-	6.42	5.26	5.69	1.58	1.46	1.52	1.59	1.36	1.47	-	-	-	-	-	-	-	-	-	-	.58
Lobster shells,	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
* Meat meal,	1	3.22	8.55	-	-	9.23	-	-	-	-	-	3.08	-	-	-	-	-	-	-	-	-	-	-
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	-	-	-	3.58	.56	2.07	-	-	-	-	-	-	-	-	-	-	.58
Meat scrap,	2	24.79	-	-	-	6.33	-	-	-	-	-	5.79	-	-	-	-	-	-	-	-	-	-	-
Morocco factory waste,	1	22.72	-	-	-	1.16	-	-	.36	-	-	2.56	-	-	-	-	19.60	-	-	1.24	-	-	24.17
* Meat and bone,	6	5.66	-	7.15	4.66	5.30	-	-	-	18.83	14.71	17.15	-	5.61	11.54	-	-	-	-	-	-	-	-
Mill sweepings,	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Mussel mud, wet,	1	60.01	27.29	-	-	.21	-	-	6.17	-	-	.10	-	-	-	.70	.93	.14	3.48	-	-	-	-
Mussel mud, dry,	1	2.24	72.02	-	-	.72	-	-	-	-	-	.35	-	-	-	-	23.39	-	8.26	-	-	-	37.60
* Muck and peat, wet,	13	64.49	13.36	1.11	.13	.55	.16	.02	.07	.13	.02	.08	-	-	-	-	.51	-	-	-	-	-	-
* Muck and peat, dry,	8	6.67	69.54	2.10	.26	.84	-	-	-	-	-	.31	-	-	-	-	.77	-	-	-	-	-	-
Oleomargarine refuse,	1	8.54	14.42	-	-	12.12	-	-	-	-	-	.88	-	-	-	-	-	-	-	-	-	-	.96
* Product from garbage plant,	1	4.14	-	-	-	2.56	-	-	.50	-	-	6.92	-	-	-	-	-	-	-	-	-	-	16.48
Pine barren grass,	1	8.48	2.40	-	-	.16	-	-	.07	-	-	.18	-	-	-	-	-	-	-	-	-	-	1.67
Pine needles,	1	9.48	3.42	-	-	.46	-	-	.03	-	-	.12	-	-	-	-	-	-	-	-	-	-	1.22
Raw wool,	1	6.95	7.54	-	-	12.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.63
Rotten brewers' grain,	1	78.77	-	-	-	.72	-	-	.04	-	-	.43	-	-	-	-	.26	.15	-	-	-	-	.59
Refuse from calico works,	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-
* Refuse from glucose factory,	1	.13	-	-	-	-	-	-	-	-	-	42.76	-	2.88	39.88	-	38.78	-	2.92	3.00	-	-	-
* Refuse from glass factory,	1	16.48	-	-	-	-	-	-	19.50	-	-	-	-	-	-	6.12	-	-	-	-	-	-	-
Rockweed, green,	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	1	10.68	35.75	-	-	1.45	-	-	4.89	-	-	2.75	-	-	-	7.90	7.66	.21	-	-	-	-	10.40
Residue from water filter,	1	94.22	-	-	-	.12	-	-	-	-	-	.05	-	-	-	-	-	-	-	-	-	-	-

Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
* Sizing paste,	1	61.45	5.58	-	-	1.13	-	-	-	-	-	.02	-	-	-	-	-	-	-	-	-	-	-
* Sizing waste,	1	74.00	-	-	-	.01	-	-	40	-	-	.01	-	-	-	-	-	-	-	-	-	-	1.43
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	-	-	-	15.37	11.04	13.21	-	-	-	-	-	-	-	-	-	-	1.29
Soup from horse rendering,	1	92.14	-	-	-	1.12	-	-	-	-	-	.14	-	-	-	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1	73.10	-	-	-	1.23	-	-	.07	-	-	.33	-	-	-	-	-	-	-	-	-	-	-
* Spent bone-black,	1	1.16	-	-	-	-	-	-	-	-	-	31.02	-	1.96	29.06	-	-	-	-	-	-	-	-
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks.	4	37.74	-	1.31	.46	.91	.66	.07	.25	.86	.39	.61	-	-	-	-	3.10	2.19	8.55	.41	4.86	-	28.70
* Sewage,	2	78.07	-	.77	.30	.40	-	-	.27	-	-	.85	-	-	-	-	-	-	-	-	-	.03	20.06
Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
* Soot,	2	8.60	-	-	-	.77	1.57	.17	.87	.72	.23	.47	-	-	-	-	2.92	1.19	6.38	-	-	-	71.07
* Tankage,	40	7.03	-	9.02	4.11	5.95	-	-	-	21.62	5.65	14.46	-	6.21	8.02	-	-	-	-	-	-	-	-
* Tobacco dust,	4	6.08	-	2.25	1.75	2.06	6.81	2.07	4.33	1.28	.36	.72	-	-	-	-	3.09	-	-	-	-	-	16.59
Tobacco leaves,	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
* Tobacco stalks exposed to the action of weather.	1	7.58	-	-	-	1.18	-	-	.52	-	-	.38	-	-	-	-	-	-	-	-	-	-	1.86
* Teopik fibre,	1	56.54	-	-	-	.53	-	-	1.26	-	-	.55	-	-	-	-	5.15	-	-	-	-	-	.75
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	1	29.00	-	-	-	1.06	-	-	-	-	-	3.51	-	2.94	.51	-	-	-	-	-	-	-	-
* Wool waste,	4	6.03	20.10	4.60	.39	2.63	3.74	.29	1.65	1.02	.27	.80	-	-	-	-	2.03	.06	.80	-	-	-	30.69
Wool washings, water,	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	.49	.28	-	-	-	-	-	-

3. *Refuse Substances* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Wool washings, acid,	1	-	-	-	-	-	-	-	4.20	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	-
Wool washings, alkaline,	1	92.03	3.28	-	-	.09	-	-	1.09	-	-	-	-	-	-	.92	.04	-	-	-	-	-	.22
Whale meat, raw,	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
* Whalebone scrapings,	1	6.90	-	-	-	13.01	-	-	-	-	-	.26	-	-	-	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1	99.47	.16	-	-	.004	-	-	.03	-	-	.022	-	-	-	-	.025	-	-	-	-	-	-

4. *Guanos, Phosphates, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
* Acid phosphate,	18	11.86	-	-	-	-	-	-	-	17.48	11.60	15.52	9.64	3.74	2.13	-	-	-	-	-	-	-	-
* Apatite,	2	.07	-	-	-	-	-	-	-	37.74	32.62	35.18	-	2.09	33.09	-	-	-	-	-	-	-	-
* Bone ash,	1	.34	-	-	-	-	-	-	-	-	-	39.14	-	-	-	-	-	-	-	-	-	-	-
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00

Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
* Bat guano from Havana, Cuba,	1	6.95	-	-	-	6.96	-	-	.53	-	-	5.04	-	-	-	6.17	10.89	-	5.76	-	-	-	.40
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
* Dissolved bone-black,	18	11.97	-	-	-	-	-	-	-	20.93	15.60	17.66	14.04	2.94	.76	-	-	-	-	-	-	-	-
* Double superphosphate,	2	6.27	-	-	-	-	-	-	-	50.14	45.42	47.78	18.36	20.97	8.45	-	-	-	-	-	-	-	-
* Dissolved bone meal,	7	5.73	-	4.64	1.66	2.56	-	-	-	22.26	15.04	17.93	3.95	8.72	5.26	-	-	-	-	-	-	-	-
* Damaraland guano,	1	17.70	-	-	-	5.79	-	-	3.53	-	-	14.78	4.90	5.79	4.09	7.03	14.21	2.05	-	5.94	-	5.77	9.26
* Florida rock phosphate,	2	.53	-	-	-	-	-	-	-	40.34	33.10	36.72	-	.10	36.62	-	-	-	-	-	-	-	-
* Florida soft phosphate,	1	4.46	-	-	-	-	-	-	-	-	-	26.48	-	.38	26.10	-	-	-	-	-	-	-	-
* Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45
* Novassa phosphate,	1	5.77	-	-	-	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-	-
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
* Phosphatic slag,	2	.95	-	-	-	-	-	-	-	19.80	15.70	17.75	-	6.04	13.76	-	39.24	-	-	-	-	-	9.91
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Bat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
* South Carolina rock phosphate,	3	.88	-	-	-	-	-	-	-	31.87	25.58	27.98	-	2.63	23.41	-	-	-	-	-	-	-	-
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
* Tennessee phosphate,	1	.37	-	-	-	-	-	-	.44	-	-	33.00	-	-	-	-	-	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-

5. *Animal Excrement, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
* Barnyard manure,	25	71.82	-	.69	.24	.44	.88	.26	.59	.52	.13	.34	-	-	-	-	-	-	-	-	-	-	6.95
* Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
* Hen manure,	3	34.66	-	1.83	.42	1.18	2.96	.43	1.62	3.93	.63	1.92	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
* Sheep manure,	4	9.58	17.14	2.97	.85	2.12	3.16	.68	2.03	2.24	.22	1.45	-	-	-	-	-	-	-	-	-	-	33.75

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc.													
Carbonate of potash,	538	-	-	370	-	-	-	330	-	-	-	-	8
Carnalite,	-	-	-	274	-	153	-	264	-	11	-	831	-
* Kainit,	37	-	-	255	-	379	47	127	-	405	-	413	43
Krugite,	96	-	-	168	-	105	249	176	-	639	-	133	299
* Muriate of potash,	28	-	-	998	-	134	-	11	-	-	-	976	14
Nitrate of potash,	26	-	254	905	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	27	-	310	-	-	710	-	-	-	-	-	10	10
Nitre salt cake,	121	-	46	17	-	591	-	-	-	955	-	-	78
Phosphate of potash,	75	-	-	651	750	-	-	-	-	269	-	-	18
Phosphate of ammonia,	121	-	207	-	877	-	-	-	-	249	-	-	16
* Potash refuse from manufacture of cyanide of potash,	785	-	19	147	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	22	-	413	-	-	-	-	-	-	1,200	-	-	-
* Sulfate of potash,	18	-	-	990	-	89	-	30	-	914	-	-	15

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc. — Con.													
* Sulfate of potash-magnesium,	97	-	-	498	-	125	51	-	-	885	-	52	28
* Silicate of potash,	41	-	-	491	-	-	-	-	-	-	-	-	-
* Sulfate of magnesia,	475	-	-	-	-	-	56	348	-	722	-	-	115
* Sulfate of soda,	28	-	-	-	-	-	-	-	-	1,189	-	-	-
Saltpetre waste,	51	-	44	273	-	741	15	4	-	37	-	925	-
2. Ashes, Marls, Lime Compounds, etc.													
Ashes of spent tan bark,	97	-	-	36	27	-	622	68	36	-	-	-	504
Ashes from cremation of swill,	97	-	-	79	283	-	672	37	93	-	-	-	431
Ashes from blue works,	243	1,276	-	180	-	-	-	-	-	-	-	-	246
* Ashes from cremation of garbage,	60	-	-	103	175	313	404	23	184	91	217	95	568
* Ashes from hay and straw,	8	-	-	31	20	-	104	-	-	-	-	-	1,327
* Ashes from jute waste,	4	-	-	10	11	77	121	8	152	-	-	11	1,620
* Ashes from peach tree trimmings,	11	-	-	98	49	151	375	-	210	44	-	-	271
Ammoniated marl,	66	-	32	-	208	-	-	-	-	-	-	-	-

* Bleachery refuse,	84	-	-	16	-	234	716	-	-	-	-	-	462
Bituminous coal ashes,	73	-	-	8	9	-	38	-	-	-	-	-	1,483
* Brick yard ashes,	8	-	-	72	32	-	469	-	-	-	-	-	1,066
* Cotton-seed hull ashes,	159	-	-	479	174	-	144	253	-	-	-	-	366
Corn-cob ashes,	24	-	-	142	47	-	234	-	26	-	-	-	1,042
* Carbonate of lime,	9	-	-	-	-	-	1,060	-	-	-	-	-	-
Gypse,	33	-	-	-	-	-	1,017	-	-	-	-	-	57
* Gas house lime,	446	-	-	-	-	-	873	166	-	415	-	-	121
Green sand marl (Virginia),	25	-	-	23	187	-	516	-	103	-	-	-	826
Hard-pine wood ashes,	15	-	-	203	45	-	499	-	-	-	-	-	598
* Lime refuse from soda factory,	481	-	-	-	-	-	297	-	27	463	-	-	33
Lime waste from sugar factory,	726	-	-	4	45	-	550	-	-	-	-	-	6
Lime,	-	-	-	-	-	-	1,873	-	-	-	-	-	27
* Lime-kiln ashes,	217	-	-	42	15	-	777	26	-	-	-	-	114
* Leather scrap ashes,	14	-	-	67	79	-	51	-	-	-	-	-	800
Logwood ashes,	30	-	-	2	46	-	78	-	-	-	-	-	194
Mill ashes,	11	-	-	32	9	-	699	27	-	-	-	-	727
Magnolia ashes (Florida),	32	-	-	51	9	-	-	-	-	-	-	-	122
Massachusetts marls,	274	-	-	5	21	-	810	13	14	-	571	-	69
Marl (North Carolina),	14	-	-	1	11	-	439	12	-	-	-	-	1,004
* Nova Scotia plaster (gypsum),	129	-	-	-	-	-	675	15	-	897	-	-	116
Olive earth (Virginia),	39	-	-	5	275	-	383	-	120	-	-	-	1,011

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. *Ashes, Marls, Lime Compounds, etc.* — Con.													
Onondaga plaster (New York gypsum),	265	-	-	-	-	-	600	93	-	650	164	-	197
* Picker waste ashes,	6	-	-	131	24	-	-	-	-	-	-	-	1,269
Peat ashes,	93	-	-	9	2	-	46	33	123	-	-	-	903
Railroad tie ashes,	94	-	-	18	11	-	50	-	-	-	-	-	1,604
Sea-weed ashes,	29	-	-	18	6	175	121	87	-	60	-	132	1,273
* Wood ashes,	223	-	-	113	26	-	691	66	149	-	-	-	366
* Waste lime,	16	-	-	-	-	-	1,482	-	-	-	-	-	8
Virginia marls,	320	-	-	10	2	-	145	4	-	13	145	-	1,285
3. *Refuse Substances.*													
Ammoniate,	118	-	227	-	69	-	-	-	-	-	-	-	28
* Blood and bone,	119	-	125	-	243	-	-	-	-	-	-	-	-
Bone soup,	1,658	141	23	-	25	-	-	-	-	-	-	-	-
* Bone from fish,	176	-	96	-	471	-	-	-	-	-	-	-	-
* Broom-corn seed,	148	-	30	10	11	-	-	-	-	-	-	-	-

* Banana skins,	280	-	5	109	36	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*),	325	-	85	16	4	71	41	24	-	-	-	-	111
* Concentrated wool washings,	823	-	22	203	2	-	-	-	-	-	-	-	-
* Condensed bone steam,	1,635	-	39	-	1	-	-	-	-	-	-	-	-
* Castor bean pomace,	157	114	109	24	42	-	17	6	-	-	-	-	35
* Cotton-seed meal,	138	-	141	33	51	-	-	-	-	-	-	-	6
* Cork dust,	15	-	12	7	2	-	15	2	-	-	-	-	5
* Cotton waste, wet,	527	-	22	11	15	-	42	-	-	-	-	-	838
* Cotton waste, dry,	129	-	24	24	8	-	22	-	-	-	-	-	416
Cotton dust,	654	1,019	16	9	6	-	-	-	-	-	-	-	844
* Dried blood,	180	127	197	-	41	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296	168	199	-	11	-	-	-	-	-	-	-	13
Dried soup from rendering cattle feet,	216	150	289	-	9	-	-	-	-	-	-	-	5
* Dry ground fish,	181	-	171	-	180	-	-	-	-	-	-	-	-
* Damaged grain,	843	-	29	6	11	-	-	-	-	-	-	-	-
* Deposit from Charles River,	429	-	19	12	15	-	36	-	-	-	-	-	885
* Dredgings from Cape Cod,	380	-	20	3	1	-	-	-	41	-	-	11	-
* Deposit from pond,	80	-	8	5	6	-	12	-	-	-	-	-	-
Eel grass,	708	312	17	18	6	33	43	2	-	-	-	-	21
Felt refuse,	585	671	105	-	-	-	-	-	-	-	-	-	-
* Fleshings,	139	863	151	-	6	-	-	-	-	-	-	-	-
* Fresh-cut bone,	500	-	60	-	337	-	-	-	-	-	-	-	-

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. Refuse Substances — Con.													
Fish with 20 to 40 per cent. water,	604	412	119	-	142	-	-	-	-	-	-	-	34
Fish with more than 40 per cent. water,	909	310	99	-	112	-	-	-	-	-	-	-	27
Fresh-water mud,	807	-	27	4	5	-	25	6	36	-	-	-	365
* Ground tobacco stems,	177	404	40	123	12	-	135	-	-	-	-	-	26
* Ground bones,	110	1,323	62	-	486	-	-	-	-	-	-	-	22
Glucose refuse,	162	-	52	3	6	-	4	4	-	-	-	-	1
Horn shavings,	97	-	306	-	8	-	-	-	-	-	-	-	-
* Hoof meal,	82	-	304	-	15	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	203	153	265	-	37	-	-	-	-	-	-	-	5
* Hair waste,	130	455	184	3	10	82	-	-	-	-	-	-	-
* Hop refuse,	1,691	34	12	1	2	-	-	-	-	-	-	-	17
Ivory dust,	230	1,053	133	-	491	-	-	-	-	-	-	-	-
* Jadoo fibre,	231	232	19	10	25	-	70	-	-	-	-	-	81
Jute waste,	262	-	30	2	14	-	-	-	-	-	-	-	-

