STATE OF CONNECTICUT.

ANNUAL REPORT

OF

The Connecticut Agricultural

~~C. L. Bussing~~
~~1040 Lafayette Ave~~
~~Brooklyn~~

EXPERIMENT STATION

For 1889.

PRINTED BY ORDER OF THE GENERAL ASSEMBLY.

NEW HAVEN, CONN.:
TUTTLE, MOREHOUSE & TAYLOR, PRINTERS.
1890.

OFFICERS AND STAFF FOR 1889.

STATE BOARD OF CONTROL.

Ex-officio.

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R. S. CURTISS, PH.B.

Mycologist.

ROLAND THAXTER, PH.D.

Stenographer and Clerk.

MISS F. M. BIGELOW.

In charge of Buildings and Grounds.

CHARLES J. RICE.

Laboratory Helpers.

HUGO LANGE.
HERRMANN GERCHEWSKI.

ANNOUNCEMENT.

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION was established in accordance with an Act of the General Assembly, approved March 21, 1877, "for the purpose of promoting Agriculture by scientific investigation and experiment."

The Station is prepared to analyze and test fertilizers, cattle-food, seeds, milk, and other agricultural materials and products, to identify grasses, weeds, useful or injurious insects, moulds, blights, mildews, etc., and to give information on various subjects of Agricultural Science, for the use and advantage of the citizens of Connecticut.

The Station makes analyses of Fertilizers, Seed-Tests, etc., etc., for the citizens of Connecticut, without charge, provided—

1. That the results are of use to the public and are free to publish.

2. That the samples are taken from stock now in the market, and in accordance with the Station instructions for sampling.

3. That the samples are fully described and retail prices given on the Station "Forms for Description."

The officers of the Station will take pains to obtain for analysis samples of all the commercial fertilizers sold in Connecticut; but the organized coöperation of farmers is essential for the full and timely protection of their interests. Granges, Farmers' Clubs and like Associations can efficiently work with the Station for this purpose, by sending in duly authenticated samples early during each season of trade.

All other work proper to the Experiment Station that can be used for the public benefit will be done without charge. Work for the use of individuals will be charged for at moderate rates. The Station will undertake no work, the results of which are not at its disposal to use or publish, if deemed advisable for the public good.

Results of analysis or investigation that are of general interest will be published in Bulletins, of which copies are sent to each Post Office in this State, and to every citizen of the State who applies for them. These results will be summed up in the Annual Reports made to the Governor.

It is the wish of the Board of Control to make the Station as widely useful as its resources will admit. Every Connecticut citizen who is concerned in agriculture, whether farmer, manufacturer, or dealer, has the right to apply to the Station for any assistance that comes within its province to render, and the Station will respond to all applications as far as lies in its power.

☞ Instructions and Forms for taking samples, and Terms for testing Fertilizers, Seeds, etc., for private parties, sent on application.

☞ Parcels by Express, to receive attention, should be *prepaid*, and all communications should be directed, *not to any individual officer*, but simply to the

AGRICULTURAL EXPERIMENT STATION,
NEW HAVEN, CONN.

☞ Station Grounds, Laboratories and Office are on Suburban st., between Whitney avenue and Prospect st., 1½ miles North of City Hall. Suburban st. may be reached by the Whitney ave. Horse Cars, which leave the corner of Chapel and Church sts. three times hourly, viz: on the striking of the clock and at intervals of twenty minutes thereafter.

☞ The Station has Telephone connection and may be spoken from the Central Telephone Office, 118 Court st., or from Peck & Bishop's Office in Union R. R. Depot.

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Report of the Director—

REPORT OF THE BOARD OF CONTROL.

To His Excellency, Morgan G. Bulkeley, Governor of Connecticut:

In compliance with the law establishing the CONNECTICUT AGRICULTURAL EXPERIMENT STATION, the Board of Control herewith submits its Annual Report:

Since the last report was made a new mycological laboratory has been put in operation. A special study was made by Dr. Thaxter during last winter and spring of the onion smut which has done great damage to the onion crop, particularly in the shore towns of Connecticut. Field experiments with a view of checking the ravages of this fungus disease were made by Dr. Thaxter during last spring and summer. An account of these experiments and of the success which has attended them, as well as of the other work of this department will be found in his report to the Director. During last season fungus diseases have done greater damage to our crops than is commonly the case, because of the continuous wet weather during the summer months. The constant calls made upon the Station's mycologist for information and help, especially by fruit growers, indicate that the establishment of this department by the Board of Control last year was a wise measure.

The sampling of fertilizers has been thoroughly done according to the plan followed for the last two years, and analyses have been made of every brand sold in Connecticut.

Field experiments have been carried out in different parts of the State.

Examinations of butter and molasses required by the Dairy Commissioner have been made as usual and expert evidence furnished when required in court.

Much work has also been done in other directions the results of which it has not been possible to prepare for publication at this time, but they will be fully presented in the report of the Director which is now being written.

The report of the Treasurer is herewith appended. It exhibits the financial affairs of the Station for the fiscal year ending June 30th and shows the amounts received from the several sources, the amounts spent for various purposes, what part of each has been paid from the National appropriation and what part from home receipts.

All of which is respectfully submitted:

WM. H. BREWER, *Secretary.*

November 1st, 1889.

REPORT OF THE TREASURER.

WM. H. BREWER, *in account with the Connecticut Agricultural Experiment Station.*

FOR THE FISCAL YEAR ENDING JUNE 30TH, 1889.

RECEIPTS.

Balance	$ 6.24	
From State Comptroller	8,000.00	
From U. S. Treasurer	7,500.00	
Analysis fees due from previous fiscal year	835.00	
Analysis fees due and collected this year	3,494.50	
Miscellaneous receipts	34.55	
		$19,870.29

EXPENDITURES.

	State Acc't.	U. S. Acc't.	
Salaries	$5,130.00	$5,906.25	$11,036.25
General Laboratory expenses	1,045.03	73.60	1,118.63
Mycological Investigation		199.68	199.68
Grass and Forage Investigation	191.62		191.62
Field Experiments		384.66	384.66
Gas	263.16		263.16
Water	139.50		139.50
Coal	147.50		147.50
The Establishment, Buildings, Grounds, etc.	451.43		451.43
Telephone		100.00	100.00
Printing	187.15	256.46	443.61
Stationery	112.53		112.53
Postage	76.47		76.47
Library	222.40		222.40
Mycological Library		204.35	204.35
Collecting Fertilizers	561.75		561.75

	State Acc't.	U. S. Acc't.	
New Mycological Laboratory	$2,818.73	$375.00	$3,193.73
Changes in old buildings	738.84		738.84
Insurance	91.50		91.50
Traveling Expenses of the Board	7.50		7.50
Unclassified sundries	185.18		185.18
	$12,370.29	$7,500.00	$19,870.29

MEMORANDUM.

The year's accounts were audited October 8th, 1889, by the Auditors of the State Public Accounts. Analysis fees on certain fertilizers sold in the State during the season of 1888 and due before June 30th, but not received by the Treasurer until after July 1st, are placed in this year's receipts; and analysis fees which may have been due this year before June 30th but not collected until after, will go into the new account.

WM. H. BREWER, *Treasurer.*

REPORT OF THE DIRECTOR.

During April and May last, the agents of the Station visited 127 towns and villages in all parts of the State and drew about 580 samples representing the one hundred and thirty-two different brands of commercial fertilizers which have been legally sold in the State during the year. Of each of these the Station is required by law to make and publish annually at least one analysis. Examinations of home-mixed fertilizers, manures and waste products have brought up the total number of this class of analyses to 242. Each analysis has been made in duplicate and as a rule the duplicates have been executed by different chemists.

56 analyses of feeding stuffs other than grasses and hay have been made within the year.

In connection with studies in the forage garden and a preliminary examination of some of the salt marshes of the State, 53 samples of grasses cut in different stages of growth have also been analyzed.

28 samples of maize kernel, cob, and stover, and 20 samples of potatoes have been examined to supplement the field experiments carried out in different parts of the State.

On the application of Mr. Tatem, the State Dairy Commissioner, 183 samples of vinegar, 45 of molasses, and 13 of suspected butter have been examined and evidence has been furnished in court when required for the prosecution of violators of the laws regarding butter and molasses.

Much time has been given by Dr. Osborne to a study of the nitrogenous matters contained in the kernels of maize and oats.

Considerable work has also been done by others of the Station Staff in testing and improving analytical methods, a branch of investigation which is of special importance at the present time and one which receives too little attention.

The field work of the Station has been as follows:

1. Elaborate experiment on the influence of distance of planting on the quantity and quality of the maize crop.

This has been continued from last year on the farm belonging to the estate of the late J. J. Webb, of Hamden. The results obtained in 1888 constitute Part I. of this Report.

2. On the relative agricultural value of superphosphate and various raw phosphates. Experiments conducted by W. I. Bartholomew, Putnam; W. H. Yeomans, Columbia; C. A. Sill, Saybrook; M. H. Dean, Lime Rock, and Lawrence Doyle, Harwinton.

3. On the effect of size and method of cutting seed potatoes on the quality and quantity of the crops, and, if carried on for a term of years, on the qualities of the variety. Experiments conducted on the estate of J. J. Webb and by Dennis Fenn and George F. Platt, of Milford, and C. A. Sill, of Saybrook.

4. Studies of the grasses of the salt marshes of Connecticut.

5. Studies of our native and introduced meadow grasses in the forage garden at the Station.

The laboratory and field work of the mycologist of the Station, Dr. Thaxter, are fully described in his report, pp. 127–178.

During 1889 the Station has issued five printed Bulletins aggregating 68 printed pages. These bulletins are now distributed in editions of 7500 and the demand for them is constantly increasing.

The Station correspondence has also considerably increased. During the last 12 months more than 1900 letters and manuscript reports have been sent from the Station.

Late in October, by our invitation, the State Board of Agriculture held a field-meeting at the Station attended by more than 100 farmers and their families.

A particular account of the results of the Station work during the year will be found in the following pages.

NOTE.—The investigation which is described on the following pages, 9 to 48, was made in 1888, but the results could not be prepared for publication in season for the Station Report of that year. They were accordingly printed in March, 1889, as Part I of the Annual Report for 1889. A continuation of this experiment in 1889 is described on pages 219–231 of this Report.

THE EFFECT OF THE RATE OR DISTANCE OF PLANTING ON THE QUANTITY AND QUALITY OF THE MAIZE CROP.

Indian Corn or Maize is our staple crop. More bushels of Indian Corn are raised in this State yearly than of all the other cereals together and nearly five-eighths of the acreage devoted to cereals is planted to this grain.

Maize varies more than any other cereal under changed circumstances of climate and culture and it is preserved and used for cattle food in a greater variety of ways; sometimes the whole plant is used for soiling, or for ensilage, or is fed unhusked in its field-cured condition, and at other times the largest possible yield of marketable ears is aimed at, making little account of the stover. Maize is suited to all these uses chiefly in three ways, viz: by selection of proper varieties, by cutting the crop at different stages of growth and lastly by the rate of planting.

Various experimenters in this country as well as abroad have studied the effects of rate or distance of planting on the total yield of maize and on the yield of sound ears and shelled corn. No thorough study has however been made in the United States of the effect of rate of planting both on the total yield and at the same time on the chemical composition and so on the food-value of the whole crop. The importance of the subject led this Station to undertake such a study with the assistance of Mr. J. J. Webb, of Hamden, and the results thus far obtained are given in the following pages.

The proof sheets were ready to be submitted to Mr. Webb for suggestion or correction when he was seized by a fatal illness. His death removes a firm supporter and ardent friend of this Station which he helped to establish and to manage during the first years of its existence, a farmer of rare intelligence, enterprise and business ability, and a thoroughly honest, honorable and generous citizen.

The details of the method of investigation are first given, then the tabulated statements of results, and lastly a general discussion of some of the results and their bearing on farm practice.

The object has not been to establish any special rule with regard to the rate of planting Indian Corn. The best possible rate of planting depends on a variety of conditions which are never precisely alike in any two seasons or on any two farms and therefore a fixed rule regarding it is impossible. No one rate will *every* year give the largest possible crop for that given year and land, but a certain distance of planting may *on the average* through a term of years be expected to give the best results. Many who grow corn in this State have doubtless been led by the experience of years to adopt such a distance of planting and the most intelligent agricultural practice is generally the safest guide.

But a clearer idea of the conditions of growth which are affected by the rate of planting and of the general effect of rate of planting on the quality as well as the quantity of the harvest will help to make our agricultural practice more intelligent.

DETAILS OF THE EXPERIMENT.

The Field.

Mr. Webb, very kindly set aside for the experiment an acre and a half of level meadow land which had been in grass for five years, and was in fair condition as regards fertility. He also most generously put at our disposal his men, teams and tools at such times as they were needed throughout the season.

After plowing and harrowing, the piece was laid out in three parallel strips, each about 408 feet long and 68 feet wide running north and south. A four-foot space separated these strips.

On two adjacent strips an ammoniated superphosphate was very evenly sown broadcast with a machine at the rate of 1,000 pounds per acre. On the third strip, the same superphosphate was sown at the rate of 2,000 pounds per acre. This superphosphate contained 4 per cent. of nitrogen, 7 per cent. of potash and 9.8 per cent. of phosphoric acid. It was prepared by mixing thoroughly—

185	pounds	sulphate of ammonia.
140	"	dried blood.
185	"	muriate of potash.
780	"	dissolved bone black.
1290	"	

The whole field was then thoroughly harrowed. In the next place each strip was accurately divided into six plots, each 64 feet long [68 feet wide], with four foot spaces between them. The general arrangement is shown in the following diagram, Table I. The measurements were all carefully made and afterwards verified by another person to insure accuracy. Each plot contained 4,352 square feet or very nearly one-tenth of an acre. For ready reference the plots were lettered as in the diagram. Afterwards the field was marked and drills opened four feet apart running north and south.

Planting and Cultivation.

The planting was done on the 23rd and 24th of May except plots M to Q which were planted May 29th. This delay was unintentional but unavoidable.

The seed planted on the first series of plots, from A to F was a large dent variety of maize known as White Edge Dent. Mr. Webb has raised it for years with perfect satisfaction, but this locality is probably about as far north in New England as will admit ripening without injury by frost. On the second series of plots, from G to L was planted a small flint variety of maize called Rhode Island White Cap. The seed was given to us by Mr. Bartholomew of Putnam, who has raised it for many years, and improved it by selection. This variety is hardy any where in the State. The same variety was planted on plot R, the intention being to use it also on plots P and Q but unfortunately our supply of seed failed and plots M to Q were therefore planted with the White Edge Dent mentioned above. The planting was done wholly by hand and by the working force of the Station.

The design was to grow one stalk to every four feet in the row [rows 4 feet apart] on the most southerly plots, A, G and M; one stalk to every two feet, on the next plots, B, H and N; one stalk to a foot on plots C, I and O; two stalks to a foot on D, J and P; four stalks to a foot on the next plots and eight stalks to a foot on plots F, L and R.

TABLE. I.—DIAGRAM OF THE FIELD.

North.

F 8704 plants. ½ square foot to a plant. 8 stalks to a foot in the row.	L 8 stalks to a foot.	R 8 stalks to a foot.
E 4352 plants. 1 square foot to a plant. 4 stalks to a foot in the row.	K 4 stalks to a foot.	Q 4 stalks to a foot.
D 2176 plants. 2 square feet to a plant. 2 stalks to a foot in the row.	J 2 stalks to a foot.	P 2 stalks to a foot.
C 1088 plants. 4 square feet to a plant. 1 stalk to a foot in the row.	I 1 stalk to a foot.	O 1 stalk to a foot.
B 544 plants. 8 square feet to a plant. 1 stalk every 2 feet in the row.	H 1 stalk every 2 feet.	N 1 stalk every 2 feet.
A 272 plants. 16 square feet to a plant. 1 stalk every 4 feet in the row.	G 1 stalk every 4 feet.	M 1 stalk every 4 feet.

South.

Plots A to F and M to Q were planted with White Edge Dent maize.
Plots G to L and plot R were planted with R. I. White Cap, a flint maize.

A measuring line was used in each drill and the kernels dropped very accurately in place. An extra quantity was planted to insure a perfect stand and to be thinned out where necessary. In one or two spots, particularly on plot H, moles destroyed the seed and these were replanted on June 11th. When the maize-plants were about 6 inches high the Station force thinned them out, taking care not to disturb the roots of those which were left and using the measuring line as before to control the accuracy of the spacing.

It will be seen that in this field we can study the effects of the rate of planting on two varieties of maize; one a large and the other a small variety, we can also with each of these varieties compare the effect of rate of planting both on well fertilized land, and on *heavily* fertilized land.

Mr. Webb had the crop thoroughly cultivated, following his usual farm practice.

CUTTING AND STACKING THE CROP.

On the 20th of September the corn was cut and stacked in the way described below on all the plots except M to R which were cut on the 27th. The appearance of the crops at that time was as follows:—

Plot G, one stalk every four feet, very little lodged, husks all yellow, kernels hard.

Plot H, one stalk every two feet, very little lodged, husks yellow, rather green on the north end of the plot.

Plot I, one stalk every foot. Lodged more than H. Stalks noticeably smaller, ears almost as ripe as on H.

Plot J, two stalks to a foot. Lodged a good deal more than any of the previous-named plots, ears smaller and a little greener.

Plot K, four stalks to a foot. Stalks smaller than on J and worse lodged, ears poor and small.

Plot L, eight stalks to a foot. Not so much lodged, perhaps because nearer a grove which protects it from north to northeast winds. Greener than K, ears smaller.

The same observations apply to the corresponding plots in the other two rows.

It is evident that the stalks on the edges of each plot must be more or less affected by the crop growing on the adjacent plots. For instance the stalks on the south end of plot B are somewhat shaded by those of plot A which stand only half as thick. On the east they are shaded by those of plot H which are planted at a like distance apart, but which are not nearly as tall and leafy. On the north lies the more closely planted plot C, but on the west side the plot is not at all shaded. To counteract as far as possible these inequalities of light the crop was harvested and weighed on only one half of each plot, and this half was the central area corresponding in shape to that of the whole plot. Each of these *inner plots* therefore had an area of *one-twentieth of an acre.*

The number of plants in each inner plot and the area of ground surface for each plant are as follows. The plants of course are not evenly distributed over this area in this experiment.

	Number of stalks on the plot.	Number of square feet of ground surface per plant.
Plots A, G, and M, One stalk in four feet	136	16
" B, H, and N, " " " two "	272	8
" C, I, and O, " " to a foot	544	4
" D, J, and P, Two stalks to "	1088	2
" E, K, and Q, Four " " "	2176	1
" F, L, and R, Eight " " "	4352	½

The method of cutting and stacking is as follows:—

1st, Establish the corner boundaries of the inner plot which is to be harvested and weighed, and mark them with stakes.

2d, Carry a stout cord around fastened to these stakes to mark off the plot for harvesting.

3d, Count the number of stools or stalks in the inner plot, note if any are missing and how many. Cut a corresponding number, just outside the inner plot and lay them inside.

4th, Draw a sample for analysis. This is done by going through the inner plot from each south corner to the diagonally opposite north corner and cutting one or more stalks from each row, till the number cut is from 8 to 10 per cent. of the total number on the plot. This makes a very large sample to prepare for analysis, but it is probably no larger than is necessary to secure accuracy. This laboratory sample is tied up in from one to four small bundles, each having a piece of red flannel attached, and a label. These bundles are carried to the north end of the plot.

5th, The men then cut the crop which is outside the inner plot, bind it in small gavels, and stack it in the space between the rows of plots. This is done under constant supervision of an officer of the Station.

6th, The crop on the inner plot, which now stands by itself without any chance for mixing with outside corn, is cut by the men and stacked in three or more stacks of the usual size which stand in line through the center of the inner plot. The laboratory sample in each case is put in the center of the northern stack on each plot.

Harvesting and Weighing.

The weather from the time of cutting to the time of husking and weighing was quite unfavorable for curing the crop having been wet or rainy most of the time.

On Oct. 30th and 31st the crop was harvested and weighed. Three joists were bolted together at one end making a tripod, each stack of maize was tightly corded around the middle, a steelyard was attached, and by a rope and pulley made fast to the bolt of the tripod, two or three men hoisted each stack so that it swung clear and it was weighed by an officer of the Station. As soon as the north stack on each plot was weighed, the laboratory sample was taken out, carried to the Station barn and immediately separated into leaves, stripped stalks, sound kernels, soft kernels, sound cobs, soft cobs and husks, and each of these parts was at once weighed and labeled.

Each plot thus furnished 7 samples, all of which were dried, cut fine when necessary, subsampled and ground for analysis, record of all weights being kept so that the analyses could be reckoned back on to the undried or field-cured crop.

After weighing the total crop, the men husked it out with special care not to overlook the imperfect ears or "nubbins." The ears were then sorted and weighed by the Station force.

This completed the field work. The extent of the laboratory work will be seen in the discussion of the results.

Our thanks are also due to Mr. Webb's foremen, Mr. Gage and Mr. Baldwin, for their interest and hearty coöperation in carrying out an experiment which necessarily interfered more or less with the regular course of their farm work.

RESULTS OF THE EXPERIMENT.

A. QUANTITY OF CROPS.

EFFECT OF DISTANCE OF PLANTING ON THE GROSS YIELD.

Table II, page 17, gives the weight in pounds of field-cured crop on the several inner plots. The table shows these facts :—

1. The flint variety of maize produced on one-twentieth of an acre 426.6 pounds of field-cured crop, when the plants stood 4 feet apart; when there were twice as many plants, 2 feet apart, the yield was 100 pounds more; doubling this number of plants, gave an increase of 85 pounds; but when the number of plants was again doubled, two to a foot, the yield instead of increasing, diminished, and still more when the number of plants was again doubled and quadrupled.

2. Maize of the dent variety produced on one-twentieth of an acre 447 pounds of field-cured crop when the plants stood 4 feet apart and the yield quite steadily increased with the thickness of planting, though not by any means proportionally thereto so that the plot where the stand was thickest had the heaviest field-cured crop.

3. Where the quantity of fertilizer was doubled the yield of the dent variety was considerably increased, but the plot with plants two to a foot yielded more than the two plots which were planted closer.

Since a large and variable portion, ranging from 43 to 60 per cent. of the gross yield of the field-cured crops is water, which has no value, the true measure of production is the *dry weight* of the crop.

EFFECT OF DISTANCE OF PLANTING ON THE QUANTITY OF WATER-FREE MATTER IN THE CROP.

Table III, page 17, gives the weight in pounds of dry matter produced on the several inner plots, each containing one-twentieth of an acre.

It will be noticed that there are three plots M, N, and O [maize of the dent variety with extra phosphate] for which the dry crop is missing. The reason is that the huskers who had been set at work by the foreman on another piece of ground finished their job there, and then, in his absence, volunteered some work on the

TABLE II.—GROSS WEIGHTS OF FIELD-CURED CROPS.—POUNDS PER 1-20TH ACRE.

	One stalk in four feet. Plots G, A, and M.	One stalk in two feet. Plots H, B, and N.	One stalk to a foot. Plots I, C, and O.	Two stalks to a foot. Plots J, D, and P.	Four stalks to a foot. Plots K, E, and Q.	Eight stalks to a foot. Plots L, F, and R.
Flint Maize	426.6	524.6	**609.0**	555.8	521.0	471.6
Dent Maize	447.0	626.0	761.9	745.5	770.0	**779.0**
Flint Maize, with extra phosphate	....	....	....	....	....	624.7
Dent Maize, with extra phosphate	336.0	677.0	836.5	**958.6**	883.6	....

TABLE III.—WEIGHT OF DRY MATTER IN FIELD-CURED CROPS.—POUNDS PER 1-20TH ACRE.

	One stalk in four feet. Plots G, A, and M.	One stalk in two feet. Plots H, B, and N.	One stalk to a foot. Plots I, C, and O.	Two stalks to a foot. Plots J, D, and P.	Four stalks to a foot. Plots K, E, and Q.	Eight stalks to a foot. Plots L, F, and R.
Flint Maize	206.4	263.2	**344.9**	293.3	291.7	248.9
Dent Maize	178.1	302.5	367.5	**399.0**	371.8	365.5
Flint Maize, with extra phosphate	....	....	....	....	....	356.5
Dent Maize, with extra phosphate	....	....	....	470.2	395.6	....

experimental field and had husked out the crop on plots M, N, and O, laboratory sample and all, before they were discovered, thus destroying that part of the experiment.

The table shows :—

1. Maize of the flint variety produced most dry matter when the plants stood a foot apart in the row. Thicker planting as well as thinner planting decreased the yield.

2. The dent variety produced most dry matter when the plants stood two to a foot in the row. Thicker planting than this decreased the yield of dry matter. The increased weight of gross yield noticed above with the thicker stand was wholly made up of water.

3. The extra phosphate also increased in every case the dry weight of the crop.

Weights of the Separate Parts of the Water-free Maize Plant in the Total Crops.

Table IV, page 19, shows the yield in pounds of the several parts of the water-free maize plants on the different plots, each of which contains one-twentieth of an acre.

Regarding first the flint variety:—

1. The yield of sound kernels, or dry shelled corn, increased steadily with the thickness of planting up to a stand of two plants to the foot.

The yield fell off rapidly when that limit was passed and eight plants to a foot produced no sound kernels* at all. The highest yield of dry matter was from planting a foot apart. But a thicker planting in this case yielded more sound kernels. Extra phosphate produced some sound ears with the thickest planting.

2. The yield of soft kernels followed the opposite course. It was smallest where the yield of sound kernels was largest and increased as the sound kernels decreased.

3. The dry weight of leaves increased regularly with the thickness of planting and was greatest where the stand was thickest. The extra phosphate decreased the yield.

4. The dry weight of stripped stalks increased with the thickness of planting up to a stand of one plant to a foot—a distance which gave the largest yield of dry matter—and then fell off with thicker planting though the very closest planting gave nearly

* By sound kernels are meant kernels from marketable ears, as distinguished from either "nubbins" or soft ears.

Table IV.—Total Weights of Matter in the Different Parts of the Water-free Crop. Pounds per 1-20th Acre.

		Sound Kernels.*	Soft Kernels.	Leaves.	Stripped Stalks.	Husks.	Sound Cob.	Soft Cob.
Flint maize,	G, One stalk in four feet	66.45	28.57	41.05	29.11	22.90	11.53	6.86
	H, One " " two "	124.64	20.42	49.59	32.76	26.27	5.07	4.49
	I, One " to a foot	143.46	21.44	58.15	**64.88**	**26.94**	**24.94**	5.13
	J, Two stalks to a foot	**162.81**	13.62	58.78	41.03	22.90	3.29	.91
	K, Four " "	121.27	29.27	80.14	29.62	20.42	5.48	5.47
	L, Eight "	none	**64.30**	**98.49**	63.68	9.97	none	**12.47**
Flint maize, Extra phosphate,	R, Eight stalks to a foot	60.23	55.72	79.66	125.08	16.27	9.22	10.36
Dent maize,	A, One stalk in four feet	54.84	10.56	37.38	46.09	14.32	9.42	5.45
	B, One " " two "	131.19	7.00	57.22	63.94	21.36	19.72	2.02
	C, One " to a foot	147.88	12.91	72.68	78.21	**26.61**	**25.90**	3.26
	D, Two stalks to a foot	**164.60**	15.47	88.07	95.07	23.30	9.36	3.17
	E, Four " "	49.12	36.87	116.09	131.74	20.28	8.28	9.42
	F, Eight " "	17.30	**43.00**	**138.50**	**140.32**	13.24	2.18	**11.00**
Dent maize, Extra phosphate,	M, One stalk in four feet	....	....	....	....	....	....	....
	N, One " " two "	....	....	....	....	....	....	....
	O, One " " to a foot	....	....	....	....	....	....	....
	R, Two stalks to a foot	177.39	23.71	108.84	115.39	28.93	11.05	4.89
	Q, Four "	33.89	49.06	126.60	143.95	22.41	6.55	13.10

* By sound kernels are meant kernels from marketable ears as distinguished from either "nubbins" or soft ears.

as large a yield of dry canes as any other, and the extra phosphate nearly doubled this yield.

5. The yield of husks increased and decreased with the yield of sound and soft kernels as was to be expected.

6. The yield of cobs showed irregularities which create suspicion of errors in weighing.

Regarding next the dent variety:—7. The dent variety showed nearly the same course as the flint variety in the increase and decrease of sound and soft kernels and leaves, due to rate of planting but there was a striking difference in the water-free weight of stripped stalks. While the weight of water-free stalks of the flint variety was greatest where the plants stood one to a foot in the row, the weight of water-free stalks of the dent variety increased steadily with the thickness of stand and was greatest where the stand was thickest—eight plants to a foot.

This table supplies interesting data for a comparison of these two strikingly dissimilar varieties of Indian Corn. But as other data will appear when the chemical composition of the varieties is examined, the comparison will be reserved till all the facts gathered have been presented. See page 37.

Proportions of Kernels, Leaves, Stalks, etc. in the Water-Free Crop.

Table V, page 21, shows in per cents. what fraction or part of the total dry weight of crop on each plot consisted of sound kernels, what of leaves, stripped stalks, etc.

For instance when the plants of the flint variety stood 4 feet apart 32.1 per cent. or nearly one third of the total dry weight was contained in the kernels and 19.9 per cent. or about one-fifth in the leaves, and so on.

It appears from this table :—

1. The proportion of sound kernels of the flint variety to total water-free crop increased with thickness of planting up to a stand of two stalks to a foot and then with closer planting decreased rapidly, while the proportion of kernels of the dent variety to total crop was greatest when the stand was one stalk to two feet and the proportion decreased with thicker planting. The extra phosphate increased the proportion of sound kernels of flint maize but rather decreased it in the case of the dent variety. The larger percentage of soft kernels on plots A and G where the planting was thinnest is explained by the extraordinary suckering on those plots which produced many nubbins.

Table V.—Percentage in Parts of the Total Water-free Crop.

		Sound Kernels.	Soft Kernels.	Leaves.	Stripped Stalks.	Husks.	Sound Cob.	Soft Cob.
Flint maize,	G, One stalk in four feet	32.1	13.8	19.9	14.1	**11.61**	5.6	3.4
	H, One " " two "	47.4	7.8	18.9	12.4	9.9	1.9	1.7
	I, One " to a foot	41.6	6.2	16.8	18.8	7.9	**7.2**	1.5
	J, Two stalks to a foot	**55.5**	1.3	20.0	13.9	7.8	1.2	.3
	K, Four " "	41.6	10.0	27.4	10.2	7.0	1.9	1.9
	L, Eight " "	none	**25.9**	**39.6**	**25.6**	3.9	none	**5.0**
Flint maize, Extra phosphate,	R, Eight stalks to a foot	16.8	15.6	22.4	35.2	4.5	2.6	2.9
Dent maize,	A, One stalk in four feet	30.8	5.9	20.9	25.8	**8.2**	5.3	**3.1**
	B, One " " two "	**43.3**	2.3	19.0	21.1	7.1	6.5	.7
	C, One " to a foot	40.3	3.5	19.8	21.3	7.2	**7.0**	.9
	D, Two stalks to a foot	41.3	3.9	22.1	23.8	5.8	2.3	.8
	E, Four " "	13.3	9.9	31.2	35.5	5.4	2.2	2.5
	F, Eight " "	4.7	**11.8**	**37.9**	**38.4**	3.6	0.6	3.0
Dent maize, Extra phosphate,	M, One stalk in four feet	....	....	....	....	....	....	....
	N, One " " two "	....	....	....	....	....	....	....
	O, One " to a foot	....	....	....	....	....	....	....
	P, Two stalks to a foot	37.8	5.0	23.1	24.5	6.2	2.4	1.0
	Q, Four " "	8.6	12.4	32.0	36.4	5.7	1.6	3.3

2. The proportion of leaves to total dry crop was the inverse of that of the ears, or was largest where the proportion of sound kernels was smallest. The extra phosphate decreased the proportion of dry weight of leaves of the flint variety but increased the proportion of leaves of the dent variety.

3. The proportional yield of stripped stalks showed some irregularities, but in each variety the relative yield of canes was largest where the stand of maize was thickest. The proportion of dry weight of stalks of the dent variety increased regularly from the plot where the stand was one stalk to two feet up to the thickest stand. It was not materially changed by the addition of extra phosphate.

B. CHEMICAL COMPOSITION OF THE CROPS.

Percentage Composition of the Field-cured Crops.

Table VI, page 23, gives the chemical composition of the field-cured crops and Table VII the chemical composition of the separate parts of the crops. These tables by themselves show little in regard to the comparative quality of the crops because the water is such a large and varying quantity. They furnish the basis, however, for the subsequent calculations, and are necessary as a matter of record.

It will be seen that the dent variety contains considerably more water than the flint, as would be expected. The flint variety was more mature and drier than the other at the time of cutting.

The quantity of water in the field-cured crop is larger than usual because of the very wet weather that prevailed while the crop was field-curing in the stacks. The variations in the water-content of field-cured maize stover are remarkable. When housed after curing, it does not always continue to lose weight by drying, but may increase in weight by absorbing water from the air so as to weigh more by a quarter of its original weight late in the winter than it did in the fall. Thus Norfolk white corn grown by Mr. Webb in 1874, for fodder, when cut, September 1, contained 86 per cent. of water. When field-cured, Nov. 11, it had 27 per cent., and was then got into the barn in excellent condition. But on Feb. 8th, after much warm and damp weather it contained 54 per cent. of water. That is, five tons of maize fodder got in on the 11th of November, became eight tons in February as it lay in the barn, and this gain of three tons was wholly water absorbed from the air, the barn giving perfect shelter. (Conn. Ag. Ex. St., 1878, 64.)

Table VI.—Percentage Composition of Field-cured Crops.

		Water.	Ash.	Albuminoids. (N × 6.25).	Fiber.	Nitrogen-free Extract.	Crude Fat.
Flint Maize,	G, One stalk in four feet	**51.61**	1.98	5.42	8.03	31.29	1.67
	H, One " two "	49.82	1.77	**5.64**	7.47	33.49	1.81
	I, One " to a foot	43.36	**2.01**	5.22	10.18	37.22	2.01
	J, Two stalks to a foot	47.22	1.89	5.07	8.03	35.73	2.06
	K, Four " "	44.02	1.97	4.60	9.96	**37.37**	**2.08**
	L, Eight " "	47.22	1.85	3.62	**12.65**	33.25	1.41
Flint Maize, Extra Phosphate,	R, Eight "	42.93	2.17	4.18	13.04	35.95	1.73
Dent Maize,	A, One stalk in four feet	**60.17**	**1.74**	4.01	8.35	24.50	1.23
	B, One " " two "	51.68	1.59	**4.49**	9.03	31.53	1.68
	C, One " " to a foot	51.78	1.59	3.85	9.32	31.84	1.62
	D, Two stalks to a foot	46.47	1.73	4.01	10.38	**35.59**	**1.82**
	E, Four " "	51.71	1.55	3.06	11.84	30.65	1.19
	F, Eight " "	53.08	1.47	2.72	**12.52**	29.19	1.02
Dent Maize, Extra Phosphate,	M, One stalk in four feet	....	....	....	....	....	....
	N, One " " two "	....	....	....	....	....	....
	O, One " " to a foot	.....	....	...	....	....	....
	P, Two stalks to a foot	50.95	1.66	3.83	9.73	32.23	1.60
	Q, Four " "	55.23	1.66	2.94	11.39	27.61	1.17

Table VII.—Percentage Composition of the Separate Parts of the Crops, Field-cured.

		Water.	Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free extract.	Crude Fat.
Sound Kernels.							
Flint maize,	G, One stalk in four feet	26.58	1.15	10.55	.86	56.78	4.08
	H, “ “ “ two “	28.06	.92	9.61	.84	56.83	3.74
	I, “ “ to a foot	27.04	1.06	8.57	.85	58.39	4.09
	J, Two stalks “ “	29.38	.86	8.52	.90	56.31	4.03
	K, Four “ “ “	25.27	1.18	5.55	.81	60.96	4.23
	L, Eight “ “ “	-----	-----	-----	-----	-----	-----
	R,* “ “ “ “	32.11	.62	6.19	.85	56.38	3.85
Dent maize,	A, One stalk in four feet	36.17	1.07	7.95	.95	50.29	3.57
	B, “ “ “ two “	31.00	1.05	8.28	1.11	54.57	3.99
	C, “ “ to a foot	37.37	.91	6.38	.96	50.78	3.60
	D, Two stalks “ “	32.40	.78	6.23	1.19	55.51	3.89
	P,* “ “ “ “	36.63	.78	6.01	1.00	52.01	3.57
	E, Four “ “ “	37.85	.77	4.82	.97	52.15	3.44
	Q,* “ “ “ “	35.97	.69	4.40	.91	54.50	3.53
	F, Eight “ “ “	37.17	.79	5.46	.93	52.23	3.42
Soft Kernels.							
Flint,	G, One stalk in four feet	23.95	1.02	10.26	.76	59.74	4.27
	H, “ “ “ two “	27.70	.94	9.70	.94	56.87	3.85
	I, “ “ to a foot	30.80	.96	9.81	.79	53.67	3.97
	J, Two stalks “ “	74.80	.37	3.25	.30	19.89	1.39
	K, Four “ “ “	26.68	1.01	8.52	.98	58.79	4.02
	L, Eight “ “ “	24.94	.74	7.05	.77	62.52	3.98
	R,* “ “ “ “	32.80	.70	6.66	.83	55.53	3.48
Dent,	A, One stalk in four feet	57.53	.91	5.44	.89	33.46	1.77
	B, “ “ “ two “	31.21	1.20	8.56	1.03	54.06	3.94
	C, “ “ to a foot	34.00	1.04	8.00	1.06	52.24	3.66
	D, Two stalks “ “	37.36	.97	7.30	1.10	50.05	3.22
	P,* “ “ “ “	40.16	.83	6.78	1.08	47.72	3.43
	E, Four “ “ “	37.20	.73	6.27	.93	51.48	3.39
	Q,* “ “ “ “	37.89	.80	6.23	1.10	50.45	3.53
	F, Eight “ “ “	36.12	.73	5.52	.97	52.90	3.76
Leaves.							
Flint,	G, One stalk in four feet	39.92	5.55	6.29	17.39	29.54	1.31
	H, “ “ “ two “	36.16	5.51	6.44	19.18	31.48	1.23
	I, “ “ to a foot	42.80	5.17	4.96	17.74	28.30	1.03
	J, Two stalks “ “	35.26	5.81	5.31	20.28	32.22	1.16
	K, Four “ “ “	22.53	5.73	5.41	27.40	37.39	1.54
	L, Eight “ “ “	28.48	4.28	4.65	22.54	38.75	1.30
	R,* “ “ “ “	32.89	5.58	5.18	20.55	34.40	1.40
Dent,	A, One stalk in four feet	33.64	6.11	8.28	18.72	31.74	1.52
	B, “ “ “ two “	26.70	5.52	7.36	20.95	38.15	1.32
	C, “ “ to a foot	18.19	6.72	7.88	24.16	41.43	1.62
	D, Two stalks “ “	26.23	6.04	6.41	21.86	38.12	1.34
	P,* “ “ “ “	27.79	5.82	6.48	21.72	36.90	1.29
	E, Four “ “ “	24.88	4.81	5.89	22.79	40.26	1.37
	Q,* “ “ “ “	23.14	5.53	6.10	23.33	40.36	1.54
	F, Eight “ “ “	32.19	3.67	4.45	22.06	36.44	1.19

* Extra fertilizer.

Table VII—Continued.

		Water.	Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free extract.	Crude Fat.
Stripped Stalks.							
Flint.	G, One stalk in four feet	76.14	1.55	2.84	6.88	12.13	.46
	H, “ “ “ two “	74.93	1.22	2.38	8.35	12.73	.39
	I, “ “ to a foot	59.66	1.88	2.83	14.02	20.75	.86
	J, Two stalks “ “	67.28	1.67	1.76	11.89	16.97	.43
	K, Four “ “ “	78.53	.86	1.15	7.96	11.18	.32
	L, Eight “ “ “	70.32	.81	1.83	9.47	17.00	.57
	R,* “ “ “ “	51.33	1.95	2.98	16.80	25.98	.98
Dent.	A, One stalk in four feet	76.25	1.22	1.90	8.51	11.70	.42
	B, “ “ “ two “	73.98	.99	1.68	9.64	13.27	.44
	C, “ “ to a foot	68.47	1.05	1.53	11.97	16.48	.50
	D, Two stalks “ “	61.06	1.07	1.62	14.89	20.84	.52
	P,* “ “ “ “	67.69	.94	1.49	12.02	17.42	.44
	E, Four “ “ “	66.47	.69	1.38	10.86	20.14	.46
	Q,* “ “ “ “	67.47	.84	1.53	10.84	18.73	.59
	F, Eight “ “ “	66.70	.63	1.37	10.25	20.63	.42
Husks.							
Flint.	G, One stalk in four feet	48.46	2.27	3.22	16.20	29.06	.79
	H, “ “ “ two “	58.47	2.26	2.90	13.03	22.69	.65
	I, “ “ to a foot	53.94	2.03	2.44	14.71	26.23	.65
	J, Two stalks “ “	51.93	2.26	1.95	16.18	26.98	.70
	K, Four “ “ “	33.64	2.07	2.60	22.69	38.18	.83
	L, Eight “ “ “	26.71	1.86	3.22	23.63	43.57	1.01
	R,* “ “ “ “	45.72	1.84	2.54	17.81	31.36	.73
Dent.	A, One stalk in four feet	63.59	1.47	2.06	11.96	20.37	.55
	B, “ “ “ two “	53.83	1.76	2.28	15.08	26.36	.69
	C, “ “ to a foot	50.98	1.54	2.12	15.96	28.72	.68
	D, Two stalks “ “	48.44	1.68	2.42	16.61	30.05	.80
	P,* “ “ “ “	52.93	1.73	2.59	14.92	27.03	.81
	E, Four “ “ “	48.70	1.37	2.84	15.18	31.14	.77
	Q,* “ “ “ “	76.60	.61	1.28	6.79	14.26	.46
	F, Eight “ “ “	48.56	1.29	2.73	15.15	31.52	.75
Sound Cobs.							
Flint.	G, One stalk in four feet	48.61	.75	1.10	17.89	31.43	.22
	H, “ “ “ two “	88.32	.12	.26	4.17	7.09	.04
	I, “ “ to a foot	49.09	.56	1.28	18.61	30.28	.18
	J, Two stalks “ “	92.31	.09	.16	2.77	4.58	.03
	K, Four “ “ “	85.38	.19	.36	5.25	8.75	.07
	L, Eight “ “ “	-----	-----	-----	-----	-----	-----
	R,* “ “ “ “	60.38	.53	.81	14.70	23.42	.16
Dent.	A, One stalk in four feet	65.73	.45	1.06	10.88	21.69	.20
	B, “ “ “ two “	61.59	.42	.80	13.01	24.00	.18
	C, “ “ to a foot	61.94	.41	.82	12.40	24.20	.23
	D, Two stalks “ “	84.66	.14	.28	5.29	9.58	.05
	P,* “ “ “ “	80.19	.24	.47	6.48	12.55	.07
	E, Four “ “ “	59.89	.51	.88	13.80	24.73	.19
	Q,* “ “ “ “	51.45	.60	1.14	15.94	30.71	.16
	F, Eight “ “ “	66.25	.39	.73	11.68	20.75	.20

* Extra fertilizer.

TABLE VII—CONTINUED.

		Water.	Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free extract.	Crude Fat.
	SOFT COBS.						
Flint.	G, One stalk in four feet	38.00	1.37	2.92	20.87	36.44	.40
	H, " " " two "	43.96	.97	2.15	19.62	32.96	.35
	I, " " to a foot	55.25	.92	2.19	15.62	25.71	.31
	J, Two stalks " "	76.85	.43	.78	8.12	13.63	.19
	K, Four " " "	40.35	1.10	2.28	20.75	35.17	.35
	L, Eight " " "	37.72	1.09	1.32	22.10	37.43	.34
	R,* " " " "	60.38	.53	.81	14.70	23.42	.16
Dent.	A, One stalk in four feet	71.28	.64	1.49	8.22	18.14	.23
	B, " " " two "	53.16	.78	2.47	14.57	28.72	.30
	C, " " to a foot	52.86	.67	1.78	14.71	29.76	.22
	D, Two stalks " "	57.92	.69	1.42	13.65	25.94	.38
	P,* " " " "	64.90	.62	1.38	11.34	21.51	.26
	E, Four " " "	61.76	.66	.89	12.95	23.42	.32
	Q,* " " " "	62.38	.60	1.46	12.20	23.16	.20
	F, Eight " " "	58.24	.66	1.39	14.17	25.27	.27

* Extra phosphate.

PERCENTAGE COMPOSITION OF THE DRY MATTER IN THE FIELD-CURED CROPS.

Table VIII, page 27, gives the chemical composition of the dry-matter harvested from each plot. It does not indicate the total yield of the chemical ingredients, but only the relative quantity of each. To illustrate, take the first horizontal column of the table. 4.08 per cent. or 4.08 pounds in every hundred of the dry matter raised on the plot which had one stalk in four feet were ash or mineral matter, 11.20 per cent. or pounds per hundred were albuminoids, and so on.

The table brings out the following facts :

Ash.—The ash of the flint variety shows no very striking changes due to distance of planting. The thinnest planted maize, Plot A, had the largest percentage of ash, but on all the other plots the percentage was practically the same.