* Kiln dust from brewery,	194	-	86	43	19	-	16	-	-	-	-	-	142
* Linseed meal,	165	-	114	30	29	-	-	-	-	-	-	-	12
Lobster shells,	145	-	90	-	70	-	445	26	-	-	-	-	5
* Meat meal,	64	171	185	-	62	-	-	-	-	-	-	-	-
Meat mass,	242	272	209	-	41	-	-	-	-	-	-	-	12
Meat scrap,	496	-	127	-	116	-	-	-	-	-	-	-	-
Morocco factory waste,	454	-	23	7	51	-	392	-	-	25	-	-	483
* Meat and bone,	113	-	106	-	343	-	-	-	-	-	-	-	-
Mill sweepings,	190	-	75	13	24	-	-	-	-	-	-	-	109
Madder,	239	-	18	48	7	-	79	10	-	-	-	-	93
Mussel mud, wet,	1,200	546	4	123	2	14	19	3	70	-	-	-	-
Mussel mud, dry,	45	1,440	14	-	7	-	468	-	165	-	-	-	752
* Muck and peat, wet,	1,290	267	11	1	2	-	10	-	-	-	-	-	-
* Muck and peat, dry,	133	1,391	17	-	6	-	15	-	-	-	-	-	-
Oleomargarine refuse,	171	288	242	-	18	-	-	-	-	-	-	-	19
* Product from garbage plant,	83	51	-	10	138	-	-	-	-	-	-	-	330
Pine barren grass,	170	48	3	1	4	-	-	-	-	-	-	-	33
Pine needles,	190	68	9	1	2	-	-	-	-	-	-	-	24
Raw wool,	139	151	258	-	-	-	-	-	-	-	-	-	73
Rotten brewers' grain,	1,575	-	14	1	9	-	5	3	-	-	-	-	12
Refuse from calico works,	81	-	86	-	239	-	-	-	-	-	-	-	-
* Refuse from glucose factory,	3	-	-	-	855	-	776	-	58	60	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Refuse from glass factory,	330	-	-	390	-	122	-	-	-	-	-	-	-
Rockweed, green,	1,370	474	12	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214	715	29	98	55	148	153	4	-	-	-	-	208
Residue from water filter,	1,884	-	2	-	1	-	-	-	-	-	-	-	-
Sponge refuse,	145	-	49	-	64	-	79	25	-	-	-	-	781
* Sizing paste,	1,229	112	23	-	.4	-	-	-	-	-	-	-	-
* Sizing waste,	1,480	-	.2	8	.2	-	-	-	-	-	-	-	29
Soap-grease refuse,	585	1,028	22	-	3	-	-	-	-	-	-	-	26
Soup from horse rendering,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent bone-black,	23	-	-	-	620	-	-	-	-	-	-	-	-
Sumac waste,	1,261	136	24	65	-	-	23	65	-	-	-	-	45
Starch waste from rubber factory,	200	5	.4	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks,	755	-	18	5	12	-	62	44	171	8	97	-	574

* Sewage,	1,561	-	8	5	17	-	-	-	-	-	-	1	401
Salt mud,	1,067	824	8	7	-	19	18	7	83	-	-	-	698
* Soot,	172	-	15	17	9	-	58	24	128	-	-	-	1,421
* Tankage,	141	-	119	-	289	-	-	-	-	-	-	-	-
* Tobacco dust,	122	-	41	87	14	-	62	-	-	-	-	-	332
Tobacco leaves,	261	420	55	145	9	-	83	43	6	-	-	-	83
* Tobacco stalks exposed to action of weather,	152	-	24	10	8	-	-	-	-	-	-	-	37
* Teopik fibre,	1,131	-	11	25	11	-	103	-	-	-	-	-	15
Turf,	386	127	39	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	580	-	21	-	70	-	-	-	-	-	-	-	-
* Wool waste,	121	402	53	33	16	-	41	1	16	-	-	-	614
Wool washings, water,	-	-	-	78	-	10	6	-	-	-	-	-	-
Wool washings, acid,	-	-	-	84	-	8	12	4	-	-	-	-	-
Wool washings, alkaline,	1,841	66	2	22	-	18	1	-	-	-	-	-	4
Whale meat, raw,	890	21	97	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	682	-	14	-	13	-	452	-	-	-	-	-	138
* Whale bone scrapings,	14	-	260	-	5	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1,989	3	.08	.6	.44	-	.5	-	-	-	-	-	-
4. Guanos, Phosphates, etc.													
* Acid phosphate,	237	-	-	-	310	-	-	-	-	-	-	-	-
* Apatite,	1	-	-	-	704	-	-	-	-	-	-	-	-
* Bone ash,	7	-	-	-	783	-	-	-	-	-	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Concluded.

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
4. *Guanos, Phosphates, etc.* — Con.													
Bone-black,	92	-	-	-	566	-	-	-	-	-	-	-	73
Brockville phosphate,	50	-	-	-	704	-	-	-	-	-	-	-	129
Bat guano from Texas,	802	365	129	26	75	-	-	-	-	-	-	-	40
Bat guano from Florida,	313	-	195	35	67	-	-	-	-	-	-	-	387
* Bat guano from Havana, Cuba,	139	-	139	11	101	123	218	-	115	-	-	-	8
Cuban guano,	485	-	33	-	267	-	-	-	-	-	-	-	63
Caribbean guano (orchilla),	146	-	-	-	535	-	799	66	-	54	-	-	25
* Dissolved bone-black,	239	-	-	-	353	-	-	-	-	-	-	-	-
* Double superphosphate,	125	-	-	-	956	-	-	-	-	-	-	-	-
* Dissolved bone meal,	115	-	51	-	359	-	-	-	-	-	-	-	-
* Damaraland guano,	354	-	116	71	296	141	284	41	-	119	-	115	185
* Florida rock phosphate,	11	-	-	-	734	-	-	-	-	-	-	-	-
* Florida soft phosphate,	89	-	-	-	530	-	-	-	-	-	-	-	-
* Mona Island guano,	266	-	15	-	438	-	750	-	-	-	-	-	49

* Novassa phosphate,	115	-	-	-	491	-	-	-	-	-	-	-	-
Odorless phosphate,	60	-	-	8	391	-	1,028	-	-	-	50	-	183
* Phosphatic slag,	19	-	-	-	355	-	785	-	-	-	-	-	198
Peruvian guano,	296	752	157	52	305	-	-	-	-	-	-	-	132
Rat guano from Florida,	206	-	66	137	46	-	-	-	-	-	-	-	23
* South Carolina rock phosphate,	18	-	-	-	560	-	-	-	-	-	-	-	-
South Carolina floats,	17	-	-	-	468	-	-	-	-	-	-	-	403
South American bone ash,	140	-	-	-	718	-	898	-	-	-	-	-	90
* Tennessee phosphate,	7	-	-	9	660	-	-	-	-	-	-	-	-
Upton phosphate,	181	-	-	-	803	-	-	-	-	-	-	-	-
5. Animal Excrement, etc.													
* Barnyard manure,	1,436	-	8.8	11.8	6.8	-	-	-	-	-	-	-	139
* Compost,	34	-	15.8	19.4	11.2	-	-	-	-	-	-	-	-
Drainage from manure heap,	1,864	73	19.6	17.6	4.8	-	-	-	-	-	-	-	-
Goose manure,	978	-	4.2	16.2	19	-	-	-	-	-	-	-	-
* Hen manure,	693	-	23.6	32.4	38.4	-	23.8	17.8	-	24.8	-	-	470
Hen house refuse,	147	-	14.2	20.6	20.1	-	-	-	-	-	-	-	1,421
Horse manure,	225	-	14.8	56.4	29.2	-	-	-	-	-	-	-	252
Poudrette, dry,	105	709	71.6	9.8	115	-	-	-	-	-	-	-	93
* Sheep manure,	192	343	42.4	40.6	29	-	-	-	-	-	-	-	675

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

H. D. HASKINS.

1. Analyses of fruits.
2. Analyses of garden crops.
3. Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. (C. A. Goessmann.)

1. Analyses of Fruits.

Fertilizing Constituents of Fruits (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
* Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
* Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
* Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
* Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
* Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–

Fertilizing Constituents of Fruits — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Rosaceæ — *Con.*										
* Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
* Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
* Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Viticeæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. Analyses of Garden Crops.

Fertilizing Constituents of Garden Crops (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ: —										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
* Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
* Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — *Con.*										
* Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
* Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositæ : —										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
* Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
* Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–

Convolvulaceæ: —										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ: —										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
* White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
* Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
* White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
* Corn, whole plant, green,	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Corn, kernels,	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
* Corn, kernels,	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
* Corn, whole ears,	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
* Corn stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–

Leguminosæ: —										
Hay of peas, cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
* Cow-pea (*Dolichos*), green,	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
* Small pea (*Lathyrus Sylvestris*), dry,	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Peas, seed,	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans, seed,	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw,	166	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
* Velvet beans, kernel,	111.6	31.1	–	13.2	–	–	–	7.7	–	–
* Velvet beans, with pod,	115.2	19.6	–	13.1	–	–	–	8.4	–	–
* Leaves and stems of velvet beans,	58.8	28.6	–	–	–	–	–	–	–	–
Liliaceæ: —										
* Asparagus,	942	3.3	–	3.29	–	–	–	1.08	–	–
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
* Onions,	892	–	4.9	1.8	.1	.4	.2	.7	–	–

Fertilizing Constituents of Garden Crops — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Solanaceæ: —										
Potatoes,	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
* Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–
Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
* Tomatoes,	940	1.7	–	3.6	–	.3	.2	.4	–	–
Tobacco leaves,	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
* Tobacco, whole leaf,	103.1	24.3	–	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
* Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–

Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
* Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
* Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Many of the foregoing analyses were compiled from the tables of E. Wolff. Those marked with a star (*) are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass., and since 1895, at the chemical division of the Hatch Experiment Station of the Massachusetts Agricultural College.

3. Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits and Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits.			
Ericaceæ : —			
* Cranberries,	1	3.0	–
* Cranberries,	1	3.33	2.66
Rosaceæ : —			
Apples,	1	2.7	2.0
* Apples,	1	1.9	1.3
* Peaches,	1	1.3	–
Pears,	1	3.6	1.2
Strawberries,	1	1.4	–
* Strawberries,	1	2.6	–
* Strawberry vines,	1	.7	–
Cherries,	1	3.3	–
Plums,	1	4.3	–
Saxifragaceæ : —			
* Currants, white,	1	2.8	–
* Currants, red,	1	2.1	–
Gooseberries,	1	1.9	–

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits — Con.			
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
Garden Crops.			
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
* Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
* Sugar beets,	1	4.8	2.2
Sugar beet tops,	1	2.3	1.7
Sugar beet leaves,	1	5.7	4.3
Sugar beet seed,	1	1.5	–
* Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
* Spinach,	1	19.2	6.8
Compositæ: —			
Lettuce, common,	1	5.3	–
Head lettuce,	1	3.9	2.2
* Head lettuce,	1	7.7	4.0
Roman lettuce,	1	2.3	1.8
Artichoke,	1	.63	–
* Artichoke, Jerusalem,	1	2.8	2.7

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Convolvulaceæ: —			
Sweet potato,	1	4.6	3.0
Cruciferæ: —			
White turnips,	1	3.6	2.3
* White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
* Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
* White cabbage,	1	11.0	7.6
Cabbage leaves,	1	4.1	1.7
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ: —			
Corn, whole plant, green,	1	3.7	1.9
* Corn, whole plant, green,	1	2.2	2.8
Corn kernels,	1	.6	2.8
* Corn kernels,	1	.6	2.6

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Gramineæ — *Con.*			
* Corn, whole ears,	1	.8	2.5
* Corn stover,	1	4.4	3.7
Leguminosæ: —			
Hay of peas, cut green,	1	3.4	3.4
* Cow-pea (*Dolichos*), green,	1	3.1	2.9
* Small pea (*Lathyrus Sylvestris*), dry,	1	3.4	4.2
Peas, seed,	1	1.2	4.3
Pea straw,	1	2.8	4.0
Garden beans, seed,	1	1.2	4.0
Bean straw,	1	3.3	–
* Velvet beans, kernel,	1	1.7	4.0
* Velvet beans, with pod,	1	1.56	2.3
* Leaves and stems of velvet beans,	–	–	–
Liliaceæ: —			
* Asparagus,	1	3.05	3.06
Asparagus,	1	1.3	3.6
Onions,	1	1.9	2.1
* Onions,	1	2.6	–
Solanaceæ: —			
Potatoes,	1	3.6	2.1
* Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Solanaceæ — *Con.*			
Potato tops, unripe,	1	3.7	5.3
* Tomatoes,	1	8.7	4.5
Tobacco leaves,	1	6.2	5.3
* Tobacco, whole leaf,	1	13.46	5.65
Tobacco stalks,	1	3.1	2.7
* Tobacco stems,	1	10.7	3.8
Umbelliferæ : —			
Carrots,	1	2.7	2.0
* Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
Carrot tops, dry,	1	8.0	5.1
Parsnips,	1	3.8	2.8
* Parsnips,	1	3.3	1.2
Celery,	1	3.5	1.1

4. Analyses of Insecticides.

	Moisture.	Arsenious Oxide.	Copper Oxide.	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Insoluble Matter in Hydrochloric Acid.
Average of twelve analyses, Paris green,	1.22	57.91	32.08	-	-	-	4.74	-	-	-	-	-	-	-	-	.20
Average of four analyses, "Lion brand new-process Paris green."	4.64	54.91	7.93	-	-	-	-	-	-	-	6.65	-	15.76	.35	-	1.00
Average of fourteen analyses of Paris green collected in the general markets in 1900-1901.	.81	57.73	29.45	-	-	-	-	-	-	-	-	-	-	-	-	-
Pink arsenoid (lead arsenite),	.35	40.16	-	53.83	-	-	-	-	-	-	-	-	-	-	-	-
Green arsenoid (copper arsenite),	1.44	50.77	31.90	-	-	-	-	-	-	-	-	-	-	-	-	-
White arsenoid (barium arsenite),	2.35	31.90	-	.96	-	48.31	-	-	-	-	-	3.19	-	-	-	-
Laurel green,	7.64	7.34	13.50	-	-	-	-	-	-	-	-	-	26.31	-	-	-
Bug death,	.03	-	-	1.58	78.86	-	-	-	-	-	-	-	-	-	3.80	-
Sulphatine,	1.40	-	2.61	-	-	-	-	-	-	48.28	4.73	-	18.60	-	-	1.63
Death to rose bugs,	2.95	-	1.05	-	-	-	-	-	-	34.53	4.35	-	17.76	-	-	.49
Professor De Graff's carpet bug destroyer,	95.81	-	-	-	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
Oriental fertilizer and bug destroyer,	87.14	2.38	-	-	-	-	-	-	-	-	.64	3.00	-	3.50	-	-
Non-poisonous potato bug destroyer,	-	-	-	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	40.89	-	-	-	-	-	-	.53	-	-	-	-	1.47	16.31	.01	-
Tobacco liquor,	-	-	-	-	-	-	-	4.68	-	-	-	-	-	-	-	-
Nicotina,	10.00	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.31
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.12
Peroxide of silicate,	1.65	.57	.33	-	-	-	-	-	-	-	49.66	-	41.18	-	-	2.31

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, JR., J. W. KELLOGG.

Part I. — Outline of Year's Work.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Dairy legislation.
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Part II. — Dairy and Feeding Experiments.

- A. Effect of feed on the composition of milk, butter fat, and on the consistency or body of butter.
- B. Notes on summer forage crops.

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- C. Analyses of dairy products.
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Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The general correspondence of this division has increased considerably during the last five years, due especially to the establishment of the feed control, and to the work in connection with the dairy law. More than the usual number of inquiries have been received relative to milk, cream, water, feed stuffs and methods of feeding. Some letters can be answered very quickly, while others require time and study. The total number of letters written during the year ending December 15 has been 2,186.

B. Extent of Chemical Work.

In the last report attention was called to the fact that the ever-increasing demand on the chemists' time for work of a routine character — the analyses of water, milk, cream and feed stuffs — very seriously interfered with the extent of experimental work. This has been particularly the case the past year, due largely to the amount of time required in connection with the dairy law. In fact, the work of investigation has been seriously curtailed, which is much to be regretted.

There have been sent in for examination 242 samples of water, 164 of milk, 1,557 of cream, 15 of pure and process butter, 48 of oleomargarine, 106 of feed stuffs and 5 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 148 samples of milk and cream, 80 of butter fat and 563 of fodders and feed stuffs.

There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 694 samples of concentrated feed stuffs. This makes a total of 3,622 substances analyzed during the year, as against 3,036 last year and 2,045 in the previous year. Work on the pentosans and galactan, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, forty-five candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 5,041 pieces of glassware have been tested for accuracy.

C. Character of Chemical Work.

(*a*) *Water.* — It has been the custom, ever since the establishment of the Massachusetts State Experiment Station, in 1882, to make sanitary analyses of drinking waters free of cost to all citizens of Massachusetts. Work of this character has increased until it has become quite burdensome. Acting with the approval of the Experiment Station committee, the following rules were adopted, and went into effect July 1: —

1. Hereafter, all parties wishing to secure a sanitary analysis of water at the Hatch Experiment Station must make known their desire by postal or letter, whereupon a glass bottle, securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express to the applicant.
2. According to a recent official ruling, no party shall be allowed to have more than *two* samples of water tested at this station free of cost in a single month. Additional analyses may be obtained within this time at a cost of two dollars each, providing the resources of the station permit.

Heretofore, parties have been allowed to send in any number of samples, at any time, in any kind of vessel. One result of this custom was, that the station often received more samples than could be properly handled, and other work was crowded to one side. Now it is possible to regulate the number of samples by the time at our disposal. Because of the large amount of work on hand, it has become necessary to refuse water samples during the months of November and December of the present year. Again, many persons had only an imperfect understanding of the method of taking and shipping a sample; consequently, the water was often received in improper condition, rendering the results of very questionable value. At present, a clean, glass-stoppered bottle is shipped the applicant, together with full instructions. The chemist, therefore, feels reasonably sure that the sample under examination is a fair one, and the results obtained are of a more positive character.

Samples are received not only from farmers, but from persons following various trades and professions. They are practically all from wells, springs and ponds in towns and villages not having a public water supply. Many are of fair quality, others quite suspicious, while some are entirely unfit for use. Some samples have been found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning, as many persons have found, to their sorrow. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.* It is not considered necessary to publish the results of the various analyses made, as they convey no particular information that could be of general interest.

(*b*) *Dairy Products and Feed Stuffs.* — More than the usual number of samples of milk and cream have been received during the past year. They were sent largely for the purpose of determining the amount of butter fat they contained. Some farmers are desirous of knowing the quality of milk produced by their animals, while others, who sell cream to the different creameries, wish to ascertain how closely the station tests agree with those made by the local creamery. Quite frequently samples of milk are received from milkmen whose product has been found to be below the standard by the inspector or milk contractor. In such cases the determination of both total solids and fat is made. The results of all analyses are returned within a few days, together with as full information as possible.

Printed circulars are also sent, containing information concerning the quality of the milk produced by different breeds of animals, and the necessary instruction relative to the best methods to be used in estimating the butter producing capacity of dairy herds.

In addition to the above, this division examines milk, cream and butter collected in western Massachusetts by the agent of the Dairy Bureau. The work is confined largely to the detection of oleomargarine, and is paid for by the Bureau, at a definite price for each determination.

The number of feed stuffs sent for examination was a trifle less than usual, due to the fact that quite thorough information of this character is now furnished in the feed bulletins issued from time to time by this division. During the winter and early spring a considerable number of samples of cotton-seed meal were received, tested, and the results returned without delay.

(*c*) *Chemical Investigation.* — So far as possible, it is the intention of this division to continue its investigation of some of the various dairy and feeding problems demanding solution. At present the time is devoted to the examination of butter fat, the manufacture of butter, and the digestibility of concentrated feed stuffs and summer forage crops. Work of this character is to be found in connection with Part II. of this report.

D. Cattle Feed Inspection.

The inspection of cattle feeds has been carried on in much the same manner as in previous years. Bulletin No. 71, comprising forty pages, was issued early in the year. This contains analyses of 653 cattle feeds, 33 poultry feeds, 46 so-called condimental foods for horses, cattle and poultry, together with full discussion of the results obtained. The interested reader is referred to it. When warranted, additional information is issued as press bulletins and sent to about one hundred newspapers in the State. Should any material be found seriously adulterated, a special circular is sent at once to the grain dealers in every town. Two complete inspections have been made during the present year, resulting in the collection of 698 samples. They are now under examination, and the results thus far obtained allow the following deductions: —

(*a*) The larger part of the *cotton-seed meal* is now guaranteed, and is of excellent quality. A few unguaranteed meals were found mixed with more or less hulls. *Farmers are strongly urged to buy only guaranteed meals.*

(*b*) *Gluten meal* and *feed* are nearly always accompanied with a guaranty, and are free from any foreign admixtures.

(*c*) *Wheat bran* and *middlings* are seldom adulterated. Purchasers are recommended, however, to give preference to those articles branded with the name of reputable manufacturers, or to examine the article closely before buying, in order to note its quality.

(*d*) *Mixed feed*, so called, consists of the entire wheat offal or mixtures of bran, coarse and flour middlings. The larger the proportion of flour middlings, the more valuable the feed. Different brands show noticeable variations in the proportions of the several ingredients. Farmers can obtain a very *desirable* mixed feed by mixing equal parts by weight of bran and flour middlings or red dog flour. Such a feed will be decidedly preferable to many of the brands now on the market, and the cost will not be increased. Most mixed feeds are entirely free from adulteration. A few samples were found containing a considerable quantity of ground corn cobs. Some were marked Kentucky Milling Company, others Kentucky, and a few were without brand. Several samples contained a noticeable amount of wheat screenings. Mixed feed containing cobs can generally be recognized by the hard, woody nature of the material when chewed. A close inspection of the feed will reveal the presence of screenings. Consumers are *especially cautioned* against such feeds.

(*e*) Oat offal, the refuse from the oat meal mills, contains large quantities of oat hulls. Two brands, namely, "X" and "Boston," were practically all hulls. The price of the offal varied from $16 to $27 a ton. It is relatively a *very expensive feed*.

(*f*) Dried brewers' grains and malt sprouts offer cheap sources of protein, provided they can be obtained.

In general, it can be said that the number of brands is increasing each year, practically all of which are the by-products from different manufacturing industries. The better class of feed stuffs, as put out by firms of established reputation, are not adulterated; irresponsible firms, however, are making systematic attempts to put out inferior goods. This is noticed especially in the persistent attempt to sell cotton-seed meal mixed with fine-ground hulls for genuine meal; in the substitution of fine-ground corn cobs for middlings in mixed feeds; in the offering of fine-ground rice hulls to dealers for the purpose of adulterating standard grains; and in the use of oat offal rather than ground oats in the mixing of the so-called provender (cracked corn and ground oats).

The following is the text of the present feed stuff law: —

[Chapter 117, Acts and Resolves of 1897.]

Section 1. The director of the Hatch Experiment Station of the Massachusetts Agricultural College is hereby authorized and directed, in person or by deputy, to take samples not exceeding two pounds in weight from any lot or package of concentrated commercial feed stuff, used for feeding any kind of farm live stock, which may be in the possession of any manufacturer, importer, agent or dealer, cause the same to be analyzed for the amount of crude protein and crude fat contained therein, as well as for other ingredients if thought advisable, and cause the results of the analyses to be published from time to time in especially prepared bulletins, with such additional information as circumstances advise: *provided, however*, that in publishing the results of the analyses, the name of the jobbers or local dealers selling the said feed stuffs shall not be used, but the commodity analyzed shall be identified and described by the name of the manufacturer, or the commercial name or designation by which it is known in the trade.

Section 2. Whenever requested, said samples shall be taken in the presence of the party or parties in interest or their representative, and shall in all cases be taken from a parcel or number of packages which shall not be less than five per cent. of the whole lot inspected, shall be thoroughly mixed and then divided into two equal samples and put in glass vessels and carefully sealed, and a label placed on each vessel stating the name or brand of the feed stuff or material sampled, the name of the manufacturer when possible, the name of the party from whose stock the sample was taken, and the time and place of taking; said label shall be signed by the director, or his deputy, and by the party or parties in interest or their representative if present at the taking and sealing of the samples. One of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled.

SECTION 3. To defray the expenses of collecting and analyzing the samples and of publishing the results, the sum of twelve hundred dollars shall be allowed and paid annually in semi-annual payments from the treasury of the Commonwealth into the treasury of the Massachusetts Agricultural College.

SECTION 4. This act shall take effect on the first day of July in the year eighteen hundred and ninety-seven.

The above law simply provides for collecting and analyzing the samples and for the publication of the results. It prevents the publication of the names of the jobbers or local dealers selling the feed stuffs. It was the best that could be procured at the time. In the light of our experience, it is believed that this law should be changed and a more comprehensive one made, with the following points emphasized: —

1. An explicit statement of those feed stuffs included and those not included within the law.

2. The tagging of each package with the brand, name and place of business of the manufacturer or sponsor, net weight, and a guaranty of protein, fat and fibre.

3. The prohibiting of adulteration of any grain or recognized by-product with any foreign material whatsoever, unless the name and quantity of said material is clearly specified on the package.

4. The filing upon request by each manufacturer of a certified sample of each distinct brand of feed stuff offered for sale.

5. Instructions concerning the collection and analyzing of the feed stuffs and the publication of the results.

6. A penalty for obstructing an agent in the collecting of samples, and for selling articles which are not as represented.

7. The appropriation from the State treasury of at least double the sum now appropriated for the purpose of carrying out the provisions of the new law.

Laws similar to the one outlined are now in operation in Maine, New Hampshire, Vermont, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland and Wisconsin. It is believed that the enactment of a law including the points outlined above would be for the true interest of producers and consumers alike.

E. Dairy Legislation.

The Massachusetts Legislature during the session of 1901–1902 passed the following law: —

[Chapter 202.]

An Act to provide for the protection of dairymen.

Be it enacted, etc., as follows:

Section 1. All bottles, pipettes or other measuring glasses used by any person, firm or corporation, or by any employee or agent thereof, at any creamery, cheese factory, condensed milk factory, milk depot, or other place, in this state, in determining by the Babcock test, or by any other test, the value of milk or cream received from different persons or associations at such creameries, factories or milk depots as a basis of payment for such milk or cream, shall before use be tested for accuracy. Such bottles, pipettes or measuring glasses shall bear in ineffaceable marks or characters the evidence that such test has been made by the authority named in section two of this act. No inaccurate bottles, pipettes or glasses shall bear such marks or characters, but when found inaccurate shall be marked "Bad."

Section 2. It is hereby made the duty of the director of the Hatch Experiment Station of the Massachusetts Agricultural College, or of some competent person designated by him, to test all bottles, pipettes or other measuring glasses, as required by section one of this act. The director of the experiment station shall receive for such service the amount of the actual cost incurred, and no more, the same to be paid by the persons or corporations for whom it is rendered.

Section 3. Within six months after this act takes effect, and once each year thereafter, the director of the Hatch Experiment Station, or his authorized agent, shall inspect at the expense of the owners all centrifugal or other machines used by any person, firm or corporation, or by any agent or employee thereof, for the testing of milk or cream in fixing the value thereof; and the director of the experiment station or his authorized agent shall cause all such machines to be put into condition to obtain accurate results with the Babcock test or other tests, at the expense of the owners thereof. Such machines may be replaced by new ones at the option of the persons to whom they belong.

SECTION 4. No person shall, either by himself or in the employ of any other person, firm or corporation, manipulate the Babcock test, or any other test, whether mechanical or chemical, for the purpose of measuring the butter fat contained in milk or cream as a basis for determining the value of such milk or cream, or of butter or cheese made from the same, without first obtaining a certificate from the director of the Hatch Experiment Station that he or she is competent to perform such work. Rules governing applications for such certificates and the granting of the same shall be established by the said director. The fee for issuing such a certificate shall in no case exceed two dollars, the same to be paid by the applicant to the said director, to be used in meeting the expenses incurred under this act.

SECTION 5. It shall be the duty of the director of the Hatch Experiment Station to test farmers' samples of milk or cream by the Babcock method, and report the results of each test, the cost of such test to be paid by the farmer. The director shall also test by the Babcock method, samples of milk or cream sent from any creamery, factory or milk depot in the state by its proper representative, the actual cost of such tests to be borne by the sender. The experiment station shall publish and distribute such information concerning the Babcock test, and the taking and forwarding of samples, as it deems necessary under this section.

SECTION 6. Any person violating any provision of this act shall be fined not more than twenty-five dollars for the first offence and not more than fifty dollars for each subsequent offence.

SECTION 7. This act shall take effect on the first day of July in the year nineteen hundred and one. [*Approved March 26, 1901.*

The execution of the above law having been referred to this division, a circular was prepared, giving the text of the law, together with such rules and regulations as it seemed wise to make for the carrying out of its several provisions. There seeming to be doubt in some instances as to whom the law applied, the following interpretation was made, which is believed to be correct and in accordance with the spirit of the law: —

1. All parties employing the Babcock or similar test

simply as a protection against adulteration, the results of which in no way affect the price of milk or cream to either the producer or consumer, shall be considered exempt from the law.

2. All parties employing the Babcock or similar test (as described in section 4) for the purpose of measuring the butter fat contained in the milk or cream, as a basis for determining or fixing the value of such milk or cream (to either producer or purchaser), shall be considered subject to the requirements of the law.

The law practically resolves itself into three sections: (1) the testing of glassware for accuracy of graduation: (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — The scale on the neck of the cream, whole and skim milk bottles is tested for accuracy of graduation by the mercury method, as described by Farrington & Woll in their work entitled "Testing milk and its products." Pipettes and acid measures are tested for accuracy by carefully measuring the amount of water they deliver. The following limits of error were adopted: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30-35-40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	:25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.10
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	-	.10
Pipettes, milk,	17.60	-	.10
Acid measures,	17.50	-	.20

All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast, working under twenty-five pound pressure. The necessary air pressure for the blast is obtained by a double-acting power air pump,* with a thirty-gallon reservoir.

It became necessary at first to test the ware in use by all creameries and milk depots. Now, practically none is received from these sources, but rather from the large supply houses, who furnish tested ware whenever requested. There has been examined to date 5,041 pieces, of which 291 pieces, or 5.77 per cent., have been found to be incorrect. One order from a large supply house, numbering 441 pieces, contained 149 pieces, or 33.8 per cent., incorrectly graduated. The wisdom, therefore, of this section of the law is apparent without further argument.

Manufacturers are now inclined to be more careful concerning the quality and accuracy of glassware supplied, for the reason that a large part is examined by the several experiment stations before coming into the hands of the users.

Examination of Candidates.† — It seemed wise to require candidates to present themselves at the station laboratory for examination. In all, 45 candidates have been examined to date. Scarcely any were found to be free from faults, but the larger number appeared to understand the general principles of manipulation. A few were noticeably careless, and had but an imperfect understanding of the process. As much instruction as possible was given in the time at our disposal, an especial effort being made to correct the serious faults. In furtherance of this idea, the following circular concerning the points especially to be observed in making the test was printed, and a copy given to each party examined: —

1. Milk or cream should be carefully and thoroughly mixed, — *never* by shaking the sample, but by gently rotating it and by pouring from one vessel to another. All cream adhering to the

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* No. 3, A. Babcock & Bishop Company, New York.

† The inspection of the glassware and the examination of candidates were largely in charge of Mr. E. B. Holland, who gave these matters very careful attention.

sides and stopper of the retaining vessel must be incorporated, and the resulting mixture should show no solid particles of fat. A small fine wire sieve is of great value in detecting the imperfect (lumpy) condition of a sample and in preparing the same for pipetting.

2. Pipette immediately after preparing the sample, filling the pipette *slowly*, and taking care to avoid air bubbles. Hold the pipette in a *vertical* position when lowering the liquid to the mark, and always read with the entire meniscus above the line. In transferring milk or cream to the test bottles, avoid, so far as possible, the smearing of the entire neck with the liquids.

3. Cream testing above 25 per cent. of fat should always be weighed, as accurate results cannot be secured with the pipette.

4. In adding the acid, turn the bottle so as to wash down all milk or cream adhering to the sides of the neck, and mix at once. Rotate the bottle until all the lumps of casein are thoroughly dissolved, and the resulting mixture is *black* in color. Never slight the mixing, and avoid throwing the fat up into the neck.

5. Whirl at least five, two, and two minutes. In filling with hot water, allow the water to run down the sides of the neck, and thus avoid stirring up the contents of the bottle.

6. In reading the column of fat, it is safer to use a pair of dividers than to trust to the unaided eye; read the *centre* of the fat column from the *lowest* to the *highest* limit.

Inspection of Machines. — The inspection of Babcock machines, in accordance with section 3 of the law, is now in progress. Mr. Nathan J. Hunting, a graduate of the college in the class of 1901, is charged with the execution of this work. It is not possible at present to make any definite report, other than to state that a number of machines have thus far been condemned and others have been ordered repaired.

F. Miscellaneous.

Under this heading it is desired to call attention to the compilation of analyses of cattle feeds and dairy products prepared by Messrs. Holland and Smith, and published as Part III. Tables of a similar character were printed in the ninth report of this station. The present compilation — representing the analysis of different substances made since the establishment of the Massachusetts State Experiment

Station — has been thoroughly revised, and some feeds that are no longer on the market or were of only temporary interest have been omitted. This is especially true of a number of concentrated by-products, where the process of manufacture has been noticeably changed and improved.

Tables showing the coefficients of digestibility of all American feed stuffs, similar to those published in the ninth report, are also presented. Work of this nature requires a great amount of time, and severely taxes the resources of the station staff.

Part II. — Dairy and Feeding Experiments.

J. B. LINDSEY.*

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

Experiments of this character have been in progress since 1898. A general outline of those previously completed will be found in the preceding (thirteenth) report of this station (pages 14–33).

During the autumn and winter of 1900–1901 another series was conducted, for the purpose of noting particularly the effect of cotton-seed meal with a minimum amount of oil, and likewise with the addition of cotton-seed oil, on the relative proportions of the several ingredients in milk and butter fat and on the body of the butter. It is intended at present only to briefly outline the character of the experiment, and to call attention to a few of the more important facts; the full data will be published later.

Plan of Experiment. — Ten cows were divided into two herds of five each. During the first period both herds received the same or so-called standard ration. During the three subsequent periods Herd I. continued to receive the standard ration as in the first period, and in case of Herd II. a portion of the standard ration was replaced by cotton-seed meal, cotton-seed oil and Cleveland flax meal.

Table I. — *Duration of Experiment.*

Periods.	Dates of Experiment.	Length in Weeks.
First period, both herds standard ration, . .	Nov. 17 through Dec. 7,	3
Second period, Herd II., cotton-seed ration, .	Jan. 5 through Feb. 8,	5
Third period, Herd II., cotton-seed oil ration, .	Feb. 23 through April 6,	6
Fourth period, Herd II., Cleveland flax meal ration.	April 20 through May 16,	4

* Together with E. B. Holland, P. H. Smith, Jr., and J. W. Kellogg.

TABLE II. — *Approximate Daily Rations (Pounds).*

First period: both herds, standard ration.

HERDS.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I.,	9	-	-	-	8-12	10
Herd II.,	9	-	-	-	8-12	10
Second period: Herd I., standard ration; Herd II., cotton-seed ration.						
Herd I.,	9	-	-	-	8-12	10
Herd II.,	5	3	-	-	8-12	10
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.						
Herd I.,	9	-	-	-	8-12	10
Herd II.,	5	3	.5	-	8-12	10
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.						
Herd I.,	9	-	-	-	8-12	10
Herd II.,	4	-	-	3	8-12	10

The standard ration consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meal. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter. It was intended to secure cotton-seed meal with a minimum percentage of oil, but, in spite of all efforts, the lowest obtainable contained 8 per cent. The extra cotton-seed oil fed in the third period was mixed with the grain ration.

Table III. — *Average Composition of Milk.*

First period: both herds standard ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.15	5.00	9.15	.538	.73
Herd II., ...	14.27	4.93	9.34	.546	.72
Second period: Herd I., standard ration; Herd II., cotton-seed ration.					
Herd I., ...	14.16	5.06	9.10	.550	.73
Herd II., ...	14.30	4.98	9.32	.562	.71
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.					
Herd I., ...	14.22	5.05	9.17	.557	.73
Herd II., ...	14.75	5.40	9.35	.565	.72
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.					
Herd I., ...	14.32	5.12	9.21	.565	.74
Herd II., ...	14.81	5.06	9.75	.616	.74

Composite samples of milk were taken from each herd for five days in each week, and tested for total solids, fat, nitrogen and ash. The milk from each herd showed no noticeable variations in composition during the first two periods. In the third, or cotton-seed oil period, the milk of Herd I. remained as in the preceding periods, while the total solids and fat of Herd II. showed an increase of about .40 per cent. at the beginning of the period, and this increase maintained itself until the close of the period. The solids not fat, nitrogen and ash remained unchanged. In the fourth, or Cleveland flax meal period, the milk from Herd I. remained practically unchanged, increasing a trifle in all ingredients, due to advanced lactation. In case of the milk from Herd II. the fat decreased to the percentage produced in the second period (before the cotton-seed oil was fed), while the total solids remained as high as in the cotton-seed oil period. The solids not fat and the nitrogen showed a noticeable increase. The increase of the nitrogen percentage apparently explains why the total solids did not show the same relative decrease as did the total fat. The ash remained unaffected.