The per cent. of ash of the dent variety decreased as the plants stood closer, and there is a difference of 1.2 per cent. in the ash between the thickest and thinnest planted plots. Extra phosphate increased the per cent. of ash of both varieties of maize.

TABLE VIII.—PERCENTAGE COMPOSITION OF THE DRY MATTER IN THE FIELD-CURED CROPS.

		Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free Extract.	Fat.
Flint maize,	G, One stalk in four feet	**4.08**	11.20	16.60	64.68	3.44
	H, One " two "	3.53	**11.25**	14.88	66.74	3.60
	I, One " to a foot	3.55	9.21	17.98	65.73	3.53
	J, Two stalks to a foot	3.58	9.60	15.23	**67.70**	**3.89**
	K, Four " "	3.52	8.22	17.79	66.77	3.70
	L, Eight " "	3.51	6.88	**23.97**	63.00	2.66
Flint maize, Extra phosphate,	R, Eight "	3.80	7.32	22.57	63.15	3.16
Dent maize,	A, One stalk in four feet	**4.38**	**10.05**	20.97	61.51	3.09
	B, One " two "	3.28	9.28	18.69	65.28	**3.47**
	C, One " to a foot	3.29	7.99	19.33	66.03	3.36
	D, Two stalks to a foot	3.23	7.49	19.40	**66.48**	3.40
	E, Four " "	3.23	6.33	24.54	63.47	2.43
	F, Eight " "	3.12	5.80	**26.68**	62.23	2.17
Dent maize, Extra phosphate,	M, One stalk in four feet	----	----	----	----	----
	N, One " two "	----	----	----	----	----
	O, One " to a foot	----	----	----	----	----
	P, Two stalks to a foot	3.39	7.80	19.83	65.71	3.27
	Q, Four "	3.71	6.56	25.46	61.66	2.61

Albuminoids.—The albuminoids of both varieties in general followed the same course as the ash or mineral matter. The dry matter from the plots where the stand was thinnest had the largest per cent. of albuminoids, and this percentage quite regularly decreased and was least in the dry matter of the most thickly planted plots. The difference is very striking: Thus the percentage of albuminoids in the dry matter from Plot G, where flint maize stood one stalk in four feet, was 11.2, but where it stood eight stalks to a foot (Plot L) the percentage was but a little more than one-half that, 6.88.

Fiber.—The per cent. of fiber on Plots G and A, one plant in four feet, was larger than on some of the following plots, but with exception of those plots and Plot J, the per cent. of fiber increased with the thickness of planting and was largest where the planting was thickest.

The extra phosphate did not sensibly affect the per cent. of fiber.

Nitrogen-free Extract.—The per cent. of nitrogen-free extract was largest where the stand was two or four stalks to a foot, Plots J, K and D, and decreased where the stand was either thicker or thinner.

Fat.—The per cent. of fat did not seem to be particularly affected by the stand of the crop, though it was least where the stand was thickest.

To recapitulate: the per cent. of ash and albuminoids in the water-free crop was greatest where the stand of maize was thinnest and decreased regularly as the stand was thicker, being least where the plants stood closest. This difference was quite small in the case of ash, but very large in the case of albuminoids.

The per cent. of fiber was largest where the stand was thickest and probably decreased pretty regularly as the stand of maize was thinned. There was the largest percentage of nitrogen-free extract where the stand of maize was neither very close nor very thin, but from two to four stalks to a foot.

We are now in position to ascertain the

Total Quantities of Water, Ash, Albuminoids, etc. Harvested from Each Plot.

These have been calculated from the data already presented and are given in Table IX, page 29, which plainly shows the real value of the crops. Study of the results with *the flint variety of maize* shows:

Table IX.—Total Production of Water, Ash, Albuminoids, etc. on Each Plot.

Pounds per 1-20th, Acre.

		Field-cured.	Dry matter.	Water.	Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free extract.	Fat.
Flint maize,	G, One stalk in four feet	426.59	206.43	220.16	8.42	23.12	34.25	133.53	7.11
	H, " " two "	524.55	263.24	261.31	9.28	29.61	39.17	175.68	9.50
	I, " " to a foot	**609.00**	**344.94**	**264.06**	**12.25**	**31.79**	**62.00**	**226.69**	**12.21**
	J, Two stalks " "	555.79	293.34	262.45	10.51	28.17	44.65	198.58	11.43
	K, Four " " "	521.00	291.67	229.33	10.25	23.98	51.89	194.74	10.81
	L, Eight " " "	471.58	248.91	222.67	8.73	17.08	59.66	156.81	6.63
Flint maize, Extra phosphate,	R, Eight stalks to a foot	624.72	356.54	268.18	13.56	26.10	81.50	224.57	10.81
Dent maize,	A, One stalk in four feet	447.00	178.06	268.94	7.79	17.91	37.34	109.53	5.49
	B, " " two "	626.00	302.45	323.55	9.93	28.08	56.52	197.41	10.51
	C, " " to a foot	761.91	367.45	394.46	12.09	29.36	71.03	242.61	12.36
	D, Two stalks " "	745.50	**399.04**	346.46	**12.87**	**29.92**	77.39	**265.30**	**13.56**
	E, Four " " "	770.00	371.80	**398.20**	11.99	23.53	91.24	235.97	9.07
	F, Eight " " "	**779.00**	365.54	413.46	11.40	21.20	**97.54**	227.46	7.94
Dent maize, Extra phosphate,	M, One stalk in four feet	336.00	....	....	....	....	....	....	....
	N, " " two "	677.00	....	....	....	....	....	....	....
	O, " " to a foot	838.50	....	....	....	....	....	....	....
	P, Two stalks " "	958.55	471.20	488.35	15.93	36.66	93.26	308.98	15.37
	Q, Four " " "	883.62	395.56	488.06	14.67	25 96	100 65	243.94	10.34

1. The quantity of ash or mineral matter, of albuminoids, of fiber, of nitrogen-free extract and of fat, every valuable ingredient in the crop, was largest when the plants stood one to a foot, plot I.

2. A stand of two to a foot, plot J, produced very little more of any ingredient than a stand of one to two feet, plot H. The single exception to this is nitrogen-free extract. Plot J produced 23 pounds more of this substance than plot H.

Examining the results with *the dent variety of maize* it appears:

3. The quantity of ash or mineral matter, of albuminoids, of nitrogen-free extract and of fat was largest when the plants stood two to a foot, plot D, but the largest quantity of fiber was produced by the thickest planting, eight plants to a foot, plot F.

4. A stand of one plant to a foot produced more of every ingredient except fiber than a stand of four to a foot, so the rate which would have given the maximum yield was either two to a foot or between one and two to a foot.

5. In every case the extra phosphate produced an increase of all the ingredients of the crop.

Comparative Development of the Individual Maize Plant.

We have seen that the largest total yields both of shelled corn and of stover have been on plots where the plants stood one to a foot or two to a foot in the row. Standing at these distances there were 544 and 1088 plants on the plots respectively. But plots A, G and M contained only 136 plants. While the total yield on these last-named plots was less, it is interesting and important to know how the production of the *single plants* compared with that of plants standing closer together. This question has an important bearing on the raising of corn for seed.

Table X, page 31, gives the total water-free weight of the different parts of 1000 maize plants grown at the different distances named.

Examination of these figures shows that the individual plants which stood furthest apart, and had the most light and the most soil at their disposal attained the greatest development in all their parts. It also shows that the yield per plant quite regularly decreased as the stand became thicker though not by any means proportionally to the closeness of the stand. To

Table X.—Comparative Development of the Maize Plant.

Weight in pounds of Water-free product of 1000 Seed Kernels, for each of the distances named.

		Field-cured weight.	Water-free weight.	Sound kernels.	Soft kernels.	Leaves.	Canes.	Husks and cobs.
Flint maize,	G, One stalk in four feet	**3136.8**	**1517.7**	**488.3**	**210.1**	**301.8**	**214.0**	**303.6**
	H, " " two "	1928.4	967.5	458.2	75.1	182.3	120.4	131.7
	I, " " to a foot	1120.6	634.6	264.0	39.5	107.0	119.4	104.9
	J, Two stalks "	510.8	269.5	149.6	3.3	54.0	37.7	24.9
	K, Four " "	239.6	134.1	55.7	12.4	36.8	13.6	14.4
	L, Eight " "	108.4	57.2	none	14.7	22.6	14.6	5.1
Flint maize, Extra phosphate,	R, Eight stalks to a foot	143.6	81.1	13.8	12.8	18.3	28.7	8.2
Dent maize,	A, One stalk in four feet	**3286.8**	**1309.6**	403.2	**77.6**	**274.9**	**338.9**	**214.6**
	B, " " two "	2301.1	1112.0	**482.3**	25.7	210.3	235.1	158.4
	C, " to a foot	1401.9	676.2	272.1	23.8	133.7	143.9	102.6
	D, Two stalks "	685.1	366.7	151.3	14.2	80.9	87.4	32.8
	E, Four " "	344.2	171.0	22.6	17.0	53.4	60.6	17.4
	F, Eight " "	179.1	84.0	4.0	9.9	31.9	32.2	6.0
Dent maize, Extra phosphate,	M, One stalk in four feet	2470.6	....	....	....	....	....	....
	N, " " two "	2488.6	....	....	....	....	....	....
	O, " to a foot	1537.5	....	....	....	....	....	....
	P, Two stalks "	881.0	432.1	163.0	21.8	100.0	106.0	41.2
	Q, Four " "	406.4	182.0	15.6	22.6	58.2	66.2	19.3

illustrate:—Where the stalks of dent maize stood eight to a foot 1000 plants produced 84 pounds of dry matter. When the distance between the plants was doubled, 4 stalks to a foot, the yield per 1000 plants was also doubled, 171 pounds. When the distance between plants was again doubled, 2 stalks to a foot, the yield was again more than doubled, 366.7 pounds. But doubling the distance again, having 1 stalk to a foot, did not quite double the yield per 1000 plants, it was only 1.8 times as large. Again doubling the distance, 1 stalk in two feet, increased the yield per 1000 plants 1.6 times and another doubling of the distance, leaving only one plant in four feet increased the yield of 1000 plants only 1.2 times. Evidently a larger yield per 1000 plants could not be expected from planting stalks of this dent variety more than 4 feet apart each way. That is, under the conditions of this experiment the individual dent maize plant about reached its maximum development when the single plants stood at a distance from each other of four feet.

It would seem as if the smaller flint maize ought to attain its maximum development with a smaller area of soil, i. e. with closer planting than the dent variety, but this has not been the case in this experiment. With each doubling of the distance between the plants the proportional increase in the yield per 1000 maize plants was as follows:—

	8 plants to a foot.	4 plants to a foot.	2 plants to a foot.	1 plant to a foot.	1 plant in 2 feet.	1 plant in 4 feet.
Distance between plants	$1\frac{1}{2}$ ins.	3 ins.	6 ins.	12 ins.	24 ins.	48 ins.
Dent variety	1	2	2.1	1.8	1.6	1.2
Flint variety	1	2.3	2.0	2.4	1.5	1.6

Which means that when the distance between plants in the row was doubled, from $1\frac{1}{2}$ inches to 3 inches, the yield of a thousand dent maize plants was two times as large and of flint 2.3 times as large. So when the distance was doubled from twenty-four to forty-eight inches, while the yield of 1000 plants of the dent variety was 1.2 times as large at forty-eight as at twenty-four inches the yield of the flint was 1.6 times as large; from which it is fair to conclude that a greater distance between plants would produce almost no increase in yield of the individual dent maize plant but probably would produce further increase in that of the flint variety.

Table XI, page 33, shows the quantity of ash, albuminoids, fiber, nitrogen-free extract and fat, harvested from 1,000 maize

Table XI.—Comparative Development of the Maize Plant.

Pounds of Ash, Albuminoids, etc., in 1,000 plants, for each of the distances named.

		Dry Weight.	Ash.	Albuminoids. (N. × 6.25)	Fiber.	Nitrogen-free Extract.	Fat.
Flint maize,	G, One stalk in four feet	**1517.7**	**61.97**	**169.76**	**251.64**	**982.90**	**52.33**
	H, One " two "	967.5	34.15	108.56	143.73	645.70	34.96
	I, One " to a foot	634.6	22.54	58.49	114.00	417.10	22.47
	J, Two stalks " "	269.5	9.66	25.85	41.08	182.39	10.52
	K, Four " "	134.1	4.71	11.03	23.85	89.50	4.97
	L, Eight " "	57.2	2.01	3.92	13.72	36.02	1.53
Flint maize, Extra phosphate,	Eight " "	81.1	3.11	6.00	18.45	51.05	2.49
Dent maize,	A, One stalk in four feet	**1309.6**	**57.26**	**131.79**	**274.65**	**805.55**	**40.35**
	B, One " two "	1112.0	36.54	103.22	207.49	726.07	38.68
	C, One " to a foot	676.2	22.24	45.98	130.69	454.55	22.74
	D, Two stalks " "	367.7	11.84	27.53	71.20	244.48	12.47
	E, Four " "	171.0	5.51	10.82	41.97	108.53	4.17
	F, Eight " "	84.0	2.62	4.88	22.43	52.24	1.83
Dent maize, Extra phosphate,	M, One stalk in four feet	----	----	----	----	----	----
	N, One " two "	----	----	----	----	----	----
	O, One " to a foot	----	----	----	----	----	----
	P, Two stalks " "	432.1	14.65	33.70	85.64	284.00	14.11
	Q, Four " "	182 0	6.74	11.94	46.30	112.26	4.76

plants when planted at the different distances named. It shows that not only the total dry weight per plant regularly increases with increased distance of planting, but that the weight of each food-ingredient in it increased at a similar rate. It is a striking fact that the percentage of albuminoids in the dry matter *from the individual maize plant* regularly increased as the stand of plants was thinner. The following table gives the percentage composition of the water-free product of plants growing on the plots named. See also page 27.

Table XII.—Percentage Composition of Single Plants on Plots G to L.

	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
G, One stalk in four feet	**4.08**	11.20	16.60	64.68	3.44
H, " " " two "	3.53	**11.25**	14.88	66.74	3.60
I, " " to a foot	3.55	9.21	17.98	65.73	3.53
J, Two stalks to a foot	3.58	9.60	15.23	**67.70**	**3.89**
K, Four " "	3.52	8.22	17.79	66.77	3.70
L, Eight " "	3.51	6.88	**23.97**	63.00	2.66

The percentages of all the other ingredients showed no very decided changes except on Plot L. But the percentage of albuminoids regularly and rapidly diminished from Plot G where the plants were four feet apart each way to Plot L where they stood eight to a foot in rows four feet apart.

The Quantities of Nitrogen, Phosphoric Acid and Potash taken from the Land by the Crops.

Table XIII gives the pounds *per acre* of nitrogen, phosphoric acid and potash taken from the land by the crops. It appears that the quantities of these elements removed are largest where the crops are largest, as was to be expected. The average quantities removed for those rates of planting which are nearest to ordinary farm practice—drills four feet apart and stalks one or two to a foot in the drill—are given in Table XIV, and for comparison are also given the quantities of nitrogen, phosphoric acid and potash in a crop of the same variety of flint maize raised in 1887, by Mr. Bartholomew at Putnam. Mr. Bartholomew's corn was planted in hills 3¼ feet apart each way and five stalks in a hill. The actual yield was 4972 pounds of dry matter per acre, but the ingredients named are reckoned to a yield of 6382 pounds for comparison with Mr. Webb's crop.

Table XIII.—Pounds of Nitrogen, Phosphoric Acid and Potash Contained in the Crops per Acre.

		Nitrogen. Pounds.	Phosphoric Acid. Pounds.	Potash. Pounds.
Flint maize,	G, One stalk in four feet	74.0	27.6	55.1
	H, " " " two "	94.8	42.6	42.9
	I, " " to a foot	**101.7**	**47.1**	**60.8**
	J, Two stalks " "	90.1	43.1	48.4
	K, Four " " "	76.7	36.9	30.2
	L, Eight " " "	54.7	26.1	31.7
Flint maize, Extra phosphate,	R, Eight stalks to a foot	83.5	41.6	66.1
Dent maize,	A, One stalk in four feet	57.3	21.2	49.9
	B, " " " two "	89.9	36.9	48.6
	C, " " to a foot	94.0	38.5	48.5
	D, Two stalks " "	**95.7**	**40.2**	**51.7**
	E, Four " " "	75.3	34.1	41.5
	F, Eight " " "	67.8	27.2	34.7
Dent maize, Extra phosphate,	P, Two stalks to a foot	117.3	53.5	78.9
	Q, Four " " "	83.1	39.0	54.8

Table XIV.—Average Quantities of Nitrogen, Phosphoric Acid and Potash Removed in the Corn Crop per Acre.

	Mr. Webb's Crop, 1888. Dent Corn.	Mr. Webb's Crop, 1888. Flint Corn.	Mr. Bartholomew's, 1887. Flint Corn.
Nitrogen	94.8	95.9	94.1
Phosphoric Acid	39.4	45.1	29.4
Potash	50.2	54.6	92.7
Total Water-free crop	7665	6382	6382

It is seen that the quantity of nitrogen removed is practically the same in all cases and that Mr. Bartholmew's crop of flint corn removed much more potash and much less phosphoric acid than Mr. Webb's. A partial explanation of this may lie in the fact that Mr. Bartholomew's land is relatively poor in available phosphoric acid. Though the flint maize yielded less, its demands on the soil were slightly larger than those of the dent for the three ingredients, nitrogen, phosphoric acid and potash. Pound for pound, a crop of flint corn takes very considerably more of them than does dent corn, but this extra demand was fully repaid in the more concentrated nature of the feed produced by the flint variety.

The Effect of Rate of Planting as Modified by Manuring.

Wollny has shown in experiments with beets, potatoes and peas that on land which was well manured and rich in plant-food, the maximum crop was produced with a thinner planting than was required on poorer land, or in other words, the richer the land the thinner may be the seeding. He calls attention to the popular notion that fresh stable manure makes grain lodge and shows that the lodging results from too thick seeding. A rate of seeding which is just right for poor land is altogether too thick for rich land; for here the plants grow more vigorously, and therefore need more room than on poor land. When crowded they shade each other, become watery, loose-textured, and break down or lodge under a strong wind, and so it may happen that a well-manured piece of ground under experiment will give actually less crop than an unmanured piece of the same size planted in the same way. The action of any fertilizer can only be truly ascertained when the plants to which it is applied have room for unhindered development. This is a point which should be specially regarded in field-experiments with fertilizers.

Now to apply this to our corn experiment. The land was in good heart to begin with. The plots from A to L, as already explained, had an ammoniated superphosphate applied to them in the spring at the rate of 1,000 pounds to the acre, and Plots M to R had double that quantity. This last would be regarded as an excessive quantity perhaps, though it was all applied broadcast.

Of the plots which had 1,000 pounds per acre the largest yield of water-free crop of the dent variety was on Plot D, two stalks to a foot. On the plots which received 2,000 pounds per acre the largest gross yield was on Plot P, also two stalks to a foot. Unfortunately we could not ascertain the water-free weights on three of the plots, but the water-free crop on P was larger than on the next thicker planted, Q.

In every case the yield with 2,000 pounds of superphosphate to the acre was larger than that on the corresponding plot with 1,000 pounds. This last holds also for the one plot of flint maize which had a double quantity of phosphate. These facts indicate, while they do not absolutely prove that the maximum crop was produced by about the same rate of planting—two stalks to a foot in the case of dent corn—whether the land had 1,000 or 2,000 pounds of phosphate per acre.

If we had planted plots showing smaller differences of distance, say one stalk to a foot, one to ten inches, one to eight inches, and one to six inches, we might then have found a difference in the rate of planting which yielded the maximum crop, between the sets of plots that had 1,000 pounds and those that had 2,000 pounds per acre.

The extra phosphate on each plot, without exception, not only increased the total yield over the corresponding plot which had half the quantity of phosphate, but also increased the yield of each food-ingredient of the crop. It also slightly increased the percentage of albuminoids in the water-free crop. It also increased the development of the individual corn plant as shown in Tables X and XI. We have no accurate data for calculating the money gain or loss caused by applying the extra phosphate. The best comparison we can make is between Plots D and P, both being planted alike, but P having extra phosphate.

	D. *Pounds.*	*Per Acre.*	P. *Pounds.*	Increase in per cent.
Total Water-free crop,	7980		9404	17.8
Sound shelled corn, water-free,	3292		3547.8	7.7

The gain of sound shelled corn amounts to about 5 bushels per acre [with 14 per cent. of water] and of field-cured stover to about 1670 pounds [with 30 per cent. of water.] Evidently the extra phosphate did not pay here, nor was it to be expected that it would. The quantity used was made excessive in order to bring out if possible the effects of a heavy application of fertilizer on the relative yield of the plots having a different rate of planting.

Our experiment only shows that when the land was in good condition to start with and had besides a liberal application of superphosphate, a distance of planting which produced a maximum yield, would also produce the maximum yield when the quantity of superphosphate was doubled.

It is possible that if the land had received no phosphate at all, a thicker rate of planting than two stalks to a foot or one stalk to a foot would have given the maximum yield.

Comparison of the Flint and Dent Varieties of Maize.

A. Difference in the Relative Effects of Distance of Planting.

We have seen that in this experiment a certain rate of planting produced a maximum crop, while both a thicker and a thinner rate of planting diminished the yield.

With a distance of 4 feet between rows the dent variety produced the largest water-free crop when the stalks stood two to a foot in the row, or 21,760 stalks to the acre. When there were four to a foot, or 43,520 stalks per acre, the crop was scarcely larger than when there were only one quarter of that number, i. e. one to the foot or 10,880 per acre. 87,040 stalks per acre gave one-twelfth less crop than one quarter of that number, 21,760. When the land was more highly fertilized, having a ton of nitrogenous superphosphate per acre, instead of half a ton the result was the same; i. e. two stalks to a foot in the rows gave the largest crop.

The yields of water-free ears and stover of the dent variety were as follows:—

TABLE XV. DENT MAIZE.

	Ears.	Stover.	Total Crop.
One stalk in four feet,	80.3	97.8	178.1
" " " two "	159.9	142.6	302.5
" " to a foot,	190.0	177.5	367.5
Two stalks " "	**192.6**	206.4	**399.0**
" " " " *	217.0	253.2	470.2
Four " " "	103.7	268.1	371.8
" " " " *	102.6	293.0	395.6
Eight " " "	73.5	**292.0**	365.5

* With extra phosphate.

From this it appears that the quantity of stover regularly increased as the planting was made closer, but not the total crop or the quantity of ears.

Moreover, it appears from Table IX that the largest quantities of ash or mineral matter, of albuminoids, fat, and nitrogen-free extract [starch, sugar, gum and the like] were harvested from the plot which was planted at the rate of two stalks to a foot while the plots which were thicker planted yielded more fiber only.

That is the total water-free crop of dent maize was largest and the total quantity of each food ingredient except fiber was greatest on the plot where the rate of planting was two stalks to a foot in the row.

Let us now turn to the flint variety of maize. Table III shows that with a distance of four feet between rows, the flint variety produced the largest water-free crop when the plants stood *a foot apart* in the row,—while the maximum crop of the dent variety was produced by a closer planting, i. e. *two stalks to a foot.*

10,880 stalks to the acre of flint maize gave the maximum yield, while twice that number or 21,760 stalks to the acre gave the maximum yield of dent maize.

The yields of water-free ears and stover of the flint variety were as follows:—

TABLE XVI. FLINT MAIZE.

	Ears.	Stover.	Total Crop.
One stalk in four feet,	113.4	93.0	206.4
One " " two "	154.6	108.6	263.2
One " to a foot,	**195.0**	149.9	**344.9**
Two stalks " "	170.6	122.7	293.3
Four " " "	161.5	130.2	291.7
Eight " " "	76.8	**172.1**	248.9
" " " " *	135.5	221.0	356.5

* With extra phosphate.

One stalk to a foot produced a larger yield of stover likewise than any other rate of planting except the closest, eight to a foot.

While the total weight of ears was largest where the rate of planting was one stalk to a foot, the most sound kernels were harvested from thicker planting.

Table IX, shows that the largest quantities of each food-ingredient in the flint maize were also harvested from the plot where the stalks stood *one to a foot*, while in case of the dent variety, *two stalks to a foot* gave the largest yield of these ingredients.

These differences between the flint and dent varieties are worth notice. Here are two varieties of maize extremely unlike in their appearance. The dent is a very large kind, standing from two and a half to three feet taller than the flint variety, with much larger and heavier stalks, larger and heavier leaves, longer and larger ears, and having the reputation of yielding much more per acre. The flint variety is very much smaller, small even for a flint. It would seem as if the dent would make larger demands on the mineral matters and water of the soil, and on the light and air than the flint variety, and therefore would not yield the largest possible crop with a rate of planting which would be best for the small flint variety, but would need to be planted much thinner. So if a rate of one plant to a foot gave the maximum crop of the flint variety we should expect a greater distance, say one stalk in 14, 18, or 24 inches, would give the largest crop of dent maize. But the reverse appears to be the case. Under the conditions of this experiment at least, the dent variety required a *closer* planting than the flint to get the highest yield.

This difference, we believe, is to be explained by differences in the nature of the variety which have been induced by selection of seed and method of culture.

Mr. Webb has raised this White Edge Dent for fifteen years or more and has planted it in rows four feet apart with stalks about one to a foot—rather closer than this of late years—his object being not to produce the most and best ears but rather to get the most feed and to feed the whole crop, ears and stover cut up together, to his cows. That is, he has grown his corn close and has carefully selected his seed from ears that did best *when grown in that way.*

Mr. Bartholomew has raised the Rhode Island White Cap and selected the seed with equal care for a long time. He aims rather for the largest crop of sound, perfectly developed ears, less attention being given to the stover. He usually plants in hills, at a wider distance than Mr. Webb. In consequence, his variety is more prolific of ears, which are small, but very firm and perfect. It would seem then that the fact which we have noted that the large dent maize produced its maximum crop when the stand was closer than that which gave the maximum yield of the smaller flint is to be partly or wholly explained by differences inherent in the variety which are more potent in determining the requirements of the crop as to light and area of soil than the physical difference in size.

B. Differences of Yield between the Dent and Flint Varieties under the same Conditions of Planting.

In Table XVII a comparison is made of the average total yields of flint and dent maize on the two plots where the rate of planting most nearly corresponds with usual farm practice, that is, two plants to a foot, and one to a foot, respectively, in rows four feet apart. The yield is calculated to the acre. All the conditions of growth were as nearly alike as it is possible to make them in the case of the two varieties.

TABLE XVII.—YIELD OF DENT AND FLINT MAIZE PER ACRE.

	Flint variety.	Dent variety.
Total crop	11648.0	15074.0
Water-free crop	6382.8	7665.0
Sound kernels	3062.7	3124.9
Soft kernels	250.6	283.8
Leaves	1169.3	1607.5
Stripped stalks	1059.1	1732.8
Husks	498.4	499.1
Sound cob	282.3	352.6
Soft cob	60.4	64.3

If we call the yield of the flint variety 100 in each case the yields of the dent will stand as follows:

	Flint.	Dent.
Total dry matter	100	120
Sound kernels	100	102
Soft "	100	113
Total "	100	103
Leaves	100	138
Stripped stalks	100	163
Husks	100	101
Sound cobs	100	125
Soft cobs	100	106

The above figures show:

1. The dent variety yielded twenty per cent., or one-fifth more of water-free crop than the flint.

2. The yield of sound shelled corn and of total shelled corn of the dent was only slightly larger than of the flint.

3. The increased yield of crop in the case of the dent variety was large in leaves, but chiefly in stripped stalks.

Table V shows that on the plots above named, where the rate of planting agrees best with common farm practice, the average yield of sound ears of the flint variety was 52.8 per cent. of the whole crop, while of the dent variety it was 45.5 per cent., and that the ratio of cob to shelled corn was 1 to 11.6 in the flint and 1 to 8.8 in the dent variety. That is, the dent had a larger relative quantity of cob than the flint.

C. Differences in Chemical Composition between the Dent and Flint Varieties.

From Table IX is calculated the average chemical composition of the water-free crops of flint and dent, including only the plots named above, and from other data is calculated the average composition of the water-free sound kernels:

Table XVIII.—Composition of the Water-free Crop and of the Sound Kernels of the Flint and Dent Varieties.

	Water-free Crop.		Sound Kernels.	
	Flint.	Dent.	Flint.	Dent.
Ash	3.86	3.26	1.33	1.42
Albuminoids	9.41	7.74	11.93	9.71
Fiber	16.60	19.36	1.20	1.66
Nitrogen-free extract	66.72	66.26	79.88	81.46
Fat	3.71	3.38	5.66	5.75
	100.00	100.00	100.00	100.00

From Table VI it appears that the field-cured crops of flint corn had on the average 47.2 per cent. of water, while the dent variety had 52.5 per cent. This is due to the fact that the flint ripened earlier and was drier when cut.

Regarding next the *chemical composition* of the water-free crop it appears that the chief differences between the two varieties are in the percentages of albuminoids and fiber. The water-free crop of the dent variety has in round numbers two and three-quarters per cent. more fiber, and one and three-quarters per cent. less albuminoids than the flint variety, and is, in so far, pound for pound less valuable as cattle food.

Regarding the composition of the sound kernels, the most striking difference between the two is in albuminoids. The dent variety has two and two-tenths per cent. less albuminoids than the flint. This might perhaps be explained by the fact that the flint was quite fully ripe when cut, but the dent was not, so that the kernels of the flint were fully filled, while in case of the dent the transportation of matter from stem and leaves to the kernel was checked by the cutting. But the higher percentage of albuminoids in the total crop of flint maize could hardly be accounted for in that way.

D. Differences in yield of Food-ingredients between the Dent and Flint Varieties.

Table XIX gives the total yield per acre of ash or mineral matter, albuminoids, fiber, etc. for each variety calculated from the yield of the plots where the rate of planting was nearest to that commonly employed.

Table XIX.—Dent and Flint Varieties Compared as to Yield per acre of Food-ingredients.

	Ash.	Albuminoids.	Fiber.	Nitrogen-free extract.	Fat.
Dent maize	149.6	592.8	1484.2	5079.1	259.2
Flint maize	227.6	599.6	1066.5	4252.7	236.4

The dent variety yields very considerably more per acre of fiber and of nitrogen-free extract and somewhat more fat. The flint variety yields considerably more ash and about the same quantity of albuminoids as the dent.

There is another point of comparison between these two varieties which is brought out by experience in handling the crops. The flint variety molds much more readily than the dent and so cannot be handled or stored in the same way. Perhaps the explanation is that it packs much closer in the bundles or shooks than the dent, admits less circulation of air and for that reason will easier heat and spoil.

Maize Raised for Seed.

As has been shown on pages 30–33 the individual maize plant reached its fullest development when the plants stood far apart. The individual plant yielded a greater weight of water-free substance as well as of kernel and of all its other parts when it stood four feet from its neighbors than when it stood any closer. Some of the ears were remarkably large and if care had been taken to remove suckers which were very abundant and vigorous where the corn was thinnest planted, the yield of sound corn per plant would doubtless have been still larger.

If these plants were then the most productive in every way would it not pay to select from them seed corn for the next year and annually to plant some corn for seed much thinner than for the main crop, thus securing seed which should be specially prolific as is indeed occasionally recommended? The question is not so simple as it might seem at first glance.

Unquestionably the productiveness of a given variety of corn is kept up and increased within certain limits by selecting the most perfect ears in the crop each year for the next year's seeding. But it must be considered that the given variety is raised continually in the same way, being planted at approximately the same rate year after year and the ears are selected from plants which *planted in that way* are the most productive. Now if maize is planted each year very thin for seed, it is almost certain that a sub-variety or strain will be established which will require to be planted further apart, in order to get a maximum crop than the original strain from which it originated and this maximum crop *may* not be any larger or even as large as that of the variety from which it came. Experiments in this direction would be extremely interesting.

Maize for Ensilage.

The special rates of planting followed in this experiment will not prove the best in all practice, of course, but the fact remains always and every where that the maximum yield possible under the given conditions of soil, cultivation and weather can be diminished by too thick planting as well as by thin planting, and this holds doubtless for maize cut green for ensilage as well as for maize which is allowed to ripen.

Very frequently in the endeavor to prevent the formation of ears, to fully utilize the ground and to make the crop tender and succulent by thick planting, the quantity of crop is considerably lessened. When maize is planted for ensilage or to be field-cured and fed without husking—as is Mr. Webb's practice—what is chiefly wanted is the maximum production of albuminoids, fat and carbhydrates.

The claim may be made that the aim is not *wholly* to get the largest yield of food-ingredients, but to get it free from hard stalks which are not as fully utilized by cattle as the leaves and immature ears and that while a larger crop may be got with thinner planting the thickest planting is actually the most profitable because the stalks are tender. In our opinion the claim is not a sound one. Feeders of ensilage agree that even large butts of stalks if properly cut are eaten clean, field-cured stalks if cut and shredded are also eaten clean, and when simply cut in an ensilage cutter Mr. Webb finds that there is very little waste.

There is no reason to believe that stalks which are eaten are any less digestible than other parts of the maize plant. Again there is a larger percentage of stalk in maize which stands closest as is shown in Table V though the stalks are quite small and tender. But again even if we reckon as valuable only half the substance of the stalks when planted two to a foot, and all the substance of the stalks as valuable when planted four or eight to a foot—a disparity which certainly does not exist,—the thinner

planting would still yield considerably more digestible albuminoids and fat than the thicker planting, and only a little less carbhydrates.

If a suitable variety of maize is planted at a rate to insure the maximum crop at harvest time, the quantity of ears or of stalks in it, will not damage it either for ensilage or for cutting up and feeding without husking in the field-cured condition.

It is however possible that a rate of planting which would give a maximum crop if cut when the maize was in the silk or just tasselling, would be too close to give the maximum crop if cut when the ears had fully formed. That is, it is possible, that when maize is to be cut *before it is fully developed* a thicker planting is advisable than when it is to be allowed to mature.

In the preceding pages we have reviewed the effects of the rate of planting on the quality and quantity of a single crop. The discussion may be closed with a very brief statement of the general facts regarding the subject which have been established by elaborate and painstaking work done elsewhere. These have been taken in substance from Dr. Ewald Wollny's treatise on the Planting and Cultivation of Farm Crops.

1. Other things being equal the largest possible *quantity* of crop can only be got by a certain rate of planting. Thinner or thicker seeding than this rate will lessen the crop. See Table III, page 17.

2. The *quality* of the crop is generally the best when the seeding is thin. The more ground given to single plants of a root crop, for instance, *within certain limits*, the larger and heavier will be the single roots or tubers, or in case of a grain crop the greater the distance of planting the plumper and heavier will be the grain ; i. e. a rate of planting which secures the best development of the individual plant is too thin or too low a rate to secure the largest crop. See page 30 and Table XI.

3. The proportion of straw or stover to grain increases as the stand is thicker. See Tables XV and XVI, pages 38 and 39.

4. While in general the yield of the single plant increases with the increase in the quantity of soil at its disposal up to a certain limit,—which of course is different for different species and varieties of plants,—this increase is not directly proportional to the increased area. See page 32.

These facts cannot be wholly explained by the limited capacity of the soil to furnish plant food. Plants do not by any means develop or yield proportionally to the quantity of plant food at their disposal or the area of soil at their command. There are a variety of other *factors of growth* which are also influenced by distance of planting. Among these are :

5. *Light.*—The plants of any crop always shade each other more or less, both from direct sun-light and from the diffused light of the sky. The thicker the stand the denser will be the shade, i. e. the smaller will be the quantity of light at the disposal of the individual plant. Without light, of course there can be no true growth ; when light is deficient growth is checked and the crop is smaller than it otherwise would be. There is no evidence that our crops ever suffer from *excess* of light, but they frequently suffer as a whole and almost always suffer in the individual development of the separate plants from lack of light, under the ordinary methods of planting.

6. *Heat.*—Fallow ground in summer, other conditions being alike, is warmer at and near the surface than ground covered by a crop, and the closer the stand of the crop the cooler will be both the surface soil and the air just above the surface.

The reason is that the ground surface is shielded by leaves from the direct rays of the sun, and their heat is largely expended in evaporating water rather than in heating the soil, and the less the heat penetrates the foliage the less the air will circulate and the greater will be the radiation of heat at night.

Now since the development and activity of the roots is affected very greatly by the soil temperature, it follows that the crop production is affected by the soil temperature, and so indirectly by the rate of planting.

7. *Water.*—While the evaporation per *single plant* of a crop thinly planted is greater than from one of a crop planted close, the *total evaporation* from thick planted crops is vastly greater than from those thin planted. Hence in time of drought the former is likely to suffer first and most. On the other hand, when rains are excessive the reverse may be the case ; the thick-planted crop may do best because the larger evaporation by the crop tends to keep the soil from being saturated with water and so from being deprived of air.

8. On the particulars already cited, light, heat and moisture depends largely the *tillering* of our cereals. Light is perhaps the chief factor, but the others have also a decided effect. Where the seeding of grain is thinnest, other things being equal, is the greatest tendency to tiller and a rate of planting which would otherwise be too thin is corrected in a way by this tendency.

There are certain *special conditions* (to be distinguished from the general factors of growth already noted, such as light, heat and moisture) which modify the effects of rate of planting on the quantity and quality of the crop. Among these are

9. *Variety.*—As a general rule larger varieties which have a greater development of roots and leaves need more ground ; i. e. a thinner rate of planting for their normal development than small varieties.

10. *Quality of Soil.*—First as regards the available plant food in it : the largest possible crop will be raised on a given soil which is heavily manured, with a thinner rate of seeding than would give the largest crop on the same soil, when unmanured. That is, a rich soil needs less seed to give a maximum crop than a poor soil.

The reason is evident. On rich land the growth and development of roots and leaves is much greater, and the demands made for light and heat are larger than on poor land. If now as much seed is sown on rich land as would be required to get the best possible crop on land containing less plant food, other things being equal, the plants on account of their more luxuriant growth will stand too thick and so the yield will be depressed.

Again, as regards the physical character of the soil : it follows from what has been said as to water that, other things being equal, soils retentive of moisture may be thicker planted than light, dry soils, always remembering that a soil which is really wet is a cold soil and thick planting also keeps the soil colder. The deeper the tilth, the more thorough the tillage and the cleaner of weeds is the soil, the thinner may be the planting.

Again, the more unfavorable the conditions of climate and weather are to the development of plants the thicker must be the sowing.

And lastly, the quality of the seed, whether old or fresh, heavy or light, large or small, has a great effect on the relative profitableness of different rates of planting. A proper discussion of this subject would carry us too far for the limits of this paper.

A brief summary of the results of this investigation is, from the nature of the case, impossible. We repeat here the special points which have been studied, giving references to the pages on which the conclusions reached are tabulated or summarized.

Effect of Distance of Planting on

A. Quantity of crop.

1. The gross yield. p. 16.
2. The quantity of dry (water-free) matter in the crop. p. 18.
3. The total weight of the separate parts of the dry crop. p. 18.
4. The proportional quantity of dry matter in each part of the crop. p. 20.

B. Quality of crop.

1. Percentage composition of the field-cured crops. p. 23.
2. Percentage composition of the separate parts of the field-cured crops. p. 24.
3. Percentage composition of the dry matter in the field-cured crops. p. 26.
4. Total quantity of food ingredients in the crops. p. 29.
5. Comparative development of the individual maize plant. p. 30.
6. Comparative composition of the individual maize plant. p. 33.
7. The quantities of nitrogen, phosphoric acid and potash removed in the crop. p. 34.

Effect of Rate of Planting as modified by Manuring. p. 36.

Comparison of Flint and Dent Maize.

A. Difference in relative effects of distance of planting. p. 37.

B. Difference in yield under same conditions of planting. p. 40.

C. Difference in chemical composition. p. 41.

D. Difference in yield of food ingredients. p. 42.

Maize raised for Seed. p. 43.

Maize for Ensilage. p. 44.

General facts regarding distance of planting. p. 45.

THE CONNECTICUT FERTILIZER LAW.

The General Assembly at its session in 1882 passed a Fertilizer Law which went into effect September 1, 1882, and which repealed and took the place of all previous legislation on this subject. The law is still in force without any amendment.

Copies of the law may be had on application to the Station.

Attention is specially called to the following points:

1. In case of fertilizers that retail at ten dollars or more per ton, the law holds the SELLER responsible for *affixing a correct label or statement* to every package or lot sold or offered, as well as for the *payment of an analysis fee* of ten dollars for each fertilizing ingredient which the fertilizer contains or is claimed to contain, *unless* the MANUFACTURER OR IMPORTER shall have provided labels or statements and shall have paid the fee. Sections 1 and 3.

The Station understands "the fertilizing ingredients" to be those whose determination in an analysis is necessary for a valuation, viz: Nitrogen, Phosphoric acid and Potash. The analysis-fees in case of any fertilizer will therefore be ten, twenty or thirty dollars, according as one, two or three of these ingredients are contained or claimed to exist in the fertilizer

2. The law also requires, in case of any fertilizer selling at ten dollars or more per ton, that a *sealed sample* shall be deposited with the Director of the Station by the MANUFACTURER OR IMPORTER, and that a *certified statement* of composition, etc., shall be filed with him.

A statement of the per cents. of Nitrogen, Phosphoric acid (P_2O_5) and Potash (K_2O), and of their several states or forms, will suffice in most cases. Other ingredients may be named if desired.

In all cases the per cent. of *nitrogen* must be stated. Ammonia may also be given when actually present in ammonia salts, and "ammonia equivalent to nitrogen" may likewise be stated.

The per cent. of soluble and reverted phosphoric acid may be given separately or together, and the term "available" may be used in addition to, but not instead of soluble and reverted.

Insoluble phosphoric acid may be stated or omitted.

In case of Bone, Fish, Tankage, Dried Meat, Dried Blood, etc., the chemical composition may take account of the two ingredients: Nitrogen, Phosphoric Acid.

For Potash Salts give always the per cent. of Potash (potassium oxide); that of Sulphate of Potash or Muriate of Potash may also be stated.

The chemical composition of other fertilizers may be given as found in the Station Reports.

3. It is also provided that EVERY PERSON in the State, who sells *any commercial fertilizer of whatever kind or price* shall annually report certain facts to the Director of the Experiment Station, and on demand of the latter shall deliver a sample for analysis. Section 4.

4. All "CHEMICALS" that are applied to land, such as: Muriate of Potash, Kainite, Sulphate of Potash and Magnesia, Sulphate of Lime (Gypsum or Land Plaster), Sulphate of Ammonia, Nitrate of Potash, Nitrate of Soda, etc.—are considered to come under the law as "Commercial Fertilizers." Dealers in these chemicals must see that packages are suitably labeled. They must also report them to the Station, and see that the analysis fees are duly paid, in order that the Director may be able to discharge his duty as prescribed in Section 9 of the Act.

It will be noticed that the State exacts no license tax either for making or dealing in fertilizers. For the safety of consumers and the benefit of honest manufacturers and dealers, the State requires that it be known what is offered for sale, and whether fertilizers are what they purport to be. With this object in view the law provides, in section 9, that all fertilizers be analyzed and it requires the parties making or selling them to pay for these analyses in part; the State itself paying in part by maintaining the Experiment Station.

OBSERVANCE OF THE FERTILIZER LAW.

MANUFACTURERS who have paid Analysis Fees as required by the fertilizer Law, and FERTILIZERS for which the fees have been thus paid for the year ending May, 1890.

Firm.	*Brand of Fertilizer.*
Apothecaries Hall Co., Waterbury, Conn.	Victor Phosphate.
Baker, H. J. & Bro.. 215 Pearl St., N. Y.	A. A. Ammoniated Superphosphate. Potato Manure. Corn Manure. Ground Bone. Castor Pomace.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	Stockbridge Grain Manure. " Forage Crop Manure. " Vegetable Manure. Bowker's Hill and Drill Phosphate. Fish and Potash. Ammoniated Dissolved Bone. Pure Dry Fish.
Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	Bradley's Superphosphate. B. D. Sea Fowl Guano. Complete Manure for Potatoes and Vegetables. Complete Manure for Top Dressing Grass and Grain. Complete Manure for Corn and Grain. Potato Manure. Farmers New Method Fertilizer. Original Coe's Superphosphate. Pure Fine Ground Bone. Ground Bone and Potash, Circle Brand. Fish and Potash, "A" Brand. " " " Anchor Brand.
Coe, E. Frank, 16 Burling Slip, N. Y.	High Grade Ammoniated Superphosphate. Red Brand Excelsior Guano. Potato Fertilizer. Alkaline Bone. Ground Bone. Fish and Potash.
Cooper's, Peter, Glue Factory, 17 Burling Slip, N. Y.	Peter Cooper's Bone Dust.
Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	New Rival Ammoniated Superphosphate. Buffalo Phosphate No. 2. Special Potato Manure. Pure Ground Bone. Ammoniated Bone Superphosphate. Potato, Hop and Tobacco Phosphate. Queen City Phosphate. Vegetable Bone Superphosphate. Ammoniated Wheat and Corn Phosphate.