TABLE IV. — *Average Analysis of Butter Fat.*

First period: both herds standard ration.

Number Samples, Each Herd.	Saponification Equivalent.		Insoluble Acids.		Reichert Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
6 samples, .	229.3	231.8	88.95	88.72	29.02	30.54	33.44	32.46	28.28	29.29
Second period: Herd I., standard ration; Herd II., cotton-seed meal ration.										
10 samples, .	228.7	230.3	88.03	87.81	29.08	30.32	33.75	34.10	27.98	29.58
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.										
12 samples, .	233.3	225.3	88.19	88.57	28.97	28.82	34.04	36.46	27.35	33.78
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.										
8 samples, .	228.9	228.4	-	-	28.08	26.81	34.04	33.42	29.21	29.87

It will be seen that, excepting for minor variations, the butter fat produced by Herd I. remained unchanged throughout the several periods. In the cotton-seed meal period the fat produced by Herd II. increased a little in its melting point, but otherwise no particular change is noted. In the cotton-seed oil period the fat in case of Herd II. showed a decrease in its Reichert Meissl number and a noticeable increase in the melting point and iodine number, as compared with previous periods. In the Cleveland flax meal period the butter fat produced by Herd II. became similar in composition to that produced by Herd I., excepting the Reichert

Meissl number, which somewhat decreased. This decrease in volatile acids was also noticed in a previous experiment, when linseed meal was fed with apparently unsatisfactory results, so far as the quality of the butter was concerned.

Two lots of butter were made weekly, the same conditions prevailing in case of each herd. These butters were scored by W. A. Gude of New York and O. Douglass of Boston: —

TABLE V. — *Average Butter Scores.*

Scorers.	Flavor.		Body.		Color.		Salt.		Style.		Total.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds standard ration.												
Gude, .	36.5	38.0	24.8	24.6	15.0	15.0	10	10	5	5	91.3	92.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.6	93.7
Second period: Herd I., standard ration: Herd II., cotton-seed meal ration.												
Gude, .	36.8	37.3	24.5	24.8	14.9	14.8	10	10	5	5	91.2	91.9
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.8	94.1
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.												
Gude, .	36.9	37.0	24.1	24.6	14.9	15.0	10	10	5	5	90.9	91.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	92.7	93.1
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.												
Gude, .	36.0	35.0	25.0	24.7	15.0	15.0	10	10	5	5	91.0	89.7
Douglass, .	-	-	-	-	-	-	-	-	-	-	91.6	90.1
Standard Score.												
Gude, .	45.0	45.0	25.0	25.0	15.0	15.0	10	10	5	5	100.0	100.0
Douglass, .	50.0	50.0	20.0	20.0	15.0	15.0	10	10	5	5	100.0	100.0

So far as the judgment of practical scorers is concerned, little difference was noted in the flavor and body of the butter made from the different rations. The butter made from the cotton-seed meal and from the cotton-seed oil rations appears to have been a trifle more satisfactory, on the whole, than that made from the standard ration, and that made from the Cleveland flax meal ration a trifle less so. Judging from the remarks of Mr. Gude, the tendency of the standard ration and the cotton-seed meal ration was to produce a hard, crumbly butter, which the cotton-seed oil counteracted, causing it to become softer and more yielding in its nature.

The observation of the writer was that the butter produced by the cotton-seed meal ration was a little softer than that produced by the standard ration.

The butter produced by the cotton-seed oil ration was noticeably softer and more yielding than that produced by the standard ration. The difference was not sufficient to render the former butter objectionable, from a commercial stand-point. At a temperature of 80° F. the standard ration butter stood up well and could be handled, although somewhat soft; while the cotton-seed oil butter was handled with difficulty, appearing to have lost its consistency or body.

The butter produced by the flax meal ration was not noticeably different from that produced by the standard ration butter. Most of the cows during this period were in advanced stage of lactation, so that the results obtained are not particularly satisfactory.

TABLE VI. — *Average Degrees of Penetration (Millimeters).*

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.7	4.6	4.5	4.4	4.4	5.0	5.2	5.4

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped from a definite height. No differences were noted excepting in the third period, when the plunger penetrated deeper into the butter produced by the cotton-seed oil, showing its more yielding character.

Results. — The following are the most important results :—

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

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

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

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

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

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

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

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

B. Notes on Summer Forage Crops.

J. B. LINDSEY.

This division has carried on experiments with green crops for a number of years, in order to ascertain those best suited to local conditions for summer forage. The results of these observations were published in Bulletin No. 72, issued in the spring of 1901. Observations with a number of crops have been continued the past season.

Wheat and Winter Vetch. — This is one of the earliest spring forage crops. It has been grown at this station for two consecutive years, with very satisfactory results. A full description of the crop and method of cultivation is found in the above bulletin. About one-third of an acre was seeded the first of the present September, and has made an excellent growth and promises well for the coming season. The experience obtained with this mixture leads to the conclusion that it is decidedly preferable to winter rye for early forage, although not ready to cut until a week later. The vetch thus far has proved perfectly able to withstand the winter. The digestibility of this mixture, both green and in the form of hay, has been made, but the results are not yet available for publication.

Corn and Cow Peas. — It has been the intention, so far as practicable, to grow mixtures of legumes and non-legumes, in order to increase the amount of protein in the several forage crops. For a number of years corn and medium green soy beans have been grown together quite successfully. The past season Longfellow corn and black cow-peas were sown together in rows three and one-half feet apart, with an Eclipse corn planter, at the rate of ten quarts of corn and seven quarts of peas to the acre. The soil was rather of a light loam, and somewhat sensitive to drought. The rainfall proved sufficient, and the yield was heavy, being at the rate of twenty-three tons to the acre. The peas spread out, nearly covering the space between the rows, twining themselves at the same time about the stalks of corn. The crop was harvested with some difficulty, because of its tangled condition, but proved quite satisfactory for green fodder. This mixture, as well as that of corn and soy beans, will be grown again the coming season. It is believed that such fodder combination will enable the farmer to get along with less purchased grain.

Barnyard Millet. — Several plots of this fodder were grown and fed the past season. The results fully confirm the opinion concerning this crop expressed in last year's report. Its chief value is unquestionably for green forage. The first crop, sown about the middle of May, can be cut as early as July 15 to 20, and if successive seedings are made, green forage may be had until into September. Cutting should begin just before the heads appear, and the crop is at its best for eight to ten days thereafter. After it is headed it becomes tough, and animals refuse quite a portion of it. In order, therefore, to secure green fodder from such a source for a considerable period, it is necessary that small pieces of ground be seeded every ten days. This millet succeeds best upon warm, rather heavy, moist, fertile soils. Such conditions favor the production of sixteen to twenty tons to the acre, and even larger yields have been reported. Upon light soils the writer prefers corn, or corn and beans, for a soiling crop, after August 15. The millet when in blossom is probably as nutritious as corn fodder at the same stage of growth. Corn fodder, however, can be grown until more or less eared, and still be readily eaten, and in this condition the corn will naturally have a superior feeding value.

Barnyard millet is unsuited for hay, and is only to be preferred to corn for silage when for any reason it is not possible to secure a crop of corn.

Part III. — Compilation of Analyses of Fodder Articles and Dairy Products, made at Amherst, Mass., 1868–1901.

Prepared by E. B. HOLLAND and P. H. SMITH, JR.

A. Composition and Digestibility of Fodder Articles.
- I. — Green fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Mixed and miscellaneous.
- II. — Silage.
- III. — Hay and dry, coarse fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Straw.
  - (*e*) Mixed and miscellaneous.
- IV. — Vegetables, fruits, etc.
- V. — Concentrated feeds.
  - (*a*) Protein.
  - (*b*) Starchy.
  - (*c*) Poultry.

B. Fertilizer Ingredients of Fodder Articles. (For classification, see A and C.)

C. Analyses of Dairy Products.

A. Composition and Digestibility of Fodder Articles.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition: Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition: Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility: Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility: Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I.—Green Fodders.																			
(a) Meadow Grasses and Millets.																			
Johnson grass (*Andropogon halepensis*),	1	75*	1.4	1.2	8.9	13.2	0.3	4.6	35.7	53.0	1.2	-	-	-	-	-	-	-	-
Orchard grass, ...	7	70	2.1	2.9	10.4	13.7	0.9	9.7	34.8	45.6	3.0	-	-	-	-	-	-	-	-
Tall oat grass, ...	4	70	1.6	2.3	10.8	14.7	0.6	7.5	36.0	49.0	2.2	-	-	-	-	-	-	-	-
Japanese millet (variety uncertain), .	3	80	1.1	1.2	7.1	10.2	0.4	6.0	35.4	50.9	2.1	-	-	-	-	-	-	-	-
Pearl millet (*Pennisetum spicatum*), .	1	75	1.7	1.8	8.6	12.6	0.3	7.2	34.4	50.5	1.0	-	-	-	-	-	-	-	-
Fox-tail millets. Common millet (*Chætochloa italica*), .	16	75	1.2	1.9	8.1	13.2	0.6	7.4	32.4	52.7	2.5	1.2	5.8	9.0	0.4	4.7	23.0	35.8	1.7†
Fox-tail millets. Canary bird seed millet (*Chætochloa italica*).	1	80	1.6	1.0	7.1	10.0	0.3	5.0	35.5	50.0	1.5	-	-	-	-	-	-	-	-
Fox-tail millets. Early harvest millet (*Chætochloa italica*),	1	80	1.4	1.1	7.4	9.7	0.4	5.5	37.0	48.5	2.0	-	-	-	-	-	-	-	-
Fox-tail millets. Golden millet (*Chætochloa italica*), . .	1	75	1.5	1.0	8.7	13.4	0.4	4.0	34.8	53.4	1.6	-	-	-	-	-	-	-	-
Fox-tail millets. Hungarian grass (*Chætochloa italica*), .	3	75	1.8	2.4	7.2	13.1	0.5	9.8	28.6	52.3	2.0	1.5	5.1	8.9	0.3	6.3	20.3	35.6	1.3
Fox-tail millets. Japanese millet (*Chætochloa italica*), .	12	80	1.2	1.7	6.2	10.5	0.4	8.2	31.2	52.5	2.0	1.0	4.1	7.1	0.3	5.0	20.6	35.7	1.3‡
Barnyard millet (*Panicum crus-galli*), .	7	80	1.7	1.9	6.5	9.5	0.4	9.5	32.5	47.6	1.9	1.2	4.3	6.5	0.3	5.8	21.5	32.4	1.2

Broom-corn millets. Millet (*Panicum miliaceum*),	1	80	1.1	1.1	5.3	11.7	0.8	5.8	26.5	58.4	3.8	-	-	-	-	-	-	-	-
Broom-corn millets. Broom-corn millet (*Panicum miliaceum*),	1	80	1.2	1.3	6.4	10.7	0.4	6.5	32.0	53.5	2.0	-	-	-	-	-	-	-	-
Broom-corn millets. Japanese broom-corn millet (*Panicum miliaceum*).	2	80	1.2	0.9	6.2	11.4	0.3	4.5	31.0	57.0	1.5	-	-	-	-	-	-	-	-
Broom-corn millets. Hog millet (*Panicum miliaceum*),	1	80	1.4	1.5	6.5	10.2	0.4	7.5	32.5	51.0	2.0	-	-	-	-	-	-	-	-
(*b*) *Cereal Fodders.*																			
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	12.9	37.6	38.1	2.8	2.3	5.7	6.8	0.4	9.3	22.9	27.1	1.7
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	10.4	29.0	52.8	2.8	1.9	4.5	9.4	0.4	7.5	17.7	37.5	1.7§
Corn fodder,	39	80	0.9	1.6	4.5	12.6	0.4	8.0	22.5	63.0	2.0	1.0	2.7	9.3	0.3	4.8	13.5	46.6	1.5
Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	7.1	24.4	60.0	2.4	-	-	-	-	-	-	-	-
Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	13.8	30.0	45.0	3.1	2.5	4.0	7.1	0.6	9.9	15.9	28.4	2.1
Oats in bloom,	1	75	1.7	1.6	9.0	12.0	0.7	6.5	36.0	48.1	2.8	-	-	-	-	-	-	-	-
Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	10.9	34.4	45.9	2.7	-	-	-	-	-	-	-	-
Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	6.1	36.4	48.7	2.6	-	-	-	-	-	-	-	-
Rye,	2	75	1.4	1.9	8.0	13.2	0.5	7.5	31.8	52.9	2.1	1.4	4.6	8.8	0.3	5.4	18.1	35.4	1.3‖
Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	10.7	33.0	47.3	2.6	-	-	-	-	-	-	-	-
(*c*) *Legumes.*																			
Alfalfa (*Medicago sativa*),	6	75	2.0	3.4	7.7	11.4	0.5	13.6	30.7	45.8	1.9	-	-	-	-	-	-	-	-
Horse bean (*Faba vulgaris*),	1	85	0.9	2.5	4.3	6.9	0.4	16.7	28.6	46.0	2.7	-	-	-	-	-	-	-	-
Soy bean (*Glycine hispida*),	14	75	2.6	4.4	6.8	10.1	1.1	17.5	27.1	40.4	4.6	3.3	3.2	7.4	0.6	13.1	12.7	29.5	2.5¶
Soy bean (early white),	4	75	3.2	4.2	5.6	11.3	0.7	16.7	22.3	45.3	2.7	3.2	2.6	8.3	0.4	12.5	10.5	33.1	1.5

* Water in green fodders varies with stage of growth and rainfall.
† Same coefficients used as for Hungarian grass.
‡ Same coefficients used as for barnyard millet.
§ Same coefficients used as for barley.
‖ Average coefficients for barley and oats.
¶ Same coefficients applied to all soy beans.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — Green Fodders — *Con.*																			
(*c*) *Legumes* — Con.																			
Soy bean (medium green),	1	75	3.3	4.8	5.9	10.0	1.0	19.3	23.7	40.0	4.0	3.6	2.8	7.3	0.5	14.5	11.1	29.2	2.2
Soy bean (medium black),	2	75	3.1	4.7	5.9	10.0	1.3	18.9	23.4	39.9	5.2	3.5	2.8	7.3	0.7	14.2	10.1	29.1	2.8
Soy bean (late),	4	75	3.3	5.7	5.3	10.0	0.7	22.7	21.1	40.0	2.7	4.3	2.5	7.3	0.4	17.0	9.9	29.2	1.5
Alsike clover (*Trifolium hybridum*),	8	75	2.9	4.1	6.8	10.6	0.6	16.5	27.2	42.4	2.5	-	-	-	-	-	-	-	-
Crimson clover (*Trifolium incarnatum*),	2	75	3.5	3.9	7.5	9.5	0.6	15.8	29.8	38.1	2.4	3.0	4.2	7.0	0.4	12.2	16.7	28.2	1.6
Mammoth red clover (*Trifolium medium*),	4	75	2.4	3.8	7.2	11.1	0.5	15.4	28.7	44.2	2.1	-	-	-	-	-	-	-	-
Medium red clover (*Trifolium pratense*),	5	75	2.1	3.5	7.7	11.0	0.7	13.9	30.6	44.1	2.7	2.4	4.1	8.6	0.5	9.3	16.2	34.4	1.7
Sweet clover (*Melilotus alba*),	4	75	2.4	4.7	7.9	9.3	0.7	18.8	31.6	37.2	2.8	-	-	-	-	-	-	-	-
Sand lucern,	1	75	2.4	4.1	5.3	12.5	0.7	16.4	21.2	50.0	2.6	-	-	-	-	-	-	-	-
Cow-pea (*Vigna catjang*),	3	80	1.9	3.4	4.3	9.6	0.8	17.2	21.7	47.8	3.9	2.6	2.6	7.8	0.5	13.1	13.0	38.7	2.3
Canada beauty pea (*Pisum arvense*),	1	80	1.6	3.2	5.8	8.9	0.5	16.1	29.0	44.3	2.7	2.6	3.6	6.3	0.3	13.2	18.0	31.5	1.4*
Canada field pea (*Pisum arvense*),	1	80	1.8	3.9	6.3	7.5	0.5	19.7	31.6	37.2	2.7	3.2	3.9	5.3	0.3	16.2	19.6	26.4	1.4
English gray pea (*Pisum arvense*),	1	80	1.9	4.1	6.1	7.3	0.6	20.6	30.2	36.4	3.2	3.4	3.8	5.2	0.3	16.9	18.7	25.8	1.7

Prussian blue pea (*Pisum arvense*),	1	80	1.8	3.7	6.0	7.8	0.7	18.7	30.0	39.1	3.4	3.0	3.7	5.5	0.4	15.3	18.6	27.8	1.8
Flat pea (*Lathyrus sylvestris wagneri*),	2	80	1.8	5.8	4.9	6.6	0.9	29.0	24.8	32.9	4.3	-	-	-	-	-	-	-	-
Sainfoin (*Onobrychis sativa*),	1	75	2.1	*4.4	6.0	11.6	0.9	17.4	24.0	46.5	3.5	-	-	-	-	-	-	-	-
Serradella (*Ornithopus sativus*),	3	80	2.1	2.9	5.9	8.7	0.4	14.4	29.5	43.3	2.2	-	-	-	-	-	-	-	-
Sulla (*Hedysarum coronarium*),	2	75	2.3	4.3	5.2	12.5	0.7	17.1	20.7	50.2	2.7	-	-	-	-	-	-	-	-
Scotch tares (*Vicia sativa*),	1	80	2.4	3.9	5.7	7.7	0.3	19.5	28.3	38.3	1.7	-	-	-	-	-	-	-	-
Spring vetch (*Vicia sativa*),	3	80	1.7	3.5	6.0	8.3	0.5	17.4	30.2	41.6	2.4	2.5	2.6	6.3	0.3	12.3	13.3	31.6	1.4
Hairy or sand vetch (*Vicia villosa*),	1	80	1.7	4.0	6.3	7.8	0.2	20.0	31.6	38.9	1.1	3.3	3.8	5.9	0.1	16.6	19.3	29.6	0.8
Kidney vetch (*Anthyllis vulneraria*),	1	80	2.7	3.7	3.1	9.8	0.7	18.4	15.3	48.9	3.7	-	-	-	-	-	-	-	-
(*d*) *Mixed and Miscellaneous.*																			
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	13.8	33.8	41.2	3.1	2.2	2.9	5.0	0.4	10.6	14.5	25.1	1.9
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	13.8	32.4	45.2	2.3	-	-	-	-	-	-	-	-
Corn and soy bean,	1	80	1.3	2.7	4.3	11.2	0.5	13.8	21.3	56.1	2.4	-	-	-	-	-	-	-	-
Millet and peas,	1	80	1.8	2.4	7.5	8.0	0.3	12.0	37.5	39.9	1.5	-	-	-	-	-	-	-	-
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	14.1	30.0	44.1	3.0	2.0	4.0	6.7	0.3	10.1	20.1	33.5	1.7
Vetch and oats (1-1),	3	80	1.8	3.0	6.3	8.4	0.5	15.1	31.4	42.1	2.7	2.3	4.3	5.7	0.2	11.3	21.4	28.6	1.3
Vetch and oats (1-4),	1	80	1.8	2.7	6.0	8.8	0.7	13.3	30.0	43.8	3.8	-	-	-	-	-	-	-	-
Wheat and vetch,	2	80	1.5	3.2	6.5	8.2	0.5	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
Apple pomace,	3	83	0.4	1.2	2.9	11.7	0.8	7.1	17.0	68.8	4.7	-	-	-	-	-	-	-	-

* Same coefficients applied to all Canada peas.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition: Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition: Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility: Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility: Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — *Con.*																			
(*d*) *Mixed and Miscellaneous* — Con.																			
Sugar beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	14.0	25.0	59.0	1.0	0.9	2.1	5.0	-	8.8	20.7	49.6	-
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	19.7	14.3	36.8	1.9	-	-	-	-	-	-	-	-
Carrot tops,	1	80	2.8	4.2	2.7	9.9	0.4	21.2	13.6	49.3	2.0	-	-	-	-	-	-	-	-
Prickley comfrey (*Symphytum asperrimum*),	1	87	2.8	2.3	1.5	6.1	0.3	17.7	11.5	46.9	2.4	-	-	-	-	-	-	-	-
Purslane (*Portulaca oleracea*),	1	91	1.5	2.3	1.6	3.4	0.2	25.1	17.7	37.4	2.7	-	-	-	-	-	-	-	-
Dwarf Essex rape (*Brassica napus*),	1	85	2.4	1.9	2.9	7.2	0.6	12.9	19.3	47.8	4.3	1.7	2.5	6.6	0.3	11.5	16.8	43.9	2.1*
Summer rape (*Brassica napus*),	1	85	2.8	2.1	2.7	6.9	0.5	14.3	17.8	45.7	3.6	1.9	2.4	6.4	0.2	12.7	15.5	42.0	1.7
Winter rape (*Brassica napus*),	1	85	3.3	2.3	1.8	7.1	0.5	15.0	12.1	47.1	3.6	2.1	1.6	6.5	0.2	13.4	10.5	43.3	1.7
Sorghum (*Andropogon sorghum*),	6	80	1.4	1.8	5.4	11.0	0.4	8.8	27.0	55.3	1.8	-	-	-	-	-	-	-	-
Spurrey (*Spergula arvensis*),	1	72	2.6	2.9	7.0	15.4	0.1	10.3	25.0	55.0	0.4	-	-	-	-	-	-	-	-
Teosinte (*Euchlæna Mexicana*),	2	70	2.3	2.3	9.4	15.6	0.4	7.6	31.3	52.1	1.2	-	-	-	-	-	-	-	-

II. — Silage.																			
Apple pomace,	1	85	0.6	1.2	3.3	8.8	1.1	8.0	22.0	58.7	7.3	-	-	-	-	-	-	-	-
Corn,	45	80	1.1	1.7	5.4	11.1	0.7	8.5	26.8	55.7	3.5	1.0	3.8	8.4	0.6	4.8	18.8	42.3	2.9
Corn and soy bean,	4	76	2.4	2.5	7.2	11.1	0.8	10.4	30.0	46.3	3.3	1.6	4.7	8.3	0.7	6.8	19.5	34.7	2.7
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	6.5	28.8	52.3	3.1	-	-	-	-	-	-	-	-
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	13.3	34.3	34.3	4.8	1.6	5.0	4.3	0.7	7.7	23.7	20.2	3.5
III. — Hay and Dry Coarse Fodders.																			
(*a*) *Meadow Grasses and Millets.*																			
Barnyard grass (*Panicum crus-galli*),	1	14	8.6	13.1	29.0	33.6	1.7	15.2	33.7	39.1	2.0	-	-	-	-	-	-	-	-
Barnyard millet (*Panicum crus-galli*),	7	14	7.3	8.2	28.0	40.9	1.6	9.5	32.5	47.6	1.9	5.3	17.4	21.3	0.7	6.1	20.2	24.8	0.9
Canada blue grass (*Poa compressa*),	1	14	4.8	5.9	31.3	42.1	0.9	6.9	36.4	48.9	2.2	-	-	-	-	-	-	-	-
Hungarian grass (*Chætochloa italica*),	3	14	6.3	8.4	24.6	45.0	1.7	9.8	28.6	52.3	2.0	5.0	16.7	30.2	1.1	5.9	19.4	35.0	1.3
Italian rye grass (*Lolium italicum*),	4	14	6.4	7.1	28.6	42.2	1.6	8.4	33.2	49.0	1.9	-	-	-	-	-	-	-	-
Kentucky blue grass (*Poa pratensis*),	3	14	6.4	7.7	30.5	39.7	1.7	8.9	35.5	46.1	2.0	4.4	19.2	21.0	0.7	5.1	22.4	24.4	0.9
Meadow fescue (*Festuca elatior pratensis*),	7	14	7.1	5.8	32.2	39.3	1.6	6.8	37.4	45.6	1.9	3.0	21.6	23.2	0.9	3.5	25.1	26.9	1.0
Orchard grass (*Dactylis glomerata*),	7	14	5.9	8.3	29.9	39.3	2.6	9.7	34.8	45.6	3.0	4.9	17.9	21.6	1.4	5.7	20.9	25.1	1.6
Perennial rye grass (*Lolium perenne*),	4	14	7.9	10.1	25.4	40.5	2.1	11.8	29.5	47.1	2.4	-	-	-	-	-	-	-	-
Red top (*Agrostis alba vulgaris*),	6	14	4.6	6.5	28.5	44.9	1.5	7.6	33.2	52.2	1.7	4.0	17.4	27.8	0.8	4.6	20.3	32.4	0.9
Red top (early cut),	1	14	4.3	5.8	30.9	43.3	1.7	6.8	35.9	50.3	2.0	3.5	18.9	26.9	0.9	4.1	21.9	31.2	1.0
Red top (late cut),	1	14	4.1	6.0	31.0	43.2	1.7	7.0	36.0	50.2	2.0	3.7	18.9	26.8	0.9	4.3	21.9	31.1	1.0
Tall oat grass (*Arrhenatherum elatius*),	4	14	4.6	6.4	30.9	42.1	1.9	7.4	36.0	49.0	2.2	3.3	17.0	24.4	1.1	3.8	19.8	28.4	1.2

* Same coefficients applied to all varieties of rape.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition. Fresh or Air-Dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition. Water-Free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Fresh or Air-Dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Water-Free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—Hay and Dry Coarse Fodders — *Con.*																			
(*a*) *Meadow Grasses and Millets* — Con.																			
Timothy (*Phleum pratense*),	8	14	4.2	8.4	28.1	43.4	1.9	9.7	32.7	50.5	2.2	4.0	14.6	26.9	1.0	4.6	17.0	31.3	1.1
Timothy (early cut),	1	14	4.0	5.7	31.0	43.5	1.8	6.6	36.1	50.6	2.1	3.3	18.3	27.8	1.0	3.8	21.3	32.4	1.2
Timothy (late cut),	1	14	3.9	5.2	29.7	45.2	2.0	6.0	34.6	52.6	2.3	2.3	13.9	27.1	1.0	2.7	16.3	31.6	1.2
White top (*Agrostis vulgaris var*),	1	14	6.0	11.2	24.4	41.5	2.9	13.0	28.4	48.2	3.4	6.8	14.9	25.7	1.5	7.9	17.3	29.9	1.7
English hay (mixed grasses),	81	14	5.2	7.9	27.5	43.1	2.3	9.2	31.9	50.1	2.7	4.6	16.5	25.4	1.1	5.3	19.1	29.6	1.3
Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	7.1	32.7	52.4	2.4	-	-	-	-	-	-	-	-
Rowen,	20	14	6.1	10.9	23.6	42.3	3.1	12.7	27.4	49.2	3.6	7.5	15.8	27.9	1.5	8.8	18.4	32.5	1.7
Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	8.3	31.0	51.8	2.2	2.4	8.8	20.5	0.8	2.8	10.2	23.8	1.0
Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	9.8	29.5	50.8	2.6	-	-	-	-	-	-	-	-
Black grass (*Juncus Gerardi*),	3	16	7.4	7.0	24.3	43.1	2.2	8.3	28.9	51.3	2.7	4.1	14.3	22.4	1.0	4.8	17.1	26.7	1.2
Branch grass (*Distichlis spicata*),	2	16	7.6	6.8	22.4	45.1	2.1	8.1	26.6	53.7	2.5	3.8	12.1	22.1	0.7	4.5	14.4	26.3	0.9
Flat sage (*Spartina stricta maritima var?*),	1	16	8.2	6.6	25.0	41.8	2.4	7.8	29.7	49.8	2.9	3.4	15.0	23.0	0.9	4.1	17.8	27.4	1.0

High grown salt hay (largely *Spartina patens*).	1	16	7.0	6.3	22.2	46.4	2.1	7.5	26.4	55.3	2.5	3.8	11.8	24.6	0.8	4.5	13.9	29.3	0.9
Fox grass (*Spartina patens*),	2	16	5.8	6.7	22.5	46.9	2.1	8.0	26.8	55.8	2.5	4.0	11.9	24.9	0.8	4.8	14.2	29.6	0.9
Cove mixture (black grass and red top),	1	16	6.0	7.4	23.2	45.6	1.8	8.8	27.6	54.3	2.1	3.6	13.9	24.2	0.7	4.2	16.6	28.8	0.8
Mixed salt hay (largely fox grass and branch grass).	1	16	8.4	5.5	22.5	45.5	2.1	6.5	26.8	54.2	2.5	2.3	13.1	23.7	0.6	2.7	15.5	28.2	0.7
Salt hay (variety uncertain),	2	16	4.3	3.4	24.0	49.8	2.5	4.0	28.6	59.3	3.0	1.4	13.9	25.9	0.7	1.7	16.6	30.8	0.8
(b) Cereal Fodders.																			
Corn stover, from field,	41	40	3.9	4.6	20.6	30.1	0.8	7.6	34.2	50.2	1.4	1.7	13.2	17.5	0.5	2.7	21.9	29.1	1.0
Corn stover, very dry,	41	20	5.2	6.1	27.4	40.2	1.1	7.6	34.2	50.2	1.4	2.2	17.5	23.3	0.8	2.7	21.9	29.1	1.0
Oats,	6	15	6.9	11.7	25.5	38.3	2.6	13.8	30.0	45.0	3.1	6.8	12.8	13.4	1.6	8.0	15.0	15.8	2.0
(c) Legumes.																			
Alsike clover,	8	15	9.7	14.0	23.1	36.1	2.1	16.5	27.2	42.4	2.5	9.2	12.2	25.6	1.1	10.9	14.4	30.1	1.3
Mammoth red clover,	4	15	8.2	13.1	24.4	37.6	1.7	15.4	28.7	41.2	2.1	-	-	-	-	-	-	-	-
Medium red clover,	5	15	7.4	11.8	26.0	37.5	2.3	13.9	30.6	44.1	2.7	6.8	14.0	24.0	1.3	8.1	16.5	28.2	1.5
(d) Straw.																			
Barley,	2	15	4.8	6.5	32.2	39.0	2.5	7.7	37.9	45.9	2.9	-	-	-	-	-	-	-	-
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	9.8	41.4	37.8	1.5	-	-	-	-	-	-	-	-
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	5.5	42.5	42.7	2.1	-	-	-	-	-	-	-	-
Millet (*Chætochloa italica*),	1	15	5.3	3.6	35.2	39.5	1.4	4.2	41.4	46.5	1.7	-	-	-	-	-	-	-	-
Millet (*Panicum crus-galli*),	1	15	4.6	5.2	30.4	42.7	2.1	6.1	35.8	50.2	2.5	-	-	-	-	-	-	-	-
Millet (*Panicum miliaceum*),	1	15	5.2	3.3	35.9	38.1	2.5	3.9	42.2	44.8	3.0	-	-	-	-	-	-	-	-
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	4.9	41.8	45.1	1.4	-	-	-	-	-	-	-	-
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	7.3	35.9	50.4	1.6	-	-	-	-	-	-	-	-

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition. Fresh or Air-dry Substance.						Composition. Water-free Substance.				Digestibility. Fresh or Air-dry Substance.				Digestibility. Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—Hay and Dry Coarse Fodders —*Con.*																			
(*e*) *Mixed and Miscellaneous.*																			
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	14.4	30.0	44.1	3.0	7.3	16.8	20.3	0.5	8.6	19.8	23.8	0.6
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	15.1	31.4	42.1	2.7	7.7	17.6	19.3	0.4	9.1	20.7	22.7	0.5
Wheat and vetch,	2	15	6.4	13.8	27.7	35.0	2.1	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	7.8	36.1	46.7	2.4	-	-	-	-	-	-	-	-
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	14.8	19.8	54.2	3.0	-	-	-	-	-	-	-	-
IV.—Vegetables, Fruits, etc.																			
Apples,	2	78	0.7	1.0	1.5	18.3	0.5	4.5	6.8	83.2	2.3	-	-	-	-	-	-	-	-
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	13.1	4.1	76.9	0.9	-	-	-	-	-	-	-	-
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	25.7	9.3	54.8	2.3	-	-	-	-	-	-	-	-
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	12.5	5.8	71.7	0.8	-	-	-	-	-	-	-	-

Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	11.0	6.7	75.1	0.7	1.5	0.9	10.5	0.05	10.0	6.7	75.1	0.4
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	11.8	9.1	68.2	1.8	1.0	-	4.2	-	9.1	-	65.5	-
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	11.7	6.7	70.8	0.8	1.0	0.3	7.7	-	8.8	2.9	64.4	-
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	9.1	10.0	70.9	1.8	-	-	-	-	-	-	-	-
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	4.5	10.9	77.3	5.5	-	-	-	-	-	-	-	-
Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	6.5	7.5	75.0	3.5	-	-	-	-	-	-	-	-
Potatoes,	22	80	0.9	2.1	0.5	16.4	0.1	10.2	2.6	82.0	0.5	1.0	-	14.8	-	4.6	-	7.3	.07
Potatoes,	93	80	-	-	-	14.3*	-	-	-	71.5*	-	-	-	-	-	-	-	-	-
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	7.1	10.0	71.5	1.4	-	-	-	-	-	-	-	-
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	11.0	12.0	66.0	2.0	1.4	1.2	6.3	0.2	9.9	12.0	63.4	1.7
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	10.9	11.8	65.5	1.8	1.0	1.0	6.8	0.2	8.7	8.7	62.2	1.5
V. — CONCENTRATED FEEDS.																			
(a) Protein.																			
Cotton-seed meal,	129	7.0	6.5	45.1	6.1	24.2	11.1	48.5	6.6	26.0	11.9	39.7	3.4	14.8	9.4	42.7	3.6	15.9	11.1
Cotton-seed meal (low grade),	31	8.0	4.7	27.1	17.6	35.2	7.4	29.5	19.1	38.3	8.0	-	-	-	-	-	-	-	-
Cleveland flax meal,	19	9.0	5.3	38.3	8.8	36.2	2.4	42.1	9.7	39.8	2.6	32.4	7.0	31.1	2.3	35.8	7.8	34.2	2.5
Linseed meal (new process),	8	9.0	5.8	35.8	8.5	38.0	2.9	39.3	9.3	41.8	3.2	30.4	6.8	32.7	2.8	33.4	7.4	36.0	3.1
Linseed meal (old process),	55	8.5	5.2	35.3	8.5	36.5	6.0	38.6	9.2	39.9	6.6	31.4	4.9	28.5	5.3	34.4	5.2	31.1	5.9
Chicago gluten meal,	49	9.5	1.0	37.2	2.2	47.9	2.2	41.1	2.4	52.9	2.5	32.7	-	43.1	2.1	36.2	-	47.6	2.4
Cream gluten meal,	50	9.0	0.9	34.3	2.2	51.6	2.0	37.7	2.4	56.7	2.2	30.2	-	46.4	1.9	33.2	-	51.0	2.1
King gluten meal (new process),	3	9.0	-†	32.0	-†	-†	2.9	35.2	-	-	3.2	28.2	-	-	2.7	31.0	-	-	3.0

* Starch by inversion. † Not determined.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—Concentrated Feeds—*Con.*																			
(*a*) *Protein*—Con.																			
King gluten meal (old process),	6	7.0	1.2	33.3	1.8	43.6	13.1	35.8	1.9	46.9	14.1	29.3	-	39.2	12.3	31.5	-	42.2	13.3
Buffalo gluten feed,	55	8.5	2.2	26.5	7.2	52.6	3.0	29.0	7.9	57.4	3.3	22.8	5.6	46.8	2.5	24.9	6.2	51.1	2.8
Davenport gluten feed,	2	8.5	1.9	26.2	6.3	53.8	3.3	28.6	6.9	58.8	3.6	22.5	4.9	47.9	2.8	24.6	5.4	52.3	3.0
Glen Cove gluten feed,	11	8.5	0.6	27.2	5.3	55.4	3.0	29.7	5.8	60.5	3.3	23.4	4.1	49.3	2.5	25.8	4.5	53.9	2.8
Golden gluten feed,	1	8.5	0.9	29.4	5.0	53.5	2.7	32.1	5.5	58.5	2.9	25.3	3.9	47.6	2.3	27.6	4.3	52.1	2.4
Marshalltown gluten feed,	3	8.5	-*	27.1	-*	-*	3.2	29.6	-	-	3.5	23.3	-	-	2.7	25.5	-	-	2.9
Bockford Diamond gluten feed,	15	8.5	1.1	25.2	7.1	54.9	3.2	27.5	7.8	60.0	3.5	21.7	5.5	48.9	2.7	23.7	6.1	53.4	2.9
Waukegan gluten feed,	13	8.5	1.1	26.5	7.7	52.8	3.4	29.0	8.4	57.7	3.7	22.8	6.0	47.0	2.9	24.9	6.6	51.4	3.1
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	24.9	10.3	50.4	11.5	15.7	-	37.2	10.1	17.2	-	40.8	11.2
Dried brewers' grains,	5	8.0	3.8	23.1	10.8	49.4	4.9	25.1	11.7	53.7	5.4	18.3	5.7	28.6	4.5	19.8	6.2	31.2	4.9
Wet brewers' grains,	1	77.0	0.7	6.7	3.8	9.8	2.0	29.0	16.7	42.5	8.5	5.3	2.0	5.7	1.8	22.9	8.9	24.7	7.7
Dried distillers' grains (average different brands).†	5	8.0	2.0	27.3	11.1	42.2	9.4	29.7	12.1	45.8	10.2	20.2	-	34.6	8.8	22.0	-	37.6	9.6