Cumberland Bone Co., Portland, Me.	Cumberland Superphosphate. Seeding Down Fertilizer.
Darling, L. B. Fertilizer Co., Pawtucket, R. I.	Animal Fertilizer. Extra Bone Phosphate. Pure Ground Bone.
Davidge Fertilizer Co., 121 Front St., N. Y.	Potato Manure. Vegetator. Special Favorite.
Downs & Griffin, Derby, Conn.	Ground Bone.
Great Eastern Fertilizer Co., Rutland, Vt.	Gt. Eastern General Fertilizer for Grass and Grain. Gt. Eastern General Fertilizer for Vines and Tobacco. Gt. Eastern General Fertilizer for Oats, Buckwheat, and Seeding Down Phosphate.
Kelsey, E. R., Branford, Conn.	Fish and Potash.
Lister's Agricultural Chemical Works, Newark, N. J.	Ammoniated Dissolved Bone. Standard Superphosphate of Lime. Celebrated Ground Bone.
Ludlam, Frederick, 140 Maiden Lane, N. Y.	Cecrops Fertilizer. Cereal Fertilizer.
Mapes' Formula & Peruvian Guano Co., 158 Front St., N. Y.	Complete Manure for Light Soil. " " " general use. " " " "A" Brand. Potato Manure. Tobacco Manure, Conn. Brand. Fruit and Vine Manure. Corn Manure. Fine Dissolved Bone. Tobacco Manure, Wrapper Brand. Peruvian Guano. Grass and Grain Spring Top Dressing.
Meyer, C. Jr., Maspeth, L. I.	Acme Fertilizer. Acme Fertilizer, "E" Brand.
Miller, G. W., Middlefield, Conn.	Flour of Bone Phosphate. Pure Ground Bone.
Miller H. S. & Co., Newark, N. J.	Bone Meal. Harvest Queen Phosphate. Special Potato Manure.
Mitchell, A. Tremley, N. J.	Standard Phosphate.
National Fertilizer Co., Bridgeport, Ct.	Chittenden's Complete Fertilizer. " Ammoniated Bone Phosphate. Chittenden's Fish and Potash. " Ground Bone.
Nuhn, F. Waterbury, Conn.	Self-Recommending Fertilizer.
Orient Guano M'f'g Co., 16 and 18 Exchange Place, N. Y.	Orient Complete Manure. Fish and Potash.

Pacific Guano Co., Tremont Bank Building, Boston, Mass.	Soluble Pacific Guano. Fish and Potash.
Peck Bros., Northfield, Conn.	Pure Ground Bone.
Plumb & Winton, Bridgeport, Conn.	Ground Bone.
Prentice, Chas., Putnam, Conn.	Phosphate. Ground Bone.
Quinnipiac Co., New London, Conn.	Phosphate. Pine Island Phosphate. Potato Manure. Market Garden Manure. Fish and Potash—Crossed Fishes Brand. Fish and Potash—Pequot Brand. Dry Ground Fish Guano. Bone Meal.
Red Seal Castor Oil Co., St. Louis, Mo., by Olds & Whipple, Hartford.	Red Seal Castor Pomace.
Reed Fertilizer Co., New York, N. Y.	Farmers' Friend Brand. Lion Brand. High Grade Farmers' Friend. Samson or Lion Special.
Rogers & Hubbard Co., Middletown, Ct.	Complete Potato and Tobacco Manure. Fairchild's Formula for Corn and General Crops. Fairchild's Formula for Seeding Down. Raw Knuckle Bone Flour. Strictly Pure Fine Bone. Pure Ground AX Bone.
Sanderson, L., 87 Long Wharf, New Haven, Conn.	Formula "A." Sulphate of Ammonia. Kainit. Nitrate of Soda. Blood, Bone and Meat. Dissolved Bone Black. Muriate of Potash. Sulphate of Potash. Fine Ground Bone.
Shoemaker & Co., M. L., Philadelphia, Penn., by F. Ellsworth, Hartford.	Swift-Sure Bone Meal. Swift-Sure Superphosphate.
Standard Fertilizer Co., 118½ Milk St., Boston, Mass.	Standard Fertilizer. Standard Guano.
Taylor Bros., Rock Fall, Conn.	Ground Bone.
Thompson & Edwards Fertilizer Co., Union Stock Yards, Chicago, Ill.	Blood and Bone Animal Guano.
Wilkinson & Co., 52 and 54 Williams St., N. Y.	Economical Bone Fertilizer.
Williams & Clark Co., 81 Fulton St., N. Y.	Americus Ammoniated Bone Superphosphate. Potato Phosphate. Bone Meal. Royal Bone Phosphate. Universal Phosphate. Tobacco Phosphate.

ANALYSES OF FERTILIZERS.*

During 1889, 242 samples of fertilizers have been analyzed. Of these, a small number were examined for private parties and for testing methods in connection with other Experiment Stations, and the remainder for the general use of the citizens of the State.

During April and May last Messrs. H. W. Yeomans, of Columbia and Dennis Fenn of Milford, agents of this Station, collected samples of Commercial Fertilizers in all parts of Connecticut. 127 towns and villages have been visited, distributed as follows:

Hartford Co.	24
Tolland Co.	11
Windham Co.	17
New London Co.	8
Middlesex Co.	14
New Haven Co.	19
Fairfield Co.	18
Litchfield Co.	16
	127

These gentlemen drew about 580 samples by using the method of sampling which is described on page 91 of the Report of this Station for 1884.

In this way one or more samples were secured of nearly every brand of fertilizer which is offered for sale within the State. When several samples of a single brand were drawn in different parts of the State the analysis was performed, not on any single sample, but on a mixture made of an equal weight of each of the several samples. Thus, it is believed, the average composition of the goods is more fairly represented than by the analysis of any single sample.

The Station agents are instructed in every case to open at least three packages of each brand for sampling and if the number of packages is large, to take a portion from every tenth one, by means of a sampling tube which withdraws a section or core through the entire length of the bag or barrel.

* The matter of this and several subsequent pages, explanatory of the sampling and valuation of fertilizers, is copied, with a few appropriate alterations, from the Report for 1887. This repetition appears to be necessary for the use of readers who have not seen former Reports.

As a rule the Station will not analyze samples—

1. From dealer's stock of less than one ton.
2. From stock which has lain over from last season.
3. From stock which evidently is improperly stored, as in bags lying on wet ground or exposed to the weather, etc.

The Station desires the co-operation of farmers, farmers' clubs and granges in calling attention to new brands of fertilizers and in securing samples of all goods offered for sale. All samples drawn by other than Station agents *must* be drawn in accordance with the Station's Instructions for sampling and properly certified, if the station analysis is desired. A copy of these instructions and blank certificates will be sent on application.

Samples are analyzed as promptly as possible in the order in which they are received. As soon as an analysis is completed a copy of it is sent to the party who furnished the sample and also to the manufacturer, in order that there may be opportunity for explanation or protest, if desirable, before the results are published in the Bulletin.

The following "Explanations" are intended to embody the principles and data upon which the valuation of fertilizers is based, a knowledge of which is essential to a correct understanding of the analyses that are given on subsequent pages.

Explanations Concerning the Analysis of Fertilizers and the Valuation of their Active Ingredients.

Revised.

Nitrogen is the most rare, and commercially, the most valuable fertilizing element.

Free Nitrogen is indeed universally abundant in the common air, but in this form its effects in nourishing vegetation are as yet obscure.

Organic Nitrogen is the nitrogen of animal and vegetable matters, which is chemically united to carbon, hydrogen and oxygen. Some forms of organic nitrogen, as those of blood, flesh and seeds, are highly active as fertilizers; others, as found in leather and peat, are comparatively slow in their effect on vegetation, unless these matters are chemically disintegrated.

Ammonia (NH_3) *and nitric acid* (N_2O_5) are results of the decay of *organic nitrogen* in the soil and manure heap, and contain Nitrogen in its most active forms. They occur in commerce—the former in sulphate of ammonia, the latter in nitrate of soda. 17 parts of ammonia or 66 parts of pure sulphate of ammonia contain 14 parts of nitrogen. 85 parts of pure nitrate of soda also contain 14 parts of nitrogen.

Phosphorus is, next to nitrogen, the most costly ingredient of Fertilizers, in which it always exists in the form of phosphates, usually those of calcium, iron, and aluminum, or in case of some "superphosphates" in the form of free phosphoric acid.

Soluble Phosphoric acid implies phosphoric acid or phosphates that are freely soluble in water. It is the characteristic ingredient of Superphosphates, in which it is produced, by acting on "insoluble" or "reverted" phosphates, with diluted sulphuric acid (oil of vitriol). Once well incorporated with the soil it gradually becomes reverted phosphoric acid.

Reverted (reduced or precipitated) Phosphoric acid means strictly, phosphoric acid that was once easily soluble in water, but from chemical change has become insoluble in that liquid. In present usage the term signifies the phosphoric acid (of various phosphates) that is freely taken up by a strong solution of ammonium citrate, which is therefore used in analysis to determine its quantity. "Reverted phosphoric acid" implies phosphates that are readily assimilated by crops.

Recent investigation tends to show that soluble and reverted phosphoric acid are on the whole about equally valuable as plant-food and of nearly equal commercial value. In some cases, indeed, the soluble gives better results on crops, in others the reverted is superior. In most instances there is probably little to choose between them.

Insoluble Phosphoric acid implies various phosphates not soluble in water or ammonium citrate. In some cases the phosphoric acid is too insoluble to be readily available as plant-food. This is especially true of the crystallized green Canada Apatite. Bone-black, bone-ash, South Carolina Rock and Navassa Phosphate when in coarse powder are commonly of little repute as fertilizers though good results are occasionally reported from their use. When *very finely pulverized* ("floats") they more often act well, especially in connection with abundance of decaying vegetable matters. The phosphate of calcium in raw bones is nearly insoluble, because of the animal matter of the bones, which envelopes it; but when the latter decays in the soil, the phosphate remains in essentially the "reverted" form. The phosphoric acid of "Thomas-Slag" and of "Grand Cayman's Phosphate" is freely taken up by crops.

Phosphoric acid in all the Station analyses is reckoned as "anhydrous phosphoric acid" (P_2O_5) also termed among chemists, phosphoric anhydride, phosphoric oxide, and phosphorus pentoxide.

Potassium is the constituent of Fertilizers, which ranks third in costliness. In plants, soils and fertilizers, it exists in the form of various salts, such as chloride (muriate), sulphate, carbonate, nitrate, silicate, etc. Potassium itself is scarcely known except as a chemical curiosity.

Potash signifies the substance known in chemistry as potassium oxide (K_2O), which is reckoned as the valuable fertilizing ingredient of "potashes" and "potash salts." In these it should be freely soluble in water and is most costly in the form of sulphate, and cheapest in the shape of muriate (potassium chloride).

The Valuation of a Fertilizer, as practised at this Station, consists in calculating the *retail Trade-value* or *cash-cost* (in raw materials of good quality) of an amount of nitrogen, phosphoric acid and potash equal to that contained in one ton of the fertilizer.

Plaster, lime, stable manure and nearly all of the less expensive fertilizers have variable prices, which bear no close relation to their chemical composition, but guanos, superphosphates and similar articles, for which $30 to $50 per ton are paid, depend chiefly for their trade-value on the three substances, *nitrogen*, *phosphoric acid* and *potash*, which are comparatively costly and steady in price. The trade-value per pound of these ingredients is reckoned from the current market prices of the standard articles which furnish them to commerce.

The consumer, in estimating the reasonable price to pay for high-grade fertilizers, should add to the *Trade-value of the above-named Ingredients*, a suitable margin for the expenses of manufacture, etc., and for the convenience or other advantage incidental to their use.

The average Trade-values or retail cost in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid and potash, as found in the New England, New York and New Jersey markets, are as follows:—

THE TRADE-VALUES FOR 1889 OF FERTILIZING INGREDIENTS IN RAW MATERIALS AND CHEMICALS.

The average Trade-Values or *retail cost per pound* of the ordinarily occurring forms of nitrogen, phosphoric and potash are as follows:

	Cts. per lb.
Nitrogen in ammonia salts	19
nitrates	17
Organic nitrogen in dry and fine ground fish, meat and blood	19
in cotton seed meal and castor pomace	15
in fine bone and tankage	16½
in fine medium bone and tankage	13
in medium bone and tankage	10½
in coarser bone and tankage	8½
in hair, horn shavings and coarse fish scrap	8
Phosphoric acid, soluble in water	8
in ammonium citrate*	7½
in dry ground fish, fine bone and tankage	7
in fine-medium bone and tankage	6
in medium bone and tankage	5
in coarser bone and tankage	4
in fine ground rock phosphate	2
Potash as high-grade Sulphate and in forms free from Muriate (or Chlorides)	6
as kainit	4½
as muriate	4½

These Trade-values were agreed upon by the Experiment stations of Massachusetts, New Jersey, Pennsylvania and Connecticut, for use in their respective States during 1889. They are the average prices at which, during the six months preceding March last, the respective ingredients were retailed for cash, in our large markets, in those raw materials which are the regular source of supply. They also correspond to the average wholesale price for the six months ending March 1st, plus about 20 per cent. in case of goods for which we have wholesale quotations. The valuations obtained by use of the above figures will be found to correspond fairly with the *average retail prices* at the large markets of standard raw materials, such as:

Sulphate of Ammonia,	Muriate of Potash,
Nitrate of Soda,	Sulphate of potash,
Dried blood,	Plain Superphosphate,
Azotin,	Dry Ground Fish,
Ammonite,	Bone and Tankage,

Ground So. Carolina Rock.

* Dissolved from 2 grams of the unground phosphate previously extracted with pure water, by 100 c. c. neutral solution of Ammonium Citrate, sp. gr. 1.09, in 30 minutes, at 65° C., with agitation once in five minutes. Commonly called "reverted" or "backgone" Phosphoric Acid.

VALUATION OF SUPERPHOSPHATES, SPECIAL MANURES AND MIXED FERTILIZERS OF HIGH GRADE.

The organic nitrogen in these classes of goods is reckoned at the price of nitrogen in raw materials of the best quality.

Insoluble Phosphoric Acid is reckoned at 3 cents, unless found to be from rock phosphate. In this latter form Insoluble Phosphoric Acid costs but 2 cents per pound. Potash is rated at 4½ cents, if sufficient chlorine is present in the fertilizer to combine with it to make muriate. If there is more Potash present than will combine with the chlorine, then this excess of Potash is reckoned at 6 cents.

In most cases the valuation of the Ingredients in Superphosphates and Specials falls below the retail price of these goods. The difference between the two figures represents the manufacturer's charges for converting raw materials into manufactured articles and selling them. These charges are for grinding and mixing, bagging or barreling, storage and transportation, commission to agents and dealers, long credits, interest on investments, bad debts, and finally, profits.

The majority of the manufacturers agree that the average cost of mixing, bagging, handling and cartage ranges from $3.00 to $4.50 per ton.

In 1889 the average selling price of Ammoniated Superphosphates, and Guanos was $34.10, the average valuation was $29.10, and the difference $5.00—an advance of 17.2 per cent. on the valuation and on the wholesale cost of the fertilizing elements in the raw materials.

In case of Special Manures the average cost was $40.25, the average valuation $35.20, and the difference $5.05, or 14.3 per cent. advance on the valuation.

To obtain the Valuation of a Fertilizer we multiply the pounds per ton of Nitrogen, etc., by the trade-value per pound. We thus get the values per ton of the several ingredients, and adding them together we obtain the total valuation per ton.

In case of *Ground Bone*, the sample is sifted into four grades and we separately compute the nitrogen-value of each grade by multiplying the pounds of nitrogen per ton, by the per cent. of each grade, taking $\frac{1}{100}$th of that product, multiplying it by the trade-value per pound of nitrogen in that grade, and taking this final product as the result in cents. Summing up the separate values of each grade, thus obtained, together with the values of each grade of phosphoric acid, similarly computed, the total is the Valuation of the sample of bone.

The uses of the "Valuation" are twofold:

1, To show whether a given lot or brand of fertilizers is worth, as a commodity of trade, what it costs. If the selling price is not higher than the valuation, the purchaser may be tolerably sure that the price is reasonable. If the selling price is twenty to twenty-five per cent. higher than the valuation, it may still be a fair price; but in proportion as the cost per ton exceeds the valuation there is reason to doubt the economy of its purchase.

2, Comparisons of the valuations and selling prices of a number of similar fertilizers will generally indicate fairly which is the best for the money.

But the valuation is not to be too literally construed, for analysis cannot always decide accurately what is the *form* of nitrogen, etc., while the mechanical condition of a fertilizer is an item whose influence cannot always be rightly expressed or appreciated.

For the above first-named purpose of valuation, the trade-values of the fertilizing elements which are employed in the computations should be as exact as possible, and should be frequently corrected to follow the changes of the market.

For the second-named use of valuation frequent changes of the trade-values are disadvantageous, because two fertilizers cannot be compared as to their relative money-worth, when their valuations are deduced from different data.

Experience leads to the conclusion that the trade-values adopted at the beginning of a year should be adhered to as nearly as possible throughout the year, notice being taken of considerable changes in the market, in order that due allowance may be made therefor.

The Agricultural value of a fertilizer is measured by the benefit received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad, general rule, it is true that Peruvian guano, superphosphates, fish-scraps, dried blood, potash salts, etc., have a high agricultural value which is related to their trade-value, and to a degree determines the latter value. But the rule has many exceptions, and in particular instances the trade-value cannot always be expected to fix or even to indicate the agricultural value. Fertilizing effect depends largely upon soil, crop and weather, and as these vary from place to place, and from year to year, it cannot be foretold or estimated except by the results of past experience, and then only in a general and probable manner.

CLASSIFICATION OF FERTILIZERS ANALYZED.

The fertilizers and manurial waste products analyzed at the Station laboratory from November 1st, 1888, to November 1st, 1889, were as follows:

Raw Materials Commonly Used in Mixed Fertilizers.

1. *Containing Nitrogen as the Chief Valuable Ingredient.*

Nitrate of Soda	3
Sulphate of Ammonia	2
Dried Blood	1
Cotton Seed Meal	6
Castor Pomace	3
Horn Shavings	1

2. *Containing Phosphoric Acid as the Chief Valuable Ingredient.*

Bone Black	1
Phosphatic Guano	2
Dissolved Bone Black	5

3. *Containing Potash as the Chief Valuable Ingredient.*

High Grade Sulphate of Potash	1
Double Sulphate of Potash and Magnesia	4
Muriate of Potash	4
Kainit	2
Sylvinit	1

4. *Containing Nitrogen and Phosphoric Acid.*

Bone Manures	31
Tankage	8
Dry Ground Fish	2

Mixed Fertilizers.

Nitrogenous Superphosphates and Guanos	82
Special Manures	36
Home-mixed Fertilizers	12

Miscellaneous Fertilizers and Manures.

Cotton Hull Ashes	12
Unleached Wood Ashes	9
Ashes from flues of boiler	1
Tobacco Stems	2
Wool Waste	1
Damaged Corn	1
Muck	1
Salt Marsh Mud	3
Mussels	1
Plaster	1
Yard Manure	2
Hall's Coral Fertilizer	1
Total	242

These analyses are discussed in the order above given on the following pages.—In all cases where the contrary is not stated, the samples were drawn by agents of the Station. The regular retail prices are in all cases given. By special terms with the dealer in many cases the actual cash prices paid have been much less.

I. Raw Materials of High-Grade Containing Nitrogen as the Chief Valuable Ingredient.

Nitrate of Soda.

Nitrate of Soda is mined in Chili and purified there before shipment. It usually contains about 16 per cent. of nitrogen, equivalent to 97 per cent. of pure nitrate of soda. It contains besides, a little salt and some moisture. The usual guarantee is "96 per cent." of nitrate of soda equivalent to 15.8 per cent. of nitrogen.

2438. Stock of Rogers & Hubbard Co., Middletown. Guaranteed 98 per cent.

2468. Sold by L. Sanderson, New Haven. From stock bought by W. H. Hammond, Elliott. Guaranteed 95 per cent.

2427. Stock of L. Sanderson, New Haven. Guaranteed 95 per cent.

Analyses.

	2438	2468	2427
Moisture	1.59	2.61	1.31
Salt [sodium chloride]	.60	.79	.36
Sulphate of soda	.27	.73	3.02
Pure Nitrate of soda	97.54	95.87	95.20
Matters insoluble in water	----	----	.11
	100.00	100.00	100.00
Contains nitrogen	16.07	15.80	15.70
Cost per ton	$56.00	55.00*	55.00
Nitrogen costs per pound in cents	17.4	17.4	17.5

* Dealer's regular price at store.

Sulphate of Ammonia.

This article, now made on a large scale as a by-product of gas-works, usually contains over 20 per cent. of nitrogen, the equivalent of from 94 to 97 per cent. of sulphate of ammonia. The rest is chiefly moisture. The usual guarantee is 25 per cent. of ammonia which is equivalent to 20.6 per cent. of nitrogen, but commercial sulphate of ammonia commonly contains less than that quantity.

2405. From stock of L. Sanderson, New Haven. Guaranteed 25 per cent. of ammonia.

2443. From stock bought by Dennis Fenn of C. Meyer, Jr., Maspeth, L. I. Guaranteed 24.5 per cent. of ammonia.

Analyses.

	2405	2443
Nitrogen	20.46	20.88
Equivalent ammonia	24.85	25.35
Cost per ton	$75.00	74.60
Nitrogen costs per pound in cents	18.3	17.9

Dried Blood.

This material consists chiefly of the blood of cattle killed at slaughter houses, which is dried by steam or in kilns till it contains from 10–12 per cent. of water, and in that condition will keep indefinitely.

2631. Stock of L. Sanderson, New Haven. This contained 12.20 per cent. of nitrogen and cost $50 per ton, making **the cost of nitrogen 20.5 cents per pound.**

Cotton Seed Meal.

The seed of the cotton plant, after ginning to remove the cotton fibre, passes through a mill which hulls or decorticates it. The hulled seed is ground and the oil is expressed. The ground cake from the presses is used as a cattle food and fertilizer. The hulls are burned for fuel in the oil factory and the ashes, which contain from 20 to 30 per cent. of potash, are also used as a fertilizer.

2421. Sold by J. E. Soper & Co., Boston. Sampled and sent by Edmund Halladay, Suffield.

2596. Sold by Olds & Whipple, Hartford. Sampled and sent by Station Agent.

2450. Sold by J. E. Soper & Co., Boston. Sampled and sent by H. S. Frye, Poquonock. Guaranteed 7.74 per cent. nitrogen.

2449. Sold by J. E. Soper & Co., Boston. Sampled and sent by H. S. Frye, Poquonock. Guaranteed 7.74 per cent. nitrogen.

2492. Sold by C. L. Spencer, Suffield, to Edward Austin. Sampled and sent by Allen Wilson, Suffield.

2494. Sold by Allen Wilson, Suffield, to Edward Austin. Sampled and sent by Allen Wilson.

ANALYSES.

	2421	2596	2450	2449	2492	2494
Nitrogen	6.94	7.50	7.17	6.75	6.87	6.65
Phosphoric acid	2.71	3.49	2.70	2.56	3.22	3.48
Potash	1.85	2.06	1.84	1.83	2.03	1.94
Cost per ton	$23.00*	26.00	24.00*	24.00*	27.00	27.00
Nitrogen costs per pound in cents	12.2	12.4	12.5	13.5	14.6	14.9

* In car lots.

Nos. **2449** and **2450** were received from H. S. Frye, Poquonock, who states that they are fair samples from a car lot bought of J. E. Soper & Co., Boston, on sample shown, and analysis giving 7.74 per cent. nitrogen; that the meal came in bags of all sizes from 75 to 160 pounds, and that it was of all grades and colors, light and dark, coarse and fine; that after correspondence the seller charged one dollar less per ton than was at first asked. Mr. Frye estimates that 20 per cent. of the meal is coarse. The mechanical condition of the two grades is as follows:

	2449	2450
Fine, smaller than $\frac{1}{50}$ inch	3	52
Fine medium, smaller than $\frac{1}{25}$ inch	1	22
Medium, smaller than $\frac{1}{12}$ inch	4	22
Coarse, larger than $\frac{1}{12}$ inch	92	4
	100	100

The coarse meal which apparently contained more hulls, contained also .40 per cent. less nitrogen and by reason also of its coarseness was much less valuable as a fertilizer.

Valuing phosphoric acid and potash at 7 and 6 cents per pound respectively—the rates used in the valuation of mixed fertilizers—nitrogen in cotton seed meal has cost at retail from 12½ to 15 cents per pound. It still remains, as last year, the cheapest source of quickly available nitrogen.

CASTOR POMACE.

This is the ground residue or cake of castor beans from which castor oil has been extracted by pressure.

2439. Stock of F. Ellsworth, Hartford. Guaranteed 5.75 per cent. nitrogen, 1.80 phosphoric acid, 1.30 potash.

2595. Made by the Red Seal Castor Oil Co., St. Louis. Sold by Olds & Whipple, Hartford.

2584. Made by H. J. Baker & Bro., 215 Pearl St., New York. Sampled from stock of W. F. Andross, E. Hartford, and W. W. Clark, Simsbury.

ANALYSES.

	2439	2595	2584
Nitrogen	5.52	5.54	5.60
Phosphoric acid	2.37	2.12	1.88
Potash	1.16	1.04	1.04
Cost per ton	$25.00	25.00	25.00
Nitrogen costs per pound	18.3 cts.	18.7 cts.	18.9 cts.

The price of Castor Pomace has advanced $5.00 per ton since the spring of 1888 and in consequence it has become one of the most costly sources of nitrogen, whereas in 1888 it was one of the cheapest.

HORN SHAVINGS.

2634. Sent by Lawrence Doyle of Harwinton. These shavings which are quite fine are stated to be from a factory in which the horn is boiled in a mixture of raw linseed oil and tallow previous to working it. Applied in very large amount the shavings are said to have been rather a damage than a benefit to land. The sample contained considerable insoluble foreign matter and 8.43 per cent. of nitrogen.

II. RAW MATERIALS OF HIGH GRADE CONTAINING PHOSPHORIC ACID.

BONE BLACK OR BONE CHAR.

2475. Sampled and sent by E. R. Kelsey, Branford. Taken from a factory where small articles of iron are case-hardened. It contains 7.98 per cent. of sand and soil and 34.98 per cent. of phosphoric acid. This material is little if any quicker in its action than raw South Carolina rock, but is an excellent material for making superphosphate, and when it is produced as a waste product in small quantities only, may sometimes be had for the carting or at a low price. Directions for treating it with acid are given in the Report of this Station for 1883, page 29. Mr. Kelsey's method of treating it and the results are given on the next page.

Dissolved Bone Black.

This material is a superphosphate prepared by treating refuse bone black from sugar refineries with oil of vitriol which renders nearly all of the phosphoric acid soluble in water.

2447. Sold by C. Meyer, Jr., Maspeth, L. I. From stock of Dennis Fenn, Milford. Guaranteed 16 per cent. phosphoric acid.

2428. Sold by L. Sanderson, New Haven. Guaranteed 16 per cent. soluble and reverted.

2471. Sold by L. Sanderson, New Haven. From stock bought by W. H. Hammond, Elliott.

2451. Sold by L. Sanderson, New Haven.

2633. Dissolved Bone Black made by E. R. Kelsey from Bone Char No. **2475** by the following formula: 175 pounds oil of vitriol 50° B., 60 pounds of water and 235 pounds of bone black. Its cost is not known. The valuation would be $26.45 per ton.

Analyses.

	2447	2428	2471	2451	2633
Soluble phosphoric acid	13.33	16.95	15.32	15.59	12.75
Reverted phosphoric acid	3.93	.06	.68	.08	3.50
Insoluble phosphoric acid	1.74	none	.12	.09	1.99
Cost per ton	$26.00	26.00	26.00*	26.00	----
Soluble phosphoric acid costs per pound in cents	**7.2**	**7.6**	**8.1**	**8.3**	**----**

* Regular retail price at dealer's store.

Valuing reverted and insoluble phosphoric acid at 7½ and 2 cents per pound respectively, soluble phosphoric acid has cost from 7 to 8⅓ cents per pound. Attention is again called to the fact that soluble phosphoric acid can be bought a good deal cheaper in dissolved South Carolina rock. Granges, and farmers' clubs that buy in considerable quantity would do well to inquire for it.

III. Raw Materials of High Grade Containing Potash.

High Grade Sulphate of Potash.

This material contains over 96 per cent. of pure sulphate of potash or about the same quantity of actual potash as the muriate, but contains no more than a trace of chlorine.

2444. Sold by C. Meyer, Jr., Maspeth, L. I. From stock bought by G. F. Platt, Milford. Guaranteed 52 per cent. potash. The analysis is given in the next table.

Double Sulphate of Potash and Magnesia.

This material is usually sold as "sulphate of potash" or "manure salt," on a guarantee of "48–50 per cent. sulphate," which is equivalent to 25.9–27 per cent. of actual potash. It contains, besides some 46–50 per cent. of sulphate of potash, over 30 per cent. of sulphate of magnesia, chlorine equivalent to 3 per cent. of common salt, besides sulphates of soda and lime, with varying quantities of moisture.

2423. Double sulphate of potash. Stock of L. Sanderson, New Haven. Guaranteed 50 per cent. sulphate.

2469. Sulphate of potash. Sold by L. Sanderson, New Haven, to W. H. Hammond, Elliott. Guaranteed 50 per cent. sulphate.

2445. Sulphate of potash. Sold by C. Meyer, Jr., Maspeth, L. I. From stock bought by G. F. Platt, Milford. Guaranteed 27 per cent. actual potash.

2495. Sulphate of potash. From stock bought of Merritt, Beach & Co., New Milford. Sampled and sent by Mr. Bostwick, New Milford.

Analyses.

	2444	2423	2469	2445	2495
Actual potash	52.23	27.82	25.40	25.98	23.61
Equivalent sulphate of potash	96.6	51.3	46.9	48.1	43.5
Cost per ton	$61.20	30.00	30.00*	30.60	40.00
Potash costs per pound in cents	**5.8**	**5.4**	**5.9**	**5.9**	**----**

* Regular price at dealer's store.

The high grade sulphate of potash (No. 2444) at $61.20 per ton is about as cheap a source of potash as the double Sulphate at $30.00.

Muriate of Potash.

Commercial muriate of potash contains about 80 per cent. of muriate of potash (potassium chloride), 15 per cent. or more of common salt (sodium chloride), and 4 per cent. or more of water. It is generally retailed on a guarantee of 80 per cent. muriate, which is equivalent to 50.5 per cent. of actual potash.

2446. From stock bought of C. Meyer, Jr., Maspeth, L. I., by G. F. Platt, Milford. Guaranteed 82 per cent. muriate.

2442. Stock of L. Sanderson, New Haven. Guaranteed 80 per cent. muriate.

2434. Stock of the Rogers & Hubbard Co., Middletown. Guaranteed 80 per cent. muriate.

2470. From stock bought of L. Sanderson, New Haven, by W. H. Hammond, Elliott. Guaranteed 80 per cent. muriate.

ANALYSES.

	2446	2442	2434	2470
Actual potash	51.75	52.11	52.39	46.58
Equivalent muriate	81.9	82.3	82.8	73.6
Cost per ton	$41.60	42.50	44.00	*42.50
Cost of potash per pound in cents	**4**	**4.1**	**4.2**	4.6

* Regular price at dealer's store.

KAINIT.

Kainit is less uniform in composition than the other potash salts. It contains from 11 to 15 per cent. of potash, more than that quantity of soda, and rather less magnesia. These "bases" are combined with chlorine and sulphuric acid. Unless "calcined" it contains more water than the sulphate or muriate of potash. It is usually sold on a guarantee of 12 to 15 per cent. of potash, or 23 to 25 per cent. "sulphate of potash." It cannot properly be called or be used as a sulphate of potash, because it contains more than enough chlorine to combine with all the potash present and there is every reason to believe that its potash exists as muriate and not as sulphate.

2467. Sold by L. Sanderson, New Haven, to W. H. Hammond, Elliott. Guaranteed 12 per cent. of potash.

2425. Sold by L. Sanderson, New Haven.

ANALYSES.

	2467	2425
Actual potash	13.20	12.58
Cost per ton	$12.50	12.50
Potash costs per pound in cents	**4.7**	**4.9**

SYLVINIT.

This is a product of the Stassfurt potash industry which is used by manufacturers of mixed fertilizers and may be offered in the retail trade. Like kainit it is offered as a "Sulphate of Potash," but like kainit also, it cannot be properly regarded as such, for it does not contain enough sulphuric acid to combine with all the potash present, and moreover, contains between three and four times as much chlorine as sulphuric acid. A sample,

No. **2629,** drawn from a single bag in New York City, had the following composition :

Water	7.25
Potash	16.65
Soda	27.10
Lime	2.08
Magnesia	3.37
Sulphuric acid	11.06
Chlorine	41.35
Matters insoluble in water	.74
	109.60
Deduct oxygen equivalent to chlorine	9.34
	100.26

Sylvinit contains rather more potash than kainit and consists of sulphates and muriates of potash and soda, the muriates preponderating.

IV. RAW MATERIALS CONTAINING NITROGEN AND PHOSPHORIC ACID.

BONE MANURES.

The terms "Bone Dust," "Ground Bone," "Bone Meal" and "Bone" applied to fertilizers, may in some cases signify material, made from dry, clean and pure bones such as shank bones used in making knife handles ; in other cases these terms refer to the result of crushing fresh or moist bones which have been thrown out either raw or after cooking, with more or less meat, tendon, and grease—and if taken from garbage or ash heaps, with ashes or soil adhering ; again they denote mixtures of bone, blood, meat and other slaughter-house refuse which have been cooked in steam-tanks in order to recover grease, and are then dried and sold as "tankage ;" or, finally, they apply to bone from which a large share of the nitrogenous substance has been extracted in the glue manufacture. The nitrogen of all these varieties of bone when they are in the same state of mechanical subdivision has essentially the same fertilizing value.

Since the establishment of this Station, twelve years ago, there has been a great improvement in the mechanical condition of the bone manures sold in Connecticut, as is seen from the following

2470. From stock bought of L. Sanderson, New Haven, by W. H. Hammond, Elliott. Guaranteed 80 per cent. muriate.

ANALYSES.

	2446	2442	2434	2470
Actual potash	51.75	52.11	52.39	46.5[illegible]
Equivalent muriate	81.9	82.3	82.8	73.6
Cost per ton	$41.60	42.50	44.00	*42.50
Cost of potash per pound in cents	**4**	**4.1**	**4.2**	4.6

* Regular price at dealer's store.

KAINIT.

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2467. Sold by L. Sanderson, New Haven, to W. H. Hammond, Elliott. Guaranteed 12 per cent. of potash.

2425. Sold by L. Sanderson, New Haven.

ANALYSES.

	2467	2425
Actual potash	13.20	12.58
Cost per ton	$12.50	12.50
Potash costs per pound in cents	**4.7**	**4.9**

SYLVINIT.

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Since the establishment of this Station, twelve years ago, there has been a great improvement in the mechanical condition of the bone manures sold in Connecticut, as is seen from the following

BONE MANURES.—SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Cost Per Ton.
2577	Pure Ground Bone.	Downs & Griffin, Derby, Conn.	Atwood & Wilson, Watertown.	$30.00
2424	Fine Ground Bone.	L. Sanderson, 87 Long Wharf, New Haven, Conn.	Manufacturer.	35.00
2579	Fine Bone.	Chas. Prentice, Putnam, Conn.	R. S. Williams, Hampton.	34.00
2581	Pure Ground Bone.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	E. C. Dennis, Stafford Springs.	33.00
			G. A. Dickinson, Haddam.	36.00
			R. A. Parker, Warehouse Point.	38.00
			Waterbury & June, Greenwich.	35.00
2440	Pure Ground Bone.	C. Meyer, Jr., Maspeth, L. I.	Bought of manufacturer by G. F. Platt, Milford.	35.00
2575	Ground Bone.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	J. L. Bragg, Canaan.	37.00
			Chandler & Morse, Putnam.	34.00
2601	Chittenden's Ground Bone.	National Fertilizer Co., Bridgeport, Conn.	F. P. Burr & Co., Middletown.	35.00
			L. W. Currier, Bridgeport.	35.00
2578	Pure Ground Bone.	Peck Bros., Northfield, Conn.	J. H. French, Cheshire.	----
2614	Pure Bone Meal.	Williams & Clark Co., 81 Fulton St., New York.	B. E. Johnson, Higganum.	35.00
			W. E. Payne, Rockville.	35.00
			Daniel Morgan, Poquonock.	35.00
2574	Ground Bone with Potash.	E. Frank Coe, 16 Burling Slip, New York.	Simon Banks, Southport.	28.00
			Hillhouse & Taylor, Willimantic.	35.00

BONE MANURES.—SAMPLED BY THE STATION.

Station No.	Name or Brand.	Chemical Analysis.		Mechanical Analysis.					Cost per ton.	Valuation per ton.	Percentage difference between cost and valuation.
				Finer than				Coarser than 1/6 inch.			
		Nitrogen.	Phos. Acid.	1/50 inch.	1/25 inch.	1/12 inch.	1/6 inch.				Valuation exceeds cost.
2605	H. S. Miller's Ground Bone	1.85	25.52	58	25	17	--	--	$28.00	$38.12	26.5
2435	Rogers & Hubbard Co's Raw Knuckle Bone Flour	3.60	25.70	74	24	2	--	--	37.00	45.73	19.0
2436	Rogers & Hubbard Co's Strictly Pure Fine Bone	3.80	22.80	51	32	17	--	--	34.00	39.82	14.6
2441	Meyer's Pure Ground Bone	3.37	22.36	62	37	1	--	--	35.00	39.77	11.9
2597	Quinnipiac Pure Bone	3.00	23.77	54	26	17	3	--	34.00	38.59	11.8
2576	Darling's Ground Bone	2.40	24.69	65	24	11	--	--	35.00	39.48	11.3
2431	Rogers & Hubbard Co's Pure Ground AX Bone	3.72	21.90	43	20	25	12	--	32.00	35.95	10.9
2466	Sanderson's Fine Ground Bone	1.87	27.57	50	25	17	8	--	35.00	39.24	10.7
2580	Shoemaker's Swift Sure Bone Meal	5.15	23.32	53	30	17	--	--	40.00	44.51	10.1
2577	Downs & Griffin's Pure Ground Bone	4.09	22.60	18	17	31	34	--	30.00	32.72	8.3
2424	Sanderson's Fine Ground Bone	1.69	27.55	46	21	26	7	--	35.00	38.00	7.9
2579	Chas. Prentice's Fine Bone	4.24	22.72	34	23	19	24	--	34.00	36.47	6.7
2581	Bradley's Pure Ground Bone	4.06	21.07	35	45	20	--	--	35.00	37.06	5.5
2440	Meyer's Pure Ground Bone	2.94	23.07	45	28	26	1	--	35.00	36.63	4.4
2575	Crocker's Ground Bone	4.37	23.98	23	25	25	27	--	35.00	36.54	4.2
2601	Chittenden's Ground Bone	2.58	23.63	44	26	15	15	--	35.00	35.27	.7
											Cost exceeds valuation.
2578	Peck Bros' Pure Ground Bone	4.03	20.09	6	28	26	40	--	30.00	28.76	4.3
2614	Williams & Clark's Pure Bone Meal	4.07	18.57	37	25	23	15	--	35.00	32.31	8.3
2574	Ground Bone with Potash	1.62	*17.88	35	30	22	13	--	31.50	26.57	18.5

* Also contains 1.49 per cent. of Potash.

ation $37.49. The agreement between average cost and valuation is near enough to be satisfactory and shows that the Station's trade values are substantially correct as regards bone.

2. *Manufacturers' Samples and Samples sent by Purchasers.*

2406. Plumb & Winton's Pure Ground Bone. Made by Plumb & Winton, Bridgeport. From stock sold to T. E. Platt, Newtown. Sampled and sent by T. E. Platt.

2412. Self-Recommending Fertilizer. Made and sampled by F. Nuhn, Waterbury.

2452. Ground Bone. Made and sampled by Plumb & Winton, Bridgeport.

2585. Lister's Celebrated Ground Bone. Sold by Lister's Fertilizer Chemical Works, Newark, N. J.

2586. Darling's Bone. Sold by L. B. Darling Fertilizer Co., Pawtucket, R. I. Sampled and sent by R. A. Moore, Kensington.

2619. Ground Bone. Made and sampled by Taylor Bros., Rockfall.

2635. Pure Ground Bone. Made by Downs & Griffin, Derby. Sampled and sent by E. H. Wakeley, Ansonia.

MECHANICAL ANALYSES.

	2406	2412	2452	2585	2586	2619	2635
Fine, smaller than $\frac{1}{50}$ inch	49	64	59	35	53	25	21
Fine medium, smaller than $\frac{1}{25}$ inch	16	15	18	25	23	26	24
Medium, smaller than $\frac{1}{12}$ inch	15	14	13	20	22	27	36
Coarse, larger than $\frac{1}{6}$ inch	20	7	10	20	2	22	19

CHEMICAL ANALYSES.

	2406	2412	2452	2585	2586	2619	2635
Nitrogen	3.01	3.73	4.80	2.92	3.00	3.21	4.00
Phosphoric Acid	20.10	20.98	18.55	11.55	23.61	21.23	23.72
Potash	----	2.96	----	----	----	----	----
Cost per ton	$30.00		30.00		35.00		30.00
Valuation per ton	$31.97	40.07	36.94	20.77	38.14	31.42	35.52

TANKAGE.

2430. Sold by L. Sanderson, New Haven. Sampled by J. H. Hale, South Glastonbury.

2426. Blood, Bone and Meat. Sold by L. Sanderson, New Haven.

2472. Blood, Bone and Meat. Sold by L. Sanderson. From stock purchased by W. H. Hammond, Elliott.

2442. Sold by C. Meyer, Jr., Maspeth, L. I. From stock sold to G. F. Platt, and Dennis Fenn, Milford.

MECHANICAL ANALYSES.

	2430	2426	2472	2442
Fine, smaller than $\frac{1}{50}$ inch	92	78	46	14
Fine medium, smaller than $\frac{1}{25}$ inch	8	12	26	26
Medium, smaller than $\frac{1}{12}$ inch	--	7	18	26
Coarse, larger than $\frac{1}{6}$ inch	--	3	10	34

CHEMICAL ANALYSES.

	2430	2426	2472	2442
Nitrogen	4.55	4.18	6.60	8.41
Phosphoric acid	21.44	21.78	12.26	2.29
Cost per ton	$35.00	35.00	35.00	28.60
Valuation per ton	$44.43	41.86	33.01	21.50

The low valuation of **2442** is due to its coarse mechanical condition. The coarsest lumps were however readily pulverizable.

2598. Blood and Bone Animal Guano. Made by Thompson & Edwards Fertilizer Co., Chicago, Ill. Sampled from stock of Arnold Warren, Willimantic. Guarantee 2.4 per cent. Nitrogen, 13.7 phosphoric acid and 7 per cent. sulphate of potash.

2618. Blood and Bone Animal Guano. Made and sampled by Thompson and Edwards Fertilizer Co. Guaranteed Nitrogen 5.4 per cent., phosphoric acid 11.4.

The manufacturers objected to the analysis of the first sample **2598**, alleging that it did not represent the brand they were then offering. They stated that they had changed their formula and that the new sample, **2618**, fairly represented the goods now sold in Connecticut. The analyses follow :

	2598	2618
Nitrogen as ammonia	.21	
Nitrogen, organic	2.37	7.36
Soluble phosphoric acid	.40 }	8.97
Reverted phosphoric acid	6.56 }	
Insoluble phosphoric acid	6.73 }	
Potash	.91	
Chlorine	.49	
Cost per ton	$36.00	
Valuation per ton	$25.23	31.82

The mechanical analysis of **2618** was as follows:

Fine, smaller than $\frac{1}{50}$ inch	48	per cent.
Fine medium, smaller than $\frac{1}{25}$ inch	29	"
Medium, smaller than $\frac{1}{12}$ inch	20	"
Coarse, larger than $\frac{1}{12}$ inch	3	"
	100	"

Dry Ground Fish.

2582. Pure Dry Ground Fish. Sold by Bowker Fertilizer Co., Boston. Sample drawn from stock of Carter and Strong, Manchester, price $40.00, and F. S. Bidwell, Windsor Locks, price $37.00. It contained 7.94 per cent. of nitrogen.

As the manufacturer's guarantee and the Station analysis refer alone to nitrogen this article is not included among the ammoniated superphosphates given on subsequent pages.

Mixed Fertilizers.

I. Nitrogenous Superphosphates and Guanos.

Here are included mixed fertilizers containing nitrogen, phosphoric acid and in most cases potash, which are not designed by their manufacturers for use on any special crops. "Special Manures" are noticed further on. Fish scrap is classified with these goods because it is sometimes acidulated with oil of vitriol to preserve it, thus making it a nitrogenous superphosphate.

1. *Samples drawn by Station Agents.*

In the tables on pages 77 to 89 are given fifty-eight analyses of this kind.

After the name of a brand the names of a number of dealers are frequently given. This indicates that a sample of this brand was drawn by our agent from each dealer named and that the corresponding analysis was made on a mixture of equal parts of all these samples.

The Station assumes full responsibility for accuracy of sampling and analysis only on such samples as are drawn by its own agents. On samples drawn by other persons the Station holds itself responsible only for the accuracy of analysis, but requires before making an analysis a formal statement that the person who drew the sample did it in accordance with the Station directions. A blank form for this statement is furnished on application.

Nitrogenous Superphosphates and Guanos Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2647	Pure Bone Dissolved in Sulphuric Acid.	Mapes' Formula and Peruvian Guano Co., 158 Front St., N. Y.	Mapes' Branch, Hartford.	$33.00	$33.00
			H. K. Brainard, Thompsonville.	36.00	
2583	Quinnipiac Dry Ground Fish.	Quinnipiac Co., New London.	D. C. Wood, Stratford.	40.00	
			Manufacturer.	36.00	
			Olds & Whipple, Hartford.	38.00	
			Martin Bros., Wallingford.	19.00	----
2556	Fish and Potash, Pequot Brand.	Quinnipiac Co., New London.	Mapes Branch, Hartford.	40.00	40.00
2573	Peruvian Guano.	Mapes' Formula and Peruvian Guano Co., 158 Front St., N. Y.	F. Ellsworth, Hartford.	38.00	38.00
2557	Swift-Sure Superphosphate.	M. L. Shoemaker & Co., Phila., Pa.	J. P. Barstow & Co., Norwich.	37.00	35.00
			W. H. Hammond, Elliott. (Purchaser).	----	
2464	Sanderson's Formula.	L. Sanderson, 87 Long Wharf, New Haven.	E. B. Clark, Milford.	30.00	----
2555	Pine Island Phosphate.	Quinnipiac Co., New London.	Martin Bros., Wallingford.	30.00	31.00
			Olds & Whipple, Hartford.	35.00	
2524	Fish and Potash, Anchor Brand.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	F. S. Bidwell, Windsor Locks.	31.00	
			R. A. Parker, Warehouse Point.	33.00	
			W. B. Martin, Rockville.	35.00	
2535	Bowker's Fish and Potash.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	W. R. McDonald, Cromwell.	32.25	
			Carter & Strong, Manchester.	35.00	
			F. S. Bidwell, Windsor Locks.	31.00	
			J. H. Fish, Newington.	31.00	----
2508	Cumberland Superphosphate.	Cumberland Bone Co., Portland, Me.	A. P. Smith, Lebanon.	35.00	
			W. E. Wheeler, Jr., Mystic.	35.00	
			L. D. Post, Andover.	36.00	39.00
2517	Complete Manure, for general use.	Mapes' Formula and Peruvian Guano Co., 158 Front St., N. Y.	Mapes Branch, Hartford.	39.00	
			W. H. Childs, Manchester.	40.00	
			Southington Lumber and Feed Co., Southington.	38.00	

NITROGENOUS SUPERPHOSPHATES AND GUANOS SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2553	Fish and Potash.	Orient Guano Mfg. Co., Orient, L. I.	E. A. Buck & Co., Willimantic.	$35.00	----
2604	Harvest Queen Phosphate.	H. S. Miller & Co., Newark, N. J.	Geo. W. Andrews, Naugatuck.	30.00	----
2621	Meyer's Acme Fertilizer, "E" Brand.	C. Meyer, Jr., Maspeth, L. I.	Gilbert Thompson, Essex.	34.00	
			A. N. Clark, Milford.	32.00	
			A. S. Russell & Co., Meriden.	33.00	
2510	Complete Manure, "A" Brand.	Mapes' Formula and Peruvian Guano Co., 158 Front St., N. Y.	Wilson & Burr, Middletown.	36.00	$36.00
			Birdsey & Foster, Meriden.	37.00	
			Mapes Branch, Hartford.	36.00	
2518	Standard Fertilizer.	Lister's Agricultural Chem. Works, Newark, N. J.	S. J. Hall, Meriden.	30.00	32.50
2484	Quinnipiac Phosphate.	Quinnipiac Co., New London, Ct.	R. W. Burchard, Darien.	38.00	----
			Jas. P. Little, Columbia.	36.00	
			J. M. Belden, New Britain.	36.00	
			Olds & Whipple, Hartford.	38.00	
			Chandler & Morse, Putnam.	34.00	
			W. W. Cooper, Suffield.	38.00	
			D. C. Wood, Stratford.	37.00	
			E. N. Pierce & Co., Plainville.	37.00	
			E. A. Godfrey, Southport.	36.00	
2520	Animal Fertilizer.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. P. Barstow & Co., Norwich.	36.00	----
			Waldo Tillinghast, Plainfield.	36.00	
			W. W. Cooper, Suffield.	38.00	
2536	A. A. Ammoniated Superphosphate.	H. J. Baker & Bro., 215 Pearl St., N. Y.	Buckland & Hardin, Glastonbury.	37.50	----
			W. T. Gregory & Co., Milford.	37.50	
			E. J. Dickerman, Mt. Carmel.	36.75	
			D. N. Benton, Guilford.	36.00	
			W. F. Andross, East Hartford.	37.50	
			C. J. Porter, Goshen.	37.50	
			E. H. Talcott, Torrington.	36.00	
			J. H. Ives, Danbury.	37.50	

NITROGENOUS SUPERPHOSPHATES AND GUANOS SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2479	Farmers' New Method Fertilizer.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	R. A. Parker, Warehouse Point.	$33.00	$32.00
			Prentiss & Young, Norwich.	32.00	
			F. S. Bidwell, Windsor Locks.	30.00	
			W. W. Cooper, Suffield.	33.00	
			D. N. Clark & Sons, Milford.	33.00	
2558	Fish and Potash.	Pacific Guano Co., Boston, Mass.	C. V. DeWolf, South Manchester.	32.00	27.00
			R. S. Woodford, Plainville.	30.00	
			H. A. Stillman, Hartford.	35.00	
			A. S. Russell & Co., Meriden.	35.00	
2523	Bradley's Sea Fowl Guano.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	W. W. Cooper, Suffield.	35.00	----
			F. S. Bidwell, Windsor Locks.	32.00	
2600	Chittenden's Fish and Potash.	National Fertilizer Co., Bridgeport.	F. P. Burr & Co., Middletown.	35.00	----
			W. W. Cooper, Suffield.	35.00	
			T. H. Eldridge, Norwich.	35.00	
2545	Fish and Potash.	E. Frank Coe, 16 Burling Slip, N. Y.	W. T. Andrews, Orange.	29.00	----
2477	Bradley's Superphosphate.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	H. M. Rose, Milford.	38.00	35.00
			Waterbury & June, Greenwich.	38.00	
			C. A. Sharp, Abington.	38.00	
			R. A. Parker, Warehouse Point.	35.00	
			H. A. Merriam, Rocky Hill.	38.00	
			Dix & Welles, Wethersfield.	36.00	
			E. N. Pierce & Co., Plainville.	37.00	
			A. C. Sternberg, Hartford.	35.00	
			D. N. Clark & Sons, Milford.	37.00	
			Prentiss & Young, Norwich.	37.00	
			S. R. Woodward, Bethany.	36.00	
			F. S. Bidwell, Windsor Locks.	34.00	
			W. B. Martin, Rockville.	37.00	
			W. F. Andross, East Hartford.	37.50	
			Raymond Bros., South Norwalk.	35.00	
			Wheeler & Howe, Bridgeport.	37.00	

Nitrogenous Superphosphates and Guanos, Sampled by the Station—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2482	High Grade Ammoniated Bone Superphosphate.	E. Frank Coe, 16 Burling Slip, N. Y.	I. W. Denison, Mystic.	$33.00	
			Arnold Rudd, New London.	33.00	----
			Backus Bros., South Windham.	----	
			J. P. Barstow & Co., Norwich.	32.00	
			G. H. Loomis, Chestnut Hill.	35.00	
			W. T. Andrews, Orange.	30.00	
2543	Pelican Bone Phosphate.	H. J. Baker & Bro., 215 Pearl St., N. Y.	Hillhouse & Taylor, Willimantic.	38.00	
			E. J. Dickerman, Mt. Carmel.	31.86	----
2509	Chittenden's Complete Fertilizer.	National Fertilizer Co., Bridgeport.	L. W. Currier, Bridgeport.	40.00	----
			W. W. Cooper, Suffield.	42.00	
			D. G. Penfield, Danbury.	45.00	
			E. B. Clark, Milford.	39.00	
2514	Fish and Potash, Crossed Fishes Brand.	Quinnipiac Co., New London.	Olds & Whipple, Hartford.	37.00	----
			Martin Bros., Wallingford.	32.00	
			J. F. Silliman, New Canaan.	38.00	
			W. W. Cooper, Suffield.	35.00	
			E. N. Pierce & Co., Plainville.	35.00	
			M. O. Babcock, Branford.	35.00	
2505	Soluble Pacific Guano.	Pacific Guano Co., Boston, Mass.	B. E. Johnson, Higganum.	35.00	
			H. A. Stillman, Hartford.	35.00	$33.00
			W. F. Andross, East Hartford.	37.50	
			C. V. DeWolf, South Manchester.	38.00	
			A. S. Russell & Co., Meriden.	35.00	
			J. M. Belden, New Britain.	36.00	
			Abbott & Co., Birmingham.	38.00	
			S. B. Wheeler, Westport.	36.00	
2526	New Rival Phosphate.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Elliott Bros., Clinton.	26.00	
			W. H. Scott & Co., Pequabuck.	35.00	----

Nitrogenous Superphosphates and Guanos, Sampled by the Station—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2546	Extra Bone Phosphate.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	Geo. H. Loomis, Chestnut Hill.	$35.00	----
2504	Chittenden's Bone Superphosphate.	National Fertilizer Co., Bridgeport.	T. H. Eldridge, Norwich.	35.00	----
			E. B. Clark, Milford.	30.00	
			L. W. Currier, Bridgeport.	35.00	
			W. W. Cooper, Suffield.	35.00	
			D. G. Penfield, Danbury.	35.00	
			Waldo Tillinghast, Plainfield.	34.00	
			S. Griffiths, Moosup Valley.	40.00	
			Jas. P. Little, Columbia.	32.00	----
2533	Original Coe's Superphosphate of Lime.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	A. P. Smith, Lebanon.	33.50	----
2559	Standard Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Arnold Warren, Willimantic.	35.00	
			Dix & Welles, Wethersfield.	35.00	$35.00
2488	Americus Superphosphate.	Williams & Clark Co., 81 Fulton St., N. Y.	Jas. P. Little, Columbia.	36.00	
			H. K. Brainard, Thompsonville.	35.00	
			J. P. Barstow & Co., Norwich.	35.00	
			R. L. Bullard, Abington.	38.00	
			F. W. Martin, Clark's Corners.	34.00	
			W. E. Payne, Rockville,	35.00	
			A. M. Bowen, Eastford.	36.00	
			R. S. Williams, Hampton.	34.00	----
2541	Superphosphate of Lime.	Chas. Prentice, Putnam.	E. B. Clark, Milford.	30.00	32.00
2480	Ammoniated Dissolved Bone.	Bowker Fertilizer Co., 43 Chatham St, Boston, Mass.	W. H. Anderson, Putnam.	34.00	
			W. F. Andross, East Hartford.	33.00	
			H. A. Merriam, Rocky Hill.	33.00	
			Carter & Strong, Manchester.	33.00	
2544	Excelsior Red Brand Guano.	E. Frank Coe, 16 Burling Slip, N. Y.	D. N. Benton, Guilford.	40.00	----

NITROGENOUS SUPERPHOSPHATES AND GUANOS, SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2499	Bowker's Hill and Drill Phosphate.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	J. A. Paine, Danielsonville.	$38.00	$36.00
			H. E. Mead, Ridgefield.	40.00	
			W. H. Anderson, Putnam.	36.00	
			F. Hallock & Co., Birmingham.	35.00	
			J. E. Leonard, Jewett City.	36.00	
			C. E. Guild, Hampton.	38.00	
			F. E. Fowler, Montville.	37.00	
2554	Orient Complete Manure.	Orient Guano Mfg. Co., Orient, L. I.	E. A. Buck & Co., Willimantic.	30.00	
			G. W. Eaton, Bristol.	30.00	----
			A. B. Morse, Guilford.	28.00	
2501	Ammoniated Bone Superphosphate.	Crocker Fertilizer and Chem. Co., Buffalo, N. Y.	R. S. Williams, Hampton.	34.00	
			Chandler & Morse, Putnam.	34.00	----
			H. K. Brainard, Thompsonville.	35.00	
			J. E. Leonard, Jewett City.	36.00	
			Waldo Tillinghast, Plainville.	39.00	
			S. B. Booth, Newtown.	37.00	
2516	Economical Fertilizer.	Wilkinson & Co., New York.	H. P. Treat, Orange.	32.00	30.00
2528	Alkaline Bone.	E. Frank Coe, 16 Burling Slip, N. Y.	F. H. Tillinghast, Central Village.	31.00	----
			E. C. Dennis, Stafford Springs.	30.00	
			Hillhouse & Taylor, Willimantic.	36.00	
2547	Ludlam's Cecrops Fertilizer.	Fred'k Ludlam, 140 Maiden Lane, N. Y.	A. L. Kuran, Tolland.	42.00	----
			R. S. Woodford, Plainville.	40.00	
			C. T. Leonard, Norwalk.	42.00	
			Starr & Bailey, Groton.	44.00	
2550	Davidge's Vegetator.	Davidge Fertilizer Co., 121 Front St., N. Y.	J. M. Burke, So. Manchester.	35.00	
			A. S. Hawkins, So. Coventry.	37.00	
2513	Fish and Potash, Plain Brand.	Quinnipiac Co., New London.	Olds & Whipple, Hartford.	33.00	
			C. S. Gillette, Cheshire.	28.00	
			H. K. Brainard, Thompsonville.	30.00	

NITROGENOUS SUPERPHOSPHATES AND GUANOS, SAMPLED BY THE STATION—*Concluded.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2563	Lion Special Fertilizer.	Reed Fertilizer Co., New York.	Edmund Halliday, Suffield.	$40.00	----
2630	Miles' I. X. L. Phosphate.	G. W. Miles, Agent, Milford.	W. E. Wheeler, Mystic.	30.00	----
			D. N. Clark & Son, Milford.	30.00	
			A. A. Hubbard, Canaan.	33.00	
2599	A. Mitchell's Standard Superphosphate.	A. Mitchell, Tremley, N. J.	Smalling Bros., Killingly.	37.00	----
					----
2561	Farmers' Friend Fertilizer.	Reed Fertilizer Co., New York.	Jas. Goldson. Warehouse Point.	35.00	----
2525	Davidge's Special Favorite.	Davidge Fertilizer Co., 121 Front St., N. Y.	C. A. McLean, Simsbury.	36.00	----
			J. M. Burke, So. Manchester.	34.00	
			A. S. Hawkins, So. Coventry.	35.00	
2562	High Grade Farmers' Friend.	Reed Fertilizer Co., New York.	Jas. Goldson, Warehouse Point.	42.00	----
2602	Ludlam's Cereal Fertilizer.	Fred'k Ludlam, 140 Maiden Lane, N. Y.	Jas. P. Little, Columbia.	32.00	----
			C. H. Cleveland, Brooklyn.	32.00	
2487	Ludlam's Cereal Fertilizer.	Fred'k Ludlam, 140 Maiden Lane, N. Y.	A. M. Bowen, Eastford.	36.00	----
			Starr & Bailey, Groton.	34.00	
			Prentiss & Young, Norwich.	33.00	
			R. S. Williams, Hampton.	32.00	
			C. T. Leonard, Norwalk.	34.00	
			R. L. Bullard, Abington.	35.00	----
2560	Reed's Lion Brand Superphosphate.	Reed Fertilizer Co., New York.	Edmund Halladay, Suffield.	32.00	
			W. F. Andross, East Hartford.	33.00	
2542	Bradley's Extra Fine Ground Bone with Potash.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	Jas. P. Little, Columbia.	34.00	----
2552	Bradley's Fish and Potash, A Brand.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	Dimond & Hawley, Bethel.	35.00	
			Burtis & Mead, New Canaan.	33.00	

Analyses of Nitrogenous Superphosphates Sampled by the Station.

Station No.	Name or Brand.	Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.				
2647	Mapes' Dissolved Bone	----	1.08	2.33	3.41	*2.0*	4.45	11.96	2.07	18.48	----	16.41	*12.0*	----	----	----	$33.00	$39.25	19.0*
2583	Quinnipiac Dry Ground Fish	----	----	8.68	8.68	*7.5*	.84	4.59	2.33	7.76	----	5.43	*4.0*	----	----	----	36.00	42.60	15.5*
2556	Quinnipiac Fish and Potash, Pequot Brand																		
2573	Mapes' Peruvian Guano, No. 1	----	.44	2.15	2.59	*2.5*	.32	3.70	3.12	7.14	----	4.02	*3.5*	4.59	*4.0*	7.28	19.00	21.90	13.2*
2557	Shoemaker's Swift Sure Superphosphate	.06	2.25	.80	3.11	*3.3*	5.53	9.67	5.89	21.09	*22.0*	15.20	----	3.88	*4.0*	.59	40.00	43.09	7.1*
2464	Sanderson's Formula	.69	----	2.49	3.18	*2.5*	7.82	3.61	3.73	15.16	----	11.43	*9.0*	4.34	*4.0*	2.16	38.00	36.31	4.6
2555	Quinnipiac Pine Island Phosphate	.64	.06	2.54	3.24	*3.3*	6.30	1.63	2.24	10.17	*10.0*	7.93	*7.0*	7.24	*7.0*	4.51	35.00	32.82	6.7
2524	Bradley's Fish and Potash, Anchor Brand	.58	.34	1.58	2.50	*2.0*	5.30	6.79	1.23	13.32	----	12.09	*9.0*	1.32	*1.0*	1.77	32.00	29.96	6.8
2535	Bowker's Fish and Potash	----	.12	3.32	3.44	*3.3*	5.34	1.78	1.76	8.88	*5.0*	7.12	----	3.81	*3.0*	7.37	31.00	28.78	7.7
2508	Cumberland Superphosphate	----	----	2.47	2.47	*2.3*	6.65	1.72	3.46	11.83	*8.0*	8.37	----	4.47	*4.0*	4.75	31.00	28.71	7.9
2517	Mapes' Complete Manure for General Use	.53	.23	1.54	2.30	*2.0*	7.08	5.87	2.17	15.12	*12.0*	12.95	*9.0*	2.54	*2.0*	1.56	35.00	32.38	8.1
2553	Orient Fish and Potash	----	.79	2.76	3.55	*3.3*	7.97	2.92	1.99	12.88	*10.0*	10.89	*8.0*	4.42	*4.0*	2.99	39.00	35.92	8.6
2604	H. S. Miller's Harvest Queen Phosphate	----	----	3.42	3.42	*3.3*	5.20	1.17	.78	7.15	----	6.37	*5.0*	9.60	*14.0*	8.50	35.00	32.19	8.7
2621	Meyer's Acme Fertilizer, E Brand	----	----	1.76	1.76	*1.2*	9.80	1.61	.21	11.62	----	11.41	*10.0*	2.36	*1.5*	.64	30.00	27.49	9.2
2510	Mapes' Complete Manure, "A" Brand	----	.72	1.79	2.51	*2.5*	4.40	4.12	1.99	10.51	----	8.52	*10.0*	4.90	*7.0*	.38	32.50	29.68	9.5
2518	Lister's Standard Fertilizer	.51	.56	1.96	3.03	*2.5*	8.06	3.17	1.32	12.55	*12.0*	11.23	*10.0*	3.18	*2.5*	5.24	36.00	32.62	10.3
[illegible]	[illegible]	----	.33	1.54	1.87	*1.2*	8.34	2.63	1.48	12.45	*10.0*	10.97	----	1.50	*15*	.18	30.00	27.01	11.0
2484	Quinnipiac Phosphate	.58	.41	2.05	3.04	*2.5*	6.15	5.82	1.14	13.11	----	11.97	*9.0*	1.89	*2.0*	1.58	36.00	32.27	11.6

* Valuation exceeds cost.

Analyses of Nitrogenous Superphosphates Sampled by the Station—*Continued.*

Station No.	Name or Brand.	Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.				
2520	Darling's Animal Fertilizer	----	.42	2.92	3.34	*3.3*	4.91	3.53	2.80	11.24	*10.0*	8.44	----	5.03	*4.0*	4.60	$36.00	$32.07	12.2
2536	Baker's "AA" Ammoniated Superphosphate	.09	2.02	.84	2.95	*2.5*	10.39	1.38	.85	12.62	*10.0*	11.77	----	2.80	*2.0*	2.96	37.00	32.91	12.4
2479	Bradley's Farmers' New Method Fertilizer	----	.12	1.90	2.02	*1.65*	8.40	2.20	1.17	11.77	*10.0*	10.60	----	3.52	*3.0*	3.36	32.00	28.29	13.1
2558	Pacific Guano Co., Fish and Potash	----	.28	2.25	2.50	*3.0*	5.14	3.51	2.38	11.03	*6.0*	8.65	*4.0*	4.90	*4.0*	5.33	33.00	28.83	14.4
2523	Bradley's Sea Fowl Guano	----	.63	1.75	2.38	*2.5*	8.12	2.91	1.97	13.00	*11.0*	11.03	*9.0*	1.83	*2.0*	2.00	33.50	29.23	14.6
2600	Chittenden's Fish and Potash	----	.29	2.92	3.21	*3.3*	.94	5.81	4.68	11.43	*6.0*	6.75	----	5.39	*5.0*	5.00	35.00	30.07	16.3
2545	E. F. Coe's Fish and Potash	----	----	2.47	2.47	*3.0*	6.03	1.80	1.68	9.51	*6.0*	7.83	*4.0*	2.19	*4.0*	3.83	29.00	24.72	17.3
2477	Bradley's Superphosphate	.27	1.57	.78	2.62	*2.3*	8.42	2.22	1.56	12.20	----	10.64	*9.0*	2.15	*1.5*	2.55	35.00	29.63	18.1
2482	E. Frank Coe's High Grade Ammoniated Bone Superphosphate	----	.67	1.58	2.25	*2.0*	9.11	1.27	1.57	11.95	*11.0*	10.38	----	2.37	*3.0*	.20	34.00	28.74	18.3
2543	Baker's Pelican Bone Phosphate	----	1.28	.75	2.03	*1.6*	8.07	1.51	1.30	10.88	----	9.58	*8.0*	2.47	*2.0*	5.79	31.00	25.90	19.6
2509	Chittenden's Complete Fertilizer	.18	----	3.09	3.27	*3.3*	5.48	4.80	3.26	13.54	*8.0*	10.28	----	5.24	*6.0*	5.00	42.00	35.00	20.0
2514	Quinnipiac Fish and Potash, Crossed Fishes Brand	----	.50	3.48	3.98	*3.5*	2.54	3.33	1.38	7.25	*5.0*	5.87	----	4.57	*3.0*	6.31	35.00	29.12	20.1
2505	Soluble Pacific Guano	----	.23	2.68	2.91	*2.3*	7.15	2.25	1.60	11.00	*10.5*	9.40	----	2.57	*2.0*	2.63	35.00	29.14	20.1
2526	Crocker's New Rival Phosphate	.09	----	1.42	1.51	*1.2*	8.49	2.08	.95	11.52	----	10.57	*10.0*	2.14	*3.0*	1.92	30.00	24.91	20.4
2546	Darling's Extra Bone Phosphate	----	.80	1.90	2.70	*2.5*	5.67	3.16	3.13	11.96	*10.0*	8.83	----	3.44	----	3.54	35.00	29.05	20.5

ANALYSES OF NITROGENOUS SUPERPHOSPHATES SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2504	Chittenden's Bone Superphosphate	----	----	2.22	2.22	*1.6*	6.84	4.16	2.24	13.24	*10.0*	11.00	*8.0*	2.29	*2.0*	2.04	$35.00	$29.02	20.6
2533	Original Coe's Superphosphate of Lime	----	----	2.20	2.20	*2.1*	7.71	2.04	2.00	11.75	*10.0*	9.75	*8.0*	1.72	*1.0*	1.64	32.00	26.51	20.7
2559	Standard Fertilizer	----	----	1.99	1.99	*2.0*	7.71	2.65	2.77	13.13	*10.0*	10.36	*8 0*	2.04	*2.0*	2.18	33.50	27.38	22.3
2488	Williams & Clark's Americus Superphosphate	----	.91	1.46	2.37	*2.0*	9.25	1.66	.15	11.06	*11.0*	10.91	*10.0*	2.45	*2.0*	2.00	35.00	28.60	22.3
2541	Chas. Prentice's Superphosphate of Lime	----	1.09	1.09	2.18	*2.0*	3.02	5.56	6.34	14.92	----	8.58	----	2.78	*2.0*	2.62	34.00	27.77	22.5
2480	Bowker's Ammoniated Dissolved Bone	.47	1.20	.29	1.96	*2.0*	7.89	1.88	2.76	12.53	*11.0*	9.77	*10.0*	1.95	*2.0*	3.46	32.00	26.11	22.6
2544	E. Frank Coe's Excelsior Red Brand Guano	----	.76	2.48	3.24	*1.0*	7.60	.79	1.04	9.43	*10.0*	8.39	*7.0*	5.53	*11.0*	.74	40.00	32.56	22.8
2499	Bowker's Hill and Drill Phosphate	.68	----	2.05	2.73	*2.5*	7.67	2.66	2.42	12.75	*12.0*	10.33	----	1.75	*2.0*	1.80	36.00	29.29	22.9
2554	Orient Complete Manure	----	.29	1.39	1.68	*1.6*	7.83	1.78	.76	10.37	*7.0*	9.51	*8.0*	1.55	*1.0*	1.53	29.00	23.44	23.7
2501	Crocker's Ammoniated Bone Superphosphate	----	----	3.00	3.00	*2.9*	7.55	2.17	1.80	11.52	*8.0*	9.72	*8.0*	1.40	*1.0*	1.47	36.00	29.08	23.8
2516	Wilkinson's Economical Fertilizer	----	----	1.67	1.67	*1.6*	7.72	2.44	1.48	11.64	*7.0*	10.16	----	2.11	*3.0*	.25	32.00	25.69	24.6
2528	E. Frank Coe's Alkaline Bone	----	----	1.15	1.15	*1.0*	9.14	1.99	1.92	13.05	----	11.13	*9.0*	1.86	*1.8*	.27	32.00	25.25	26.7
2547	Ludlam's Cecrops Fertilizer	.65	.46	1.94	3.05	*3.3*	7.48	1.94	1.46	10.88	----	9.42	*7.0*	6.33	*7.0*	6.43	42.00	32.79	28.0
2513	Quinnipiac Fish and Potash, Plain Brand	----	.51	2.64	3.15	*2.0*	.89	3.16	1.89	5.94	*6.0*	4.05	----	4.06	*4.0*	5.84	30.00	22.91	30.9
2550	Davidge's Vegetator	----	1.08	2.18	3.26	*2.9*	5.28	.87	1.16	7.31	*6.0*	6.17	*5.0*	4.08	*4.0*	4.25	35.00	26.51	32.0

ANALYSES OF NITROGENOUS SUPERPHOSPHATES SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2563	Reed's Lion Special Fertilizer	----	----	2.78	2.78	*2.5*	6.50	2.29	1.14	9.93	*10.0*	8.79	*8.0*	5.49	*10.0*	5.67	$40.00	$30.02	33.2
2630	Miles' I. X. L. Phosphate	----	.53	1.45	1.98	*2.0*	5.69	2.25	3.36	11.30	----	7.94	*8.0*	1.26	*1.0*	.93	31.00	23.14	33.9
2599	Mitchell's Standard Superphosphate	.32	.28	1.22	1.82	*2.5*	8.84	2.56	.37	11.77	----	11.40	*9.0*	1.89	*2.5*	----	37.00	27.26	35.7
2561	Reed's Farmers' Friend Fertilizer	---	----	2.14	2.14	*2.1*	6.84	2.72	1.64	11 20	*11.0*	9.56	*9.0*	1.86	*4.0*	2.31	35.00	25.80	35.7
2525	Davidge's Special Favorite	----	----	1.52	1.52	*1.2*	8.51	2.17	1.03	11.71	*11.0*	10.68	*10.0*	1.63	*1.5*	1.41	34.00	24.75	37.4
2562	Reed's High Grade Farmers' Friend Fertilizer	----	.29	3.09	3.38	*3.3*	3.68	1.32	1.23	6.23	*6.0*	5.00	*5.0*	10.01	*10.0*	8.68	42.00	30.46	37.8
2602	Ludlam's Cereal Fertilizer	----	----	1 09	1.09	*1.2*	7.48	2.09	4.09	13.66	*11.0*	9.57	*10.0*	1.43	*4.0*	3.39	32.00	22.98	39.2
2487	Ludlam's Cereal Fertilizer	.22	----	.75	.97	*1.2*	8.85	1.36	2.76	12 97	*11.0*	10.21	*10.0*	1.66	*4.0*	4.21	32.00	22.95	39.4
2560	Reed's Lion Brand Superphosphate	----	----	1.16	1.16	*.8*	6.57	1.65	1.15	9.37	*10.0*	8.12	*8.0*	3.90	*8.0*	5.03	32.00	21.67	47.6
2542	Bradley's Extra Fine Ground Bone with Potash	.08	.29	1.60	1.97	*1.9*	2.45	4.00	4.35	10.80	*9.1*	6.45	----	2.21	*2.0*	5.95	34.00	21.97	54.8
2552	Bradley's Fish and Potash, A Brand	----	.18	2.41	2.59	*2.0*	1.94	1.50	1.99	5.43	*6.0*	3.44	----	4.31	*4.0*	9.46	34.00	20.26	67.8

FISH AND POTASH.—SAMPLED BY THE STATION.

	Quinnipiac Pequot.	Bradley's Anchor Brand.	Bowker's.	Orient.	Pacific Guano Co's.	Chittenden's.	Coe's.	Quinnipiac, Crossed Fishes Brand.	Quinnipiac, Plain Brand.	Bradley's A Brand.
	2556	**2524**	**2535**	**2553**	**2558**	**2600**	**2545**	**2514**	**2513**	**2552**
Nitrogen as Ammonia	.44	.12	----	----	.28	.29	----	.50	.51	.18
Nitrogen, Organic	2.15	3.32	2.47	3.42	2.25	2.92	2.47	3.48	2.64	2.41
Soluble Phosphoric Acid	.32	5.34	6.65	5.20	5.14	.94	6.03	2.54	.89	1.94
Reverted Phosphoric Acid	3.70	1.78	1.72	1.17	3.51	5.81	1.80	3.33	3.16	1.50
Insoluble Phosphoric Acid	3.12	1.76	3.46	.78	2.38	4.68	1.68	1.38	1.89	1.99
Potash	4.59	3.81	4.47	9.60	4.90	5.39	2.19	4.57	4.06	4.31
Cost	$19.00	$31.00	$31.00	$35.00	$33.00	$35.00	$29.00	$35.00	$30.00	$34.00
Valuation	$21.90	$28.78	$28.71	$32.19	$28.83	$30.07	$24.72	$29.12	$22.91	$20.26
Nitrogen found	2.59	3.44	2.47	3.42	2.50	3.21	2.47	3.98	3.15	2.59
Nitrogen guaranteed	2.5	3.3	2.3	3.3	3.0	3.3	3.00	3.5	2.0	2.0
Phosphoric Acid found	7.14	8.88	11.83	7.15	11.03	11.43	9.51	7.25	5.94	5.43
Phosphoric Acid guaranteed	---	5.00	8.0	----	6.0	6.0	*6.0*	*5.0*	*6.0*	----
Potash found	4.59	3.81	4.47	9.60	4.90	*5.39*	*2.19*	*4.57*	*4.06*	*4.31*
Potash guaranteed	4.0	3.0	4.0	14.0	4.0	*5.0*	*4.0*	*3.0*	*4.0*	*4.0*

ANALYSES OF MANUFACTURERS' SAMPLES OF NITROGENOUS SUPERPHOSPHATES.

Station No.	Name or Brand.	Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Valuation per Ton.
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.		
2566	Crocker Fertilizer & Chemical Co's Queen City Phosphate	----	----	1.89	1.89	*1.7*	7.13	2.02	.48	9.63	----	9.15	*8.0*	2.56	*1.0*	2.18	$24.21
2567	Crocker Fertilizer & Chemical Co's Superphosphate, No. 2	----	----	----	----	----	9.99	2.71	.83	13.53	----	12.70	*11.0*	2.62	*1.0*	2.44	22.90
2564	Crocker Fertilizer & Chemical Co's Vegetable Bone Superphosphate	1.20	.29	3.03	4.52	*5.0*	3.61	2.37	1.82	7.80	----	5.98	*6.0*	9.45	*6.0*	8.11	35.63
2570	E. R. Kelsey's Fish and Potash	----	.70	3.13	3.83	----	2.14	2.20	.10	4.44	----	4.34	----	3.47	----	.33	25 28
2572	Lister Fertilizer Chemical Works' Ammoniated Dissolved Bone	----	.44	1.81	2.25	----	6.62	3.19	2.34	12.15	----	9.81	----	1.68	----	trace	27.34
2489	G. W. Miller's Flour of Bone Phosphate	.84	.49	3.56	4.89	----	.32	4.22	3.07	7.61	----	4.54	----	6.79	----	6.15	33.04
2571	Standard Fertilizer Co's Standard Guano	----	----	1.57	1.57	*1.0*	6.96	2.12	2.83	11.91	*10.0*	9.08	*8.0*	2.39	*2.0*	2.19	24.14
2616	Williams & Clark Co's Royal Bone Phosphate	----	----	1.37	1.37	*.9*	6 38	1.76	.39	8.53	*8.0*	8.14	*8.0*	1.98	*2.0*	2.02	20.07
2615	Williams & Clark Co's Universal Dissolved Bone	----	----	1.88	1.88	*1.7*	6.95	1.83	.32	9.10	*10.0*	8.78	*8.0*	1.97	*2.0*	.34	23.42

Early in the year a circular was sent to all manufacturers whose goods were sold in Connecticut, asking them to inform the Station what would be about the average cash price of their goods in this State during the coming season. In the tables with the various *dealers'* quotations is also given for comparison the *manufacturers'* statement of the average retail cash price per ton in the State in cases where the manufacturer supplied such statement. The cash prices are usually about five per cent. lower than the credit or "time" prices.

The retail cash price of the same fertilizer as quoted by different dealers varies in some cases considerably, partly on account of differences in freight-rates, presence or absence of competition, etc. Some manufacturers arrange with their selling agents so that a given brand shall be sold at a uniform price at all points in the State, but usually the price charged is fixed by the dealer.

The last column of the table of analyses is "Percentage Difference between Cost and Valuation." Its significance and the method of calculating it may be seen by noticing the fifth analysis in the table on page 84, No. **2557**. Here the cost is $38, the valuation is $36.31, and the difference between them is $2.69. By multiplying this difference, $2.69, by 100, and dividing it by the valuation, $36.31, we get 4.6, the percentage advance of selling price over valuation, which advance should represent on the average the costs and profits of the manufacturer in converting the raw materials into a mixed fertilizer, selling it and collecting on his sales.

DIFFERENCE BETWEEN COST AND VALUATION.

Leaving out of account the last two analyses in the tables in which the cost exceeded valuation by more than 50 per cent. the average cost of 56 nitrogenous Superphosphates was $34.10 and the average valuation $29.10. The difference is $5.00, and the percentage difference 17.2.

That is, the same quantities of nitrogen, phosphoric acid and potash, which were contained in an average ton of Nitrogenous Superphosphate could have been bought in raw materials of standard quality in ton lots in this State for $29.10 cash, in the average Superphosphate they cost $34.10, and hence the manufacturers' and dealers' expenses and profits on a ton of fertilizer averaged $5.00, or 17.1 per cent. of the cost of the materials.

The percentage difference between cost and valuation has been smaller this year than in any year since the present system of valuation has been used, as the following table shows:

Year.	Average Cost.	Average Valuation.	Percentage Difference.
1889	$34.10	$29.10	17.1
1888	34.55	28.79	2.02
1887	35.74	28.44	25.6
1886	36.58	29.42	24.3
1885	37.60	30.47	23.4
1884	40.73	33.13	22.9

Guarantees.—The analyses of 23 superphosphates out of the 58 show that their composition is below the maker's minimum guarantee in one or more particulars. Thirteen are deficient in one ingredient, eight in two and two in all the three ingredients. In most cases the deficiency is due to a misleading, and in this State illegal, method of expressing the guarantee of potash.

It is required, under the law, that the quantity of *actual* potash shall be expressly stated. "Potash, Sulphate, 4 per cent." means four per cent. of *actual potash* in the form of sulphate, and not 2.16 per cent. of potash, but the expression is often used by manufacturers, when only the smaller quantity of actual potash is present in the fertilizer. Such use is deceptive.

Fish and Potash.—The analyses of this material which in past years has been a favorite fertilizer in this State, though included among nitrogenous superphosphates are also tabulated by themselves on page 88. Most of the brands are not simple mixtures of fish scrap and potash salts, as the name would imply, but contain added phosphates and in one case, No. **2600**, more than 4.5 per cent. of insoluble phosphoric acid.

Notes on particular analyses.—The analysis of Ludlam's Cereal Fertilizer No. **2487** having been unsatisfactory to the manufacturer another analysis was made, No. **2602**, on different samples collected by our Agents. The two analyses given in the tables show substantial agreement.

2. *Manufacturers' Samples.*

The fertilizers named below were not found by the Station agents in any stocks which they inspected, and accordingly the analyses were made on samples deposited at the Station by manufacturers.

2566. Queen City Phosphate, made by the Crocker Fertilizer and Chemical Co., Buffalo, N. Y.

2567. Crocker's Superphosphate, No. 2, made by the Crocker Fertilizer & Chemical Co., Buffalo, N. Y.

2564. Crocker's Vegetable Bone Superphosphate, made by the Crocker Fertilizer and Chemical Co., Buffalo, N. Y.

2570. Kelsey's Fish and Potash, made by E. R. Kelsey, Branford, Conn.

2572. Lister's Ammoniated Dissolved Bone, made by Lister's Fertilizer Chemical Works, Newark, N. J.

2489. Flour of Bone Phosphate, made by G. W. Miller, Middlefield, Conn.

2571. Standard Guano, made by the Standard Fertilizer Co., Boston, Mass.

2616. Royal Bone Phosphate, made by Williams & Clark Co., 81 Fulton Street, N. Y.

2615. Universal Dissolved Bone, made by Williams & Clark Co., 81 Fulton Street, N. Y.

II. Special Manures, sampled by Station Agents.

For Analyses and Valuations see pages 93–99.

Here are included such Nitrogenous Superphosphates as are claimed by their manufacturers to be specially adapted to the needs of particular crops.

Guarantees.—Of the thirty samples analyzed fifteen are below the maker's minimum guarantee as regards one ingredient and two are below guarantee on two ingredients.

COST AND VALUATION.—In four cases the valuation exceeded the cost.

The average cost of 30 special manures has been $40.25 and the average valuation $35.20. The difference between cost and valuation has been $5.05 and the Percentage Difference 14.3. The corresponding difference in case of the superphosphates (see page 90) was 17.1 per cent.

This year, as heretofore, the Special Manures as a class have been higher-priced and more concentrated than the other nitrogenous superphosphates, and if the quality of the raw materials composing them is equally good, more economical to purchase.

The percentage difference between cost and valuation has been less the last year than in any year since 1884, when the present system of valuation was adopted, as the following statement shows:—

Special Manures Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2437	Fairchild's Formula for Seeding Down.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	$40.00	$40.00
2432	The Rogers & Hubbard Co's Complete Potato and Tobacco Manure.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	47.50	47.50
2433	Fairchild's Formula for Corn and General Crops.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	46.00	46.00
2540	Fruit and Vine Manure.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mapes' Branch, Hartford.	38.00	38.00
2503	Mapes' Corn Manure.	Mapes' Formula & Peruvian Guano Co., 158 Front St., N. Y.	Dean & Horton, Stamford.	42.00	41.00
			A. W. Northrop, Ridgefield.	43.00	
			Birdsey & Foster, Meriden.	42.00	
			S. Griffiths, Moosup Valley.	43.00	
			Wilson & Burr, Middletown.	41.00	
			Mapes' Branch, Hartford.	41.00	
			Geo. K. Nason, Willimantic.	42.00	
			J. P. Barstow & Co., Norwich.	42.00	
2548	Grass and Grain Spring Top Dressing.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mapes' Branch, Hartford.	41.00	41.00
			C. A. McLean, Simsbury.	43.00	
2549	Tobacco Manure. Wrapper Brand.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mapes' Branch, Hartford.	48.00	48.00
			C. A. McLean, Simsbury.	50.00	
2551	Complete Manure for Light or Sandy Soil.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mapes' Branch, Hartford.	44.00	44.00
			J. P. Barstow & Co., Norwich.	45.00	
2603	Special Potato Manure.	H. S. Miller & Co., Newark, N. J.	R. W. Cowles, Plantsville.	40.00	----
2522	Complete Manure for Potatoes and Vegetables.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	G. A. Dickinson, Haddam.	42.00	40.00
			Jas. P. Little, Columbia.	40.00	
			J. E. Holmes, Stratford.	42.00	

SPECIAL MANURES SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2483	Potato Manure.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mather & Granman, Darien.	$45.00	$43.00
			F. Hallock & Co., Birmingham.	45.00	
			Wheeler & Howe, Bridgeport.	45.00	
			Abbott & Co., Birmingham.	46.00	
			Mapes' Branch, Hartford.	43.00	
			E. N. Pierce & Co., Plainville.	43.00	
			Geo. K. Nason, Willimantic.	44.60	
			Wilson & Burr, Middletown.	43.00	
2506	Potato Manure.	H. J. Baker & Bro., 215 Pearl St., New York.	A. L. Winton, Bridgeport.	42.50	
			W. W. Cooper, Suffield.	42.50	----
2648	Mapes' Complete Manure for Heavy Soils.	Mapes' Formula & Peruvian Guano Co., 158 Front St., New York.	Mapes' Branch, Hartford.	44.00	44.00
			M. T. Gregory & Co., Milford.	42.50	
			E. F. Hawley, Newtown.	42.50	
2531	Special Corn Manure.	H. J. Baker & Bro., 215 Pearl St., New York.	Strong & Tanner, Winsted.	42.00	----
			W. W. Cooper, Suffield.	42.50	
2486	Potato Manure.	Quinnipiac Co., New London.	Manufacturer.	34.00	----
			D. C. Wood, Stratford.	38.00	
			E. N. Pierce & Co., Plainville.	38.00	
			J. M. Belden, New Britain.	39.00	
			Jas. P. Little, Columbia.	38.00	
			E. A. Godfrey, Southport.	37.00	
			Olds & Whipple, Hartford.	40.00	

SPECIAL MANURES SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2622	Meyer's Acme Potato Manure.	C. Meyer, Jr., Maspeth, L. I.	A. N. Clark, Milford.	$38.00	----
2530	Complete Manure for Corn and Grain.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	Strong & Tanner, Winsted.	42.00	40.00
2478	Bradley's Potato Manure.	Bradley Fertilizer Co., 27 Kilby St., Boston, Mass.	R. A. Parker, Warehouse Point.	38.00	----
			D. N. Clark & Sons, Milford.	37.00	
			F. S. Bidwell, Windsor Locks.	35.00	
			S. R. Woodward, Bethany.	37.00	
			H. M. Rose, Milford.	38.00	
			W. W. Cooper, Suffield.	36.00	
			W. F. Andross, East Hartford.	38.00	
			Rob't Payne, Woodbridge.	37.00	
			E. N. Pierce & Co., Plainville.	38.00	
			Prentiss & Young, Norwich.	----	
			Waterbury & June, Greenwich.	40.00	
			James P. Little, Columbia.	38.00	
2502	Potato, Hop and Tobacco Fertilizer.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	J. E. Leonard, Jewett City.	36.00	----
			H. K. Brainard, Thompsonville.	36.00	
			Wm. C. Russell, Orange.	36.00	
			R. S. Williams, Hampton.	36.00	
			J. M. Belden, New Britain.	38.00	
			E. N. Pierce & Co., Plainville.	36.00	

Special Manures Sampled by the Station—*Concluded.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2481	Stockbridge Vegetable Manure.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	R. W. Burchard, Darien.	$42.50	----
			Carter & Strong, Manchester.	43.00	
			F. Hallock & Co., Birmingham.	39.00	
			W. H. Anderson, Putnam.	42.50	
			J. E. Leonard, Jewett City.	42.00	
			A. P. Smith, Lebanon.	38.00	
			F. S. Bidwell, Windsor Locks.	42.00	
			C. H. Smith, Columbia.	40.00	
			E. B. Clark, Milford.	40.00	
			W. R. McDonald, Cromwell.	41.00	
			C. E. Guild, Hampton.	41.00	
			John Bruu, Naugatuck.	38.00	
2521	Ammoniated Wheat and Corn Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	E. N. Pierce & Co., Plainville.	36.00	----
			Wm. C. Russell, Orange.	34.00	
			F. S. Bidwell, Windsor Locks.	42.00	
2507	Stockbridge Grass Manure or Top Dressing.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	Carter & Strong, Manchester.	43.00	----
			W. H. Anderson, Putnam.	42.50	
			J. A. Paine, Danielsonville.	42.50	
			W. H. Anderson, Putnam.	42.50	
2532	Stockbridge Vegetable Manure.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	F. C. Hull, South Coventry.	43.00	----
			W. A. Snow, Columbia.	35.00	
2519	Great Eastern Vegetable, Vine and Tobacco Fertilizer.	Great Eastern Fertilizer Co., Rutland, Vt.	F. W. Goodrich, Portland.	35.00	----
			G. T. Sanger, Canterbury.	35.00	

Special Manures Sampled by the Station—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Manufacturers' statement of average cash price per ton.
2500	Stockbridge Corn Manure.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	J. A. Paine, Danielsonville.	$42.50	----
			Carter & Strong, Manchester.	43.00	
			H. E. Mead, Ridgefield.	45.00	
			C. E. Guild, Manchester.	41.00	
			F. S. Bidwell, Windsor Locks.	42.00	
			W. H. Anderson, Putnam.	42.50	
			H. A. Merriam, Rocky Hill.	42.00	
			F. C. Fowler, Montville.	39.00	
			W. R. McDonald, Cromwell.	42.50	
2613	Williams & Clark's Potato Phosphate.	Williams & Clark Co., 81 Fulton St., New York.	H. K. Brainard, Thompsonville.	36.00	----
			J. P. Barstow & Co., Norwich.	36.00	
			Atwood & Wilson, Watertown.	38.00	
			R. H. Hall, East Hampton.	38.00	
			S. Griffiths, Moosup Valley.	37.00	
			F. W. Martin, Clark's Corners.	34.00	
2515	Grain and Grass Fertilizer.	Great Eastern Fertilizer Co., Rutland, Vt.	Wade A. Snow, Columbia.	35.00	----
			G. T. Sanger, Canterbury.	35.00	
2608	Potato Manure.	Davidge Fertilizer Co., 121 Front St., New York.	F. F. Hitchcock, Woodbury.	42.00	----
			W. B. Coan, Long Hill.	40.00	
			W. P. Bartholomew, Bantam.	40.00	
			S. H. Daggett, Andover.	40.00	
			George Boughton, Ridgebury.	40.00	
			G. H. Platt, Redding Ridge.	34.20	
2534	Ammoniated Wheat and Corn Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	E. E. Cooley, Simsbury.	38.00	----
2529	Potato Fertilizer.	E. F. Coe, Burling Slip, New York.	John Amidon & Co., Wethersfield.	40.00	----

Analyses of Special Manures Sampled by the Station.