Atlas gluten meal,	9	8.0	1.7	31.4	10.9	35.5	12.5	31.1	11.9	38.6	13.6	23.2	-	29.1	11.8	25.2	-	31.7	12.8
Malt sprouts,	2	11.0	5.2	24.6	13.0	43.6	2.6	27.6	14.6	49.0	3.0	19.7	4.3	29.7	2.6	22.1	4.8	33.3	3.0
Wheat middlings (fine and flour),	50	10.0	3.2	18.8	3.2	60.1	4.7	20.9	3.6	66.7	5.2	16.0	1.2	52.9	4.0	17.8	1.3	58.7	4.4
Wheat middlings (coarse, so-called standard).	177	10.0	4.3	17.8	7.0	55.8	5.1	19.8	7.8	61.9	5.7	14.2	2.3	45.2	4.4	15.8	2.6	50.1	4.9
Mixed feed,	368	10.0	5.4	16.8	8.6	54.5	4.7	18.7	9.5	60.6	5.2	-	-	-	-	-	-	-	-
Mixed feed (low grade),	6	9.0	4.3	12.1	16.1	55.4	3.1	13.3	17.7	60.9	3.4	-	-	-	-	-	-	-	-
Wheat bran,	209	10.0	6.4	16.0	10.0	53.0	4.6	17.8	11.1	58.9	5.1	12.5	2.9	36.6	3.1	13.9	3.2	40.6	3.5
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	17.9	11.7	58.4	5.6	-	-	-	-	-	-	-	-
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	17.0	9.6	63.3	3.2	-	-	-	-	-	-	-	-
H-O dairy feed,	10	8.0	3.6	18.0	13.0	53.3	4.1	19.6	14.1	57.9	4.5	14.0	5.3	37.3	3.5	15.3	5.8	40.5	3.8
Buckwheat feed,	1	9.0	5.0	32.3	7.5	37.7	8.5	35.5	8.2	41.4	9.4	-	-	-	-	-	-	-	-
Buckwheat middlings,	1	11.0	4.8	22.7	4.6	50.2	6.7	25.5	5.2	56.4	7.5	-	-	-	-	-	-	-	-
Cocoanut meal,	2	8.0	3.7	20.0	12.0	39.4	16.3	22.4	13.1	42.8	17.7	-	-	-	-	-	-	-	-
Gluten flour,	1	9.0	0.7	38.4	0.2	50.8	0.9	42.2	0.2	55.8	1.0	-	-	-	-	-	-	-	-
Atlantic gluten meal,	1	7.0	1.2	41.1	1.5	46.9	2.3	44.2	1.6	50.4	2.5	-	-	-	-	-	-	-	-
Proteina,	4	8.0	2.5	21.8	10.0	51.1	6.6	23.7	10.9	55.5	7.2	-	-	-	-	-	-	-	-
Sucrene dairy feed,	6	9.0	6.6	16.8	11.7	52.8	3.1	18.4	12.9	58.0	3.4	-	-	-	-	-	-	-	-
Sucrene oil meal,	3	9.0	5.7	23.2	10.7	48.6	2.8	25.5	11.7	53.4	3.1	-	-	-	-	-	-	-	-
Horse beans,	1	14.0	3.8	25.8	7.0	48.6	0.8	30.0	8.1	56.5	1.0	-	-	-	-	-	-	-	-
Red adzinki beans,	2	14.0	3.6	21.0	4.0	56.7	0.7	24.4	4.7	65.9	0.8	-	-	-	-	-	-	-	-
Saddle beans,	1	14.0	5.3	13.0	4.1	49.4	14.2	15.1	4.8	57.4	16.5	-	-	-	-	-	-	-	-

* Not determined.

† See thirteenth report, p. 44.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—Concentrated Feeds—*Con.*																			
(*a*) *Protein*—Con.																			
Soy beans (variety uncertain),	4	14.0	5.1	30.8	4.9	28.2	17.0	35.8	5.7	32.8	19.8	-	-	-	-	-	-	-	-
Soy bean meal,	1	14.0	4.7	32.9	3.7	29.2	15.5	38.3	4.3	33.9	18.0	29.6	1.9	21.0	13.2	34.5	2.2	24.4	15.3
Ground flax seed,	2	7.0	3.5	23.5	5.5	23.3	37.2	25.3	5.9	25.0	40.0	-	-	-	-	-	-	-	-
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	21.0	19.4	54.9	1.8	15.7	4.6	46.4	0.9	17.4	5.0	51.6	1.0
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	53.3	3.8	26.8	11.8	44.6	0.8	22.7	9.6	48.5	0.9	24.7	10.5
(*b*) *Starchy.*																			
Barley kernels,	1	11.0	2.7	10.3	5.5	68.6	1.9	11.6	6.2	77.1	2.1	-	-	-	-	-	-	-	-
Ground barley,	5	13.0	2.3	11.3	5.7	65.8	1.9	13.0	6.5	75.6	2.2	7.9	2.9	60.5	1.7	9.1	3.3	69.6	2.0
Broom-corn seed,	1	14.0	2.2	9.6	7.1	63.6	3.5	11.2	8.3	73.9	4.0	-	-	-	-	-	-	-	-
Broom-corn meal,	1	14.0	2.0	9.6	6.9	64.0	3.5	11.2	8.0	74.3	4.1	-	-	-	-	-	-	-	-
Buckwheat kernels,	1	12.0	1.9	9.9	10.3	63.5	2.4	11.3	11.7	72.1	2.7	-	-	-	-	-	-	-	-
Corn kernels,	32	11.0	1.4	10.8	1.9	70.2	4.7	12.1	2.1	78.9	5.3	-	-	-	-	-	-	-	-
Corn meal,	56	14.0	1.4	9.5	1.9	69.9	3.3	11.0	2.2	81.3	3.9	6.5	-	66.4	3.0	7.5	-	77.2	3.6

Sweet corn kernels,	3	11.0	1.9	12.5	2.4	64.9	7.3	14.0	2.7	72.9	8.2	-	-	-	-	-	-	-	-
Corn and cob meal,	37	11.0	1.4	8.9	6.7	68.4	3.6	10.0	7.5	76.8	4.1	5.0	3.1	60.2	3.0	5.6	3.1	67.6	3.4
Barnyard millet seed,	1	11.0	3.3	12.2	7.6	60.3	5.6	13.7	8.6	67.7	6.3	-	-	-	-	-	-	-	-
Millet seed (variety uncertain),	4	12.0	2.6	11.1	7.7	62.9	3.7	12.5	8.8	71.5	4.2	-	-	-	-	-	-	-	-
Oat kernels,	5	11.0	2.9	12.9	8.5	59.6	5.1	14.5	9.6	66.9	5.7	11.1	2.6	47.1	4.2	12.5	3.0	52.9	4.7*
Ground oats,	3	12.0	3.3	11.4	8.7	60.8	3.8	13.0	9.9	69.1	4.3	8.9	1.7	46.2	3.2	10.1	2.0	52.5	3.6†
Wheat kernels,	7	11.0	1.8	12.4	2.3	70.8	1.7	13.9	2.6	79.6	1.9	-	-	-	-	-	-	-	-
Ground wheat,	1	12.0	1.9	12.1	2.9	69.2	1.9	13.7	3.3	78.6	2.2	-	-	-	-	-	-	-	-
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	9.2	0.4	72.4	6.4	-	-	-	-	-	-	-	-
Cassava starch refuse,	1	12.0	1.6	0.8	6.1	78.8	0.7	0.9	6.9	89.6	0.8	-	-	-	-	-	-	-	-
Cerealine,	4	11.0	2.6	11.1	4.9	62.7	7.7	12.5	5.5	70.5	8.6	8.9	4.0	59.6	6.2	10.0	4.5	67.0	7.0
Cocoa dust,	1	7.0	6.3	14.4	5.5	42.7	24.1	15.5	5.9	45.9	25.9	-	-	-	-	-	-	-	-
Cocoa shells,	1	5.0	8.4	18.0	15.9	50.9	1.8	18.9	16.7	53.6	1.9	-	-	-	-	-	-	-	-
Cocoanut meat,	1	1.0	0.8	9.9	7.5	15.3	65.5	10.0	7.5	15.1	66.1	-	-	-	-	-	-	-	-
Chop feed,	3	11.0	0.8	10.2	12.7	60.1	5.2	11.5	14.3	67.5	5.8	6.8	7.9	50.5	4.3	7.7	8.9	56.7	4.8
Corn bran,	2	11.0	2.0	10.8	12.4	59.8	4.0	12.1	13.9	67.2	4.5	-	-	-	-	-	-	-	-
Corn cobs,	6	8.0	1.3	2.7	31.3	56.2	0.5	2 9	34.0	61.1	0.6	0.5	17.8	27.0	-	0.6	19.4	29.3	-
Corn screenings,	1	11.0	2.1	7.4	2.9	72.6	4.0	8.3	3.3	81.5	4.5	-	-	-	-	-	-	-	-
Corn and oat feed,	47	10.0	3.0	9.1	10.0	64.7	3.2	10.1	11.1	71.9	3.6	6.5	4.8	53.7	2.8	7.2	5.3	59.7	3.1
Corn, oat, and barley feed,	8	10.0	3.1	11.4	8.3	62.4	4.8	12.7	9.2	69.3	5.3	-	-	-	-	-	-	-	-
Cotton hulls,	5	11.0	2.6	5.3	39.7	39.0	2.4	6.0	44.6	43.8	2.7	-	15.9	16.0	2.1	-	17.8	18.0	2.3
Cotton-hull bran,	1	11.0	1.9	2.3	35.0	48.7	1.1	2.6	39.3	54.7	1.2	-	-	-	-	-	-	-	-

* Horses. † Ruminants.

A. Composition and Digestibility of Fodder Articles — Concluded.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — Concentrated Feeds — *Con.*																			
(*b*) *Starchy* — Con.																			
Cotton-seed feed,	4	11.0	3.1	10.5	36.0	35.9	3.5	11.8	40.5	40.3	3.9	5.4	16.6	19.8	3.0	6.0	18.6	22.2	3.4
Flax-seed screenings,	1	7.0	5.4	15.7	16.5	44.5	10.9	16.9	17.8	47.8	11.7	-	-	-	-	-	-	-	-
Hominy meal,	28	9.0	2.6	11.2	4.4	64.5	8.3	12.3	4.8	70.9	9.1	-	-	-	-	-	-	-	-
H-O horse feed,	12	9.0	3.1	12.6	9.8	62.0	3.5	13.8	10.8	68.1	3.9	9.3	3.4	49.0	2.9	10.2	3.8	53.8	3.0
Maizeline,	1	5.0	2.7	10.0	7.9	66.0	8.4	10.5	8.3	69.5	8.9	-	-	-	-	-	-	-	-
Mellin's Food refuse,	1	7.0	3.9	11.4	7.1	67.2	3.4	12.3	7.6	72.2	3.7	-	-	-	-	-	-	-	-
Canada oat feed,	2	7.0	5.4	13.2	24.8	44.7	4.9	14.2	26.7	48.1	5.3	-	-	-	-	-	-	-	-
Oat feed (average quality),	86	7.0	5.2	8.2	20.9	55.7	3.0	8.8	22.5	59.9	3.2	6.6	9.0	37.3	2.7	7.1	9.7	40.1	2.8
Oat feed (low grade),	2	7.0	4.6	2.7	30.2	54.4	1.0	2.9	32.5	58.5	1.1	1.7	9.7	18.0	0.9	1.8	10.4	19.3	1.0
Oat meal,	1	9.0	1.9	16.8	1.1	64.5	6.7	18.4	1.2	70.9	7.4	-	-	-	-	-	-	-	-
Oat middlings,	1	11.0	4.2	10.8	17.4	53.3	3.3	12.1	19.5	59.9	3.7	-	-	-	-	-	-	-	-
Parson's "Six-dollar" feed,	1	11.0	7.9	10.0	17.9	51.1	2.1	11.2	20.1	57.4	2.4	-	-	-	-	-	-	-	-

Pea bran,	2	11.0	2.7	10.0	39.7	35.6	1.0	11.3	44.5	40.0	1.2	-	-	-	-	-	-	-	-
Peanut feed,	2	10.0	2.6	8.9	56.4	16.6	5.5	9.9	62.7	18.4	6.1	6.3	6.2	8.1	5.0	7.0	6.9	9.0	5.5
Peanut husks,	1	13.0	1.2	5.0	66.0	13.1	1.7	5.7	75.9	15.1	1.9	-	-	-	-	-	-	-	-
Quaker dairy feed,	32	8.0	4.6	13.2	16.8	54.3	3.1	14.3	18.3	59.0	3.4	10.7	7.2	36.4	2.8	11.6	7.9	39.5	3.0
Louisiana rice bran,	1	11.0	9.4	8.7	13.3	49.0	8.6	9.8	14.9	55.0	9.7	-	-	-	-	-	-	-	-
Rice meal,	2	11.0	8.2	11.8	5.3	50.8	12.9	13.2	6.0	57.0	14.6	7.3	-	46.7	11.7	8.2	-	52.4	13.3
Rye bran,	2	11.0	4.1	15.6	3.5	63.5	2.3	17.8	4.0	71.3	2.6	-	-	-	-	-	-	-	-
Rye feed,	3	11.0	2.7	13.1	3.2	67.4	2.6	14.7	3.6	75.7	2.9	10.5	-	59.3	2.3	11.8	-	66.6	2.6
Rye middlings,	1	11.0	3.6	11.7	3.3	65.4	5.0	13.2	3.7	73.5	5.6	-	-	-	-	-	-	-	-
Schumacher's stock food,	14	8.0	4.0	11.3	11.8	60.3	4.6	12.3	12.8	65.5	5.0	-	-	-	-	-	-	-	-
Stalk, corn, and cob feed,	1	10.0	2.7	7.5	17.2	60.5	2.1	8.3	19.2	67.2	2.3	-	-	-	-	-	-	-	-
Starch refuse,	2	12.0	1.8	4.8	3.8	76.3	1.3	5.4	4.3	86.7	1.5	-	-	-	-	-	-	-	-
Sucrene chop feed,	1	9.0	6.4	11.4	13.9	56.9	2.4	12.5	15.3	62.5	2.7	-	-	-	-	-	-	-	-
Victor corn and oat feed,	39	10.0	3.5	8.6	11.3	62.9	3.7	9.6	12.6	69.9	4.1	6.1	5.4	52.2	3.2	6.8	6.1	58.0	3.6
Wheat flour,	2	12.0	0.4	9.9	0.1	76.8	0.8	11.2	0.1	87.3	0.9	-	-	-	-	-	-	-	-
(c) Poultry.																			
American poultry food,	14	8.0	2.9	13.1	6.5	63.6	5.9	14.2	7.1	69.1	6.4	-	-	-	-	-	-	-	-
Cut bone,	1	26.0	21.5	20.7	-	0.2	31.6	28.0	-	0.3	42.6	-	-	-	-	-	-	-	-
Raw ground bone,	1	8.0	64.4	23.9	-	3.4	0.3	26.0	-	3.7	0.3	-	-	-	-	-	-	-	-
Cut clover,	2	10.0	6.8	17.9	20.5	41.8	3.0	19.9	22.8	46.4	3.4	-	-	-	-	-	-	-	-
H-O poultry food,	3	9.0	2.7	17.4	4.4	60.2	5.3	19.1	5.9	66.2	5.8	-	-	-	-	-	-	-	-
Meat and bone meal,	26	6.0	37.5	40.6	-	7.5	10.2	43.1	-	8.0	10.9	-	-	-	-	-	-	-	-
Meat scrap,	4	9.0	15.3	49.5	-	5.0	21.2	54.4	-	5.5	23.2	-	-	-	-	-	-	-	-

B. Fertilizer Ingredients of Fodder Articles.*

[Figures equal percentages or pounds in 100.]