Station No.	Name or Brand.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen, Organic.	Nitrogen: Total Nitrogen Found.	Nitrogen: Nitrogen Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid: Total Found.	Phosphoric Acid: Total Guaranteed.	Phosphoric Acid: Available: Found.	Phosphoric Acid: Available: Guaranteed.	Potash: Found.	Potash: Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2437	Fairchild's Formula for Seeding Down	----	---	2.89	2.89	2.5	----	----	----	18.54	17.5	----	----	13.12	12.5	10.00	$40.00	$45.30	11.7*
2432	Rogers & Hubbard Co's Complete Potato and Tobacco Manure	3.16	----	2.24	5.40	5.0	----	----	----	15.74	14.5	----	----	9.89	10.0	none	47.50	50.82	6.5*
2433	Fairchild's Formula for Corn and General Crops	3.13	----	2.30	5.43	5.5	----	----	----	14.63	12.5	----	----	11.61	12.5	8.70	46.00	47.60	3.4*
2540	Mapes' Fruit and Vine Manure	.39	.57	1.66	2.62	1.6	7.72	1.61	.90	10.23	7.0	9.33	----	10.30	11.0	none	38.00	37.47	1.4
2503	Mapes' Corn Manure	.93	1.32	1.71	3.96	3.7	7.89	3.23	1.55	12.67	10.0	11.12	----	6.58	7.0	5.89	41.00	39.00	5.1
2548	Mapes' Grass and Grain Spring Top Dressing	1.13	1.68	1.81	4.62	4.1	5.93	3.45	2.65	12.03	7.0	9.38	5.0	5.97	5.0	5.08	41.00	38.73	5.8
2549	Mapes' Tobacco Manure, Wrapper Brand	.65	4.17	1.47	6.29	6.2	1.89	2.51	1.55	5.95	4.5	4.40	----	11.71	10.5	1.24	48.00	44.92	6.8
2551	Mapes' Complete Manure for Light or Sandy Soil	.85	2.21	2.44	5.50	4.9	5.94	2.82	1.48	10.24	7.0	8.76	----	6.40	6.0	6.45	44.00	40.93	7.5
2603	H. S. Miller's Special Potato Manure	----	----	4.22	4.22	3.7	6.57	.58	.23	7.38	----	7.15	8.5	7.71	7.0	trace	40.00	36.82	8.7
2522	Bradley's Complete Manure for Potatoes and Vegetables	.47	.34	2.96	3.77	3.7	8.25	2.14	.79	11.18	9.0	10.39	8.0	5.61	6.0	5.54	40.00	36.07	10.9
2483	Mapes' Potato Manure	1.08	1.25	1.50	3.83	3.7	6.12	3.40	1.95	11.47	8.0	9.52	8.0	7.17	6.0	.38	43.00	38.63	11.3
2506	Baker's Potato Manure	----	2.82	1.21	4.03	3.3	6.66	1.32	.72	8.70	----	7.98	5.8	9.39	10.0	3.94	42.50	38.08	11.6
2648	Mapes' Complete Manure for Heavy Soils	.86	1.85	2.07	4.78	4.9	6.94	3.08	2.93	12.95	10.0	10.02	----	3.29	3.0	.31	44.00	39.13	12.5
2531	Baker's Special Corn Manure	----	3.78	.87	4.65	4.9	6.61	1.04	.96	8.61	----	7.65	6.3	7.87	7.0	8.28	42.50	37.47	13.4
2486	Quinnipiac Potato Manure	.74	.44	2.33	3.51	2.5	3.60	4.22	1.20	9.02	----	7.82	6.0	5.98	5.0	.59	38.00	32.79	15.8

* Valuation exceeds cost. A mixture of bone and chemicals. Nitrogen and Phos. acid valued as in bone, not as in Superphosphates.

Analyses of Special Manures Sampled by the Station—*Continued.*

Station No.	Name or Brand.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen, Organic.	Nitrogen: Total Nitrogen Found.	Nitrogen: Nitrogen Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid: Total Found.	Phosphoric Acid: Total Guaranteed.	Phosphoric Acid: Available: Found.	Phosphoric Acid: Available: Guaranteed.	Potash: Found.	Potash: Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2622	Meyer's Acme Potato Manure	----	1.58	1.07	2.65	2.9	3.83	3.77	1.49	9.09	7.0	7.60	----	8.92	9.0	3.99	$38.00	$31.86	19.2
2530	Bradley's Complete Manure for Corn and Grain	.38	.53	2.21	3.12	3.3	7.89	2.25	1.17	11.31	10.0	10.14	8.0	5.33	4.5	5.31	40.00	33.19	20.5
2478	Bradley's Potato Manure	----	.12	2.54	2.66	2.5	6.25	2.00	2.33	10.58	8.0	8.25	6.0	5.16	5.0	3.73	36.00	29.21	23.2
2502	Crocker's Potato, Hop and Tobacco Fertilizer	----	----	2.12	2.12	2.0	8.72	2.09	.78	11.59	8.0	10.81	----	3.98	3.5	3.79	36.00	29.20	23.2
2481	Stockbridge Vegetable Manure	.58	.71	1.83	3.12	3.2	7.29	2.19	1.58	11.06	8.0	9.48	7.0	6.45	5.0	6.68	41.00	33.23	23.4
2521	Crocker's Ammon. Wheat and Corn Phosphate	----	----	2.47	2.47	2.0	8.96	1.83	.64	11.43	----	10.79	10.0	2.33	1.8	1.26	36.00	29.15	23.5
2507	Stockbridge Grass Manure for Top Dressing	2.37	----	2.02	4.39	5.0	5.21	1.91	3.48	10.60	6.0	7.12	3.0	4.72	5.0	4.75	41.00	33.20	23.5
2532	Stockbridge Vegetable Manure	.20	1.09	1.93	3.22	3.2	7.34	2.17	1.47	10.98	8.0	9.51	7.0	5.59	5.0	5.37	41.00	33.06	24.0
2519	Great Eastern Vegetable, Vine and Tobacco Fertilizer	----	.21	1.91	2.12	2.1	6.34	2.50	1.61	10.45	----	8.84	8.0	5.84	6.0	5.00	35.00	28.18	24.2
2509	Stockbridge Corn Manure	1.03	----	2.32	3.35	3.2	6.06	3.85	2.87	12.78	9.0	9.91	8.0	3.45	4.0	3.62	41.00	32.63	25.6
2613	Williams & Clark Co's Potato Phosphate	----	.94	1.54	2.48	2.0	6.76	1.00	.22	7.98	8.0	7.76	7.0	5.83	6.0	3.53	36 00	27.46	31.1
2515	Great Eastern Grain and Grass Fertilizer	----	----	2.63	2.63	2.9	6.65	2.34	1.32	10.31	----	8.99	8.0	1.87	2.0	1.98	35.00	26.61	31.5
2608	Davidge's Potato Manure	----	.85	2.15	3.00	2.9	7.58	1.84	1.26	10.68	10.0	9.42	9.5	3.67	4.5	4.06	40.00	30.35	31.8
2534	Crocker's Ammon. Wheat and Corn Phosphate	----	----	2.47	2.47	2.0	8.61	1.88	.77	11.26	----	10.49	10.0	2.41	1.8	2.26	38.00	28.62	32.8
2529	E. Frank Coe's Potato Manure	----	----	2.05	2.05	2.0	7.58	1.40	1.32	10.30	----	8.98	8.0	5.09	6.0	2.36	38.00	27.98	35.7

ANALYSES OF SPECIAL MANURES SAMPLED BY THE STATION.

Station No.	Name or Brand.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2437	Fairchild's Formula for Seeding Down	----	---	2.89	2.89	2.5	----	----	----	18.54	17.5	----	----	13.12	12.5	10.00	$40.00	$45.30	11.7*
2432	Rogers & Hubbard Co's Complete Potato and Tobacco Manure	3.16	----	2.24	5.40	5.0	----	----	----	15.74	14.5	----	----	9.89	10.0	none	47.50	50.82	6.5*
2433	Fairchild's Formula for Corn and General Crops	3.13	----	2.30	5.43	5.5	----	----	----	14.63	12.5	----	----	11.61	12.5	8.70	46.00	47.60	3.4*
2540	Mapes' Fruit and Vine Manure	.39	.57	1.66	2.62	1.6	7.72	1.61	.90	10.23	7.0	9.33	----	10.30	11.0	none	38.00	37.47	1.4
2503	Mapes' Corn Manure	.93	1.32	1.71	3.96	3.7	7.89	3.23	1.55	12.67	10.0	11.12	----	6.58	7.0	5.89	41.00	39.00	5.1
2548	Mapes' Grass and Grain Spring Top Dressing	1.13	1.68	1.81	4.62	4.1	5.93	3.45	2.65	12.03	7.0	9.38	5.0	5.97	5.0	5.08	41.00	38.73	5.8
2549	Mapes' Tobacco Manure, Wrapper Brand	.65	4.17	1.47	6.29	6.2	1.89	2.51	1.55	5.95	4.5	4.40	----	11.71	10.5	1.24	48.00	44.92	6.8
2551	Mapes' Complete Manure for Light or Sandy Soil	.85	2.21	2.44	5.50	4.9	5.94	2.82	1.48	10.24	7.0	8.76	----	6.40	6.0	6.45	44.00	40.93	7.5
2603	H. S. Miller's Special Potato Manure	----	----	4.22	4.22	3.7	6.57	.58	.23	7.38	----	7.15	8.5	7.71	7.0	trace	40.00	36.82	8.7
2522	Bradley's Complete Manure for Potatoes and Vegetables	.47	.34	2.96	3.77	3.7	8.25	2.14	.79	11.18	9.0	10.39	8.0	5.61	6.0	5.54	40.00	36.07	10.9
2483	Mapes' Potato Manure	1.08	1.25	1.50	3.83	3.7	6.12	3.40	1.95	11.47	8.0	9.52	8.0	7.17	6.0	.38	43.00	38.63	11.3
2506	Baker's Potato Manure	----	2.82	1.21	4.03	3.3	6.66	1.32	.72	8.70	----	7.98	5.8	9.39	10.0	3.94	42.50	38.08	11.6
2648	Mapes' Complete Manure for Heavy Soils	.86	1.85	2.07	4.78	4.9	6.94	3.08	2.93	12.95	10.0	10.02	----	3.29	3.0	.31	44.00	39.13	12.5
2531	Baker's Special Corn Manure	----	3.78	.87	4.65	4.9	6.61	1.04	.96	8.61	----	7.65	6.3	7.87	7.0	8.28	42.50	37.47	13.4
2486	Quinnipiac Potato Manure	.74	.44	2.33	3.51	2.5	3.60	4.22	1.20	9.02	----	7.82	6.0	5.98	5.0	.59	38.00	32.79	15.8

* Valuation exceeds cost. A mixture of bone and chemicals. Nitrogen and Phos. acid valued as in bone, not as in Superphosphates.

ANALYSES OF SPECIAL MANURES SAMPLED BY THE STATION—*Continued.*

Station No.	Name or Brand.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen Found.	Nitrogen Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Cost per Ton.	Valuation per Ton.	Percentage Difference between Cost and Valuation.
2622	Meyer's Acme Potato Manure	----	1.58	1.07	2.65	2.9	3.83	3.77	1.49	9.09	7.0	7.60	----	8.92	9.0	3.99	$38.00	$31.86	19.2
2530	Bradley's Complete Manure for Corn and Grain	.38	.53	2.21	3.12	3.3	7.89	2.25	1.17	11.31	10.0	10.14	8.0	5.33	4.5	5.31	40.00	33.19	20.5
2478	Bradley's Potato Manure	----	.12	2.54	2.66	2.5	6.25	2.00	2.33	10.58	8.0	8.25	6.0	5.16	5.0	3.73	36.00	29.21	23.2
2502	Crocker's Potato, Hop and Tobacco Fertilizer	----	----	2.12	2.12	2.0	8.72	2.09	.78	11.59	8.0	10.81	----	3.98	3.5	3.79	36.00	29.20	23.2
2481	Stockbridge Vegetable Manure	.58	.71	1.83	3.12	3.2	7.29	2.19	1.58	11.06	8.0	9.48	7.0	6.45	5.0	6.68	41.00	33.23	23.4
2521	Crocker's Ammon. Wheat and Corn Phosphate	----	----	2.47	2.47	2.0	8.96	1.83	.64	11.43	----	10.79	10.0	2.33	1.8	1.26	36.00	29.15	23.5
2507	Stockbridge Grass Manure for Top Dressing	2.37	----	2.02	4.39	5.0	5.21	1.91	3.48	10.60	6.0	7.12	3.0	4.72	5.0	4.75	41.00	33.20	23.5
2532	Stockbridge Vegetable Manure	.20	1.09	1.93	3.22	3.2	7.34	2.17	1.47	10.98	8.0	9.51	7.0	5.59	5.0	5.37	41.00	33.06	24.0
2519	Great Eastern Vegetable, Vine and Tobacco Fertilizer	----	.21	1.91	2.12	2.1	6.34	2.50	1.61	10.45	----	8.84	8.0	5.84	6.0	5.00	35.00	28.18	24.2
2509	Stockbridge Corn Manure	1.03	----	2.32	3.35	3.2	6.06	3.85	2.87	12.78	9.0	9.91	8.0	3.45	4.0	3.62	41.00	32.63	25.6
2613	Williams & Clark Co's Potato Phosphate	----	.94	1.54	2.48	2.0	6.76	1.00	.22	7.98	8.0	7.76	7.0	5.83	6.0	3.53	36 00	27.46	31.1
2515	Great Eastern Grain and Grass Fertilizer	----	----	2.63	2.63	2.9	6.65	2.34	1.32	10.31	----	8.99	8.0	1.87	2.0	1.98	35.00	26.61	31.5
2608	Davidge's Potato Manure	----	.85	2.15	3.00	2.9	7.58	1.84	1.26	10.68	10.0	9.42	9.5	3.67	4.5	4.06	40.00	30.35	31.8
2534	Crocker's Ammon. Wheat and Corn Phosphate	----	----	2.47	2.47	2.0	8.61	1.88	.77	11.26	----	10.49	10.0	2.41	1.8	2.26	38.00	28.62	32.8
2529	E. Frank Coe's Potato Manure	----	----	2.05	2.05	2.0	7.58	1.40	1.32	10.30	----	8.98	8.0	5.09	6.0	2.36	38.00	27.98	35.7

Year.	Average Cost.	Average Valuation.	Percentage Difference.
1889	$40.25	$35.20	14.3
1888	39.47	33.99	16.1
1887	42.52	35.20	20.9
1886	42.56	36.70	16.0
1885	44.80	38.70	16.0
1884	49.95	44.20	13.0

2. *Manufacturers' Samples.*

The brands named below were not found in any stock inspected by the station agents and the analyses were therefore made on samples deposited by manufacturers in accordance with the requirements of the fertilizer law.

2565. Crocker's Special Potato Manure, made by Crocker Fertilizer & Chemical Co., Buffalo, N. Y.

2568. Cumberland Seeding Down Fertilizer, made by the Cumberland Bone Co., Portland, Maine.

2569. Great Eastern General Fertilizer for Oats, Buckwheat and Seeding Down, made by the Great Eastern Fertilizer Co., Rutland, Vt.

2617. Williams & Clark's Americus Brand Tobacco Fertilizer, made by Williams & Clark Co., 81 Fulton street, N. Y.

Analyses and Valuations.

	2565	2568	2569	2617
Nitrogen as nitrates	1.85	.32	---	----
Nitrogen as ammonia	.25	.40	----	1.19
Organic nitrogen	1.39	1.06	.98	2.37
Total nitrogen found	3.49	1.78	.98	3.56
Nitrogen guaranteed	3.7	1.7	.9	4.1
Soluble phosphoric acid	5.75	1.95	7.11	5.73
Reverted phosphoric acid	2.78	4.56	1.41	.65
Insoluble phosphoric acid	1.40	16.90	.76	.14
Total phosphoric acid found	9.93	23.41	9.28	6.52
Phosphoric acid guaranteed	----	18.0	----	6.0
Available phosphoric acid found	8.53	6.41	8.52	6.38
Available phosphoric acid guaranteed	8.0	----	8.0	5.0
Potash found	6.61	.21	3.95	6.85
Potash guaranteed	5.5	1.0	4.0	8.0
Chlorine	5.98	.46	6.97	2.75
Valuation per ton	$32.68	23.55	21.24	30.88

HOME-MIXED FERTILIZERS.

Following are analyses of all the samples of Home-mixed Fertilizers which have been sent to the Station this year, with such facts as could be obtained regarding their cost, etc. The formulas by which the fertilizers were mixed are first given, followed by the table of analyses and valuations with some explanations and further remarks regarding them.

2455. Mixture for General Use. Made by the late J. J. Webb, Hamden.

Formula.

834	pounds Dissolved Bone Black, costing		$10.43
666	" Tankage,	"	9.32
208	" Sulphate of Ammonia,	"	7.80
292	" Muriate of Potash,	"	5.84
2000	"	"	$33.39
	Add freight to New Haven		1.60
	Total cost of raw material per ton		$34.99

Mr. Webb bought the above chemicals on guarantee, intending to have a mixture containing Nitrogen 4.75 per cent., Phosphoric Acid 8 per cent. and Potash 7.75 per cent. The analysis given further on will show how closely the calculation agreed with the actual composition.

2456. Mixture for Corn. Made by Dennis Fenn, Milford.

Formula.

700	pounds of Ground Bone,	costing	$10.50
500	" " Tankage,	"	7.15
1000	" " Dissolved Bone Black,	"	13.00
300	" " Sulphate of Ammonia,	"	11.19
250	" " Muriate of Potash,	"	5.20
200	" " Double Sulphate of Potash and Magnesia,	"	3.06
2950	"	"	$50.10

Cost of materials $50.10, or $34.00 per ton delivered at Milford.

2457. Mixture No. 1 and **2458,** Mixture No. 2. Made by C. T. Merwin & Son, Milford.

FORMULAS.

	Mixture No. 1.		Mixture No. 2.	
Sulphate of Ammonia,	166 lbs., costing	$6.19	133 lbs., costing	$4.99
Tankage,	666 " "	9.52	530 " "	7.58
Bone,	--- " "	---	400 " "	6.02
Dissolved Bone Black,	834 " "	10.84	670 " "	8.71
Muriate of Potash,	334 " "	6.95	267 " "	5.55
	2000 " "	$33.50	2000 " "	$32.85

Cost of materials $33.50 and $32.85 respectively, delivered at Milford.

2474. Mixture made by Edward Davis of Whitneyville.

FORMULA.

Home made Superphosphate	350	pounds.
Fish Scrap	350	"
Sulphate of Ammonia	110	"
Muriate of Potash	150	"
	960	

The Superphosphate was made by dissolving in oil of vitriol refuse bone char from a factory where bone was used for case-hardening. The cost of material is unknown.

2588. Mixture for General Use. Made by N. D. Platt, Milford.

FORMULA.

500 pounds	Sulphate of Ammonia,	costing	$18.65
2000 "	Tankage,	"	28.60
500 "	Bone,	"	7.53
2000 "	Dissolved Bone Black,	"	26.00
500 "	Muriate of Potash,	"	10.40
270 "	High grade Sulphate of Potash,	"	8.26
5770 "	Total		$99.44

Cost of materials delivered at Milford $34.50 per ton.

2589. Mixture made by N. S. Platt, Cheshire.

FORMULA.

100 pounds	Bone,	costing	$1.75
300 "	Blood, Bone and Meat,	"	5.25
800 "	Dissolved Bone Black,	"	10.40
300 "	Double Sulphate of Potash and Magnesia,	"	4.50
1500 "	Total.	"	$21.80

Cost of the materials in New Haven	$29.07 per ton
Add freight	1.20

Cost of materials delivered at Cheshire $30.27

2591. Mixture made by R. M. Treat, Woodmont.

FORMULA.

900 pounds	Tankage,	costing	$12.87
340 "	Sulphate of Ammonia,	"	12.68
200 "	Ground Bone,	"	3.01
2000 "	Dissolved Bone Black,	"	26.00
560 "	Muriate of Potash,	"	11.65
4000 "			$66.21

Cost of materials delivered at Woodmont $33.11 per ton.

2592. Mixture for Corn. Made by Geo. F. Platt, Milford.

FORMULA.

450 pounds	Tankage,	costing	$6.44
450 "	Ground Bone,	"	6.77
232 "	Sulphate of Ammonia,	"	8.65
384 "	Dissolved Bone Black,	"	4.99
305 "	Muriate of Potash,	"	6.34
179 "	High-grade Sulphate of Potash,	"	5.48
2000 "			$38.67

Cost of materials delivered at Milford $38.67 per ton.

2593. Mixture for Potatoes. Made by G. F. Platt, Milford.

FORMULA.

500 pounds	Sulphate of Ammonia,	costing	$18.65
2500 "	Tankage,	"	35.75
2500 "	Ground Bone,	"	37.63
2500 "	Dissolved Bone Black,	"	32.50
750 "	Muriate of Potash,	"	15.60
550 "	Sulphate of Potash,	"	16.83
9300 "			$156.96

Cost of materials delivered at Milford $33.75 per ton.

2594. Mixture for Potatoes. Made by Dennis Fenn, Milford.

FORMULA.

200 lbs.	Sulphate of Ammonia,	costing	$7.46
500 "	Tankage,	"	7.15
650 "	Bone,	"	9.78
1000 "	Dissolved Bone Black,	"	13.00
250 "	Muriate of Potash,	"	5.20
800 "	Double Sulphate of Potash and Magnesia,	"	12.24
3400			$54.83

Cost of materials delivered at Milford, $32.26 per ton.

The raw materials used for these mixtures were for the most part purchased from L. Sanderson, of New Haven and C. Meyer, Jr., of Maspeth, L. I., and were sampled by station agents and analyzed early in the season. Knowing their composition and the quantity of each which was used, the composition of the mixtures can be calculated, assuming that all weights were correctly taken, that the materials had not lost or gained moisture and that both mixing and sampling had been thorough. These calculated analyses are given in the table to compare with the actual composition of the mixtures. The agreement is quite satisfactory, with the single exception of No. **2589**.

The mechanical condition of these mixtures is excellent and their chemical composition corresponds with that of the ready mixed "special fertilizers" and ammoniated superphosphates of the highest grade.

The cost above given is in every case based on the regular cash ton prices of the trade. The *actual* cost in many, if not all, of these cases has been considerably reduced by special club rates which are given where a number of farmers give a cash order through an agent for a car lot or more.

The average cost of materials in these home-mixed fertilizers has been $33.79 per ton delivered at the purchaser's freight station. Two dollars will fully cover the cost of screening and mixing. [From a dollar to a dollar and a half is the estimate of those who have done the work.] *At the highest estimate*, therefore, the average cost of these home-mixed fertilizers has been $35.79 per ton. The average valuation has been $38.65 per ton. In no case has the valuation been less than the cost of the chemicals mixed. The valuation of ready-mixed fertilizers on the other hand is quite uniformly less than their cost.

The advantages claimed for home-mixing are:

1. Each ingredient can be separately examined by the purchaser and if necessary sent to the Experiment Station for analysis. The detection of inferior forms of nitrogen or phosphoric acid is much easier and more certain in a single article than in a mixture.

2. It is self-evident that an intelligent farmer by home-mixing is better able than any one else can be to adapt the composition of his fertilizers to the special requirements of his land as well as of his crop, and how greatly the soil-requirements vary in this State,

Home-Made Fertilizers. Analyses and Valuations.

Station No.	Name.	Nitrogen. As Ammonia.	Nitrogen. Organic.	Nitrogen. Total. Found.	Nitrogen. Total. Calculated.	Phosphoric Acid. Soluble.	Phosphoric Acid. Reverted.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total. Found.	Phosphoric Acid. Total. Calculated.	Potash. Found.	Potash. Calculated.	Chlorine.	Valuation per ton.	Cost of Chemicals (unmixed).
2455	Estate of J. J. Webb, Mixture	2.50	2.44	4.94	*4.97*	5.73	2.38	.69	8.80	*8.69*	7.89	*7.56*	....	39.02	34.99
2456	Dennis Fenn, Corn Mixture	2.11	1.86	3.97	*4.28*	4.46	5.56	2.46	12.48	*12.22*	6.54	*6.16*	4.61	38.06	34.00
2457	C. T. Merwin & Son, Mixture No. 1	1.96	2.52	4.48	*4.50*	6.14	2.02	.64	8.80	*8.70*	9.35	*8.60*	....	38.68	33.50
2458	" " No. 2	1.60	2.91	4.51	*4.24*	6.20	3.94	1.62	11.76	*11.51*	6.61	*6.90*	....	39.89	32.85
2474	Edward Davis, Mixture	2.89	1.61	4.50	....	3.43	2.15	2.28	7.86	....	8.98	....	7.74	34.80	....
2588	N. D. Platt, Mixture	2.04	2.65	4.69	*5.00*	4.44	4.03	1.07	9.54	*9.50*	8.05	*7.00*	4.80	39.35	34.50
2589	N. S. Platt, Mixture	....	1.83	1.83	*.95*	9.70	3.62	1.28	14.60	*14.92*	3.15	*5.56*	.17	32.38	30.27
2591	R. M. Treat, Mixture	1.95	1.95	3.90	*3.80*	7.48	3.10	.83	11.41	*11.20*	7.62	*7.30*	....	38.80	33.11
2592	George F. Platt, Corn Mixture	2.65	2.34	4.99	*5.02*	2.70	4.95	1.54	9.19	*9.29*	14.07	*12.56*	7.40	45.56	38.67
2593	George F. Platt, Potato Mixture	1.22	2.73	3.95	*4.24*	3.42	6.68	2.37	12.47	*11.83*	7.41	*7.27*	4.03	39.20	33.75
2594	Dennis Fenn, Potato Mixture	1.26	1.74	3.00	*3.09*	4.05	4.69	1.56	10.30	*10.27*	9.98	*9.93*	3.66	36.38	32.26

even over a small area, is strikingly shown by the field experiments annually reported by our farmers through the Stations.

3. It is claimed that the same quantity and quality of plant food costs much less in home-mixtures than in ready-made mixtures because the cash purchaser of fertilizer chemicals deals directly with the importer or manufacturer, not with the middleman or retailer, and receives quotations without reference to the prices asked in his neighborhood by retailers of the same goods.

There is no longer any question as to the expediency of home-mixing in many cases. From such raw materials as are in our markets, without the aid of milling machinery, mixtures can be and *are* annually made on the farm which are uniform in quality, fine and dry and equal in all respects to the best ready-made fertilizers.

The economy of home-mixing depends, of course, on the prices which sellers of mixed goods are willing to take and on the cost of fertilizer-chemicals delivered as near the farm as mixed goods can be bought.

There is always a chance for the farmer who studies the market and the needs of his farm to save enough in the purchase of the fertilizers to make just the difference between profit and loss on a crop, and in farming, as in everything else where competition is close, profit usually comes from care in these small margins of expense. Perhaps home-mixtures are not indeed always and everywhere cheaper or more economical than commercial mixtures, but it will often happen that money can be saved by the timely purchase of raw materials and their mixture on the farm. Each individual farmer ought to be the best or only judge of the economy of home-mixing in his particular case, as well as of the "formulas" which are best adapted to his soil and crops.

The attention of those who plan to try home-mixing is called to the following particulars:

1. Nitrogen has cost most this season in ammonia salts and castor pomace, from 18–18½ cents per pound; in nitrates it has cost from half a cent to a cent less. Cotton seed meal has been as in past years the cheapest source of quickly available nitrogen which in this material has cost from 12½ to 15 cents per pound.

2. At present the only superphosphate used in home-mixtures is dissolved bone black, but soluble phosphoric acid can be bought considerably cheaper in dissolved South Carolina rock. See page 66.

Besides superphosphates there are other sources of phosphoric acid which should be considered. On some soils Thomas-Slag has given as good results as superphosphates, and there are other native phosphates in which the ratio between cost and agricultural value may be for some soils and crops as favorable as in superphosphates. Fine ground bone too, which contains from 24–30 per cent. of phosphoric acid and from 1.5–4.0 per cent. of nitrogen can be got for from \$26–32 per ton; while bone black superphosphate, containing 17 per cent. of phosphoric acid and a small fraction of 1 per cent. of nitrogen costs \$26.

3. Potash in sulphates costs about 6 cents per pound, in muriate from 4 to 4½ cents. Kainit contains large quantities of chlorine and should be regarded as an impure muriate rather than as a sulphate. Potash in kainit costs at retail more than in muriate, about 4.8 cents per pound. As may be seen on page 108 potash as carbonate and perhaps phosphate, has cost from 3.2 to 6 cents per pound in cotton hull ashes. At the lower figure they are an excellent source of potash. The only objection to their use is the great variation in quality. As a result of this the buyer can have no certainty regarding them without a chemical analysis.

Miscellaneous Fertilizers and Manures.

Cotton Hull Ashes.

2419. Dark colored. Sold by R. E. Pinney, Suffield. Sampled and sent by C. H. Wells, Suffield.

2493. Sold to Edward Austin of Suffield by Allen Wilson. Sampled and sent by Allen Wilson, Suffield.

2418. Light colored. Sold by R. E. Pinney, Suffield. Sampled and sent by C. H. Wells, Suffield.

2485. Sold by R. E. Pinney, Suffield. Sampled and sent by J. M. Brown, Poquonock.

2408. Sold by C. L. Spencer, Suffield. Sampled and sent by Edmund Halladay, Suffield.

2409. Sold by C. L. Spencer, Suffield. Sampled and sent by Edmund Halladay, Suffield.

2410. Sold by C. L. Spencer, Suffield. Sampled and sent by Edmund Halladay, Suffield.

2453. Sold by R. E. Pinney, Suffield. Sampled and sent by D. L. Brockett, Suffield.

2448. Sold by Wilder and Puffer, Springfield, Mass. Sampled and sent by B. R. Townsend, Wallingford.

2459. Sold by C. D. Cannon, Windsor Locks. Sampled and sent by I. C. Duran, Windsor Locks.

2429. Sold by R. E. Pinney, Suffield. Sampled and sent by Edmund Halladay, Suffield.

2454. Sold by R. E. Pinney to Wayne Rice, East Windsor Hill. Sampled and sent by R. E. Pinney.

Analyses of Cotton Hull Ashes.

Station Number.	2419	2493	2418	2485	2408	2409	2410	2453	2448	2459	2429	2454
Soluble phosphoric acid	2.78	2.40	1.28	2.30	.45	.48	.48	2.23	.75	.77	1.12	.03
Reverted phosphoric acid	6.44	8.07	5.77	5.67	7.80	7.93	8.06	5.98	6.43	7.05	5.46	2.20
Insoluble phosphoric acid	2.50	1.25	1.66	1.70	.34	.36	.36	2.02	1.81	.75	1.30	1.49
Potash	23.07	27.24	27.26	25.12	28.23	26.51	26.18	16.50	21.42	21.23	15.14	10.38
Cost per ton	$30.00	35.00	30.00	31.00	35.00	35 00	35.00	28.00	31.50	35.00	28.67	16.41
Valuation per ton	$42.79	49.14	44.08	43.01	46.43	44.62	44.42	33.15	37.27	37.32	28.67	16.41
Potash costs per pound in cents	3.2	3.4	3.4	3.6	3.9	4.2	4.2	4.4	4.6	5.4	6	6

The three samples from stock of C. L. Spencer, **2408**, **2409** and **2410**, were drawn from different car loads. We understand that on learning that the lots represented by samples **2429** and **2454** were inferior, Mr. Pinney returned to the purchasers the money difference between cost and valuation. The per cent. of potash in these 12 samples varies from 28.23 to 10.38. This wide difference is largely due to carelessness, if nothing worse, at the mills where coal as well as hulls has to be used as fuel and the ashes of the two fuels are allowed to mix. Such carelessness if persisted in will soon destroy the market for these ashes.

Unleached Wood Ashes.

Large quantities of unleached wood ashes are now brought into Connecticut yearly from Canada and the northwestern states and are sold for from $11 to $15 per ton, in car lots.

The following analyses have been made of ashes brought into the State this year:

2537. Canada Ashes. Bought by N. S. Platt, Cheshire, from James Hartness, Detroit, Mich. Cost, 23 cents per bushel.

2587. Sampled and sent by F. A. Griswold, Wethersfield. Bought in Hartford.

2620. Screened Ashes. Bought by C. S. Gillette, Cheshire, from W. E. Fyfe & Co., Clinton, Mass. Cost, $11.00 per ton, in car lots at Cheshire.

2624. Canada Ashes, sampled and sent by G. L. Dunham, Southington, from stock of Burritt Hills, Plainville. Cost, $11.00 per ton. One bushel weighs $57\frac{1}{2}$ pounds.

2628. Canada Ashes. Sold by Munroe, Judson & Stroup, Oswego, N. Y., to Atwood & Wilson, Watertown. Sampled and sent by D. B. Thompson, Watertown. Cost, $15.00 per ton.

2632. Sold by Forest City Wood Ash Co., London, Ont., Canada, to F. N. Bradley, Derby. Cost, $13.00 per ton.

Analyses.

	2537	2587	2620	2624	2628	2632
Potash, soluble in water	4.48	4.01	3.77	4.91	5.33	6.04
Phosphoric acid	1.77	1.05	1.70	1.77	1.19	1.32
Lime			31.55	25.90	44.54	39.02
Carbonic acid			18.26	18.30	26.46	19.60
Sand and insoluble matters			16.25	25.65	8.45	12.38

The sample **2628** is fine and nearly white. The question was asked whether it was not mixed with lime. Such is perhaps the case, the high per cent. of lime being offset by the low percentage of sand and insoluble matters.

Ashes vary a good deal in composition, and some of the samples received this year are notably deficient in potash.

The following data show the average quality of ashes. 91 samples of unleached wood ashes, analyzed by Dr. Goessmann, of Massachusetts, between the years 1868 and 1889 (Rep. Mass. Ex. St., 1888, 202, and Bull. 33), had the following average composition :

	Average.	Maximum.	Minimum.
Potash	5.5	10.2	2.5
Phosphoric acid	1.9	4.0	.3
Lime	34.3	50.9	18.0
Magnesia	3.5	7.5	2.3
Insoluble matter	12.9	27.9	2.1
Moisture	12.0	28.6	.7

16 analyses made at the Connecticut Station between 1877 and 1889 had the following average composition :

	Average.	Maximum.	Minimum.
Potash	5.3	7.7	4.0
Phosphoric acid	1.4	1.8	1.0

The ashes from household fires in New England appear to be richer both in phosphoric acid and potash. 15 analyses, 13 of which were made by Prof. Storer, of the Bussey Institution, show the following average composition :

Potash	9.63
Phosphoric acid	2.32

The quality as well as the quantity of ashes from a given weight of wood depends very much on the kind of wood as well as on its freedom from dirt, etc.

A valuable series of analyses recently made at the Georgia Experiment Station illustrates this. According to the analyses, 10,000 pounds of several different varieties of wood, [exclusive of bark and having a uniform water content], contained the following quantities of the ingredients named. The samples were selected from trees growing as nearly as possible under like conditions and of medium age. [See table of analyses on page 112.]

The facts that these analyses are of the wood only, bark being removed, that the bark contains much less of these ingredients than the wood, and that these ashes were pure—free from all sand or earth as well as carbonic acid—will explain why the percentages are so much higher than are found in analyses of ashes in market.

Leached and unleached Canada ashes have approximately the following percentage composition :

	Unleached Ashes.	Leached Ashes.
Sand, earth and charcoal	13.0	13.0
Moisture	12.0	30.0
Carbonate with some hydrate of lime	61.0	51.0
Potash [chiefly as carbonate]	5.5	1.1
Phosphoric acid	1.9	1.4
Other matters by difference	6.6	3.5
	100.0	100.0

It appears from this statement that more than half the weight of both leached and unleached ashes consists of lime, partly as hydrate but chiefly as carbonate ; the same material chemically as chalk or limestone but finer and so likely to be quicker in its action.

It has long been known that chalk or limestone may benefit both very heavy and very light lands making the one looser in texture and less apt to puddle and the other closer and more compact. It does this in the one case by separating the particles of sticky clay and in the other by filling up the interspaces of a coarse soil. A writer on agriculture in the early part of the last century says of chalk, "it causes great fertility especially on such lands as are apt to lose the riches of dungs laid on them, and to forget in a little time that they have had any kind and indulgent benefactor. Here chalk is of excellent use to drive away such ingratitude, having a retentive quality to enclose and stay the salts."

It needs to be borne in mind that potash or soda lye binds a clay soil making it heavier, more tenacious and cloddy than before, and it may be that on this account a heavy application of *unleached* ashes to a clay soil would either not help it at all or even damage it, while on light soils unleached ashes would be more beneficial than leached ashes. This favorable action on light soils has made ashes popular in this State where our soil is for the most part light and sandy. They "keep the soil moist" as the saying is, that is by filling up the pores and compacting it, the soil water is made to rise more readily in it from the subsoil bringing plant food with it and preventing drought.

Ten Thousand Pounds of Wood contained Pounds of the Ingredients named:

	Dogwood. Cornus florida.	Sycamore. Platanus occidentalis.	Post Oak. Q. obtusiloba.	Ash. F. Americana.	Red Oak. Q. rubra.	Hickory. Carya tomentosa.	White Oak. Q. alba.	Magnolia. M. grandiflora.	Georgia Pine. P. palustris.	Yellow Pine. P. mitis.	Black Pine. Picea nigra.	Chestnut. Castanea vulgaris.	Old Field Pine. P. mitis.
Potash	19.02	18.06	16.85	14.94	13.95	13.80	10.60	7.13	5.01	4.54	3.02	2.90	.79
Phosphoric acid	5.72	9.55	6.96	1.15	5.98	5.83	2.49	3.19	1.24	.96	.92	1.09	.73
Lime	26.41	24.73	35.61	7.60	27.40	18.40	7.85	14.21	18.04	15.16	12.46	7.93	12.12
Magnesia	4.67	.49	5.28	.10	3.05	4.86	.90	2.94	2.03	.74	.10	.34	1.17

The Pure* Ashes of the Woods contained the following Per cents. of the Ingredients named.

	Dogwood.	Sycamore.	Post Oak.	Ash.	Red Oak.	Hickory.	White Oak.	Magnolia.	Georgia Pine.	Yellow Pine.	Black Pine.	Chestnut.	Old Field Pine.
Potash	28.04	23.17	21.92	46.04	24.66	28.60	42.16	19.54	15.35	19.70	14.30	18.10	3.85
Phosphoric acid	8.51	12.23	9.00	3.58	10.55	11.97	9.48	8.75	3.82	4.18	4.33	6.76	4.11
Lime	38.93	31.62	46.39	23.57	48.26	37.94	29.85	38.94	55.24	65.53	58.98	49.18	67.73
Magnesia	6.80	.62	6.88	.60	5.38	10.04	3.43	8.05	6.25	3.20	.50	2.11	6.54

* Free from carbon and carbonic acid.

Besides this action of ashes which is in large part at least mechanical, they also tend to correct "sourness" of the soil. In most cases this is not due to free acid but to the presence of soluble iron salts which in undue quantity are poisonous to plants and in smaller quantity show that the soil is stagnant, and needs aeration. Ashes precipitate these salts and open the soil that contains them to the air, by making it looser in texture.

When potash salts have been used in large quantities and the potash has been largely taken up by a rapidly growing crop as tobacco, leaving most of the acid with which the potash was combined in the soil, ashes or lime may profitably be used to neutralize it. Our best tobacco growers use stone lime or cotton hull ashes largely on their tobacco land with excellent results.

A third way in which ashes benefit land is in promoting nitrification; that process by which the more or less inert nitrogenous matters in the soil, are made to yield nitrates from which our field crops obtain most if not all their nitrogen supply. This process is in some way connected with the life of low organisms, which are invariably present in fertile soils. Nitric acid can only be produced however when carbonate of lime is present to supply a base with which the acid may combine, and a soil mildly alkaline is the one most favorable to the growth of these organisms and the formation of nitrates.

Such is, in brief, our present knowledge regarding the action of ashes. It is clear that the quantities of potash and phosphoric acid present do not wholly measure the value of ashes nor does it pay to buy them simply to supply a deficiency of these two things in the manure. The quantities of potash and phosphoric acid in a ton of ashes costing $12 to $15, can be bought in the form of muriate of potash and superphosphate of lime for $8 or $9. But ashes temper certain soils making them easier to work, moister, and more retentive of manure, correcting "sourness," promoting the solution of plant food in them and so preparing the way for the use of fertilizers which directly applied might be wasted. To accomplish these ends ashes have to be used in considerable quantity and probably a single heavy dose would help more than the same quantity applied in fractions through three or four successive years if the object is to change the mechanical condition of the soil strikingly.

Ashes of Birch Twigs.

2407. Ashes from a factory where oil of birch is distilled from birch brush, which is afterwards burned in the boiler furnace. None of the branches are more than two inches in diameter at the butt.

	2407
Potash	4.86
Phosphoric acid	5.89
Sand and soil	10.84

Ashes from Boiler Flues.

A sample of ashes from boiler flues, **2460,** contained .25 per cent. of potash and 1.00 per cent of phosphoric acid.

Tobacco Stems.

2402. Kentucky Stems, sent by Robert Aitken in November, 1888, Shaker Station. Cost $10.00 per ton delivered at Shaker Station.

2403. Connecticut Stems, sent by Robert Aitken. Cost $9.50 per ton.

Analyses.

	2402	2403
Water	26.70	13.47
Organic and Volatile matters	60.18	70.85
Mineral matter	13.12	15.68
	100.00	100.00
In the organic matters is Nitrogen	1.84	1.93
In the mineral matter are,		
Potash	8.03	6.41
Phosphoric acid	.67	.53
Sand	.64	.70

The Kentucky Stems, although they contain twice as much water as the Connecticut Stems, have considerably more potash. Valuing nitrogen, phosphoric acid and potash at 17½, 7 and 4½ cents per pound respectively, the valuation of the Kentucky Stems is $14.20 and of the Connecticut Stems $12.95 per ton.

Wool Waste.

2590. Received from P. M. Augur, Middlefield. It appeared to be made up mostly of "tag-locks," unwashed wool containing considerable sheep dung.

Analysis.

Nitrogen	2.87
Phosphoric acid	.81
Potash	5.38

With nitrogen reckoned worth 8 cents, phosphoric acid 7 cents and potash 4½ cents per pound, the total valuation will be $10.57 per ton. This slowly decomposing fertilizer is especially suitable for fruit trees and grape vines or grass, where an enduring rather than quick effect is desirable.

Damaged Corn Meal.

2496. Sample of a car-load, 56,000 pounds, which was offered to parties in Suffield for $50.00. It contained 1.32 per cent. of nitrogen, about .60 per cent. of phosphoric acid and .40 per cent. of potash. In one ton of the meal, costing $1.80, there are therefore :

26.4	pounds of nitrogen at 15 cents, worth	$3.96
12.0	" phosphoric acid at 7 cents, worth	.84
8.0	" potash at 4½ cents, worth	.36
Ton-valuation		$5.16

The margin of $3.36 (valuation less cost) is not large enough to warrant transportation to any great distance.

This meal has about twice as much nitrogen as good stable or yard manure, and this nitrogen is doubtless at least twice as available or effective as that of stable manure ; it also contains nearly the same proportions of phosphoric acid and potash as stable manure. Heavy applications would for a time greatly improve the texture and water-holding capacity of light sandy soils.

Muck.

2619. Muck from Quinnipiac brick yards. Sampled and sent by T. A. Stanley, New Britain.

ANALYSIS.

Water	67.60
Organic and volatile matter	23.05
Ash	9.35
	100.00
The organic matter contains nitrogen	.46
The ash contains, phosphoric acid	.06
potash	.02
sand and soil	7.10

The *dry* muck contains:

Organic and volatile matter	71.13
Ash	28.87
	100.00
Nitrogen	1.43
Phosphoric acid	.20
Potash	.06

MUSSELS.

2413. A sample of fresh mussels. Sent by W. R. Hopson of Bridgeport, contained:

Water	50.75
Nitrogen	.56
Phosphoric acid	.10
Potash	.08

PLASTER.