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
1.—Green Fodders.					
(a) Meadow Grasses and Millets.					
Hungarian grass,	1	75	0.38	0.52	0.15
Japanese millet,	3	80	0.33	0.22	0.10
Barnyard millet,	3	80	0.30	0.67	0.10
Millet,	1	80	0.29	0.43	0.11
Orchard grass,	4	70	0.43	0.56	0.13
(b) Cereal Fodders.					
Corn fodder,	21	80	0.39†	0.27	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
(c) Legumes.					
Alfalfa,	4	75	0.55	0.39	0.14
Horse bean,	1	85	0.41	0.21	0.05
Soy bean,	1	75	–	0.49	0.14
Soy bean (early white),	1	75	0.71	0.69	0.16
Soy bean (medium green),	1	75	0.70	0.59	0.17
Soy bean (medium black),	1	75	0.88	0.62	0.20
Soy bean (late),	1	75	0.75	0.85	0.18
Alsike clover,	6	75	0.66	0.62	0.19
Mammoth red clover,	3	75	0.63	0.34‡	0.15
Medium red clover,	2	75	0.59	0.62	0.12
Sweet clover,	1	75	0.54	0.50	0.15
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09
Cow-pea,	1	80	0.36	0.20	0.11
Flat pea,	1	80	1.00	0.43	0.13
Small pea,	1	80	0.53	0.41	0.12
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	80	0.48	0.49	0.16

* Most of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably, depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations, rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

† Too high; 0.26 nearer correct. ‡ Evidently below normal.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. — GREEN FODDERS — *Con.*					
(*c*) *Legumes* — Con.					
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	80	0.48	0.60	0.13
Kidney vetch,	1	80	0.59	0.37	0.10
(*d*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	80	0.30*	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver hull buckwheat,	1	85	0.29	0.39	0.14
Carrot tops,	1	80	0.69	1.08	0.13
Prickly comfrey,	1	87	0.37	0.76	0.12
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	7	80	0.27	0.27	0.11
Teosinte,	1	70	0.47	1.18	0.06
II. — SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11
III. — HAY AND DRY COARSE FODDERS.					
(*a*) *Meadow Grasses and Millets.*					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	12	14	1.29	1.52	0.29
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23

* Too low; 0.43 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III.—Hay and Dry Coarse Fodders — *Con.*					
(*b*) *Cereal Fodders.*					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45*	1.90	0.65
(*c*) *Legumes.*					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16†	0.52
Medium red clover,	2	15	2.01	2.11	0.41
(*d*) *Straw.*					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(*e*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	15	1.29‡	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41
IV.—Vegetables, Fruits, etc.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17
Beets, red,	8	88	0.24	0.44	0.09
Sugar beets,	4	86	0.24	0.52	0.11
Yellow fodder beets,	1	89	0.23	0.56	0.11
Mangolds,	3	88	0.15	0.34	0.14
Carrots,	3	89	0.16	0.46	0.09
Cranberries,	1	89	0.08	0.10	0.03
Parsnips,	1	80	0.22	0.62	0.19
Potatoes,	5	80	0.29	0.51	0.08
Japanese radish,	1	93	0.08	0.40	0.05
Turnips,	4	90	0.17	0.38	0.12
Ruta-bagas,	3	89	0.19	0.49	0.12

* Too high; 1.90 nearer correct. † Evidently below normal.
‡ Too low; 1.80 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — CONCENTRATED FEEDS.					
(*a*) *Protein.*					
Cotton-seed meal,	24	7.0	7.22	1.85	2.50
Linseed meal (new process),	5	9.0	5.77	1.24	1.68
Linseed meal (old process),	4	8.5	5.36	1.20	1.77
Chicago gluten meal,	2	9.5	6.05	0.06	0.43
King gluten meal,	1	7.0	5.74	0.08	0.70
Gluten meal (brand uncertain),	5	8.5	5.09	0.05	0.42
Buffalo gluten feed,	5	8.5	4.24	0.06	0.34
Dried brewers' grains,	2	8.0	3.68	0.86	1.06
Atlas gluten meal,	1	8.0	4.97	0.17	0.24
Wheat middlings,	2	10.0	2.79	0.76	1.27
Wheat bran,	10	10.0	2.36	1.40	2.10
Proteina,	1	8.0	3.04	0.58	1.02
Red adzinki bean,	1	14.0	3.27	1.55	0.95
White adzinki bean,	1	14.0	3.45	1.53	1.00
Saddle bean,	1	14.0	2.08	2.09	1.49
Soy bean (variety uncertain),	2	14.0	5.58	2.10	1.97
Soy bean meal,	1	14.0	5.68	2.15	1.51
Pea meal,	1	10.0	3.04	0.98	1.81
Peanut meal,	1	8.0	7.84	1.54	1.27
(*b*) *Starchy.*					
Ground barley,	1	13.0	1.56	0.34	0.66
Corn kernels,	13	11.0	1.82	0.40	0.70
Corn meal,	3	14.0	1.92	0.34	0.71
Corn and cob meal,	29	11.0	1.38	0.46	0.56
Common millet seed,	2	12.0	2.00	0.45	0.95
Japanese millet seed,	1	12.0	1.58	0.35	0.63
Oat kernels,	1	11.0	2.05	-	-
Buckwheat hulls,	1	12.0	0.49	0.52	0.07
Cocoa dust,	1	7.0	2.30	0.63	1.34
Corn cobs,	8	8.0	0.52	0.63	0.06
Cotton hulls,	3	11.0	0.75	1.08	0.18
Oat feed,	1	7.0	1.46	0.72	0.60
Peanut feed,	2	10.0	1.46	0.79	0.23

B. Fertilizer Ingredients of Fodder Articles — Concluded.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — CONCENTRATED FEEDS — *Con.*					
(*b*) *Starchy* — Con.					
Peanut husks,	1	13.0	0.80	0.48	0.13
Louisiana rice bran,	1	11.0	1.42	0.83	1.70
Rye feed,	1	11.0	1.92	0.97	1.54
Rye middlings,	1	11.0	1.87	0.82	1.28
Schumacher's stock feed,	1	8.0	1.80	0.63	0.83
Victor corn and oat feed,	2	10.0	1.38	0.61	0.59
Damaged wheat,	1	13.0	2.26	0.51	0.83
Wheat flour,	2	12.0	2.02	0.36	0.35
(*c*) *Poultry.*					
American poultry food,	1	8.0	2.22	0.52	0.98
Wheat meal,	1	8.0	11.21	0.30	0.73
VI. — DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19*	0.16*
Human milk,	3	88.1	0.24	-	-
Skim-milk,	22	90.3	0.59	0.18†	0.20†
Buttermilk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	-	-

* From Farrington and Woll. † From Woll's handbook.

C. Analyses of Dairy Products.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Solids.			Fat.			Curd (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	3,281	19.55	10.02	13.57	10.70	1.50	4.32	3.54*	-	0.73†
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	-	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84‡	-	1.00
Skim-milk (largely from Cooley process),	358	10.48	7.68	9.20	1.80	0.05	0.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	-	-	-
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	-	-	-
Butter (salted),	117	94.84	83.41	87.56	89.33	77.95	83.31	1.17§	3.17§	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	-	-
Whole-milk cheese,	2	-	-	63.51	-	-	35.83	24.41	-	3.27
Cheese from partially skimmed milk,	2	-	-	60.23	-	-	25.62	31.18	-	3.44
Skim-milk cheese,	2	-	-	55.32	-	-	16.72	34.09	-	4.51
Cheese from skim-milk, with addition of buttermilk,	1	-	-	51.62	-	-	18.35	28.63	-	4.65
Genuine oleomargarine cheese,	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* Average of 297 analyses. † Average of 253 analyses. ‡ Nitrogen. § Average of 115 analyses.

D. Coefficients of Digestibility of American Feed Stuffs. — Experiments made in the United States.

COMPILED BY J. B. LINDSEY, ASSISTED BY NATHAN J. HUNTING.

Experiments with Ruminants.
Experiments with Swine.
Experiments with Horses.
Experiments with Poultry.

Dec. 31, 1901.

Experiments with Ruminants.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.—Green Fodders.									
(a) Meadow Grasses and Millets.									
Barnyard millet in blossom (Mass.),	3	6	67—76 70	- -	45—67 56	58—70 65	71—77 73	65—77 71	54—67 58
Japanese millet, bloom, to early seed (Storrs),	2	3	- -	62—66 64	52—58 55	45—57 50	59—63 62	64—68 67	60—72 68
Hungarian grass, early to late bloom,	3	8	61—71 66	61—74 68	- -	59—72 63	65—76 70	64—71 67	48—85 62
Grass, meadow, young,	1	1	69	-	-	65	74	72	55
Grass, meadow, young, and dried,	1	1	71	-	-	71	77	73	60
Grass, timothy,	1	3	63—65 64	- -	31—33 32	48—48 48	54—53 56	65—67 66	52—54 52
Grass, timothy rowen,	1	2	- -	65—67 66	- -	72—72 72	60—68 64	67—68 68	51—55 52
(b) Cereal Fodders.									
Corn fodder, dent, immature,	4	11	64—74 68	- -	- -	56—80 66	60—76 67	64—79 71	37—83 68
Corn fodder, dent, milk,	3	9	70	-	-	61	64	76	78
Corn fodder, dent, mature,	7	13	66	-	-	53	52	74	76
Corn fodder, dent, mature, B. & W., coarse,	1	2	51—54 52	- -	- -	20—28 24	46—47 46	57—61 59	74—82 78

Corn fodder, sweet, milk stage,	1	2	77—78 77	- -	- -	77—78 77	74—76 75	80—81 81	73—74 74
Corn fodder, sweet, roasting stage,	9	12	- -	67—79 72	22—61 48	52—69 62	54—72 60	73—82 77	62—82 74
Sorghum, blossom,	1	2	73—73 73	- -	- -	51—56 53	74—75 75	78—78 78	81—82 81
Sorghum, Early Amber, past blossom,	1	2	61—62 61	- -	- -	38—42 40	42—45 42	70—71 71	- 67
Sorghum, average both samples,	2	4	67	-	-	46	59	74	74
Barley fodder, bloom,	2	4	- -	62—71 67	- -	69—73 72	49—66 61	69—76 71	56—63 60
Barley fodder, seeds forming,	2	2	- -	66—71 68	40—44 42	67—71 69	47—65 56	- 74	48—50 49
Oat fodder, bloom (?),	1	2	- -	63—65 64	- -	75—76 75	58—63 60	63—63 63	68—71 70
Oat fodder, early seed,	2	3	- -	56—63 60	49—68 60	68—73 71	43—56 51	60—67 62	67—72 69
Rye fodder, heading,	1	2	73—74 74	- -	- -	79—80 79	80—80 80	70—71 71	74—74 74
(c) *Legumes.*									
Clover, red, late blossom,	1	2	65—67 66	- -	- -	66—68 67	52—53 53	76—79 78	63—66 65
Clover, rowen, late blossom,	1	2	- -	60—62 61	- -	61—62 62	51—54 52	64—68 65	60—61 61
Clover, crimson, late blossom,	1	3	- -	68—70 69	- -	77—77 77	54—58 56	74—75 74	63—69 66
Clover, average three samples,	3	7	-	-	-	70	54	72	64
Cow-peas, ready for soiling,	2	4	66—77 68	72—76 74	19—28 23	73—77 76	57—62 60	76—84 81	56—62 59

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I. — Green Fodders — *Con.*									
(*c*) *Legumes* — Con.									
Canada field peas, before bloom,	1	2	68	71—72 71	- -	81—83 82	62—62 62	71—71 71	50—55 52
Canada field peas, bloom to seed,	1	3	60—65 63	- -	40—45 43	79—80 80	40—52 46	72—75 74	45—53 49
Soy beans, variety uncertain, before bloom,	1	2	- -	64—67 66	- -	77—80 79	45—55 50	71—73 72	50—58 54
Soy beans, variety uncertain, seeding,	1	2	- -	61—63 62	- -	68—71 69	38—43 41	72—75 73	49—59 54
Soy beans, medium green, full bloom,	1	2	- -	62—63 63	22—28 25	76—78 77	45—49 47	69—73 71	46—54 50
Soy beans, medium green, seeding,	1	2	- -	67—67 67	16—29 23	74—76 75	49—50 50	75—77 76	54—61 58
Soy beans, medium green, seeding,	1	4	- -	65—69 67	- -	74—78 76	39—44 44	76—81 79	31—46 36
Soy beans, average all trials,	5	12	-	65	?	75	46	75	48
Spring vetch (*Vicia sativa*),	1	2	62—62 62	- -	- 17	71—72 71	42—46 44	75—77 76	57—60 59
Hairy vetch (*Vicia villosa*),	3	12	66—78 71	- -	33—55 44	79—88 83	52—73 63	68—83 76	63—82 72

(d) Mixed and Miscellaneous.									
Oats and spring vetch, bloom,	1	3	65—69 67	- -	49—55 53	73—76 75	65—72 68	66—70 68	42—52 47
Oats and peas, bloom,	2	5	69—72 70	67—69 68	45—52 49	68—82 74	54—70 64	66—77 72	51—74 64
Oats and peas, partly seeded,	3	5	- -	58—70 62	36—63 47	68—83 74	48—67 55	56—67 63	55—74 64
Winter wheat and hairy vetch,	1	3	68—69 68	- -	40—46 44	75—78 77	66—67 67	71—72 72	56—57 57
Barley and peas, bloom,	3	4	- -	55—71 65	52—55 54	73—81 75	38—61 52	56—76 68	54—65 59
Dwarf Essex rape, first growth,	1	2	88—88 88	- -	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2	81	-	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	-	63	89	87	92	48
Skim-milk, with sheep,	1	3	96—102 97	- 100	46—74 62	93—96 94	- -	- 100	- 100
II. — SILAGE.									
Corn silage, dent, immature,	5	13	60—68 64	- -	- -	42—65 54	(?)—78 70	60—70 66	64—85 71
Corn silage, dent, mature,	6	17	60—74 64	- -	- -	45—63 52	45—80 62	63—73 69	78—90 85
Corn silage, dent, stage uncertain,	1	4	53—67 60	- -	- -	19—34 24	43—64 56	61—76 68	55—79 70
Corn silage, dent, Pride of North, mature,	1	2	72—76 74	- -	24—28 26	- 45	72—73 73	81—83 82	72—82 77
Corn silage, flint, mature, small varieties,	4	11	68—78 75	66—80 77	- -	48—73 65	75—79 77	71—83 79	- 82

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II. — SILAGE — *Con.*									
Corn silage, flint, large white, partly eared,	1	2	69—70 70	72—73 72	31—37 34	56—56 56	72—72 72	75—76 76	72—74 73
Corn silage, fine crushed, steers,	1	2	60—68 64	- -	- -	32—44 38	72—78 75	60—70 65	75—77 76
Corn silage, fine crushed, sheep,	1	2	51—56 54	- -	- -	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	-	-	-	45	59	71	86
Corn silage, mature, cooked,	1	1	-	-	-	39	70	75	87
Corn silage, sweet, mature,	1	2	67—70 68	68—72 70	- -	53—55 54	68—74 71	71—73 72	82—85 83
Cow-pea silage, steers,	1	4	59—60 60	- -	- -	57—58 57	50—54 52	72—73 72	62—64 63
Clover silage, late bloom,	1	2	52—52 52	52—54 53	37—51 44	39—40 40	55—55 55	54—58 56	48—60 54
Oat and pea silage,	1	2	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Soy bean silage, goats,	1	2	52—66 59	- -	- -	71—80 76	47—62 55	46—58 52	66—77 72
Soy bean silage, steers,	1	2	50—50 50	- -	- -	54—56 55	42—44 43	61—61 61	47—52 49
Soy bean and barnyard millet silage, sheep,	1	4	54—65 59	- -	- -	55—62 57	61—73 69	54—63 59	69—75 72

Soy bean and corn silage, sheep,	1	3	66—72 69	- -	- -	63—67 65	59—73 65	73—78 75	80—84 82
Silage, mixture of corn, sunflower heads and horse beans.*	1	2	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77
Silage, mixture of corn, sunflowers (whole plant) and horse beans.†	1	2	64—67 65	68—71 69	20—31 26	57—59 58	63—68 65	72—75 74	72—76 74
III.—HAY AND DRY COARSE FODDERS.									
(a) *Meadow Grasses and Millets.*									
Timothy, in bloom,	3	5	56—66 60	56—67 60	- -	50—60 56	56—62 58	57—72 63	51—62 57
Timothy, past bloom,	5	10	47—61 53	48—62 54	- -	39—50 45	37—57 47	56—70 60	35—61 53
Timothy, average all trials,	20	48	56	57	36	48	51	62	51
Timothy, fed with cotton-seed meal, 16 hay, 1 meal,	1	2	52—56 54	- -	17—28 22	24—32 28	46—52 49	61—63 62	36—37 36
Timothy, fed with cotton-seed meal, 12 hay, 1 meal,	1	2	49—55 52	- -	9—30 20	27—38 32	43—51 47	58—62 60	52—54 53
Timothy, fed with cotton-seed meal, 8 hay, 1 meal,	1	2	44—48 46	- -	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy, fed with cotton-seed meal, 4 hay, 1 meal,	1	2	45—46 46	- -	- -	4—4 4	42—43 43	56—75 57	44—66 55
Timothy, fed with cotton-seed meal, 2 hay, 1 meal,	1	2	48—56 52	- -	- 13	- 13	34—44 39	65—71 68	72—74 73
Timothy, fed with cotton-seed meal, 1 hay, 1 meal,	1	2	47—52 49	- -	19—23 21	- -	24—26 25	68—78 73	79—87 83
Timothy, fed with cotton-seed meal, average all trials,	6	12	50	-	16	20	41	62	57
Timothy and clover, poorly cured,	1	2	54—55 55	- -	- -	37—38 38	52—54 53	- 60	- 58

* Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

† Same proportions as above.