2465. Sold by L. Sanderson, New Haven. Sampled and sent by W. H. Hammond, Elliott.

ANALYSIS.

Hydrated sulphate of lime (gypsum)	77.62
Matters insoluble in acid	7.08
Other matters, chiefly carbonate of lime	15.30
	100.00

STABLE MANURE.

Two samples of manure have been received from F. H. Stadtmueller, manager of Vine Hill Farm, West Hartford, who sent the following description :—

"We send you two samples of manure such as is being applied to the land with which we desire to attempt the maintenance of a debit and credit account relative to the amount of plant food supplied and removed. The sample contained in the box marked

ANALYSES OF MANURE.

	A	B			C	D	E	F	G	H	I	J
	Cow Man're. Winter feed.	Cow Man're. No litter.	Cow Manure **2491**	Mixed Man're. Young Cattle and Horses. **2490**	Fresh dung of Steers. No litter.	Horse Manure from N. Y.	Horse Man're, Ithaca, N. Y.	Horse Man're, N. Y. City.	Fresh dung of Horse.	Old Mixed Farm Manure	Mixed Farm Manure	Mixed Farm Manure
Water	76.19	85.30	71.69	77.08	82.30	75.76	70.79	69.30	67.28	54.70	79.95	75.57
Organic and Volatile matter	20.72	12.66	18.23	15.50	15.53	19.17		25.65	26.23	10.87		
Ash	3.09	2.04	10.08	7.42	2.17	5.07		5.05	6.49	34.43		
	100.00	100.00	100.00	100.00	100.00	100.00		100.00	100.00	100.00		
Potash	0.60	.36	.48	.71	} .27	.51	.53	.63	.22	.16	.84	.70
Soda		.04	.10	.09		.09						
Lime	0.58	.29	.17	.34	.77	.30		.74	.17	.47		
Magnesia	0.03	.19	.13	.15	.15	.19		.29	.20	.50		
Oxide of Iron and alumina		.09	.84	.63	.14	.19						
Sulphuric Acid		.04	.09	.12	.16	.09						
Phosphoric Acid	0.52	.16	.30	.34	.14	.41	.21	.67	.35	.72	.40	.29
Chlorine		.07	.06	.11	.21	.07						
Sand, clay and insoluble matters		.80	7.91	4.93	.33	3.22						
Nitrogen as												
Ammonia		.26	.13	.16	--	.26		.12	.15	.01		
Organic		.27	.30	.37	--	.27		.57	.32	.45		
Total	0.79	.53	.43	.53	.20	.53	.51	.69	.47	.46	.78	.68

1, (**2490**) was taken from a heap which was made from the accumulations of a barn containing only young growing animals and a few horses. Liberal quantities of bran, a few oats and a little corn meal, with good herds grass made up their feed. The other sample, marked 2, (**2491**) is manure made by milch cows whose feed was corn meal, bran, herds grass, hay and roots, all fed in liberal quantities. Most of the animals in the barn where this manure was made have attained their growth, have changed but little in flesh, have given a fair amount of milk and are in all stages of gestation."

The analyses of these two samples are given in the following table, and with them such other American analyses of horse manure, manure of cows and steers and mixed yard manure, as we have been able to find for comparison.

A, is Cow Manure, winter feed. Analysis made at the Bussey Institution.

B, is Cow Manure. No litter. Feed, hay as much as the cows will eat, 4 quarts wheat bran and 4 quarts mangolds. Analysis by Prof. S. W. Johnson in 1874.

C, Dung, no urine, of steers, fed 24 pounds of alfalfa per day. No litter. Analysis made at Colorado Agricultural Station.

D, Horse Manure from stables in New York city. Analysis by Prof. S. W. Johnson in 1874.

E, Horse Manure from Cornell University Agricultural Station. Horses fed liberally on oats and hay. The manure contained 30 pounds of straw bedding and 466 pounds of mixed dung and urine.

F, another sample of New York stable manure. Analysed at this Station in 1880.

G, Fresh Horse Dung from a horse fed daily with 14 pounds of timothy hay and 4 quarts of oats mixed with cracked corn. Somewhat dried. Analysis made at the Bussey Institution.

H, Old Yard Manure, made by young cattle fed in yard on hay. It represents well-rotted yard manure in its usual washed condition. Analysis made by Prof. S. W. Johnson in 1874.

I, Mixed Cow and Horse Manure from a bed two feet thick, packed solid by the treading of cattle. It was estimated that 80 tons of straw had been used as bedding and that 466 tons of manure were produced. Analysis made at Cornell University.

J, Similar to I, produced in another year when less cotton seed meal was used. Analysis made at Cornell University.

These analyses serve to give a general idea of the variations in Stable Manure. The two things which are subject to greatest variation are of course moisture and sand, clay, etc. The feed has a great effect on the quality of the manure. In its passage through the animal the food loses what is taken out by the growth of the animal and by the milk. A good deal of carbonaceous matter, which has no fertilizing value, is also burned in the system to supply animal heat, but all the rest of the food passes (undigested) into the dung or (digested) into the urine. Other things being equal, the richer the food is, the richer will be the manure.

The manure of milk cows is generally regarded as less valuable than that of other stock. This is explained by the large quantity of fertilizing material withdrawn by the milk and by the calf which is annually dropped.

According to a calculation which is made in the Report of the New Hampshire Agricultural Station for 1888, page 90, 4,000 pounds, 1,356 quarts of milk, which is assumed as the average yearly yield of a Durham cow, carry 19.2 pounds of nitrogen, 7.6 pounds of phosphoric acid and 8.3 pounds of potash. 2,600 pounds of yard manure like samples I and J contain the same quantity of nitrogen, 2,100 pounds of manure contain the same quantity of phosphoric acid, while 1,100 pounds of manure contain as much potash.

On the whole it is fair to say, that the milk of a cow carries off from the farm, in the course of a year as much plant food as a ton of ordinary stable manure.

While we have no accurate data as to the food consumed by the cows and the growing cattle that produced the two samples of manure sent by Mr. Stadtmueller, described above, we may fairly assume that the food of the cows was as concentrated as that of the growing cattle. If so, a comparison of the composition of the manure will show something of the loss due to the flow of milk and to the calf. For this comparison water, and the sand and soil are dropped from the calculation not being part of the food and subject to large accidental variation. Most of the iron and alumina was doubtless derived from the soil, but they are not reckoned out as their presence does not interfere with the comparison.

	2491 Dry Cow Manure; free from sand.	2490 Dry Manure of young cattle; free from sand.
Organic and volatile matter	89.33	86.02
Ash	10.67	13.98
	100.00	100.00
Potash	2.35	4.00
Soda	.49	.50
Lime	.83	1.83
Magnesia	.64	.84
Oxide of iron and alumina	4.16	3.56
Sulphuric acid	.44	.69
Phosphoric acid	1.47	1.92
Chlorine	.79	.64
	10.67	13.98
Total nitrogen	2.10	2.94

This comparison shows the striking deficiency of potash, lime, phosphoric acid and nitrogen in the manure of cows, due largely no doubt to the causes before mentioned.

Hall's Coral Fertilizer.

Described by the makers as follows:

"This Fertilizer ranks with the best in the world. It is more necessary to the soil than Phosphates or bone."

"It will destroy potato bugs and is sure death to all worms and insects."

"Sold by all first class dealers every where at $15.00 per ton."

Manufactured by the Vermont Chemical Fertilizer Co, Vergennes, Vt.

No. **2646.** A sample package of the above material, received from D. H. Van Hoosear, Wilton, had the following composition:

	2646
Carbonate of lime [ground limestone]	94.77
Matters insoluble in acid	3.54
Other matters by difference	1.69
	100.00

It contained only traces of nitrogen and phosphoric acid.

No further comment is necessary on the absurd claims of the manufacturer.

Review of the Fertilizer Market.

For the Thirteen Months ending Dec. 31, 1889.

Nitrogen.

Nitric Nitrogen.

The average *wholesale* quotation of nitrogen in nitrate of soda in New York was 14.6 cents per pound in November of last year. In December it rose to 15.2 cents. In April, 1889, it was quoted at 14.6; in May at 13.8, and it continued to decline to 11.9 cents in August. This is the lowest figure for the year. Since then it has risen to 12.4 cents per pound.

It has *retailed* in Connecticut during the year for about 17½ cents a pound.

Ammonic Nitrogen.

The average *wholesale* quotation of nitrogen in sulphate of ammonia in New York during the last two months of 1888 and the first three months of 1889 was 16.6 cents per pound. In April it was 16.2, in May 15.7 and in August, September and October 15.0. For the last two months it has been quoted at 15.4 cents per pound.

It has been *retailed* in Connecticut during the year for from 18 to 18½ cents per pound.

Organic Nitrogen.

The nitrogen of high-grade red blood was quoted at wholesale in New York during November and December, 1888, at about 16.2 cents per pound. It rose then to 16.6 in March, 1889, then fell off steadily; in May was quoted at 15.2, in July 14.8, in Oct. 13.8, and in Dec. at 12.7 cents per pound.

The wholesale quotations of nitrogen in low-grade black blood have been quite uniformly from .3 to .5 of a cent per pound lower than in red blood for the same month.

The wholesale quotations of nitrogen in Azotin have also followed the same fluctuations as in red blood and generally have been a fraction of a cent per pound higher.

The wholesale quotation of dried fish-scrap, which is considerably used as a source of nitrogen in mixed fertilizers, was $23.75 per ton in July, August and September. It has been quoted during the later months of the year for $21.00.

As has been shown in preceding pages, organic nitrogen has *retailed* in Connecticut the past season at about 20 cents per pound in dried blood, from 18 to 19 cents in castor pomace, and from 12.2 to 14.9 cents per pound in cotton seed meal.

PHOSPHATIC MATERIALS.

Refuse Bone Black which was quoted at wholesale in New York early in the year at about \$19.50 has been quoted at \$20.25 since July.

Rough and Ground Bone have risen from \$19.00 and \$24.00 per ton respectively in Nov. 1888, to \$21.50 and \$26.50, at which prices they are still quoted.

Ground Charleston Rock, f. o. b., N. Y., quoted early in the year at \$10.25 has been quoted since May at \$11.25.

Oil of Vitriol 66° B, was quoted at 1.10 cents per pound till July and has risen since then to $1.37\frac{1}{2}$ cents.

Acid Phosphate, 14 per cent. available, was quoted in January at 86 cents per unit at wholesale. It fell in May to $81\frac{1}{4}$ cents and has remained at that figure ever since. This is equivalent to 4.06 cents per pound for available phosphoric acid.

POTASH.

Muriate of Potash.

The *wholesale* New York market quotations of potash in the form of muriate have been very uniform and have varied month by month not more than two-tenths of a cent per pound, and closed in Dec. at 3.64 cents per pound.

It has *retailed* in Connecticut from 4 to 4.6 cents per pound.

Double Sulphate of Potash and Magnesia.

Potash in this article has been quoted at *wholesale* in New York from 4.44 to 4.63 cents per pound, showing as little fluctuation as the muriate.

It has *retailed* in Connecticut from 5.4 cents to 5.9 cents per pound within the year.

High Grade Sulphate of Potash, 98 per cent.

Potash in this article was quoted at *wholesale* in New York at 5 cents in January, fell to 4.6 cents in July and closed in December again at 5 cents per pound.

The single *retail* quotation in Connecticut the past season has been 5.8 cents per pound for potash, \$61.20 per ton for the sulphate.

Kainit.

This article has been quoted at *wholesale* in New York from \$10.15 to \$10.50 per ton, or about \$10.40 on the average. If kainit contains 12.5 per cent. of actual potash this is equivalent to about 4 cents per pound at wholesale for potash.

Potash has cost at *retail* in Connecticut from $4\frac{3}{4}$ to 5 cents per pound in Kainit.

In general, the wholesale price of nitrogen in ammonia salts has fallen slightly within the year, in nitrate of soda it has fallen very considerably and still more decidedly in organic forms such as blood and azotin: from $16\frac{1}{2}$ to $12\frac{3}{4}$ or $13\frac{1}{4}$ cents per pound.

On the other hand there has been a rise of a dollar or more per ton in phosphatic materials, bone black, bone and South Carolina Rock and also a marked rise in 66° Oil of Vitriol.

The wholesale quotations of potash salts have remained practically unchanged from the beginning to the end of the year.

The market quotations given above are taken from the "Oil, Paint and Drug Reporter," published in New York. The weekly quotations for each month are averaged, and this average is taken as the quotation for the month.

The following explanations will help in the examination of the market quotations, and will also show the basis on which they have been interpreted in this review:

Phosphate rock, kainit, bone, fish-scrap, tankage, and some other articles are quoted and sold by the ton. The seller usually has an analysis of his stock and purchasers often control this by an analysis at the time of purchase.

Sulphate of ammonia, nitrate of soda and muriate of potash are quoted and sold by the pound, and generally their wholesale and retail rates do not differ very widely.

Blood, azotin and ammonite are quoted at so much "per unit of ammonia." To reduce ammonia to nitrogen, multiply the per cent. of ammonia by the decimal .824 (or multiply the percentage of ammonia by 14 and divide that product by 17). A "unit of ammonia" is one per cent., or 20 pounds per ton. To illustrate: if a lot of tankage has 7.0 per cent. of nitrogen, equivalent to

8.5 per cent. of ammonia, it is said to contain $8\frac{1}{2}$ units of ammonia, and if quoted at $2.25 per unit, a ton of it will cost $8\frac{1}{2} \times 2.25 = \$19.13$.

The term "ammonia" is *properly* used only in those cases where the nitrogen actually exists in the form of ammonia, but it is a usage of the trade to reckon all nitrogen, in whatever form it occurs, as ammonia.

To facilitate finding the actual cost of nitrogen per pound from the cost per unit of ammonia in the market reports, the following table is given:

Ammonia at	$3.00	per unit	is equivalent	to nitrogen at	18.2	cts. per lb.
"	2.90	"	"	"	17.6	"
"	2.80	"	"	"	17.0	"
"	2.70	"	"	"	16.4	"
"	2.60	"	"	"	15.8	"
"	2.50	"	"	"	15.2	"
"	2.40	"	"	"	14.6	"
"	2.30	"	"	"	14.0	"
"	2.20	"	"	"	13.4	"
"	2.10	"	"	"	12.8	"
"	2.00	"	"	"	12.2	"
"	1.90	"	"	"	11.6	"
"	1 80	"	"	"	11.0	"

Commercial Sulphate of Ammonia contains on the average 20.5 per cent. of nitrogen, though it varies considerably in quality. With that per cent. of nitrogen (equivalent to 24.3 per cent. of ammonia),

At	4	cents per lb.	Nitrogen	costs	19.5	cents per lb.
"	$3\frac{7}{8}$	"	"	"	18.9	"
"	$3\frac{3}{4}$	"	"	"	18.3	"
"	$3\frac{5}{8}$	"	"	"	17.6	"
"	$3\frac{1}{2}$	"	"	"	17.0	"
"	$3\frac{3}{8}$	"	"	"	16.4	"
"	$3\frac{1}{4}$	"	"	"	15.8	"
"	$3\frac{1}{8}$	"	"	"	15.2	"
"	3	"	"	"	14.6	"
"	$2\frac{7}{8}$	"	"	"	14.0	"
"	$2\frac{3}{4}$	"	"	"	13.4	"

Commercial Nitrate of Soda averages 95 per cent. of the pure salt or 15.6 per cent. of nitrogen.

If quoted at	3	cents per lb.	Nitrogen	costs	19.2	cents per lb.
"	$2\frac{7}{8}$	"	"	"	18.3	"
"	$2\frac{3}{4}$	"	"	"	17.6	"
"	$2\frac{5}{8}$	"	"	"	16.9	"
"	$2\frac{1}{2}$	"	"	"	16.0	"
"	$2\frac{3}{8}$	"	"	"	15.2	"
"	$2\frac{1}{4}$	"	"	"	14.4	"
"	$2\frac{1}{8}$	"	"	"	13.6	"
"	2	"	"	"	12.8	"
"	$1\frac{7}{8}$	"	"	"	12.0	"
"	$1\frac{3}{4}$	"	"	"	11.2	"

Commercial Muriate of Potash and also High Grade, 98 per cent., Sulphate of Potash usually contain $50\frac{1}{2}$ per cent. of actual potash.

If quoted at	2.60	cents per lb.	Actual Potash	costs	5.15	cents per lb.
"	2.50	"	"	"	4.95	"
"	2.40	"	"	"	4.75	"
"	2.30	"	"	"	4.55	"
"	2.25	"	"	"	4.45	"
"	2.20	"	"	"	4.35	"
"	2.15	"	"	"	4.25	"
"	2.10	"	"	"	4.15	"
"	2.05	"	"	"	4.06	"
"	2.00	"	"	"	3.96	"
"	1.95	"	"	"	3.86	"
"	1.90	"	"	"	3.76	"
"	1 85	"	"	"	3.66	"
"	1.80	"	"	"	3.56	"
"	1.75	"	"	"	3.46	"
"	1.70	"	"	"	3.36	"

The Double Sulphate of Potash and Magnesia has about $26\frac{1}{2}$ per cent. of actual potash.

If quoted at	1.00	cent per lb.	Actual Potash	costs	3.77	cents per lb.
"	1.05	"	"	"	3.96	"
"	1.10	"	"	"	4.15	"
"	1.15	"	"	"	4.34	"
"	1.20	"	"	"	4.53	"

The following table shows the fluctuations in the wholesale prices of a number of fertilizing materials in the New York market, since April, 1885. The price given for each month is the average of the four weekly quotations in that month. Sulphate of ammonia is assumed to contain 20.5 per cent. and nitrate of soda 15.6 per cent. nitrogen, and muriate of potash $50\frac{1}{2}$ per cent. of actual potash or 80 per cent. of the pure salt.

WHOLESALE PRICES OF FERTILIZING MATERIALS.

		Cost of Nitrogen at wholesale in				Cost of Potash at wholesale in			
		Blood. Cents per pound.	Azotin or Ammonite. Cents per pound.	Nitrate of Soda. Cents per pound.	Sulphate of Ammonia Cents per pound.	Muriate of Potash. Cents per pound.	Double Manure Salt. Cents per pound.	High Grade Sulphate of Potash. Cents per pound.	Available Phosphoric Acid in Dissolved South Carolina Rock. Cents per pound.
1886.	July	14.2	14.4	14.9	14.6	3.31	---	---	---
	August	14.1	14.4	14.0	14.5	3.31	---	---	---
	September	14.1	14.4	13.7	14.4	3.40	---	---	---
	October	14.4	14.4	13.2	14.6	3.41	---	---	---
	November	14.0	14.4	12.7	14.7	3.41	---	---	---
	December	13.3	14.5	13.1	14.7	3.41	---	---	---
1887.	January	13.3	14.5	13.0	14.6	3.41	---	---	---
	February	13.5	14.5	13.6	14.6	3.41	---	---	---
	March	13.4	14.5	14.3	14.5	3.51	---	---	---
	April	13.6	14.1	14.9	14.5	3.56	---	---	---
	May	13.4	14.0	14.7	14.5	3.48	---	---	---
	June	13.1	14.0	14.0	14.5	3.41	---	---	---
	July	13.1	14.0	12.0	14.5	3.41	---	---	---
	August	12.6	13.4	11.8	14.5	3.40	---	---	---
	September	12.1	12.5	12.2	14.7	3.36	---	---	---
	October	12.1	12.3	13.0	14.9	3.36	---	---	---
	November	11.8	12.2	12.7	14.7	3.41	---	---	---
	December	12.1	12.3	13.8	14.9	3.46	4.08	---	---
1888.	January	12.2	12.3	13.8	14.9	3.48	4.24	---	---
	February	12.6	12.6	13.3	14.9	3.48	4.49	---	---
	March	13.9	13.6	13.1	14.9	3.46	4.15	---	---
	April	13.9	13.6	12.9	14.9	3.46	4.11	---	---
	May	13.9	13.6	12.8	15.2	3.52	4.24	---	---
	June	14.0	13.6	13.1	14.9	3.50	3.86	---	---
	July	14.2	13.9	13.1	14.9	3.50	3.86	---	---
	August	14.5	14.2	13.2	14.9	3.50	3.86	---	---
	September	14.6	14.2	13.9	15.3	3.71	4.38	---	---
	October	15.0	15.0	14.1	15.8	3.71	4.47	---	---
	November	15.9	16.2	14.6	16.4	3.72	4.48	---	3.89
	December	16.0	16.5	15.2	16.4	3.71	4.53	---	3.89
1889.	January	16.3	16.6	15.1	16.6	3.66	4.63	5.00	4.30
	February	16.5	17.0	15.0	16.6	3.66	4.44	5.01	4.37
	March	16.5	17.1	15.2	16.6	3.66	4.48	4.88	4.20
	April	16.0	16.1	14.6	16.2	3.57	4.44	4.85	4.10
	May	15.1	15.2	13.8	15.7	3.64	4.49	4.65	4.06
	June	14.9	14.6	12.8	15.2	3.64	4.53	4.60	4.06
	July	14.6	14.2	12.5	15.1	3.64	4.53	4.56	4.06
	August	14.6	14.2	11.9	15.0	3.64	4.53	4.56	4.06
	September	13.9	14.2	12.1	15.0	3.64	4.44	4.66	4.06
	October	13.6	13.7	12.2	15.0	3.64	4.44	4.67	4.06
	November	13.2	13.6	12.3	15.4	3.64	4.44	4.75	4.06
	December	12.6	13.3	12.4	15.4	3.64	4.44	4.98	4.06

REPORT OF ROLAND THAXTER, MYCOLOGIST.

INTRODUCTORY NOTE.

In view of the fact that the subject of Fungi and Fungus Diseases has not previously received attention in these reports, a word or two by way of introduction to the subject, may not be out of place here.

Fungus or fungous disease, that is, a disease caused by a fungus or by fungi, is the term properly applied to a majority of the ailments among plants, which are commonly and loosely designated by such names as blast, blight, mildew, mould, rot, rust, scab, scald and smut, all of which convey to the mind a more or less confused and inaccurate idea of what they are intended to distinguish. Such diseases are accurately known only by the scientific names which have been given to the fungi which cause them. For example the onion smut in Connecticut is known as *Urocystis Cepulæ; Urocystis* being the generic or group name given to all smuts having the special characters found in the onion smut, while *Cepulæ*, which notes the fact that it is found on small cultivated onions, is the special name applied to the particular species mentioned. Some accurate means for popular designation of such diseases is much to be desired: yet owing to the difficulty which the ordinary observer must needs have in distinguishing them, it is not easy to imagine a popular nomenclature of any kind, which would be other than chaotic, based as it must be on a general ignorance of the thing designated.

Whatever different names we may decide to give to them, or rather to their visible effects or products, their nature is practically the same in all cases. That is the injury is caused by certain lowly organized plants, living on or in the tissues of the plant which harbors them and is conveniently called their *host*, or *host plant*. For our purpose it is sufficiently accurate to say that their vegetative portion consists of an indefinite growth of thread-like tubes, which usually branch in growing on or through the tissues of the host, and absorb from them their contained nutriment. Such thread-like tubes are called *hyphæ*, and from them are produced the reproductive bodies of the fungus, usually in the form of what are called *spores*. The spores, which correspond in many cases to the seeds of higher plants and perform the same function, are very various in their size, shape, color and markings. Many are simple, composed of a single cell, as in fig. 33, while others are compound, divided by partitions into from two to sometimes very many cells, as in fig. 42. They are usually very minute and invisible to the naked eye except in the mass. In germination, which takes place under proper conditions of warmth and moisture, one or more hyphæ are produced from the spore or its divisions, and on or from the hyphæ thus produced, are ultimately formed more spores similar to that from which they sprang. In a general way then, and in the simplest case, the individual fungus plant may be said to consist of a spore, producing a series of threads on which are borne other spores similar to that to which they owed their origin.

Instead of producing one kind of fruit, however, like the majority of higher plants, the conditions of life are such among fungi that, in the majority of cases, a secure provision for their survival from year to year, as well as for their rapid reproduction during the growing season, demands the formation of at least two kinds of reproductive bodies, often more. One, at least, of these commonly serves as a resting stage, and is adapted to withstand unfavorable conditions, such as drought and cold, for considerable periods; while the rest are commonly short lived and are designed to spread the disease rapidly during favorable conditions. The resting stage is commonly a thick walled spore, like that of the onion *Urocystis;* but the same object of withstanding unfavorable conditions and perpetuating the fungus from year to year, is often effected through the hyphæ themselves, which may become compacted and hardened so as to retain their vitality for a considerable period and withstand very unfavorable conditions; giving rise again to a growth of spore-producing hyphæ under favorable conditions. A familiar instance of this kind is seen in the ergot of rye, etc., which, with other similar formations, is called a *sclerotium.* Still another means by which fungi may be perpetuated from year to year through the hyphæ, consists in the simple survival of the latter within the living tissues of the host plant, a renewed growth and spore-production arising from them every season. Of such *perennial* forms the common raspberry rust is a well known instance.

All fungi are parasitic, that is, are dependent for their existence on the work of other organisms, being unable to elaborate their own food. Not all of them, however, grow upon living organisms, whether plants or animals; a very great number being parasitic on dead organic matter. Members of the last class, such as the common moulds on bread, etc., have been called *saprophytes:* while such fungi as are only known to complete their cycle of growth in or upon the tissues of living plants or animals are known as *true parasites.* Although no hard and fast line can be drawn between these two classes, owing to the fact that even saprophytes may occasionally assume a parasitic habit and *vice versa,* the distinction is sufficiently well marked, and it is with the class of true parasites that we have to deal in considering the subject of fungus diseases of crops.

On certain fungus diseases of the Onion (Allium Cepa).

It is the purpose of the present account to call attention to some of the more important diseases of the onion due to the attack of parasitic fungi and prevalent in Connecticut during the past season. Particular attention has been given to the so-called "smut" of onions (*Urocystis Cepulæ*) with a view to discover some effective means of treatment or indicate the possibility of such treatment. It is with reluctance that a report of any kind upon this subject is presented after the observations of only a single season, since these results could hardly be expected to furnish more than data for a second season's work, owing to the fact that no systematic experiments for the prevention of such diseases ("smuts") other than through treatment of the seed, seem to have been previously attempted. The results obtained being, however, not wholly without practical value, are given for what they are worth; further investigation of the subject being left for another season.

The "Smut" of Onions, (*Urocystis Cepulæ* Frost.)

Plate II., figs. 1–2, and 17–28.

At a meeting of the Green's Farms Farmers' Club, held in the winter of 1887, pursuant to a motion of the club, the Experiment Station was requested to undertake an investigation of the Onion smut in view of the fact that, in various localities in the state, it has long been a destructive disease, for which no effective remedy has been found. In compliance with this request the Station has given attention to the matter during the past season, through this department, and the following is presented as a report of the preliminary investigation.

The season was in some respects an unfortunate one for such a purpose, following as it did the over-production of onions which characterized the season of 1888 and led farmers to look rather to a means of lessening than of increasing the crop. The failure of the Station in its effort to procure general information on the subject, from persons directly interested, may therefore be a natural consequence of the indifference resulting from this cause.

For the purpose of obtaining such general information, the following set of questions concerning the 'smut' was sent to persons known to be interested in onion culture :—

1. How long has the onion smut been known in your vicinity?

2. Have you noticed that the prevalence of smut is influenced by

(*a*) the variety of onions grown.

(*b*) early or late planting.

(*c*) method of cultivation and nature of soil.

(*d*) condition of weather during germination and early growth of onions.

3. How long have you known the smut to remain in the ground after the cultivation of onions has been discontinued?

4. Is this period affected by the crop grown on such land? For example, is smut as bad on land which has been used for hoed crops as on land which has been put down to grass?

5. Have you ever seen smut damaging sets or seed onions?

6. Do wild onions grow commonly in your locality, and have you ever seen them smutted?

7. What means have you used to prevent or lessen the amount of smut?

8. About what per cent. of your crop is destroyed, on an average, by smut?

9. What is your own idea as to the nature, origin and spread of smut?

10. Can you give any general information on the subject not covered by the above questions?

These questions were accompanied by the following note:

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.
NEW HAVEN, March 4, 1889.

Dear Sir: The enclosed questions are addressed to farmers interested in the cultivation of onions, for the purpose of procuring any information which may be of service in connection with experiments for the prevention of the onion smut. You will therefore confer a favor by answering them (by numbers) as far as you are able, and returning them to the enclosed address. To render the answers of any value they must represent the results of *personal* observation or experience without reference to the observations of others.

An envelope stamped and addressed to the Station accompanied this letter, which was sent to one hundred and fifteen onion raisers, and elicited only twenty-six answers. An attempt to procure information as to the general distribution of the disease in the State, through the Masters of the local Granges was also unsuccessful, owing to the failure of about half of the persons addressed to return the postal card which accompanied the inquiry in every case. Personal observation, therefore, supplemented by the previous knowledge of the disease, for the most part forms the basis of the following account.

The writer desires to express his acknowledgments to those who kindly noticed the above requests and especially his obligation to Mr. S. M. Wells, of Wethersfield, and Messrs. A. C. and E. J. Taylor and Mr. S. M. Sherwood, of Greens Farms, for their kindness in aiding his observations.

History.—Although the disease known as onion smut (*Urocystis Cepulæ* Frost) has, according to apparently trustworthy information, been known in Connecticut since about the year 1860, the first notice of the fungus as causing a serious disease of onions, is, as far as can be discovered, that contained in the report of the Massachusetts State Board of Agriculture for 1869–70, in which (Appendix p. 10) Mr. B. P. Ware refers to its injuries in Massachusetts. It is also referred to as injurious in the Report of the U. S. Commissioner of Agriculture for 1869 and 1872, and in the last mentioned volume under the heading "Onion Blight and Smut (*Genus Peronospora*)" on p. 193, several spores of the smut are figured. Although associated with other unknown bodies and placed under a genus (*Peronospora*) with which they have no possible connection, the smut spores are quite recognizable as belonging to *Urocystis Cepulæ* and are the earliest published figures of the fungus.

The next reference to the onion smut is found in an essay on the subject by Prof. W. G. Farlow, contained in the Annual Report of the Massachusetts Board of Agriculture for 1876–77, in the "Abstract of Returns of the Agricultural Societies of Massachusetts" (p. 164, with plate) a paper which forms the only basis of accurate knowledge on the subject which we possess. In this article Prof. Farlow describes the fungus which causes the disease for the first time as *Urocystis Cepulæ* Frost, this being a manuscript name appended to specimens sent to him by Mr. C. C. Frost of Brattleborough, Vermont. The history and character of the fungus are also described, so far as they were then known, and a general account given, with suggestions as to measures which would be likely to check the disease.

Up to this time the disease was considered to be peculiar to America, as is stated by Prof. Farlow in the paper referred to, but the same author in the Bulletin of the Bussey Institution, Vol. ii, p. 114, (1877) appears to consider it identical with a form found in Italy on a species of wild onion (*Allium magicum*) by Prof. Passerini and described and distributed by him in Thuemen's Mycotheca Universalis, No. 223, under the name *Urocystis magica* Pass. A further note on the subject by Prof. Farlow occurs in the Bussey bulletin, Vol. ii, p. 238.

In the same year (1877) M. C. Cooke in the Gardiner's Chronicle, p. 634, refers to the American onion smut as only a varietal form of a species (*Urocystis Colchici* (Schlecht.)) found in Europe on *Colchicum* and allied plants, but unknown in America; and calls our species "*Urocystis Colchici* variety *Cepulæ*."

In 1879, Maxime Cornu (in Comptes Rendus de l'Academie des Sciences, Vol. lxxxix, p. 51, Paris, 1879, and in the Bulletin de la Société Botanique de France, Vol. xxvi, p. 263, Paris 1879) records the appearance of the true American onion smut (*Urocystis Cepulæ*) in the neighborhood of Paris, and considers it as recently introduced from the United States. It may be observed that, previous to this, a smut was observed on the common onion (*Allium cepa*) from southern France in the herbarium of the university of Strassburg, by J. Schroeter, which is referred to as *Urocystis Colchici* in his article entitled "Remarks and Observations on certain Ustilagineæ" (smuts) in Cohn's Beiträge zur Biologie der Pflanzen, Vol. ii, p. 349, (1877), and may perhaps have been our species. A notice of the occurrence of the true onion smut in France at Rouen, is also recorded by Malbranche in the Bull. d. l. Soc. Bot. de France, 2d Series, Vol. iii, p. 277 (1881): while in the same journal, Vol. xxvii (1880), p. 39), Prof. Cornu gives certain observations on the onion smut (*Urocystis Cepulæ*), and states that he had inoculated seedlings with it and that they had died "probably" from this

cause, also suggesting that the comparative unimportance of the disease in France, as compared with America, is due to the fact that the french gardeners transplant their onion seedlings when small, selecting only healthy plants.

In the same year (1880) E. Hallier (according to Just, 1881, I, p. 261) in the Wiener Illustrirter Gartenzeitung, Vol. v, p. 519, in an article on "Der Brandpilz der Kuchenzwiebel, *Urocystis Cepæ*," calls attention to the fact that in the same journal (Nos. 7–9) in 1878, he had described and figured the fungus which had been very common in his garden in 1877. Whether this author in the paper cited describes the fungus as a new species (*U. Cepae*) cannot be stated, the periodical in question not being accessible for reference. Lastly Frank in the Botanisches Centralblatt, Vol. I, p. 186 (1880), states that he has found *Urocystis Cepulæ* near Leipsic.

Origin.—It seems probable therefore, from the above facts, that the onion smut may be indigenous in Europe, despite the circumstance that the first economic and scientific notices of it are of American origin; nor is it unlikely that, as in the case of so many other plants of a similar nature, it may be a native of both continents. The fact that it has so far been found only on the cultivated onion, renders its origin in nature a matter of doubt; yet since new forms of fungi are being continually brought to light and described as new species, it can hardly be doubted that the onion smut has been similarly overlooked in a state of nature and will ultimately be found on some wild species of onion. A case in point is furnished by the smut on the common yellow Star grass (*Hypoxys erecta* L.) referred to subsequently, which belongs to the same botanical genus (*Urocystis*) with the onion smut; and, although it is conspicuous, and preys upon a host plant of common occurrence, has never been observed, apparently, previous to the past summer, when it was found in abundance near New Haven. It is quite safe to assume then, that the onion smut originates from some wild species of onion, since it is well understood that fungi, like other plants, are no exception to the universal rule that every organism is derived from other organisms like itself, and not spontaneously evolved from "ground" or other substances; an idea much too common, the only foundation for which rests on the ignorance of those who entertain it.

The only other hypothesis in regard to the origin of the onion smut is derived from the fact that two species of smut, belonging to the same genus *Urocystis* (*Urocystis magica* and *U. Colchici*) and parasitic upon wild onions or allied plants, have been described in Europe, and are considered by some botanists to be identical with the smut of cultivated onions (*Urocystis Cepulæ*) which they hold to be merely a varietal form induced by the differences in the host plants. Neither of these European forms are, however, found in America and their structural differences are, moreover, apparently sufficient to separate them specifically from the plant we are considering.

A word may be said here in regard to the popular notion which considers "smuts" of all sorts as identical, however diverse their host plant or mode of attack may be. It is not an uncommon idea, for example, that the smut of indian corn (*Ustilago Maydis* (D. C.)) or of oats (*U. segetum* (Bull)) does not differ from that of onions, and that one disease may be derived from the other. A reference to figures 1, 15 and 16 of Plate II in the present Report, representing the spores of the onion, corn and oat smuts respectively, should convince the most skeptical of the error of this supposition, especially when it is understood that the differences there represented hold good the world over.

General Characters.—The presence of smut in onions is first indicated by one or several dark spots at different heights in the leaves of seedlings, which are seen to be more or less opaque when the plant is held up to the light. These dark appearances may be seen in the first leaf, before the second leaf has begun to develop at all, and are more commonly found just below the "knee"; though they sometimes occur above it. After a time, usually while the second leaf is developing, longitudinal cracks begin to appear on one side of these spots, which widen and show within a dry, fibrous mass, covered with a black, sooty powder made up wholly of the ripened fruit or spores of the fungus, which are blown or washed out onto the ground. In some cases the smut may appear only toward the upper end of the first leaf, and become cut off from the main body of the plant by the withering of the former. In such a case an onion which has shown smut in its first leaf appears, in some instances, to recover, showing no signs of smut in its subsequent growth: but as a rule the same dark appearance shows itself in the second leaf and those subsequently formed, and if the seedling is pulled up and examined, the whole plant will be found to be pervaded by the disease to a greater or less extent. Plants thus diseased, especially if the soil is dry, very commonly succumb early, dying while in the second or third leaf. The stronger plants, however, especially if the ground is moist, are able to resist the smut sufficiently to make a considerable growth, and many survive even up to the time of harvesting. Fig. 17, on Plate II, represents such an onion reduced to one-third its natural size, and is a typical example of the appearance presented by smutted onions that have survived until midsummer. In such specimens the smut shows itself by black elevations upon the bulb, running down to its very base, and extending upward into the leaves, the outer of which, in the present instance, have split open showing the characteristic sooty powder composed of spores mingled with the stringy mass of dead leaf tissue. As a rule such onions always die, either drying up or rotting soon after they are pulled: the popular belief that smutted bulbs frequently occur among onions after they are housed, resting apparently on the existence of an entirely different disease, subsequently described (p. 161), common on housed onions; but having no connection whatever with the smut, which it resembles only by its black color.

Distribution and Severity.—Although the information obtainable on this subject indicates that the onion smut occurs in Massachussetts, Ohio and Pennsylvania, if not in several other states, Connecticut appears to suffer more from this disease than any other locality, and although, as above mentioned, the necessary data were not obtainable for any exact statement of its local distribution, it may be said, in a general way, that the famous onion districts at or near Wethersfield and Southport, together with that portion of the state lying on the Sound between New Haven and the mouth of the Connecticut river, are the most seriously affected. Mr. S. B. Sherwood, for instance, of Greens Farms, estimates the amount of good onion land which has been given up on account of smut in that town and its vicinity to the east and west, at several thousand acres; and the amount of land at present running out from this cause is considerable.

The severity of the disease in different localities is variable. It appears at first in isolated spots here and there in a field, and from these spreads in all directions until the whole piece becomes affected, and the cultivation of onions upon it has to be discontinued. This period from the first appearance of the smut to the enforced discontinuance of the onion crop, appears to be, on new ground, never less than five years, which is the shortest ascertained interval.

Conditions Influencing Prevalence and Increase.—The prevalence of smut in onions appears to be only slightly, if at all, influenced by general conditions of weather: those which favor the germination and growth of the onion seed affecting the smut spores in exactly the same way. As will be subsequently seen, the period during the germination and earliest growth of the onion seed is the only one during which climatic conditions would be likely to have the smallest influence upon the general prevalence of the disease: since it appears to be at this time only that the fungus threads, developed from the spores, make their entrance into the onion seedling. Having once established itself within the tissues of its host plant, the smut would be developed or retarded by conditions of weather, in about the same ratio that the growth of the onion within which it was present, was developed or retarded. The general opinion, however, that the prevalence of smut in a given field is variable during successive seasons, that is that it does not always show a decided increase, seems to indicate that the conditions of weather at the critical period mentioned may have some influence in the matter.

The influence of soil upon the prevalence of the smut seems inconsiderable, although onions grown in warm light soils are usually more likely to be smutted than if they are grown in heavy, wet land. It should be mentioned, however, that whenever onions grown on low land receive the surface wash of adjacent smutty land, they show an increase of smut proportional to the amount of wash to which they are subject: in other words proportional to the increased number of smut spores, planted among them as it were, in this way. This circumstance may account for the popular impression that low land is more susceptible to smut, whereas, as just mentioned, the reverse is doubtless true.

In regard to the influence of fertilizers, little can be said. The notion that potash fertilizers form smut, and that its appearance was simultaneous with, and in any way attributable to the use of wood ashes, has no logical basis to support it, and is doubtless wholly unfounded. Whether fertilizers rich in nitrogen may be found to favor the growth of smut, is a question which may perhaps be examined with profit.

It was thought possible that the date of planting onion seed might have some influence on the prevalence of smut in a given piece; on the supposition that the smut spores having hibernated might, on the advent of warm weather, germinate at somewhere about the same time; and that matters could perhaps be arranged so that, either by very early planting the onions might get ahead of the smut, or by late planting the reverse might happen. In practice, however, this was found to be a matter of no importance, as will be seen from the results obtained by successive plantings from May 3d to June 18th, the onions resulting even from this last planting showing 40 per cent. attacked by smut.

Little can be said concerning the comparative liability to smut of the different varieties of onions. But it seems undoubtedly true that the yellow and especially the red varieties are less susceptible than the white to this, as to most other diseases affecting the crop.

Dissemination.—The popular impression that smut is disseminated principally in the planted seed is one which is quite erroneous. As a matter of fact seed onions are not attacked by smut, and the presence of smut spores *in* the seed is not to be considered for a moment as a cause of its dissemination. It is very probable, however, that smut may in some instances be carried *on* seeds grown in smutted districts, the spores adhering to their surface as any small particles of dust might do. Any course of procedure in harvesting or in preparing seed which involved the dusting of even a small amount of smutted earth upon it, would render the seed dangerous for this reason. Proper care in gathering and handling seed should, however, obviate this danger entirely.

The local dissemination of smut is due to four principal causes. First, through agricultural implements; plows, harrows, weeders, rakes, etc., which spread the soil containing smut spores, both by scattering the surface earth over a smutted field and, unless they are thoroughly cleaned, by carrying earth containing smut spores into fields subsequently worked upon. Secondly, through the adherence of the same smutted earth to the feet of men and farm animals and its consequent transportation from one part of a field to another or to different fields; an agency by no means unimportant. Thirdly, the smut spores may be readily washed with surface earth from higher to lower ground, as is a matter of common observation. Fourthly, popular opinion to the contrary, the spores being practically imponderable may be readily blown, with other dust-like material, either about the same field, or into adjoining fields. The reason that this mode of dissemination is of less importance than some others, lies probably in the fact that the spores being formed and making their exit from the onion comparatively near to the ground, are readily washed into it by rain, and have little opportunity for blowing directly into the air as is the case with corn smut, for example.

It may be mentioned here that the smut appears to be very attractive to the "flea beetles" which swarm over the ruptured parts of diseased seedlings and apparently feed upon the spores, although they do not seem to trouble the healthy onion leaf. That these or other insects may serve to spread the smut in a way similar to that observed in some other fungi, is not impossible.

Retention of Germinative Power by Spores.—It is well known that the seeds of flowering plants may retain their germinative power for a protracted period. For although the reported vitality of "mummy wheat" taken from Egyptian tombs is now wholly discredited, it has been shown by actual experiment that certain seeds will germinate after forty years or more, and a like retention of vitality is to be looked for among many spores of fungi.

The spores of the onion smut, as will be subsequently seen, are by their structure peculiarly well adapted to retain their vitality for a considerable period. To ascertain the actual duration of this period is a matter of considerable importance in considering measures for dealing effectively with the disease, yet, as will be seen, it cannot be used in practice as a means to this end. Prof. Farlow, in the paper already referred to, concludes, as a result of the information on this question given him by farmers and corroborated by the observation of Wolff upon the subject, that the power of germination in the spores of onion smut and other smuts of the same genus (*Urocystis*) endures probably not more than five years. If this were the case it would be obviously no very difficult matter to kill out the disease by putting all smutty land down to other crops than onions for five years. That this period is not as short as five years seems beyond question, as may be seen from the following instance, which appears to be well authenticated. A field on the farm of Mr. Austin Jennings at Green's Farms, was examined with some care in the summer of 1888. According to the positive statement of Mr. Jennings, corroborated by others present at the time, the field in question had not been sown with onions since 1876, the exact date being remembered from the fact that it was in "centennial year" that the piece, having become badly run out by smut, was put down to onions for the last time. Yet after a lapse of twelve years, a careful examination showed that from ten to fifty per cent. of the onions were smutted in the more seriously diseased portions of the field, at a time, moreover (midsummer), when a large number of plants must have been already destroyed and have disappeared. This circumstance points to the fact that the time during which the smut spores *may* retain their germinative power is much longer than twelve years, and that statements which place the period at twenty or twenty-five years may not be greatly exaggerated. At all events abundant evidence on the subject shows that four or five years is a period wholly insufficient to eradicate smut from land or even, in many cases, sensibly to diminish its virulence.

In regard to the influence which certain crops may have upon the period during which smut may remain in land, no definite information has been obtainable, either from personal observations or inquiry; and opinion seems equally divided in its preference for hoed crops or grass, as far as concerns any influence they may have in the matter. Theoretically, there can be little question that hoed crops should be more effective for this purpose since, in all probability, the spores which lie deepest remain dormant for the longest time; and the more thoroughly and often the earth is worked over, the more spores will be brought near the surface into a position where they would naturally germinate. For practical purposes, however, the inquiry seems almost superfluous, since, whatever the nature of cultivation on smutted land, the endurance of smut is so protracted that discontinuance of the crop cannot be considered a *remedy* of any considerable value; but rather a confession that there is no remedy. In saying this, it should not be inferred that such discontinuance and the transfer of the crop to "new" land, is not by all means the best mode of procedure as soon as the smut becomes serious.

Occurrence or Non-occurrence in Sets and Seed Onions.—This question, which is of the utmost importance in suggesting a practical basis for the treatment of smut, is one on which onion raisers seem to have the most diverse views. Careful personal observations, however, indicate that smut does *not* occur either on sets or seed onions. In very rare instances, when smut has hibernated in a comparatively sound bulb which has thus been set out already smutted, it may possibly occur; but as a matter of fact not a single example of the kind has been observed. The common occurrence of smut in "small sets," it need hardly be mentioned, has no bearing whatever on the point in question, since it would be even more likely to appear among them (as a result of thick planting) than it would upon onions cultivated in the usual manner for the annual crop. The suggestion may not be out of place here that the opinion contrary to the conclusion above expressed in regard to this matter, which amounts to a conviction in the minds of many onion raisers, rests upon the belief that blackness of any kind upon onions is attributable to smut—an idea which is quite erroneous.

Botanical History and Relations.—The group of fungi to which the onion smut belongs, together with such well known diseases as the smut of corn and oats, the "bunt" of wheat, etc., constitute a family of plants known as the *Ustilagineæ*, several hundred species of which are recorded from different parts of the world, the majority of them characterized by the production of soot-like masses of spores as in the familiar instances just mentioned. Although this smut-like material has, in most cases, very much the same appearance to the naked eye, the spores of which it is composed ~~vary~~ very greatly in size, shape and appearance, in the different genera and species into which the family has been divided. The smut of onions, as has been previously mentioned, belongs to the group or genus *Urocystis*, so named from the fact that it produces spores which are furnished with bladder-like appendages, such as are represented on Plate II. About twenty or twenty-five species of the genus are known on various plants from different parts of the world; but in all cases the spores have the same general characters, consisting of one or more central, dark, thick-walled, nearly spherical so-called resting spores (Plate II, fig. 2 x), surrounded by a variable number of bladder-like bodies, the so-called *pseudospores* (fig. 2 x'), with thinner and more transparent walls. It will thus be seen that each individual particle which goes to make up the black smut-like substance which is the visible product of the disease, is in reality an aggregation of bodies which may, like the onion smut spore, consist of a single central resting spore, surrounded by a number of pseudospores (Plate II, figs. 1, 2, etc.); or may be made up of as many as twelve or fifteen of these resting spores surrounded by a very large number of pseudospores, as in the smut of "star grass" (fig. 14); so that each particle of smut has been called a *spore ball*. The specific differences, that is the differences which enable us to separate one species of the genus *Urocystis* from another, rest mainly on the number and size of the resting spores and pseudospores respectively, which make up these spore balls in any given species.

As has been already mentioned, the smut of onions first appears to the naked eye as a dark area in the leaf, which finally bursts, letting out the black powdery mass of spores. As the diseased onion grows, unless it is killed when young, the same dark areas begin to appear on the bulbs between the veins, and extend up through all but perhaps the inner leaf as in Plate II, fig. 17; and if the onion is cut in two horizontally, it will be found that the outer "layers" are smutted to a greater or less depth, the inmost layers being often quite sound. If a thin section of a diseased part is cut and placed under the microscope, the black portions will be seen to be wholly composed of spore balls such as have been described above, which, in the onion smut, consist of usually a single, brown, thick-walled resting spore, surrounded by a variable number of pseudospores, often as many as twenty, which are quite regular in shape and size, nearly colorless and spherical, and flattened on the side by which they adhere to the resting spore. Rarely the spore ball may consist of two central resting spores instead of one; but this is exceptional. The enormous numbers of these spore balls that are produced in a single spot of smut may be imagined when we consider that the diameter of each spore ball is not more than $\frac{75}{100000}$ of an inch.

If the section examined is cut so as to include some of the living leaf tissue on the edge of the diseased portion, the origin of the spore balls may be readily seen; for this tissue will be found to be penetrated by a mass of slender fungus threads (*hyphæ*) that push their way between the cells of the leaf which they finally destroy, and as they grow give rise to the spore balls, disappearing themselves soon after the latter are formed. Figs. 24–28 on Plate II, represent the early stages by which the spore balls are formed from the hyphæ. In a general way this formation may be said to consist in the production of two or more lateral out-growths from the hyphæ, one of which assumes a more or less spherical form, while the other or others, as the case may be, grow around it; becoming branched and divided into joints which finally become rounded off into the more or less separate, bladder-like pseudospores already described. The details of this process are a matter for technical inquiry; and it is sufficient to say in brief, that the resting spore originates as a short lateral branch from a hypha, and that the pseudospores originate from other branches which grow out and surround it.

After it is mature the spore ball appears to pass through a dormant period, at least in a majority of cases, since repeated attempts to induce them to germinate, when fresh, by placing them in a moist atmosphere or in water, proved wholly unsuccessful. Germinating spores were, however, obtained in abundance from material collected in the summer and kept until January for hot-house experiments. A mass of smutted onions was left spread out in a shed for about six months, after which it was mixed with a little earth, saturated with water, and allowed to freeze hard for a week or more. After this treatment some of the smut, removed to a warm room and kept moistened, germinated quite rapidly in the fashion represented in figures 19–21 of Plate II. This germination consisted in the production from the central resting spore of usually a single short hypha of germination, which commonly branched more or less and produced, terminally or laterally, small secondary spores, the so-called sporidia (*x*, *x*), as indicated in the figures. The germination of the spores in this species has not, apparently, been previously observed, and, as will be seen from the figures, differs somewhat from the conventional form described as characteristic of certain other species of the genus; which consists in the production of simple, stout, short hyphæ from the resting spores, bearing at their summit a whorl of sporidia. This condition is approached in fig. 19, where the hypha bears two sporidia at its extremity: but this variation, which was only seen in a few cases, is manifestly merely a form of the others. In a nutrient solution, for which a decoction of onions was employed, in Van Tieghem cells, the hyphæ of germination grew very rapidly, and branching and extending themselves in all directions, also bore numerous secondary spores (fig. 18, *x*, *x*,) similar to those produced in ordinary germination, except that they were larger. These secondary spores correspond to similar forms obtained by Brefeld in his cultures of other genera of Ustilagineæ and termed by him conidia, although they appear to be in reality merely luxuriantly developed sporidia. The secondary spores or sporidia, germinated readily in water or in nutrient solutions (fig. 23): but it was impossible to observe their further development owing to the fact that the material for cultivation could not be obtained pure, and for this reason all the cultures swarmed with bacteria and were soon destroyed by them.

Absolutely pure cultures of fresh spores taken directly from the living leaf, as well as of small clumps of sporiferous hyphæ, similarly obtained, were, however, very readily made in the same decoction of onions, and grew with a luxuriance which was proportional to the concentration of the nutrient solution. Out of a very large number of such cultures, made in Van Tieghem cells, not a single one produced spores or sporidia of any kind, merely developing abundant branched and septate hyphæ, extending in all directions, and stout or attenuated according to the concentration of the decoction. The clumps of hyphæ, which were in process of forming spore balls when taken from the living onion, acted in exactly the same manner as did the spore balls themselves, producing no sporidia and ceasing to produce spore balls. Similar cultures, both of spore balls and of sporiferous hyphæ, made in sterilized flasks plugged with cotton, also produced nothing but sterile hyphæ which, after forming a spherical mass a quarter to a half an inch in diameter, gradually died without further development. It may be mentioned here that in none of the cultures was any yeast-like development noticed, similar to that described by Brefeld in other instances.

We have in New England four species of smuts belonging to the genus *Urocystis:* namely, *U. Cepulæ* Frost on onions, *U. Anemones* (Pers.) on Wood anemones, *U. occulta* (Rabh.) on rye, etc., and the form previously mentioned on Star grass (*Hypoxys erecta*) which appears to be undescribed. Figures of the spores of all these species are given on Plate II for comparison. *U. Cepulæ* resembles *U. occulta* more than the others; but is separable from it at once by the fact that the spore balls of the latter species (fig. 9) are composed of two or three resting spores more commonly than of one; while those of the former have two only very rarely, and never three. *Urocystis Anemones* differs from the smut of onions by the larger size of pseudospores and resting spores, as well as by the smaller number of the former. Lastly the *Urocystis* of *Hypoxys* (figs. 12–14) is at once separable by the large number of resting spores (one to fifteen) which may be present in a single spore ball.

It is therefore out of the question to suppose that the smut of onions may be merely a form of one of the other species of *Urocystis* found in New England: but when we turn to Europe, the number of species is greatly increased, there being about twenty in all, and of these three (including our species) grow upon members of the genus *Allium* to which the onion belongs. One of these, *Urocystis Colchici* (figs. 3–4) attacks *Colchicum* and allied plants and is said to occur on some members of the genus *Allium*. The other, *Urocystis magica*, occurs in Italy on *Allium magicum* where it was collected by Prof. Passerini and distributed, as already mentioned, under the above name in Thuemen's Mycotheca Universalis, No. 223, from which figs. 5–6 were derived. In the article of Cooke already cited, *U. Cepulæ* is considered merely a variety of *U. Colchici*, while Winter in his Pilze, p. 120, goes still further and unites all three under *U. Colchici*. Since, however, a discussion of specific identities would be out of place here, although interesting as a possible means of determining the origin of the onion smut, it need only be said that an extended examination of unlimited material shows that the onion *Urocystis*, as it occurs in Connecticut, is a well defined form, subject to very slight variations. While *U. magica* resembles it in having a single resting spore and numerous pseudospores, which are very regular in size and shape, its resting spores and and pseudospores are much larger than those of the american species: which also differs from *U. Colchici*, on the other hand, by its smaller regular pseudospores and single resting spores.

Manner of Infection.—So far as is known, then, the life history of the smut fungus is sufficiently simple. The resting spores commonly after remaining dormant for a time, which may according to circumstances extend over a period of years, germinate, giving rise to one or more hyphæ of germination. There is no reason to suppose that these hyphæ may not enter the young onion plant directly: but more commonly this is doubtless accomplished through the medium of the secondary spores or sporidia, already described as produced from them, which germinate in their turn (fig. 23), sending out a hypha which may enter the young onion directly. The chance of infection is thereby increased in a ratio almost equal to the number of sporidia formed. When it has once penetrated the host plant the hypha of germination branches and extends itself within it, ultimately producing, in the way already described (figs. 24–28), spore balls similar to that from which it sprang: thus completing the history of its development.

In considering any means of direct treatment against the onion smut, it is of the first importance to know this history as

accurately as possible in its details. It is well known that the treatment of smuts, which attack the reproductive organs of plants, like the "bunt" of wheat, is a matter of no great difficulty; since in the majority of such cases, infection takes place through the seed, for the reason that the smutted heads are harvested and threshed with the sound ones, so that more or less of the seed is sure to have smut spores adhering to it, and thus placed in a position to produce infection at germination in a large number of cases. Treatment of such seed, before sowing, with a solution of sulphate of copper or strong brine, seems to have been found effectual in checking the smut of wheat; but in the case of the onion smut we have a very different state of affairs. In this case the danger from spores adhering to the seed is slight, the infection coming from spores mixed in with the ground in which the seed is planted. It is therefore necessary to ascertain whether the resting spores germinating on or near the surface of the ground, produce sporidia which blow onto the onion plant and enter it, after it has emerged above the ground, or whether this entrance is effected wholly under ground, and if so, under what conditions. In one species of *Urocystis* (*U. Anemones*) it has been shown that sporidia, sown upon the leaves of the host plant, will infect it with this smut at the point of application; at least Dr. Plowright in his "British Uredineæ and Ustilagineæ" (p. 94), claims to have shown this experimentally. Again Cornu (Bulletin de la Société Botanique de France, 1880, p. 39–42), states that seedling onions infected with the spores of *Urocystis Cepulæ* died "probably" from this cause. In the case of certain other members of the family it has been shown definitely, however, that the infection of the host plant takes place under ground, and it seems hardly a matter of doubt, despite the questionable observation of Cornu just cited, that the same is true of the onion *Urocystis*.

Experimentally this was indicated, if not proven, in the following manner. A cylindrical glass jar was employed for the experiment, in the bottom of which was placed about an inch or two of ordinary earth of an even depth. On this was scattered a thin coating of the smut from which the germinations previously described were obtained, and into this were lightly pressed several dozen seeds of white onion. Over this was placed a layer of sterilized earth, one and a half inches thick, and the jar was then placed under a bell glass and kept in a warm room. The onions came up rapidly and while in the second leaf were with hardly an exception, killed by smut; the characteristic dark areas appearing in the first leaf soon after it rose above ground. In view of the common idea that smut is in the seed of onions, the same experiment was duplicated, omitting the layer of smut, the resulting seedlings showing no signs of smut whatever.

The fact of this subterranean infection is further confirmed by the absence of smut on sets and seed onions, as well as on transplanted seedlings; for if the young tender leaves above ground were susceptible to infection, smut would certainly occur in these cases. It may then be assumed with tolerable safety that the smut makes its entrance into the onion seedling in the ground. It may be asked, however, if this is the case, why it does not enter sets, seed onions and probably seedlings, when they are transplanted into smutty ground. The explanation of this must be sought in the fact that some plants are susceptible to certain diseases only at certain periods of their existence. For example, it has been shown that a common form of mildew (*Cystopus candidus*) which attacks the common Garden cress (*Lepidium sativum*) and its allies, is able to infect this plant only when it enters it through the first leaves or cotyledons, the hypha of germination being unable to establish itself within the plant at other points; so that when the cotyledons have withered, there is no further danger of infection. It is not improbable then that the relation of the onion seedling to the germinating smut spore may be somewhat similar. Certain observers have claimed in the case of other smuts that the hypha of germination enters the so-called collar of the embryo, where root and stem meet. This may be the case in the onion smut, yet that it also enters the first leaf seems indicated by the occurrence of isolated points of infection at its apex.

Experiments for Prevention.—Assuming that the mode of infection above described is correct, it is obvious that, in considering any means of treatment by fungicides, the usual external applications would be quite useless. The fungicides must evidently be employed so as to act under ground during the period of germination of the seed. This may be effected either by applying some substance as a top dressing and brushing it in so that it would lie in the earth about as deep as the seed was planted; or by sowing it in the drills with the seed. The first method is manifestly undesirable on account of the much greater expense involved, both in labor and cost of material used. The second, involving no labor beyond the preparation of material and about one-tenth

the amount of this material, is manifestly the only one to be considered.

Having determined on the method of application the next and most important point is to ascertain what substance will be the most effectual and cheapest for the desired purpose. In order to test this question, two sets of experiments were tried; one during the late winter and early spring in a box bed in the hot-house; the other at Green's Farms on a small piece of very smutty ground.

The first of these experiments it is hardly necessary to describe in any detail, since it was made merely to gain suggestions for the second. It is sufficient to say that fifteen rows, four feet long were planted, of which seven were treated with sulphate of iron, five with sulphate of copper, three left untreated and one planted with treated seed. The chemicals were sown on the surface of the drill in one half of each row, and in the drill in the other half. The seven rows treated with iron sulphate received applications of 4, 5, 7, 8, 9 and 12 grammes respectively. Those treated with copper sulphate had 3, 4, 4½ and 5 grammes respectively. The surface application had not the smallest effect of any kind, in either instance. The application of sulphate of copper in the drill killed a large percentage of the seed and produced no diminution in the percentage of smut. Even the large amount (twelve grammes) of sulphate of iron did not hinder germination perceptibly, and appeared to decrease the number of smutted plants decidedly. In a single row, one-half the seed was rolled, before planting, in sulphate of copper; the other half in sulphate of iron. In the first instance every seed was killed, while the iron did not hinder germination and slightly decreased the percentage of smutted plants.

The experiment therefore indicated that although sulphate of copper was quite worthless both from its injurious effect on the seed, as well as from the fact that it produced no diminution in the amount of smut, sulphate of iron appeared to have an appreciable effect against the smut while not hindering germination in the least. Surface applications of the same salts was also found to be without effect; although thoroughly washed in by constant watering.

The second experiment was tried upon very smutty ground which was hired from Mr. Austin Jennings of Green's Farms, and was wholly run out by smut in the previous year. The experimental piece was 120 feet long by 10 feet wide; the rows, running transversely, ten feet long and one foot apart. Every alternate row was left untreated for direct comparison with the treated row next it. Weighed amounts of seed were planted in each row, about ten to the foot, and at the same time the drills in which the seeds were sown were treated with certain chemicals, in sets of five each, making in all ten rows to each set, five treated and five alternate untreated. There were in all twelve of these sets, including one set of five rows planted in ground previously top dressed with sulphate of iron, in which the control rows had of course to be omitted. The chemicals, which were in the form of powders, were scattered by hand along the drills, slightly mixed with the soil and the seed then planted and covered. The substances used and the amounts per row are shown in the subjoined Table. The rows treated with "Patent germinator" were planted with seed that had been soaked according to instructions which accompanied a sample of the material, "New Preserver and Germinator of Cereals and Seeds of all Kinds," received and analyzed by the Station. One of its "notable advantages" being that it is said "to destroy insects and act effectually on the globular formed dust which participates in the formation of blight, of heat, of ergot of rye, etc.," a trial in the case of onion smut was suggested. Analysis of the article in question showed it to be an impure acetate of lead, a substance of which the fungicidal properties have not apparently been tested. The results given in the table do not seem to warrant its general adoption as a nostrum for "globular dust" or to secure an increased germination of "from 20 to 25 per cent." in the case of onions at least.

The onions came up, for the most part, during the first week of May and showed abundant evidences of smut by May 10th, while still in the first leaf. A considerable number were killed in the second leaf, a few even before this. By May 18th, when the onions were examined, the different appearance of the treated and untreated rows in some of the plots began to be apparent, and by the first of June was very marked. Those treated with sulphur and lime and with sulphide of potassium were not only visibly thicker, but much taller and healthier in appearance than the alternate untreated rows. There was also a visible, though not so striking, difference in the sets treated with hyposulphite of soda. The sets treated with iron showed no appreciable differences between the treated and untreated rows, while the copper

application was evidently injurious in both cases, the detrimental effect upon the onions themselves not being compensated for by any appreciable action on the smut.

During the summer the smutted onions died off slowly, although a considerable number survived up to the time when they were pulled (Aug. 6). At this date the number of sound onions remaining in each row is shown in the table; but owing to an accident the correct weights of those sets, only, were obtained, which had been treated with sulphur.

	Number of grammes used per row.	Average No. of plants per row, May 11.	Average No. of *sound* onions per row pulled Aug. 6.	Av. weight per row of sound onions weighed Aug. 9.
Top dressed with sulphate of iron	30	98.8	11.6	----
Seed treated with "Germinator"		100.2	8.4	----
Alternate rows untreated		95.	7.2	----
Sulphide of sodium in drills	10	90.8	29.8	----
Alternate rows untreated		98.	11.6	----
Sulphide of sodium in drills	5	98.6	38.8	----
Alternate rows untreated		103.2	6.4	----
Hyposulphite of sodium in drills	20	73.2	11.2	----
Alternate rows untreated		99.6	7.4	----
Hyposulphite of sodium } Air slaked lime } in drills	10 } 10 }	90.6	27.	----
Alternate rows untreated		101.2	10.	----
Flowers of sulphur } Air slaked lime } in drills	10 } 10 }	106.6	35.4	70.8
Alternate rows untreated		96.4	9.	16.4
Flowers of sulphur } Air slaked lime } in drills	5 } 5 }	100.4	31.6	58.4
Alternate rows untreated		91.	4.8	2.4
Sulphate of copper } Air slaked lime } in drills	10 } 10 }	71.4	17.4	----
Alternate rows untreated		91.6	10.	----
Sulphate of copper } Air slaked lime } in drills	5 } 5 }	84.2	10.	----
Alternate rows untreated		94.	6.2	----
Sulphate of iron in drills	20	72.2	58.6	----
Alternate rows untreated		89.	24.	----
Sulphate of iron } Air slaked lime } in drills	5 } 5 }	78.2	38.6	----
Alternate rows untreated		78.6	37 8	----

It will be noticed that the amount of smut in different parts of the piece varied very considerably, as indicated by the number of plants killed in the alternate rows, the rows towards the edge of the field being the least affected: but even including these, the average number of plants killed amounted to nearly 90 per cent. in the untreated rows. It is assumed that all the deaths were due to smut in making this statement. As a matter of fact the onions were carefully examined weekly during the first two months or more of their growth, and although a few cases of death from other causes were noticed, such instances were rare.

However unsatisfactory the result of the experiment may seem as shown by the figures in the appended table, the negative results are at least conclusive in some respects. It is quite evident that a remedy is not to be sought in sulphate of copper, since an application sufficient seriously to affect the germination of the seed, showed no appreciable influence upon the amount of smut. Sulphate of iron also may be discarded for the purpose in view, and the results with hyposulphite of sodium are so much inferior to those obtained with sulphur and sulphide of sodium that it also need not be considered. Having narrowed our consideration down to sulphur and sulphide of sodium the matter is further simplified from the fact that the former is far less expensive than the latter, as well as for the reason that the sulphide is much more difficult of application owing to its deliquescence when exposed to air; which was, however, obviated in the present case without much difficulty by mixing it with dry earth before applying. Since the results with the sulphide of sodium were little if at all better than those obtained with flowers of sulphur, it may also may be excluded, from the trouble and expense involved in its application.

Of the substances used then, flowers of sulphur is the only one which merits consideration from a practical standpoint, and the question remains: do the results of the present experiment point to the conclusion that treatment with this substance may be made of practical value. It will be noticed that in the final result the relative proportion is very much in favor of the smaller amount of sulphur notwithstanding the fact that no injury to the seed resulted from the larger application. The reason for this discrepancy probably lies in the fact that the smaller amount was scattered more evenly in the bottom of the drill, and the seed planted almost directly upon it; while the larger amount was mixed in with the earth before the seed was planted, so that a more direct application about the seeds resulted from the smaller than from the larger amount. The same may be said in regard to the application of sulphide of sodium, the results of which show a similar discrepancy in favor of the smaller amount. It may be therefore inferred that a slight variation in the manner of application may have a considerable influence upon the effect produced, and that better results are to be looked for from a more precise application of the fungicide.

Although the treatment with flowers of sulphur cannot now be recommended, it is hoped that the experiments of another season may give results sufficiently good to warrant such recommendation. It must be confessed that the present experiment was undertaken with but small hopes of any results whatever, beyond such as might be of negative value; and however unsatisfactory the actual outcome may appear, as regards the amount of sound onions that may be grown on the smuttiest land when treated as described, it is at least gratifying to have accomplished anything in a preliminary investigation, based largely on theoretical considerations, and unassisted by the results of any previous experiment similar to it.

As a comparative experiment the results are of some interest, since beyond the considerable variations to be noted between the treated and untreated rows in the actual number of sound onions obtained, it will be noticed that the difference in the weights shows a much greater discrepancy. In other words the onions grown in the untreated rows were mostly small and stunted, while those in the treated rows were mostly large fair bulbs.

The figures given on Plate I, represent accurately the appearance of the rows treated with sulphur and sulphide of sodium, as compared with the alternate untreated rows. The figures are direct reproductions from photographs taken on August 6th, after all smutted onions had been pulled both from the treated and untreated rows. The rows therefore represent the appearance of the *sound* onions, in either case, at the time of harvesting.

As has been already remarked the experiment is merely tentative and no claim of practical success is made for it: nor is its trial recommended unless on a very small scale, until it has been tested by another season's work which may give better or not as good results. It is manifestly unsafe to generalize from a single experiment and it can merely be said that flowers of sulphur offer a promising substance for the desired purpose.

Should this mode of treatment ultimately prove sufficiently successful to warrant its recommendation, it may be of interest to note the expense involved if the fungicide is applied by means of a hopper and the smaller amount used. The rows being planted one foot apart the cost *per acre* would be as follows:

Cost of application	$0.00
Cost of flowers of sulphur	.48
Cost of lime	.12
Total cost per acre	$0.60

In addition to the sets of experiments above described a certain number of rows were left at first unplanted. Of these, two were planted on each of the following dates: May 3d, 10th, 18th, 24th, June 5th and 18th, in order to observe the effect of early and late planting as far as it might influence the percentage of smutted onions obtained. Taking the rows in the order in which they were planted, beginning with May 8th and ending June 18th, the percentage of smutted plants in each was as follows: 75 per cent., 75 per cent., 66 per cent., 55 per cent., 50 per cent., 40 per cent. A few onion seeds were also planted in old smutted earth in the greenhouse about the middle of August, and of these also a large number came up smutted, although so many of them were destroyed sooner or later by another fungus (*Pythium*) that the exact percentage was not obtainable.

The above facts indicate that whenever smutted ground is disturbed germination of spores is likely to follow under proper conditions of heat and moisture, and that for this reason any variation in the usual date of planting would be of no advantage in endeavoring to check the disease, especially in view of the fact that the later the date of planting the more inferior are the onions obtained.

General Precautions.—Attention should perhaps be called here to a few general precautions which may be of service against the *Urocystis*, the most important of which have already been referred to in connection with its dissemination (p. 137) by farm implements, etc. Such implements should never be used on smutted ground and then upon new ground, without thoroughly washing off all adhering earth. The same may be said in regard to any means by which smutted earth may be transported.

All refuse of whatever kind that is left on the field should be *burned* as soon as practicable, and although onion land is usually

kept so clean that it cannot be burned over in the fall, this practice will be found very advantageous when it is possible.

At the second and subsequent hand weedings all onions which show smut in the second or third leaf should be pulled, collected in a basket or other convenient receptacle and burned at once. This practice involves very little trouble and the folly of leaving the larger smutted onions to discharge crop after crop of spores upon the ground, as the leaves successively mature, is apparent; especially when the enormous number of spores thus formed is considered. It is hardly an over-estimate to say that a single large onion may mature during a season something like a cubic inch of smut, which means between one and two thousand millions of spores, each capable of producing a smutty onion in the following season.

If an onion grower has unlimited land suitable for the crop it is almost superfluous to say that the best means of avoiding smut is to take up new land as soon as the old shows signs of the disease to any considerable extent; but, as has been previously remarked, this is not a *remedy* for smut, any more than it would be a remedy to stop raising onions altogether in affected sections.

Description of Plate I.

Experiment for the Treatment of *Urocystis Cepulæ* (Onion Smut).

The figures are reproduced from photographs taken directly from the experimental plots August 6, after all smutted onions had been pulled both from the rows numbered 1 to 9, *which received no treatment*, and those lettered A to F, which received treatment.

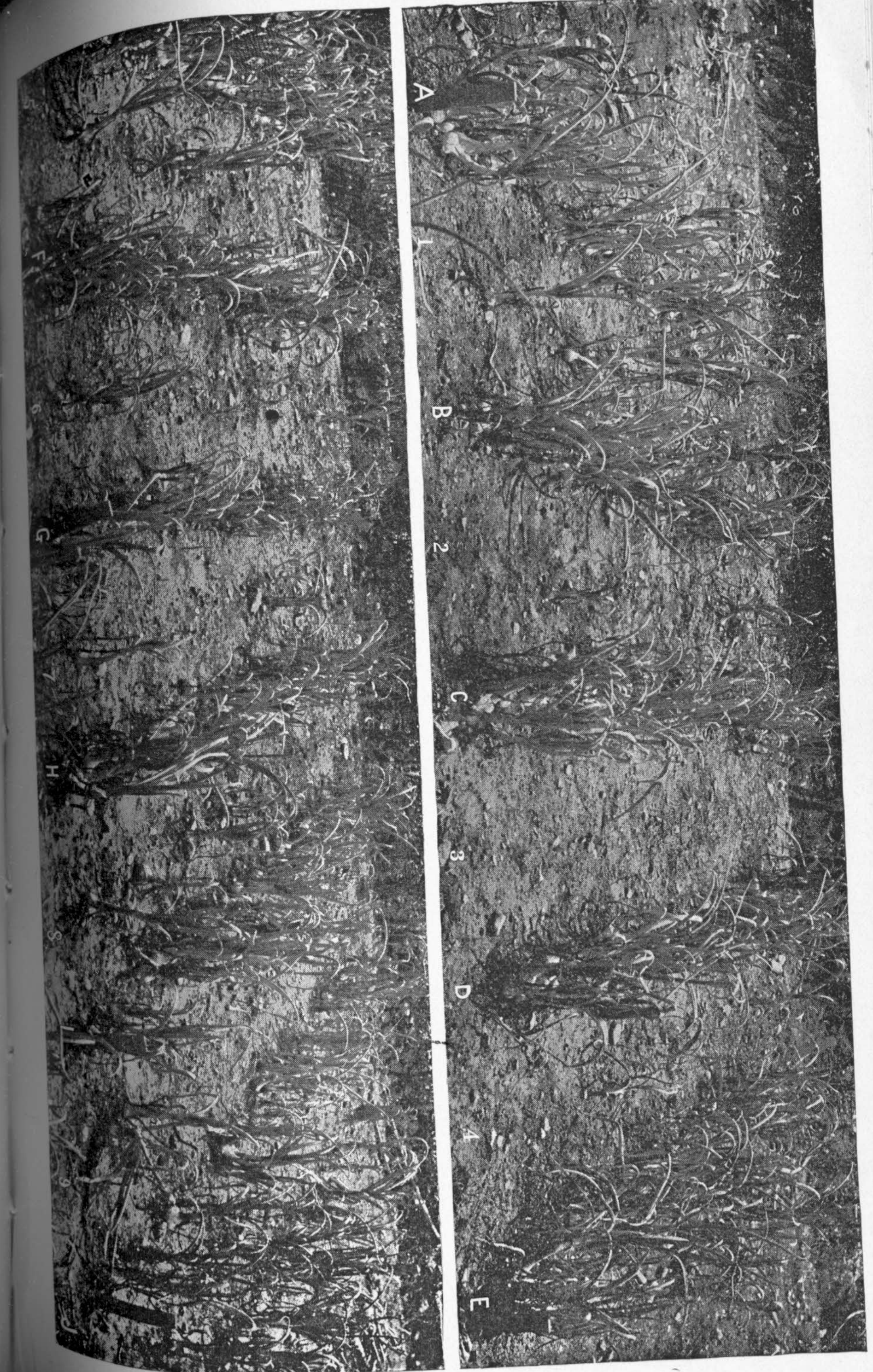
Rows A, B, C, D, E, were treated with sulphide of sodium, 5 grammes to each row.

Rows F and G were treated with 10 grammes of sulphur and 10 grammes of air-slaked lime each.

Rows H, I, J, received each 5 grammes of sulphur and 5 grammes of air-slaked lime.

Rows 1, 2, 3, 4, 5, 6, 7, 8, 9, received no treatment.

Each row was ten feet long. The upper figure being on a larger scale than the lower presents an appearance of greater vigor due to the enlargement.



Description of Plate II.

Urocystis Cepulæ Frost (Onion Smut).

Fig. 1.—Spore ball.
Fig. 2.—Spore ball in optical section, x=pseudospores, x'=resting spore.
Fig. 17.—Onion attacked by smut showing appearance in midsummer.
Fig. 18.—Spore germinating in decoction of onion and forming sporidia x.
Figs. 19–22.—Spores germinating in moist chamber, producing sporidia x.
Fig. 23.—Single sporidium germinating in water.
Figs. 24–28.—Sporiferous hyphæ from onion leaf showing successive stages in the formation of spore balls.

Urocystis Colchici (Schl.) Rab. (Smut of *Colchicum*, etc.).

Fig. 3.—Spore ball composed of a single resting spore.
Fig. 4.—Spore ball (in optical section) composed of three resting spores.

Urocystis magica Pass. (Smut of *Allium magicum*).

Figs. 5, 6.—Spore balls composed of single resting spores, one (fig. 6) in optical section.

Urocystis Anemones (Pers.) Schrt. (Smut of Wood Anemone).

Figs. 7, 8.—Spore balls composed of single resting spores, one (fig. 7) in optical section.

Urocystis occulta (Wallr.) Rabh. (Smut of Rye, etc.).

Fig. 9.—Spore ball composed of three resting spores seen in optical section.
Figs. 10–11.—Spore balls composed of single resting spores, one (fig. 10) in optical section.

Urocystis Hypoxys n. s.* (Smut of Star Grass).

Fig. 12.—Spore ball composed of one resting spore.
Fig. 13.—The same in optical section.
Fig. 14.—Spore ball composed of fourteen resting spores (three not shown in figure).

Ustilago Maydis (DeC.) Corda (Smut of Indian Corn).

Fig. 15.—Four spores.

Ustilago segetum (Bull) Ditm. (Smut of Oats, etc.).

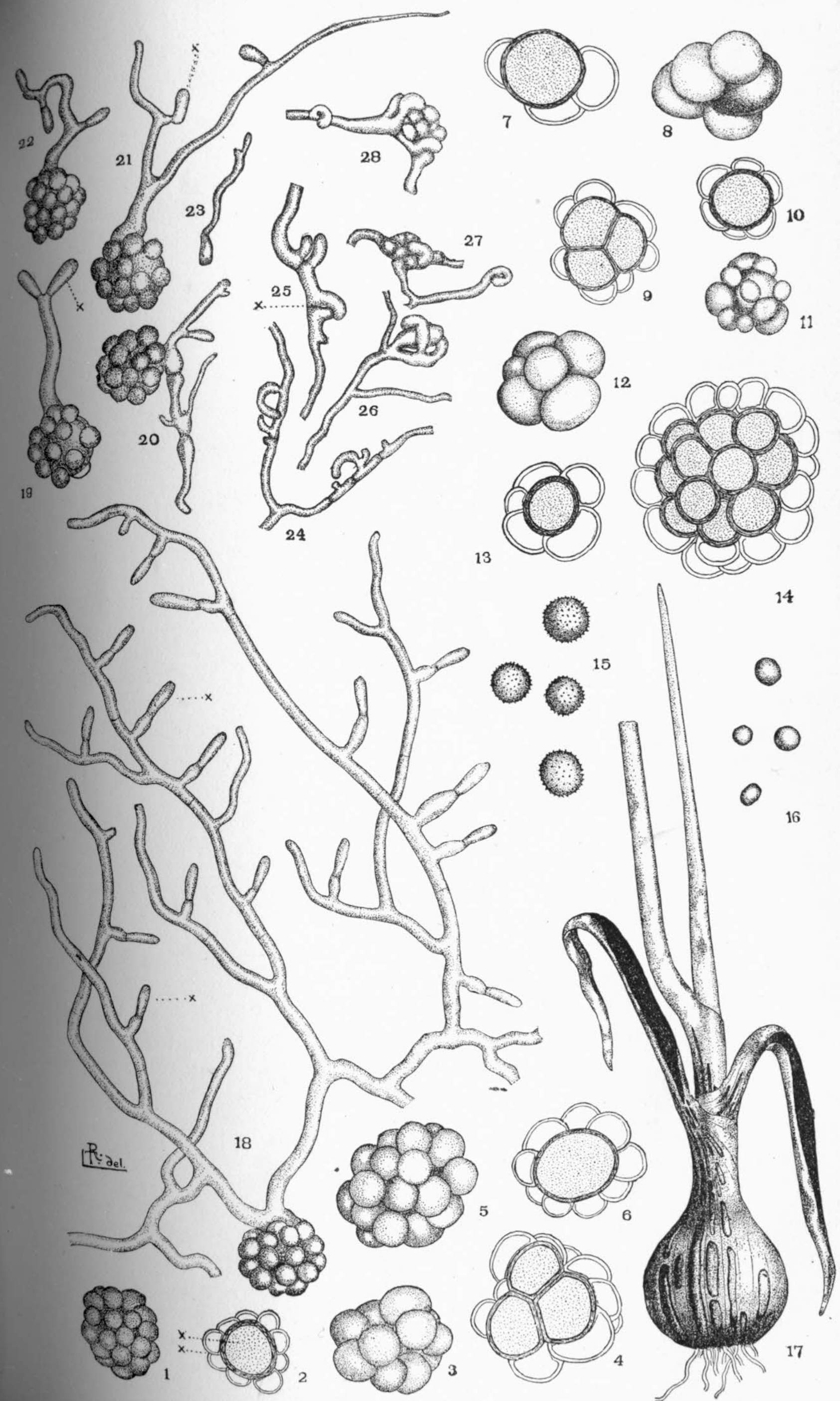
Fig. 16.—Four spores.

Of the above figures, fig. 17 is reduced to about one-third natural size. The remainder were drawn with camera lucida under a magnifying power of a little less than 700 diameters, the size being reduced in the present photo-reproduction of the original ink drawings, which were 12 × 7½ inches.

* The smut of Star Grass may be characterized as follows:

Urocystis Hypoxys n. s.

Spore masses black, in flowers (filling ovary), pedicels and peduncles (only near summit). Spore balls very irregular in size and shape, roundish or long-oblong, the largest 50–60 × 50^{mm}, the smallest about 25 × 25^{mm}. Resting spores brown, spherical or somewhat polygonal from pressure, one to ten (rarely fourteen or fifteen) in number, 13–15^{mm}. Pseudospores numerous, where the resting spore is single about eight to ten in number, somewhat flattened, variable. 8–15^{mm} in diameter.—On *Hypoxys erecta* L., June–August, New Haven, Conn.



Description of Plate III.

Phytophthora Phaseoli Thaxter (Mildew of Lima Bean).

Fig. 29.—Group of conidiophores arising from a common slightly swollen base.

Fig. 30.—Group of conidiophores pushing through stoma of bean-pod, bearing conidia at their tips.

Figs. 31–32.—Conidial spores germinating laterally and terminally and producing secondary conidia.

Fig. 33.—Conidial spore immediately before germination by zoöspores, showing slight lobulation of its contents.

Fig. 34.—Zoöspores making their exit from the apex of germinating conidium.

Fig. 35.—Conidial spore from which the contents has been discharged in an unbroken chain before any of the zoöspores have become motile.

Fig. 36.—Motile zoöspores.

Fig. 37.—Zoöspores which have come to rest, one germinating.

Macrosporium sarcinula Berk., var. *parasiticum* Thm. (Onion *Macrosporium*).

Fig. 38.—Conidiophores with spores *in situ*.

Fig. 39.—Two spores seen in optical section.

Macrosporium Porri Ellis (Larger Onion *Macrosporium*).

Fig. 40.—Conidiophores with spores *in situ*, showing sclerotioid body (x) from which they arise. (From specimen on seed onion stalk.)

Fig. 41.—Spore from seed onion stalk, seen in optical section.

Fig. 42.—Two spores from onion leaves showing extremes of size and shape.

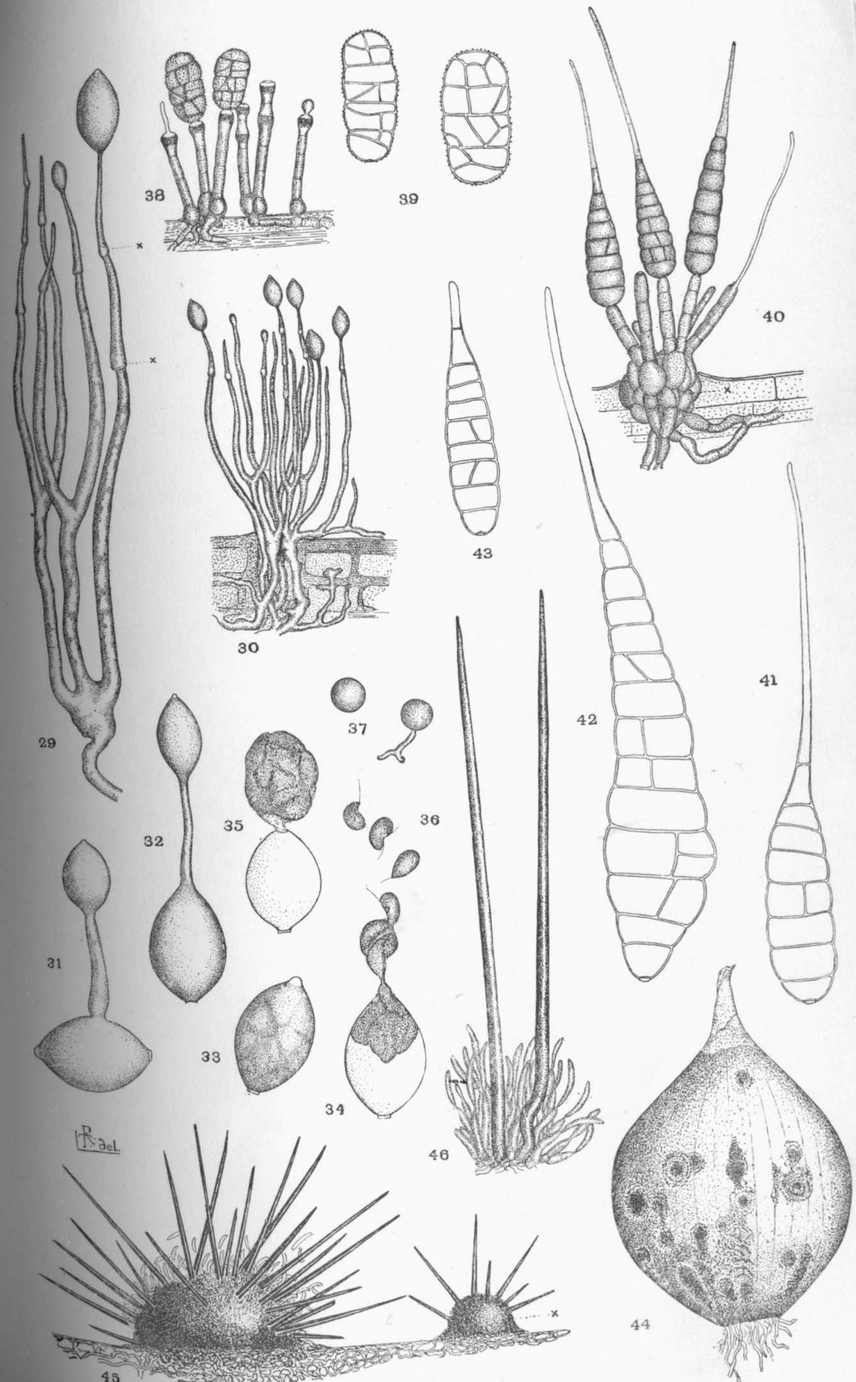
Vermicularia circinans Berk. (Onion *Vermicularia*).

Fig. 44.—Onion bulb attacked by *Vermicularia* in bin.

Fig. 45.—Mature and young (x) "perithicium," the former showing spores lying about the base of the spines.

Fig. 46.—Isolated fragment of the above showing method in which the spores are produced from the tips of the basidia, with two spines showing origin from hyphæ.

The above figures were drawn and reproduced as in Plate II. The magnifications used in the original drawing were approximately as follows: Fig. 29 × 350; Fig. 30 × 136; Figs. 31–37, 38, 41–43, 46, all × 464; Figs. 38, 40 × 232; Fig. 45 × 200.



N. Y. Engraving & Ptg. Co.

The Onion Mildew (*Peronospora Schleideni* Ung.)

Early in July of the past season, information having been received from Mr. S. M. Wells that a blight of some sort was damaging the seed onions in the town of Wethersfield and its vicinity to a serious extent, a visit was paid to the locality, and a number of fields inspected in company with the above named gentleman. The diseased condition of many of these fields was apparent without close inspection, a large percentage of the stalks in some of them having turned nearly white or yellowish, so as to give to the whole field, or certain portions of it, a decidedly sickly appearance. A closer examination of the affected stalks showed that the trouble originated as a small yellowish discolored patch, usually on one side, from which the disease spread in all directions so as often to involve the whole stalk. The only visible appearance upon the surface was an obscure, mould-like coating, white near the edges of the diseased spot and slightly reddish near the center. This appearance of mildew was also noticeable on such leaves as had not been already entirely killed by it, and was very commonly followed by a velvety black coating, sometimes covering the stalks almost entirely and forming a conspicuous feature in the diseased fields. This black appearance, being due to a fungus (*Macrosporium*) wholly unconnected with the mildew, will be referred to subsequently.

The virulence of the disease varied very greatly, according to the situation of the field attacked, low sheltered ground being the most favorable for its development; while such as were on high land, which admitted of a free circulation of air, were comparatively free from its injury. It was noticeable that, in all situations, only seed onions seemed to be thus injured, and although in many cases seed onions were growing almost side by side with market onions of the same variety, the latter were not attacked in a single instance, as far as observed.

The same locality was again visited a month later when the seed was being harvested, and the serious character of the disease was even more apparent from its effect upon the crop. In one small field especially, it was noticed that apparently not a single pod had properly matured, while in others, not so seriously attacked, not more than fifty per cent. matured any seed. The best of these pods were found to have matured seldom more than seventy-five per cent. of their seed and of this a large percentage was not capable of germination.

A microscopic examination of the diseased stalks gathered in July, showed them to be covered with the fruiting hyphæ of a mildew which was at once recognizable as belonging to the onion *Peronospora* (*P. Schleideni*). The hyphæ of the fungus penetrate the tissues of the host plant, pushing their way between the cells, the contents of which they destroy, and finally make their exit into the air, one to several at a time, growing out through the breathing pores or *stomata* of the host. After making their exit through the stomata, the hyphæ become several times branched, the ultimate branches being somewhat attenuated and curved, and bearing at their extremities large, faintly purplish spores, oval in shape and slightly pointed at either end. The disease is spread rapidly during damp weather by means of these spores, which blow or fall upon neighboring stalks or leaves, on the surface of which they germinate; sending out a short hypha which makes its entrance through the stomata already mentioned and, by its subsequent growth and ramification within its host plant, produces a new centre of disease which spreads as above described; first showing as a yellowish discoloration which may involve the whole or a large portion of the leaf or stalk. This mode of reproduction is designed for rapidly spreading the disease in summer; but like most other fungi, the mildew is provided with still another means of perpetuating itself through the agency of resting spores, or *oöspores.* While the summer spores, or *conidia*, are very short-lived, retaining their vitality at most for but a few days, the oöspores are designed to perpetuate the fungus during long periods while the conditions for its growth are unfavorable. It is by their means that it survives the winter from year to year, and it is probable that, like the resting spores of the onion smut, they may retain their power of germination for more than a single season. Unlike the conidia, the oöspores are formed not on the surface of the host plant, but from the threads which grow within its tissues. They are spherical in shape, furnished with a very thick wall, and often occur in great numbers, although none were observed in the material brought from Wethersfield.