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Mixed grasses, rich in protein,	11	46	54—63 60	- -	44—53 48	40—65 59	49—66 60	56—65 61	41—58 50
Mixed grasses, timothy predominating,	2	4	55	-	35	54	58	55	41
Red top,	2	3	58—62 60	59—64 61	- -	60—62 61	61—62 61	59—65 62	44—59 51
Orchard grass, ten days after bloom,	1	1	54	56	-	59	58	54	54
Orchard grass, stage not given,	1	2	57—60 59	- -	- -	60—60 60	60—67 64	55—57 56	55—57 56
Orchard grass, average both samples,	2	3	56	56	-	60	61	55	55
Meadow fescue (*Festuca elatior pratensis*),	1	2	60—61 61	- -	- 46	51—53 52	- 67	58—60 59	53—54 54
Tall oat grass, late blossom (*Arrhenatherum elatius*),	1	2	54—57 55	- -	39—43 41	- 51	53—57 55	56—59 58	54—58 56
Kentucky blue grass (*Poa pratensis*),	1	1	56	-	42	57	63	53	43
Canada blue grass (*Poa compressa*),	1	2	62—63 62	- -	42—42 42	43—44 43	70—71 71	63—63 63	36—39 37
Rowen, mixed grasses,	3	12	- -	63—68 65	- -	- 70	62—72 66	60—69 65	44—51 47
Rowen, chiefly timothy,	1	4	- -	62—67 64	- -	66—69 68	62—73 66	60—65 63	48—51 49

Rowen, average all trials,	4	16	-	65	-	69	66	64	47
Pasture grass,	1	3	73	73	52	73	76	74	67
Meadow, swale or swamp,	1	2	38—40 39	- -	- -	31—37 34	30—36 33	- 46	- 44
Blue-joint, bloom,	1	2	67—70 69	68—71 70	- -	68—72 70	71—73 72	66—71 69	51—53 52
Blue-joint, past bloom,	1	1	40	42	-	57	37	43	37
Buffalo grass (*Bulbilis Dactyloides*),	1	1	55	-	6	54	65	62	62
Prairie grass (*Sporobolus Asper*),	1	1	56	-	25	18	61	61	57
Johnson grass (*Andropogon halepensis*),	2	3	57	-	-	40	68	57	38
Crab grass, ripe (*Eragrostis Neo Mexicana*),	3	8	47—57 53	- -	29—52 43	30—56 38	50—66 60	50—59 53	30—52 43
Chess or cheat (*Bromus secalinus*),	1	1	45	-	23	42	46	49	32
Black grass (*Juncus Gerardi*),	2	5	50—62 56	- -	67—71 69	53—63 58	50—66 59	46—59 52	37—51 44
Fox grass (*Spartina patens*),	3	7	51—56 54	- -	57—59 58	56—63 60	46—60 53	51—55 53	17—51 36
Branch grass (*Distichlis spicata*),	2	5	49—57 52	- -	- 58	- 56	48—57 54	45—55 49	27—42 35
Salt hay mixture, fox and branch grasses, etc.,	1	2	52—56 54	- -	68—70 69	41—43 42	54—61 58	51—54 52	26—30 28
Flat sage (*Spartina stricta maritima var.*),	1	3	55—58 57	- -	61—62 62	50—55 52	60—61 60	54—57 55	33—40 36
Barnyard millet,	1	3	57—58 57	- -	63—64 63	63—64 61	60—64 62	50—52 52	41—50 46
Millet (*Chætochloa italica*),	1	2	52—58 56	- -	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III.—HAY AND DRY COARSE FODDERS—*Con.*									
(*a*) *Meadow Grasses and Millets*—Con.									
Hungarian,	1	2	64—66 65	66—67 66	- -	- 60	67—68 68	67—67 67	- 64
Golden millet,	1	1	54	-	31	23	56	58	49
Cat-tail millet (*Pennesetum spicatum*),	1	2	61—64 62	- -	- -	61—65 63	65—68 67	58—60 59	45—48 46
(*b*) *Cereal Fodders.*									
Corn stover, average all trials,	6	18	53—62 57	- -	- -	11—55 36	63—74 66	54—64 59	49—77 65
Corn stover,	1	4	53—55 53	56—58 57	- -	11—22 17	63—67 64	54—59 57	69—77 76
Corn stover, without pith,	1	3	54—57 55	55—59 57	- -	16—28 20	60—65 63	55—58 57	70—75 72
New corn product, stover minus pith, ground,	1	3	63—64 63	- -	46—55 49	57—62 60	60—61 61	65—66 66	82—83 83
New corn product, steamed,	1	3	51—59 56	- -	47—55 50	59—60 60	37—54 48	57—62 59	70—85 80
Average three trials, stover minus pith,	3	9	58	-	-	47	57	61	78
Corn stover, tops and blades,	1	2	59—60 60	- -	- -	54—57 55	71—72 71	62—63 62	71—72 71
Corn stover, blades and husks,	1	4	60—68 65	- -	15—35 23	41—55 48	67—76 73	64—71 66	53—64 58

Corn stover, leaves,	1	2	55—56 56	- -	- -	43—69 56	54—67 61	57—61 59	61—65 63
Corn stover, below ear,	1	2	64—69 67	- -	- -	15—27 21	71—75 74	65—73 69	79—80 80
Corn stover, above ear,	1	2	52—58 55	- -	- -	17—27 22	69—72 71	50—57 54	62—65 64
Corn husks,	1	2	71—73 72	- -	- -	24—35 30	78—81 80	- 75	23—42 33
Corn leaves,	1	2	62—67 65	- -	- -	28—41 35	75—80 78	66—70 68	52—59 56
Kafir corn stover, shredded,	1	4	54—58 56	- -	13—26 19	29—34 30	65—69 67	56—60 58	77—81 79
Kafir corn stover,	1	1	63	-	43	50	67	67	60
Kafir corn stover, average all trials,	2	5	57	-	24	34	67	60	75
Flint corn fodder, ears forming,	1	3	69—72 70	71—73 71	- -	69—73 70	72—73 72	71—73 71	63—71 67
Flint corn fodder, mature,	5	11	63—73 70	- -	- -	56—79 64	69—80 76	63—78 71	59—79 71
Dent corn fodder, ears not formed,	4	8	61—70 65	63—71 67	- -	57—67 62	63—77 71	57—70 64	59—72 66
Dent corn fodder, immature, B. & W.,	1	4	51—64 57	- -	- -	20—36 27	45—74 59	57—66 61	66—84 76
Dent corn fodder, in milk,	5	11	59—66 63	- -	- -	41—51 50	50—71 61	61—69 66	67—79 75
Dent corn fodder, mature, ears ground,	2	8	64—70 67	- -	16—30 23	36—47 43	62—73 68	70—77 74	56—77 66
Dent corn fodder, mature,	8	22	57—70 66	- -	- -	30—61 46	43—73 61	61—81 73	56—82 72

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn fodder, flint and dent, mature,	13	33	57—73 67	- -	- -	30—79 52	43—80 66	61—81 72	56—82 72
Corn fodder, sweet, mature,	3	6	60—71 67	62—74 70	- -	54—73 64	70—77 74	57—73 68	63—71 74
Kafir corn fodder,	1	4	59—62 61	- -	5—11 8	34—42 38	56—63 60	64—68 66	57—67 61
Sorghum fodder, leaves,	1	2	60—66 63	- -	- -	59—62 61	65—76 70	62—67 65	46—47 47
Sorghum bagasse,	1	1	61	-	-	14	64	65	46
Oat hay, bloom to milk,	2	6	51—59 55	50—61 55	35—54 45	47—66 57	54—71 58	47—58 53	44—65 53
Oat hay, milk to dough,	4	14	48—60 54	48—61 54	20—54 37	34—60 52	39—62 48	49—62 56	52—72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60
Barley hay,	1	4	59	62	-	65	62	63	41
Oat straw,	1	2	49—52 50	51—53 52	- -	- -	57—58 58	52—55 53	35—41 38

(c) Legumes.								
Alfalfa, first crop, budded to full bloom,	3	6	56—63 59	- -	34—50 42	61—70 65	31—44 40	68—76 72	26—40 35
Alfalfa, second crop, budded to full bloom,	3	6	58—62 60	- -	38—54 46	64—74 70	41—49 44	70—74 72	36—45 42
Alfalfa, third crop,	1	2	56—60 58	- -	40—49 44	68—70 69	28—40 34	71—71 71	38—45 42
Alfalfa, average three crops,	7	14	60	-	44	68	41	72	39
Alfalfa, average all trials,	13	22	61	-	46	70	43	72	43
Alsike clover, full to late bloom,	4	9	55—64 59	56—65 60	- 42	64—71 66	40—59 50	59—74 66	21—69 38
Red clover,	6	15	51—67 58	52—66 54	0—41 28	47—69 59	44—70 56	57—72 65	40—70 58
Clover rowen,	2	4	- -	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60
White clover,	1	1	66	67	-	73	61	70	51
Crimson clover,	3	9	57—65 62	52—58 56	- -	64—73 69	32—58 45	52—74 62	29—54 44
Sand or hairy vetch,	1	6	68—71 69	- -	34—46 42	81—83 82	60—63 61	71—75 73	69—74 70
Soy bean,	1	2	62—63 62	- -	- -	70—72 71	59—62 61	66—71 69	19—40 29
Cow-pea,	1	2	- 59	- -	- -	64—65 65	41—45 43	- 71	46—54 50
Peanut vine,	1	2	59—60 60	- -	- -	63—64 63	51—53 52	69—70 70	62—70 66

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*d*) *Mixed and Miscellaneous.*									
Oat and pea,	2	7	56—67 61	56—67 60	54—65 58	69—78 73	50—64 58	54—66 61	51—69 59
Oat and sand vetch,	1	2	55—55 55	56—56 56	43—46 44	64—66 65	48—50 49	58—59 59	58—67 63
Oat and spring vetch,	2	5	57—63 59	- 60	- 60	60—71 65	47—67 57	34—65 59	17—76 52
Oat and vetch, average,	3	7	58	58	56	65	55	59	55
Wheat and sand vetch,	1	3	64—65 64	- -	33—37 35	70—71 71	63—66 65	67—67 67	62—67 64
Cotton-seed hulls,	4	13	35—47 41	- -	- -	0—25 6	.5—58 47	13—46 34	58—89 79
Cotton-seed feed (4 to 1, sheep),*	2	6	54—60 56	- -	23—35 28	36—45 41	51—60 56	57—60 59	86—94 91
Cotton-seed feed (5 to 1, steers),	1	3	42—45 43	- -	20—24 22	32—41 36	28—33 31	50—59 54	83—86 84
Cotton-seed feed (7 to 1 and 6 to 1, steers),	1	3	45—46 46	- -	- 28	44—46 45	34—40 37	50—51 50	81—82 82
Cotton-seed feed (4 to 1, steers),	1	2	54	-	46	54	45	58	85
Cotton-seed feed (3 to 1 to 2 to 1, steers),	2	9	54	-	32	64	47	54	85
Average both trials (4 to 1),	3	8	56	-	33	44	53	59	90

Average all trials,	7	23	52	–	30	51	46	55	86
Parson's "Six-dollar" feed,	1	2	55—56 56	– –	10—14 12	56—62 59	45—50 47	63—65 64	80—81 81
Wild oat grass (*Danthonia spicata*),	2	3	60—68 64	61—69 65	– –	49—68 58	65—71 68	62—69 65	38—63 50
Witch grass (*Triticum repens*),	2	4	60—63 61	61—64 62	– –	49—64 58	56—68 62	62—70 66	54—60 57
Buttercups (*Ranunculus acris*),	1	2	56	57	–	56	41	67	70
White weed (*Leucanthemum vulgare*),	1	2	58	58	–	58	46	67	62
IV. — ROOTS AND TUBERS.									
Potatoes,	1	3	73—80 77	75—81 78	– –	43—45 44	– –	87—93 91	– 13
Sugar beets,	1	2	94—95 95	98—100 99	– –	90—93 91	88—113 100	100—100 100	40—53 50
Mangolds,	1	2	77—80 79	83—87 85	– –	70—80 75	27—59 43	91—92 91	– –
English flat turnips,	1	2	91—95 93	93—99 96	– –	84—95 90	89—117 100	96—97 97	82—92 88
Ruta-bagas,	1	2	84—90 87	89—93 91	– –	75—86 80	61—87 74	94—95 95	77—92 84
V. — CONCENTRATED FEED STUFFS.									
(*a*) *Protein Feeds.*									
Cotton-seed meal,	2	6	67—82 76	– –	– –	83—96 88	– 32	44—75 64	87—100 93
Cotton-seed, raw,	1	2	63—69 66	– –	– –	66—70 68	65—86 76	49—50 50	– 87
Cotton-seed, roasted,	1	2	53—58 56	– –	– –	44—50 47	62—69 66	50—53 51	68—75 72

* Four hulls to 1 meal.

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS — *Con.*									
(*a*) *Protein Feeds* — Con.									
Cleveland flax meal,	3	9	76—88 83	- 79	- -	- 83	- -	- 79	- 87
New-process linseed meal,	1	3	73—83 78	- -	- -	82—88 85	49—100 74	82—87 84	90—98 93
Average last two,	4	12	81	-	-	84	-	80	89
Old-process linseed meal,	1	3	75—82 79	- -	- -	86—93 89	38—71 57	76—79 78	85—92 89
Chicago gluten meal,	1	2	87—89 88	- -	- -	87—91 89	- -	93—94 93	92—94 93
King gluten meal,	1	2	79—82 81	- -	- -	- 91	- -	78—81 79	91—97 94
Cream gluten meal,	1	2	92—95 93	- -	- -	83—84 84	- -	85—91 88	96—99 98
Average all gluten meals,	4	8	87	-	-	88	-	88	93
Gluten feed,	5	11	85	-	-	85	76	89	83
Germ oil meal,	2	5	72—83 76	- 75	- -	65—77 73	- -	68—82 76	95—98 96
Chicago maize feed,	1	2	83—85 84	- -	- -	83—84 84	68—76 72	84—87 85	90—90 90

Dried distillery grains, brand R,	1	2	56—59 58	– –	– –	56—63 59	– ?	61—73 67	80—88 84
Dried distillery grains, X brands,	4	8	81	–	–	74	?	82	95
Dried distillery grains, Atlas gluten meal,	1	2	80—80 80	– –	– –	73—73 73	– ?	84—85 84	90—92 91
Dried brewers' grains,	1	2	62—62 62	– –	– –	78—81 79	50—55 53	59—59 59	89—93 91
Malt sprouts,	1	1	67	68	–	80	34	69	100
H-O dairy feed,	1	2	64—67 65	– –	– –	76—80 78	39—43 41	67—73 70	83—88 85
Pea meal,	1	2	85—88 87	86—89 88	– –	80—86 83	25—26 26	93—94 94	52—57 55
Soy bean meal,	2	3	75—79 78	– –	– –	89—91 90	0—73 33	68—73 71	81—98 89
Cow-pea meal,	1	2	85—88 87	– –	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Wheat bran, spring,	1	2	62—63 63	– –	– –	78—82 80	22—25 24	70—71 70	76—76 76
Wheat bran, winter,	1	3	57—66 62	– –	– –	75—79 77	– 27	62—76 65	51—80 64
Wheat bran, average all trials,	8	18	62	62	–	77	21	69	66
Wheat middlings, standard,	2	6	–	73	25	77	30	78	88
Wheat middlings, flour,	1	2	79—86 83	– –	– –	82—88 85	33—40 36	84—91 88	82—88 85
Mixed feed, adulterated with corn cobs,	1	3	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92
Rye feed, bran and middlings,	1	3	77—83 82	– –	25—48 35	78—82 80	– –	86—89 88	79—99 90

Experiments with Ruminants — Concluded.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V. — Concentrated Feed Stuffs — *Con.*									
(*b*) *Starchy feeds.*									
Corn meal,	5	14	83—98 89	- 91	- -	40—87 70	- -	85—100 94	71—99 91
Corn and cob meal,	1	3	74—83 79	- -	- -	43—65 52	2—86 45	86—91 88	82—85 84
Kafir corn meal,	2	5	54—76 66	- -	- -	36—62 53	- -	67—84 77	25—62 46
Kafir corn, unground,	2	6	29—58 43	- -	- -	28—54 41	- -	34—62 45	- -
White Kafir heads,	1	4	14—35 24	- -	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Cerealine feed,	1	3	89—92 90	- -	- -	79—81 80	72—92 82	93—97 95	78—83 81
Oats, unground,	2	6	66—74 70	68—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89
Rice meal,	1	2	71—76 74	- -	- -	- 62	- ?	89—95 92	91—92 91
Rye meal,	1	2	85—90 87	- -	- -	83—85 84	- -	89—94 92	63—65 64
Corn bran,	2	4	70—71 70	- -	- -	53—55 54	50—65 59	74—80 77	69—85 77
Rice bran,	1	2	63—66 65	- -	1—4 2	58—68 63	16—42 29	76—81 78	85—92 89

Chop feed, largely corn bran,	2	6	71—92 80	– –	– –	56—77 67	54—70 62	64—92 84	61—86 82
H-O horse feed,	2	3	70—77 74	– 78	–	71—81 75	– –	79—84 82	74—87 81
Corn and oat feed, Victor,	1	3	74—76 75	– –	– –	66—75 71	36—58 48	81—85 83	84—88 87
Oat feed, Quaker,	2	6	62	52	–	72	55	55	72
Oat feed, Royal,	1	3	42—51 47	42—53 48	33—40 37	64—72 69	20—43 33	50—54 51	86—92 88
Oat feed, excessive hulls,	1	3	29—38 34	– –	8—21 13	51—69 62	25—37 32	29—36 33	89—97 92
Oat feed, average last two,	2	6	40	–	25	65	32	42	90
Peanut feed,	1	2	32—32 32	– –	– –	70—71 71	10—13 12	41—58 49	90—90 90
Corn cobs, sheep,	1	2	59—60 59	– –	– –	13—22 17	65—66 65	60—60 60	44—56 50

Experiments with Swine.

Barley meal,	1	1	80	80	–	81	49	87	57
Maize kernels, whole,	1	1	83	83	–	69	38	89	46
Maize meal,	2	2	89—90 90	91—92 92	– –	86—90 88	29—49 39	94—94 94	78—82 80
Maize meal, with cobs,	1	1	76	77	–	76	29	84	82
Old-process linseed meal,	1	4	76—79 77	– –	8—12 10	83—90 86	10—14 12	82—87 85	78—82 80
Pea meal,	1	1	90	92	–	89	78	95	50

Experiments with Swine — Concluded.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Potatoes,	1	4	97	-	-	84	-	98	-
Wheat, whole,	1	2	72	-	-	70	30	74	60
Wheat, cracked,	1	2	82	-	-	80	60	83	70
Wheat shorts (middlings),	1	2	74—79 77	- -	- -	71—75 73	25—48 37	85—88 87	- -
Wheat bran,	1	2	54—78 66	- -	- -	74—76 75	30—39 34	56—75 66	65—78 72

Experiments with Horses.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Corn, whole,	1	2	71—78 74	- -	20—32 26	40—76 58	- -	85—92 88	43—52 48
Corn meal, same as above,	1	2	84—93 88	- -	- -	74—77 76	- -	93—99 96	70—76 73
New corn product,	1	2	40—59 50	- -	6—37 22	65—70 68	38—71 55	39—54 47	48—72 60
Oats, whole,	1	2	67—77 72	- -	31—36 33	84—87 86	13—49 31	75—83 79	80—85 82
Oats, ground, same as above,	1	2	73—78 76	- -	9—49 29	81—83 82	.6—28 14	85—87 86	79—81 80

Average of both,	2	4	74	-	31	84	22	82	81
Hay, timothy,	1	2	39—48 44	- -	29—39 34	18—24 21	37—48 43	44—50 47	44—51 47
Experiments with Poultry.									
Corn, whole kernel,	1	3	- -	- 86	- -	44—58 50	- -	90—96 92	88—95 92
Corn meal,	1	3	- -	- 85	- -	41—55 48	- -	91—92 91	92—94 93
Kafir corn, kernels,	1	3	- -	- 88	- -	50—55 53	17—22 20	94—98 96	71—76 74
Kafir meal,	1	3	- -	- 87	- -	42—44 43	30—42 35	95—97 96	82—84 83
Cow-peas,	1	3	- -	- 71	- -	32—48 40	2—43 18	86—88 87	87—90 89
Cow-pea meal,	1	3	- -	- 72	- -	40—49 44	8—11 10	84—91 88	75—98 89

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