This fungus, which is similar in nature to the downy mildew of the grape (*Peronospora viticola*), is well known in Europe as producing a serious disease of cultivated onions, occurring also on wild species. In this country it has been known to produce injury among onions in Wisconsin, specimens having been collected at Ithaca in that state by Prof. Trelease and distributed by him in Ellis' North American Fungi, No. 1412. During the past season it has also been received from Prof. Farlow on onion leaves sent to him by Mr. Fletcher of the Ottawa (Ontario) Experiment Station. It is therefore, in all probability, widely distributed in this country, although references to its occurrence do not appear to be frequent. It is perhaps best known as a serious disease among onions in the Bermuda islands, where it had become so destructive among market onions in 1886, that the legislature of the colony was induced to apply to England for some one to make an investigation into the cause of the trouble. This investigation was assigned to Mr. Arthur Shipley, and the results of his observations are given in the Kew Gardens Bulletin of Miscellaneous Information, No. 10 (London, 1887).

Although, as already stated, the disease was observed in Wethersfield only upon seed onions, in Bermuda and elsewhere it appears to be most destructive among market onions, ruining whole fields in an incredibly short space of time. Mr. Shipley attributes the severity of the disease in Bermuda partly to the fact that the onion farmers adopt the primitive method of setting out their market onions, thereby weakening the plants: a circumstance which, together with the excessive humidity of the climate, affords very favorable conditions for the spread of the disease.

In regard to remedies against this mildew, preventive rather than curative measures seem to offer the best prospect of good results. Knowing the life history of the fungus, and that it is perpetuated over winter and originates during the following season by means of resting spores, which survive in the dead tissues of the onion leaves and stalks, the necessity for destroying all such refuse needs hardly to be pointed out. The common practice of ploughing in stalks and field refuse generally cannot be too strongly condemned, and in the present instance renders the infection of onions grown on the same land another year almost certain. The stalks should invariably be burned in a manner to render their destruction as complete as possible. The repeated use, for the same crop, of land on which the *Peronospora* has appeared, should be avoided. After a severe attack of this mildew, such land should be used for other purposes for several years; and it may be said in general that in localities where the disease is known to exist the use of low sheltered land should be avoided for this crop.

Should the disease ever appear with severity among market onions, as it is known to do in Europe and the Bermuda islands, it is hardly to be doubted that an application of any of the copper mixtures which have been found so effective against the mildew of the grape, would be equally effectual in the present instance if properly applied. Any application to seed onions would be a matter of greater difficulty, unless the disease should appear while they were comparatively young.

The nature of this injury does not appear to be appreciated in the locality where it was observed and where it is known under the name of "white blast." This is owing to the fact that the mildew itself is very inconspicuous on the stalks; but it should be mentioned here that the term "white blast" is used also to refer to diseases which have no connection with that under consideration. The most serious of them, the "white blast" of market onions, is due to an insect, the onion *Thrips*, which has done the most serious and widespread injury to the crop all over the State (see p. 179). The ordinary whitening of certain stalks among seed onions, which is also known as "white blast," is likewise unconnected with the *Peronospora*.

The Onion Macrosporium. (*Macrosporium sarcinula* Berk.; variety *parasiticum* Thüm.)

Plate III. Figs. 38, 39.

It has been already mentioned that, in a majority of cases, the mildew just described was followed by a black appearance, resulting from the growth of a fungus wholly different from the *Peronospora*, namely, the onion *Macrosporium* (*M. sarcinula* var. *parasiticum*). Although more common and conspicuous among seed onions which have suffered from the mildew, this fungus appears to be almost universal among onions in the state, occurring on market as well as seed onions and sets. It is much more conspicuous on the seed stalks than elsewhere, forming a deep black, velvety coating, which sometimes involves the whole stalk. On the leaves it is less conspicuous, often brownish or not so evenly black, and when the mildew has not preceded it, it is less evenly diffused occurring here and there in patches.

Attention was first called to the occurrence of this fungus on onions by Von Thuemen, who described and distributed it as a new species (*Macrosporium parasiticum*) in his Mycotheca Universalis, No. 667, in 1877: the specimens having been collected in Bavaria, where the fungus was stated to be parasitic, for the most part, upon the onion *Peronospora*. The disease is subsequently referred to by Mr. Shipley in the paper already mentioned (Kew Bulletin of Miscellaneous Information, p. 17), in which it is described as prevalent in Bermuda in connection with the onion *Peronospora*. More recently it has been very thoroughly studied in its botanical aspects by Prof. Miyabe (Annals of Botany, vol. III, No. 9, 1889), who succeeded in tracing its life history by cultures, and concludes that it is merely a form of *M. sarcinula* Berk., a species common on various substrata.

As regards its distribution in this country nothing can be said, except that it occurs in Connecticut and Maine, and has been received in company with *Peronospora Schleideni* from Prof. Farlow on specimens collected in Ontario by Mr. James Fletcher. It is probable, however, that its occurrence is general through the more northern States at least.

In speaking of this disease, as it occurs in Bermuda, Mr. Shipley states distinctly that "this fungus (*Macrosporium parasiticum*) is only found upon the onion after it has been attacked by the *Peronospora*" and it has usually been considered as a sequel to the *Peronospora*, rather than a specific disease in itself. Prof. Farlow in an appendix to the paper of Miyabe, just mentioned, states that no trace of the mildew was discoverable in the specimens of the *Macrosporium* sent him from Bermuda, which furnished the material for the latter's studies, and it was therefore a matter of some interest to ascertain to what extent, if at all, the *Macrosporium* was an independent disease in Connecticut.

That it is entirely independent of the *Peronospora* was easily shown from the fact that, although the latter fungus was observed only in the region about Wethersfield, the *Macrosporium* was found wherever the onion was cultivated. At Green's Farms and Southport, for example, a careful examination of numerous fields, both of seed and market onions, did not disclose a single instance of injury from the mildew, while the *Macrosporium* was everywhere abundant. That the two diseases are not necessarily associated can therefore be definitely stated; but whether the *Macrosporium* is in itself a primary cause of disease in onions, is another matter not so easily determined. That it usually follows an injury of some sort may be inferred from its almost invariable association with the *Peronospora*, as well as with the injury produced by the onion Thrips, yet in several cases during the past season it was observed where no such previous injury was apparent.

A field of market sets at Green's Farms, for example, the sickly appearance of which was visible at some distance, was carefully examined early in July. The leaves were found to be covered with irregular whitish blotches and were withered and dried up at their tips. In the centre of these blotches and entirely covering the more withered portions of the leaf was found a coating of the *Macrosporium* associated with nothing else to which the injury could be attributed. A neighboring field of market onions was examined at the same time and found to be similarly, though not as severely, affected; and here also no indication was visible of previous injury by the Thrips, the *Peronospora* or any similar agency. The white blotches, when examined microscopically, showed a penetration by fungus hyphæ bearing the peculiar *Macrosporium* spores in the central portion of the spot. Isolated patches of the *Macrosporium* are also common on seed onion stalks generally, yet in such cases the entrance may have been effected through a bruise made in cultivating, or otherwise. It may be mentioned here that attempts to produce the disease by sowing spores upon healthy onion leaves were not successful.

Whatever the truth may be in this respect it is none the less certain that the fungus under consideration is seriously injurious whether it be primary or secondary. When it follows the *Peronospora*, especially upon seed onions, it extends the injury of the latter very greatly, breaking down stalks which would otherwise have kept erect and matured at least a portion of their seed, and causing the leaves to wither up entirely. In general it may be said that parts attacked by the *Macrosporium* appear to absorb and hold moisture very readily, so that the rotting away of such diseased portions is greatly hastened.

The injury of the *Macrosporium* is produced by a mass of slightly smoky branching hyphæ which penetrate to the deepest layers of cells, entering and destroying them. Certain of these hyphæ make their way to the surface, either through the breathing pores or directly through the cell walls of the epidermal layer, and in the air give rise to the oblong, dark brown spores represented in figs. 38, 39. These spores are covered with numerous short projecting points and are divided by cross partitions into numerous cells; that is they are compound, and when they germinate each of these cells may give rise to one or more hyphæ which, if favorably situated, grow into the onion plant and give rise to a new centre of infection. The studies of Miyabe have shown that this fungus is an imperfect stage of *Pleospora herbarum*. The latter fungus is characterized by the formation of nearly spherical bodies, known as *perithecia*, within which are produced numerous sac-like organs each containing eight brown compound spores, and was obtained directly from the *Macrosporium* spores. The fungus we are considering therefore, is merely a form of something else, and the name *Macrosporium* is retained to designate it only as a matter of convenience.

In regard to remedies in the case of this disease, it is not probable that any direct treatment would be advisable; but it should be kept in check by the systematic destruction of all stalks and field refuse generally, which can only be done effectually by burning. Ploughing in such refuse, or composting it, should never be resorted to under any circumstances.

The Larger Onion Macrosporium (*Macrosporium Porri* Ell.).

PLATE III, FIGS. 40–43.

IN addition to the species of *Macrosporium* just described, a second fungus nearly allied to it, and resembling it closely in its effects, occurs commonly upon seed though less frequently on market onions. The spots which it produces are paler than those which characterize *M. parasiticum*; usually more circumscribed and less inclined to inflict injury by the rotting and breaking of the seed stalk at the diseased point. It apparently does not, like *M. parasiticum*, commonly follow the onion *Peronospora*, and seems more truly parasitic in its habit than this fungus. Its dark, branching, septate hyphæ penetrate the tissues of its host in all directions, finally making their way to the surface and, just below the epidermis or within the epidermal cells or air spaces beneath the stomata, usually produce a compact sclerotioid mass of cells (Plate III, fig. 40*x*.) This body, which may consist of only a few or of a considerable number of cells, gives rise to one or several short hyphæ, bearing the large, solitary, brown, compound spores as represented in the figures. Nothing further concerning its history can be given at present, and measures suggested for the destruction of *M. parasiticum* apply equally well in the present case.

Botanically the species is of some interest. It was first described by M. C. Cooke in Grevillea, vol. viii, p. 12, as *Macrosporium Porri* Ellis, from specimens collected on Leeks (*Allium porrum*) in New Jersey by Mr. J. B. Ellis. It was subsequently distributed in Ellis' North American Fungi, No. 370, on *Allium porrum* from New Jersey, under the name *Macrosporium Porri* Cooke & Ellis. In addition to various localities in Connecticut it has been collected during the past summer at Kittery, Maine, on market onions; but beyond this nothing appears to be known of its distribution. A careful comparison of the Connecticut and Maine material of the fungus with the specimens distributed as above mentioned, and with others kindly sent by Mr. Ellis, leave no doubt as to the identity of the two. Mr. Cooke states in his description that "the large clavate spores are attenuated in the lower third of their length into a closely septate stem," a remark which indicates that they were not seen by him *in situ*, the attenuated base being in reality the apex as is shown in fig. 40, which was drawn from fresh material. The spores fall from their attachment with great readiness, yet the distinct scar at the point of attachment of the rounded base is always readily seen in detached spores. The species is therefore very possibly not a *Macrosporium* and approaches the genus *Alternaria*, although no indication was observed that the spores are ever formed in chains or consecutively from a single hypha, according to the peculiar manner of this genus. It may be mentioned that the spores vary very greatly in size and shape, as well as in the length of the attenuated end which, being usually the first point of germination, is often very greatly elongated. The spores of the form growing on seed onions differ, to some extent, from those found on the leaves, by their somewhat smaller size and greater regularity of shape. Their apex is usually more attenuated, the base evenly rounded, and in many cases there is an entire absence of any longitudinal partitions. These differences, however, do not appear to be greater than can be accounted for by the difference in the substratum.

The Onion Vermicularia (*Vermicularia circinans* Berk.).

PLATE III, FIGS. 44–46.

The outer bulb scales of the white varieties of onions, before they are harvested, are often attacked by a black growth, quite inconspicuous at this time, and composed usually of a central black dot, or small ring, outside of which one or more larger rings are arranged concentrically and with greater or less regularity. When kept in a moderately moist, warm atmosphere this black appearance extends itself with considerable rapidity, either growing in concentric circles or successive wavy lines, or forming evenly black areas on the bulb, as in fig. 44. At first this is confined to the outer layer of scales; but, as the disease extends, it penetrates several successive layers inducing decay and often presenting an appearance, beneath the outer layer, hardly distinguishable, at first sight, from the onion smut. If the black rings and blotches are examined closely they may be readily seen to be composed of numerous black points of various size, single or running together in clumps, and apparently made up for the most part of very minute bristles. A microscopic section of one of these points, shows that they are seated directly on the surface of the scale (fig. 45), the tissues of which are penetrated and disintegrated by numerous hyphæ, from which the black points themselves arise directly. The latter are composed of numerous long, black, pointed, bristle-like bodies growing directly from the hyphæ, and around the bases of which are clustered great numbers of short, colorless or slightly brownish bodies, the *basidia*, which also arise directly from the hyphæ and bear at their tips, the slender, slightly curved spores which propagate the fungus. These bodies are seen in fig. 46, which represents a very small bit of one of the black points separated and highly magnified. The spores are produced in very great numbers in a damp atmosphere, so that the black tufts become visibly whitened by them. When young, the black tufts are furnished with a sort of membrane which extends over the basidia at the base of the long bristles (fig. 45*x*); but finally disappears or remains only about the edges. Beyond this production of enormous numbers of minute spores nothing is known of its further development. In many cases, where the growth of the fungus was very luxuriant, it was found associated with large *sclerotia* which were somewhat flattened, jet black externally and white within; but it cannot be definitely stated that these were connected with the fungus producing the black tufts, and at the present writing they have shown no further development.

The fungus under consideration appears to be a species first described by Berkeley in the Gardener's Chronicle (1851, p. 595) as *Vermicularia circinans* although it has not been possible to make any comparison of our form with authentic specimens of Berkeley's species. Since, however, it answers in all particulars to the meagre description transcribed in Saccardo's Sylloge, it is tolerably safe to assume that the determination is correct.

Its economic importance, which is very considerable, rests upon the fact that, although it does not as a rule injure the onions seriously, or become conspicuous upon them until after they are housed, it often attacks them subsequently to such an extent as greatly to disfigure them, and impair their value for marketing purposes. Some idea of the serious nature of the disease may be inferred from the fact that one gentleman, whose statement is wholly reliable, estimates his actual loss from this cause during the past season at several thousand dollars.

The fungus is introduced into the onion house from the field, where it occurs not very abundantly on the bulbs before they are pulled, especially if they have been weakened from any cause, and among the housed onions it propagates itself with a severity proportional to the favorableness of the conditions offered it for the formation, dissemination and germination of its spores above described. These conditions are warmth and moisture, and the proximity of uninfected bulbs. It may be communicated by contact with diseased bulbs or with any object, such as the hands, or tools that have been subjected to such contact, and may be also spread by strong drafts which blow about the spores or dry scales containing them.

The most important precaution which can be taken against the disease, consists in housing the onions during dry weather after the bulbs are thoroughly dried off. No bins which have contained such black onions should be used a second time, until they have been thoroughly cleaned and sprinkled with quick lime, or quick lime and sulphur. All danger of heating should be avoided, and the onions stored in as cool and dry a place as possible, which can be arranged to be ventilated in dry weather and shut up when the atmosphere is moist. Should the fungus be noticed on the bulbs at the time of storing, or in any case

when there has been previous damage from this cause, it is probable that a treatment with dry air-slaked lime, such as has been recommended with success for potatoes (one bushel of lime to twenty-five bushels of onions), applied *at the time of storing*, would prove of great service in checking the spread of the fungus. The utility of this practice, however, needs confirmation by actual experiment before it can be definitely recommended. In any case, such treatment should be made at the outset, since it would have comparatively little influence after the disease was well established.

The question has been asked whether bulbs attacked by the *Vermicularia* can safely be used for seed onions, and it may be said that this can be done with perfect safety, provided that the fungus has not attacked them sufficiently to have induced rotting; since as a rule the surface layers only are affected, the bulb being otherwise sound. No infection of the seed or seed stalk is to be feared; but the old bulbs will be likely to harbor the fungus during the summer, and communicate it to market onions if planted near them.

Note on some other Diseases of Onions due to Fungi.

Although the five fungus diseases above described are the most important ones which were observed to affect the onion in Connecticut, there are numerous other fungi which are known to be injurious to this vegetable, and its near relations belonging to the same genus *Allium*. One disease which may be noticed as occurring in this State is the common "white blast" almost always met with among seed onions. It is a disease unconnected with the *Peronospora* above described, which attacks seed onion stalks, causing them to turn white and often flaccid, and only appearing here and there in the rows. It is commonly attributed to the work of the onion fly ("maggot"), but in the majority of cases the bulbs at the base of such stalks are perfectly sound. Microscopic examination usually shows the presence of numerous hyphæ on the inner side, belonging to a species of *Mucor*, accompanied by great quantities of Bacteria which collect in yellow masses. Whether either of these forms are directly connected with the "blast" cannot at present be stated.

Another fungus which did great injury to onion seedlings in the hot-house may also be mentioned. Plants attacked by this disease became white and flaccid near the base, soon falling over and withering. The cause in this case was a fungus related to the moulds (*Saprolegnia*) often destructive to fishes; and belonged to the genus *Pythium*. Whether the species is identical with *P. DeBaryanum*, also said to produce disease among various seedlings, was not determined.

No other fungi which seemed truly parasitic, were observed on cultivated onions, during the past season, although saprophytic forms were not infrequent; but in order to give some idea of the number of diseases due to fungi which are liable to occur on onions generally, both wild and cultivated, the following list of names is appended, for several of which thanks are due Prof. Seymour of Cambridge. The list is doubtless incomplete; but is nevertheless sufficiently long to serve the purpose in view.

List of Fungi Parasitic upon Members of the Genus Allium.

NAME OF FUNGUS.	NAME OF HOST.
Æcidium alliicolum Wint.,	Allium stellatum.
" Convallariæ Schm.,	" reticulatum.
" reticulatum Thm.,	" victoriale.
Acrothecium melanopus (Sz.) Sacc.,	" cepa.
Cæoma (Uredo) Alliorum Lk.,	" cepa, porrum, etc.
Cercospora Victorialis Thm.,	Allium victoriale.
Cladosporium sparsum Sz.,	" cepa.
" fasciculare (Pers) Fr.,	" sp.
Darluca aschochytoides Sacc. & Roum.,	" ampeloprasum.
Fusariella atrovirens (Berk.) Sacc.,	" sps.
Heterosporium Allii E. & M.,	" vineale.
" " var. Allii-porri, Sacc. & Br.,	" porrum.
" Ornithogali Klotsch.,	" vineale?
Macrosporium cladosporioides Desm.,	" sp.
" Porri Ellis,	" porrum.
" punctatum Kalch. & Cke.,	" schœnoprasum.
" vescicarium (Wallr.) Sacc.	" sativum.
Mucor subtilissimus Berk.,	" cepa.
Mystrosporium Alliorum Berk.,	" sp.
Perisporium exuberans Fr.,	" sp.
Peronospora Schleideni Ung.,	" cepa, etc.
Phoma alliicola Sacc. & Roum.,	" sp.
Phyllachora Cepæ (Sz.) Sacc.,	" cepa.
" penicillata (Sz.) Sacc.,	" sp.
Pleospora Allii (Rabh.) Ces. & DeNot.,	" cepa, porrum.
" Cepæ (Preuss.) Sacc.,	" cepa.
" socialis Niessl. & Kunz.,	" cepa.
Puccinia Allii (DeC.) Rud.,	" sativum, etc.
Puccinia mutabilis Ell. & Gall.,	" mutabilis.
" Porri (Low) Wint.,	" cepa, porrum, fistulosum.
" sessilis Schn.,	" ursinum.
Rhizoctonia Allii Grev.,	" ascalonicum.
Saccharomyces Allii Sor.,	" cepa.
(Sclerotium cepivorum Berk.),	" cepa.
Scolecotrichum diplodioides (Thm.) Sacc.,	" neapolitanum.
Septoria alliacea Cke.,	" sp.
" alliicola Baum.,	" flavum.
" Alliorum West,	" porrum, etc.
" viriditingens Curt.,	" tricoccum.
Sphærella allicina (Fr.) Auers.,	" sp.
" Schoenoprasi Auers.,	" porrum, etc.
Torula Allii (Harz) Sacc.,	" cepa.
Urocystis Cepulæ Frost,	" cepa.
" Colchici (Schl.) Rabh.,	" sps.
" magica Pass.,	" magicum.
Uromyces aculeatus Fckl.,	" victorialis, etc.
" ambiguus (DeC.) Fckl.,	" scorodoprasum.
" Erythronii (DeC.) Pass.,	" victorialis, etc.
" vernalis Speg.,	" striatellum.
Vermicularia circinans Berk.,	" cepa.
" dematium (Pers.) Fr.,	" cepa.
" Liliacearum S.,	" sp.
" Schoenoprasi Auers. & Fckl.,	" schœnoprasum.

MILDEW OF LIMA BEANS (*Phytophthora Phaseoli* Thaxter).*

PLATE III, FIGS. 29–37.

The Lima bean (*Phaseolus lunatus*) is, as a rule in this climate, vigorous in its growth and little troubled by fungus enemies. A fungus has, however, appeared in New Haven and vicinity within a radius of at least fifteen or twenty miles, which bids fair to become the most serious obstacle yet encountered in the cultivation of this vegetable. The disease first shows itself as a spot, having a white, woolly appearance, usually on one side of the unripe pods. This spot extends rapidly during damp weather, penetrating, and appearing on both sides of the pod, which it often covers completely with a clear, white, thick, woolly coating. At the same time the pod begins to decay and usually ends by becoming shrivelled and black. As in the case of the onion *Peronospora*, a nearly related disease, the black

* *Botanical Gazette*, vol. xiv, p. 273, Nov., 1889. Specimens are distributed in Seymour and Earle's "Economic Fungi," No. 9.

appearance which follows the mildew is not directly connected with it, but is due to the growth of several other fungi, *Cladosporium*, *Macrosporium*, *Epicoccum* and other common forms, which complete the destruction begun by the mildew. Notwithstanding the fact, however, that these common fungi have really no connection with the disease in question, they are more likely to attract notice than the mildew itself, and the dry blackened pods hanging in all directions in a diseased piece are the most noticeable feature in connection with it. The mildew does not confine itself to the pods by any means, though most conspicuous upon them; but attacks the young shoots as well, distorting them and stopping their growth, and also, though less commonly, the leaves, involving the larger veins as well as the petioles.

At Hamden, near New Haven, where it was first noticed early in September, the disease has appeared with great severity, destroying, in some cases, a very large percentage of the crop. It is said to have been known as injurious in this region for about two years; but never as much so as during the past season. It was not seen on any other than the Lima beans, nor has it been observed on the wild bean (*Phaseolus diversifolius*) common about New Haven, or on other plants belonging to the family of *Leguminosæ*. Its origin, therefore, is purely a matter of conjecture, since, although it seems scarcely probable that so conspicuous a form should have been overlooked in so thoroughly explored a region as the New England and adjacent states, it has been equally overlooked in other parts of the world, if indeed it is a foreign importation.

Examination of a section of the diseased tissue shows it to be penetrated by the irregular branching hyphæ of the fungus, which run between the cells and, collecting in the air spaces beneath the breathing pores, push out through them into the air (fig. 30) in such numbers that the latter are completely obliterated. These hyphæ (fig. 39), just at their point of exit from the breathing pores, are usually slightly swollen and give rise to one or more branches which grow almost vertically into the air, and, taken together, produce the white woolly appearance already mentioned as characteristic of the disease. These vertical branches may themselves be once dichotomously branched, that is give rise to two branches, forming a more or less symmetrical fork; while at their tips they swell out into the large, terminal, oval conidial spores represented in the figure. A peculiarity of the genus *Phytophthora*, of which this fungus constitutes only the third form known, consists in the fact that after a spore has been produced at the apex of a hypha, the hypha continues to grow at the point where the spore is attached, pushing it to one side if it has not already fallen off, and soon swelling into another spore. This may be repeated several times, the points where spores have been previously. formed, being marked by successive vescicular swellings (fig. 29 *x x*). The spores, when mature, are blown by the wind or fall upon different portions of the bean vine or adhere to other objects, and under proper conditions of moisture germinate. The germination takes place in two ways. In the one case a single hypha of germination is produced, which may enter the host plant directly or give rise to another, or secondary spore like itself (figs. 31–32) which germinates in its turn like the ordinary conidia. In the second case, which is by far the most common, the contents of the spore becomes very faintly lobular, as shown in fig. 33, and suddenly and rapidly begins to make its exit, through the ruptured apex of the spore, in the form of a continuous chain of spindle-shaped bodies, consisting of naked protoplasm; the orifice alternately expanding and contracting as each body is, as it were, squeezed out by the pressure from within. In some cases the whole contents of the spore makes its exit thus, the chain winding itself into a round or oval mass above the apex of the conidium as in fig. 35. Usually, however, the chain breaks in the course of its discharge and almost instantly a rapid motion begins, at the point of separation, which draws the spindle-shaped bodies successively apart. The motion is due to a slender thread or cilium, drawn out by the pulling apart of the narrow zone connecting two adjacent bodies, and the rapid vibration of this thread gives rise to the motion just mentioned. The spindle-shaped bodies, as soon as they are free, move irregularly for a moment, changing their shape the while, till they become contracted, the two extremities being drawn together on one side towards a small clear spot, usually present in bodies of this nature, so that in one view the outline is slightly crescent or bean-shaped (fig. 36). After or during this change of shape the motion of the cilia becomes very rapid, and the bodies, which are known as *zoöspores*, dart away in the surrounding water. After swarming for a certain time, usually about half an hour, the zoöspores come to rest, assume a spherical shape, swell considerably, become surrounded by a thin cell wall and very soon begin to germinate (fig. 37) by giving rise to a hypha which makes its way into the tissues of the host plant, thus infecting it with the disease. This whole process, owing to the minute size of the zoöspores which are less than $\frac{3}{10000}$ of an inch in diameter, may take place upon the moist surface of a leaf or other portion of the host plant, the thinnest pellicle of water being sufficiently deep for them to swim in. The usual number of zoöspores formed from spores of average size is about fifteen, so that each spore may give rise to fifteen distinct points of infection.

The discovery of this species is of some little interest botanically since, as has been mentioned, it is only the third representative at present known of the rather peculiar genus to which it belongs. The fact that one of the three is the much dreaded potato blight (*Phytophthora infestans*), the life history of which is therefore similar, is sufficient indication of how serious a disease it may become should it spread among truck gardens generally.

The third species of the genus, *Phytophthora Cactorum*, is not known to occur as yet in this country; but is destructive in Europe, where it is found on many Coniferæ, as well as upon Cactus of several varieties, Sempervivum and various other plants, not to mention decayed animal substances on which it grows as a saprophyte. It was first named *Peronospora Cactorum* by Cohn and Lebert, being subsequently described on Beech seedlings by Hartig as *P. Fagi*, and at the same time by Schenk on Sempervivum as *P. Sempervivi*. Finally all three were united under the name *Phytophthora omnivora* by DeBary who demonstrated their identity by artificial cultivation: yet there seems no necessity for rejecting the earliest name. The *Phytophthora* of Lima beans resembles *P. cactorum* in the large size of its spores, which, however, are smaller than those of the last named species and much less variable, rarely attaining a length of 50mm. Its hyphæ also are very rarely if ever septate, as in *P. Cactorum*, while it differs entirely in the branching of its conidiophores (fig. 29) as well as in numerous other points of structure or development. Although resting spores frequently occur in *P. Cactorum* they are not certainly known in the potato fungus, and were not observed in connection with the mildew of beans, although their existence must be inferred from the fact that the hibernation of the fungus in this case seems hardly explicable on any other supposition.

Before considering remedies for this disease it will be necessary to make further observations upon it in order to ascertain the date and manner of its first appearance. It may be said, however, that the destruction of all vines and refuse in the field by burning them as soon as picking is finished, cannot be too strongly urged; since the winter stage of the fungus must exist in them, whatever it may be, and will otherwise propagate the disease another year. Composting the vines or using them for fodder or bedding, as is often done, should never be resorted to; since the resting spores would be spread with the manure thus obtained. Hand picking of the diseased pods or shoots, as soon as the white mildew shows itself, should certainly check the spread of the disease; but to be effective this should be done early in the season when it first appears, probably about the middle of July.

It is hoped that more knowledge of this interesting fungus may be gained during the coming season, and any information concerning its prevalence, distribution, etc., will be greatly appreciated if communicated to this Station.

Miscellaneous Notes.

The following notes on the occurrence of a few of the many fungus diseases prevalent during the past season may be of some interest.

Helminthosporium inconspicuum C. & Ell. White blast of Indian corn. This disease was widely injurious during August and September, blighting the leaves and hindering the proper ripening of the ears. Fields affected by it look as if they had been visited by early frost. No other stage of the fungus is known and no remedies or precautions can be suggested, beyond burning affected material as far as possible, and avoiding the use of barn manure on corn fields, or fields adjacent, when such manure is derived from stock to which diseased stalks have been fed.

Ustilago Maydis (D.C.) Smut of Indian corn. This disease has been remarkable for its absence during the past season, although unusually abundant in 1888.

Monilia fructigena Pers. "Rot" of Peaches, Cherries, Plums, etc. Forming grayish pustules over the fruit which may ultimately become wholly covered by a wrinkled, powdery coating, consisting almost wholly of spores. The fungus attacks the ripe or unripe fruit before or after it is picked, and has been very destructive, to plums and peaches especially, spreading from one to another while yet hanging on the tree. Perfectly sound fruit is readily infected with it, but more commonly that which is bruised or punctured. The leaves and tender shoots are also subject to the disease. No treatment can be recommended for this fungus on the fruit, since fungicides fail to adhere sufficiently to green plums; and peaches, when attacked on the tree, are usually so mature that they would be injured by any application. All fruit, however, should be picked off and burned, or buried several feet below the ground, as soon as a spot of the disease appears upon it; for the fungus is sure to spread from this to the sound fruit. Fruit should never be left to rot under the trees, where it is certain to breed the fungus. For this reason peaches, etc., picked green to thin out an excessive yield, should never be left on the ground, but should be buried at once.

Glœosporium necator E. & E. Anthracnose of Raspberry. Produces numerous round or elongate whitish patches on the "canes," and small yellowish spots on the leaves. It is locally very destructive, ruining the new growth or stunting it badly. Two plants very much diseased, sent by Mr. H. L. Jeffrey from New Milford, were set out in the greenhouse in February in order to see if the fungus hyphæ were perennial in the old tissues and would extend from them into the new growth. The canes themselves were kept dry to avoid any fresh formation of spores from the old spots. Fresh shoots, developed from below the ground as well as from the old canes above and below the diseased spots, showed no signs of the fungus, indicating that its destruction would be complete if all diseased wood were cut in winter, below the lowest spot of *Glœosporium*, and *burned.* Spots of the previous year, as was personally observed, give rise in May to a fresh production of spores, which convey the disease to the new canes and foliage. Burning of all diseased canes in autumn or winter is of the first importance, and care should be taken to avoid keeping the raspberries too thick, in order to insure free ventilation. Treatment with fungicides would doubtless check the spread of the disease if used in season.

Caeoma nitens Schw. Blackberry rust. This is everywhere destructive among wild and cultivated varieties of raspberries and blackberries, first showing its presence by the yellow look of the stems and foliage of the new shoots, and by their usually

fascicled, wiry growth; finally appearing on the under side of the leaves as a very brilliant orange powdery coating. The fungus is perennial in the tissues of the host and is therefore incurable. Diseased plants should at once be dug up and burned as soon as they show signs of the disease, and before the orange powder appears on the under side of the leaves.

Cladosporium fulvum Cke. Forming rusty brown patches on the under side of tomato leaves, blighting the foliage in August and September, has been somewhat destructive, but is not very injurious as a rule. Should it become so it would be easily controlled by fungicides.

Phytophthora infestans (Mont.) Potato rot and blight destroyed nearly all the potato vines in the State and appeared on tomatoes in September. It can undoubtedly be controlled, in ordinary seasons, by the use of Bordeaux mixture or other fungicides. It appeared very early this year (July 7), but usually is not destructive until late in July. Treatment should be applied as soon as a single leaf is seen to be affected, and if the field has been blighted the year before, the application had best be made early in July, and may be combined with Paris green for potato bugs, as has been shown by several experimenters. (See also p. 174.)

Cercosporella Persica Sacc. Appearing in patches on the under side of peach leaves as a clear white, somewhat powdery coating, and causing the premature defoliation of the tree, was injurious in the Valley Orchard Co.'s peach orchard at Deep River. Although the trees ripened large, fair fruit, its flavor was inferior, and the early defoliation doubtless injured the maturing of the new wood and buds. No remedy can be recommended at present.

"*Fusicladium*" *pyrinum* (Lib.) one variety of pear "scab" forming dark olive patches on the leaves, usually on the under side, as well as on young fruit, which it distorts or kills, has been locally very injurious. It bears some resemblance to the scab of apples (*Fusicladium dendriticum*), but is a quite different fungus. It appears very early in the season and should be controlled by fungicides, if properly applied.

Entomosporium maculatum Lev. the "spot" of quinces, causing brownish discolorations on the leaves which fall prematurely, and unsightly patches on the fruit, has been injurious almost everywhere. The same fungus occurs more rarely, in this State at least, on pear leaves and fruit. Experiments have shown that it is readily controlled by fungicides.

Sphaerella Fragariae (Tul), Strawberry blight, has been unusually injurious, being the apparent cause of the partial or almost total failure of the crop in many sections. On the leaves it appears as a reddish spot or patch with a whitish centre, but it causes even greater injury on the fruit stems and hulls, cutting off the supply of nourishment from the berries and disfiguring them by the withering of the calyx lobes. The disease has been successfully treated with fungicides.

Sphaceloma ampelinum DeB., Anthracnose of grapes is, so far as observed, the most generally destructive disease of grapes in the State. It appears upon the leaves and young shoots, stunting them or stopping their growth entirely, and also affects the berries. It is often popularly mistaken for black rot, a quite different fungus. No very effective remedies have as yet been recommended beyond close trimming below all spots of disease, and the burning of all diseased wood or leaves, as far as possible. Spraying the vines with a 25 per cent. solution of sulphate of iron before they begin to start in the spring, and the subsequent application of equal parts of lime and flowers of sulphur as a powder to the fruit and foliage, at intervals during the growing season, has been recommended.

Puccinia coronata and *P. graminis* have been injurious, especially to oats, the first named rust being most destructive. The most widespread "rust" of oats about New Haven has, however, been due not to a fungus, but to an insect, the oat Thrips (see p. 180).

Uromyces striatus Schröt. A rust, apparently this species, has been locally destructive to clover rowen in August and September, the chestnut brown spots of Uredo spores being very conspicuous on the under side of the leaves; the winter or teleutospores, occurring mostly on the stems or petioles.

Experiments with Bordeaux Mixture.

Through the kindness of A. J. Coe, Esq., of Meriden, a test was made of the Bordeaux mixture on his vineyard, rather with a view of getting some practical knowledge of the application of fungicides than for the purpose of making an elaborate experiment. The vineyard in question contains about two acres of Concord grapes, the rows running north and south, and for

several years past the crop has been an almost total failure from black rot. The past season could hardly have been a more unfavorable one for the purpose of experimenting, rain having fallen on an average every other day during the last half of May and the whole of June, and more than every other day, on an average, through July and the first week of August. The weather was, therefore, not only as favorable as possible for the growth and spread of the fungus; but was also equally unfavorable for the successful application of fungicides, the latter being washed off more or less, almost as soon as they were applied. The mixture used was of the strength usually recommended, viz: 6 lbs. sulphate copper, 6 lbs. quick lime, 22 gallons water, and as the rows were on sufficiently level ground, the spraying was done by driving a team between them, carrying the mixture in a cask on which was mounted a force pump, with a coupling on either side connected with light hose furnished with Vermorel nozzles. With a man to pump and keep the mixture stirred, and a man at each hose, with a boy to drive, the application was made very rapidly, one side of two rows being done simultaneously. Five rows in the center of the vineyard were left untreated, and the east half, which in previous years had been the worst affected, received tolerably thorough applications; while owing to circumstances the west half had to be somewhat neglected. On the east half applications were made May 17th, when the vines were just beginning to make their first growth. The vines were sprayed again June 7th after the grapes had set, and again on the 13th and 28th of June, the 16th of July and the 3d of August. The fungus began to appear early in July, only upon the berries, and even as late as July 13th but a small percentage of the clusters on the untreated rows were attacked. When the vineyard was next seen July 29th, there was not a single cluster and very few berries still green in the untreated rows. The rot had extended from the untreated rows to the neighboring treated rows, those nearest being more generally affected: about 75 per cent., however, of the treated clusters were free from disease. When the grapes were picked Sept. 23d, the untreated rows had proved a total failure, not maturing a single cluster, while the treated rows yielded from 60 to 75 per cent. in good condition. At this date the mixture adhered to many of the clusters and was brushed off with a soft brush as they were picked, without great difficulty. The foliage was well retained in the untreated rows and wholly so in the treated rows, in fact there was not at any time much indication of disease in the leaves.

Mr. Coe also applied the Bordeaux mixture to two large trees of Lombard plums, leaving a third untreated. The trees always set an abundance of fruit which was wholly destroyed by the fruit Monilia (*Monilia fructigena*), and in addition to this disease were subject to black knot (*Plowrightia morbosa*), and to defoliation by the plum leaf fungus (*Septoria cerasina*). As a result of three very thorough applications made May 22d, June 14th, and July 16th, the two treated trees held their foliage intact up to severe frost in October, showed hardly any black knot and matured a fair amount of fruit; while the untreated tree was defoliated in August, matured no fruit, and was badly infested by the black knot. An experiment on so small a scale must be taken for not more than it is worth, yet the differences between the treated and untreated trees can hardly be explained as due to causes other than the application of Bordeaux mixture. The mixture did not adhere to the plums to any extent, which may account for the fact that the Monilia was not more effectively controlled. Hand picking of all diseased or spotted plums should have been resorted to early in the season.

An application of the Bordeaux mixture to test its effect on the potato blight (*Phytophthora infestans*) was also made on the Webb farm at Hamden. For this purpose a rectangular piece 50x150 feet was selected in the corner of a large field, and treated with a mixture containing 10 lbs. sulphate of copper, 10 lbs. lime and 30 gallons of water. The application was first made July 18th, when about one per cent. of the foliage of the field was already attacked by blight. On the following day it rained, with fog, and at night rained very heavily. This was followed by three days of fairly clear weather, but the next day (July 23d) brought more fog and a heavy thunder shower. Notwithstanding this, the mixture held fairly well, and when the vines were treated again July 25th, from 80 to 100 per cent. of the foliage in the untreated portion of the field was destroyed by blight, while not more than 5 to 10 per cent. in the treated piece was injured. One day of clear weather followed this second application, but heavy rains fell on the two succeeding days followed by one day of hot foggy weather. July 30th rain fell

in torrents, and heavy rains and fog continued every day till Aug. 3d, when another application was made. At this date the treated piece retained from 50 to 60 per cent. of its foliage, while the rest of the field was quite black, without a vestige of a green leaf. On the same day after treatment, rain and fog continued, clearing Aug. 4th, but raining again Aug. 5th. Then followed three clear days, then a warm rain Aug. 9th and 10th. On Aug. 10th, the piece was examined for the last time and was found still to retain about 25 per cent. of its foliage.

The result of the application as far as concerns the protection of the foliage must be considered very successful, when the weather which prevailed during the experiment is taken into consideration. But the comparative weight as reported by those in charge of the harvesting and weighing of the whole field (which was for the most part a field experiment conducted by the Station), showed a slight proportional difference in weight *against* the treated piece. The rows were examined personally just after they had been ploughed, however, and the number and size of the potatoes thus exposed was in several of the rows distinctly in favor of the treated plot, as could be seen by comparing the yield at the points where the treated and untreated portion of the rows met. It seems therefore probable that the unfavorable showing may have been due to some error either of those who harvested or weighed the crop. It certainly would seem very singular if the preservation of the foliage accomplished, should have been an injury to the crop, and it should be mentioned here that experiments of a similar nature tried elsewhere during the past season, have given a result very greatly in favor of the treatment, both as regards the bulk and keeping qualities of the crop.

Farmers are strongly advised to try experiments for themselves with the use of fungicides, for which full directions will be furnished by the Station on application, adapted to the particular disease which it is desired to treat, and when possible, personal supervision will be given if requested. Such coöperation on the part of farmers is much to be desired from the fact that no farm is attached to the Station, and experiments of this nature cannot otherwise be made. A bulletin on the subject of the preparation and application of fungicides will be issued shortly.

NOTES IN ANSWER TO INQUIRIES CONCERNING INJURIOUS INSECTS.*

Mamestra picta Harris.—A box containing a number of the caterpillars of this moth was received from Saybrook, where they were said to have been found injuring onions. The species is common in New England and elsewhere, the moth, of a dull red color with white underwings, being double brooded, appearing in May and July. The larvæ, which are conspicuously marked with black and yellow lines and spots, are at first gregarious; feeding in swarms on all sorts of garden vegetables, as well as many weeds; but separate as they mature. Although they eat the leaves of such a variety of plants, the onion does not commonly attract them, and no danger to this crop from them is to be feared. When they are injurious, and Paris green can be used with safety, it would doubtless prove entirely effectual against them.

From the same locality the larvæ of the following moths were also received for determination.

Telea Polyphemus Cram.—The American silk worm, a stout, large, green larva with two rows of pearly tubercles along the back, feeds on a great variety of trees, oak, birch, elm, maple and willow perhaps most commonly; but rarely if ever, in New England at least, is noticeably injurious. The larva spins a stout cocoon of coarse silk from which the large moth, buff colored with conspicuous blue and black eyes on the under wings, emerges in May and June.

Citheronia regalis Fabr.—The "Indian Chief" caterpillar, a large dark green larva with four pointed and curved red horns on the back behind the head, feeds upon hickory and walnut and is never common enough to be injurious. It changes to a chrysalis in the ground, sometimes spinning a thin cocoon under fallen wood, etc., and in June and July of the following year hatches into a large handsome moth marked with orange red, and yellow.

Phlegethontius Carolina Linn.—The "tobacco worm," injurious also to potatoes and tomatoes, is familiar to every one, and has

* The Station will gladly answer inquiries concerning injurious insects, which should be accompanied in all cases by specimens of the insect and its food plant, packed in a stout box for mailing. Such inquiries should be addressed to the Conn. Agric. Exp. Station, New Haven, Conn.

been unusually injurious to tomatoes during the past season. The brown hawk moth which it produces, with round orange yellow spots along the sides of its body, hatches from the subterranean chrysalis in June and July. Both this and the "tomato worm" (*P. Celeus* Hubn.) are so large and conspicuous that they can be readily picked by hand. The latter species is comparatively rare in southern Connecticut: but replaces *P. Carolina* almost entirely further north.

Cœlodasys unicornis A. & S.—A number of brown hunch-backed larvæ with a green patch behind the head, received from Lakeville, proved to be this species, and were said to have been found on plum trees. The larvæ, beyond their odd shape, are peculiar for a biting, volatile acid which they secrete when handled, irritating when inhaled; but not poisonous, and common to all larvæ of the same genus and its allies (*Oedemasia*, *Ianassa*, etc.) The present species feeds on numerous plants, especially those belonging to the rose family (Rosaceæ); but, although common, is rarely injurious. The inconspicuous greenish gray moth is double brooded, the larvæ of the second brood hibernating in a brittle cocoon, changing to a chrysalis and then a moth in May and June.

Ecpantheria scribonia Stoll.—A large, black, hairy caterpillar, red between the segments, was received from West Haven. It spun a slight cocoon in the autumn and hatched during the winter in a warm room. The large, stout bodied, white moth, marked with irregular black rings, is rare in New England; but common in the Southern States, where, however, it does not appear to be injurious.

Crioceris Asparagi Linn.—Several complaints have been received of the depredations of the asparagus beetle which in some localities, has completely stripped the asparagus of its foliage. The brightly colored beetle hibernates, like the potato beetle, coming out in the spring to lay its eggs on the young market shoots. The eggs hatch into a dark blackish-brown larva which feeds on the asparagus till it is mature, changing to a chrysalis, and then to the beetle again, which lays another batch of eggs, so that several successive broods follow each other through the summer; the last brood of beetles hibernating as above mentioned.

It is a well known European pest, and was introduced into this country about 1859; appearing about New York, where it eventually became very destructive, extending into the neighboring states. To obviate their injury all volunteer growth, as well as the seedlings between the rows, should be destroyed, so that the beetles will be forced to lay their eggs upon the market shoots which can be cut and sold before the latter hatch. When cutting has been discontinued entirely, Paris green applied in the usual way several times during the season will destroy the larvæ effectually.

Coleothrips 3-fasciata Fitch.—A "rust" of oats has been the cause of much complaint throughout the State during the past summer, and where examined proved to be due, in most cases, not to the common fungus rusts (*Puccinia coronata* and *P. graminis*); but to a minute insect which Mr. Pergande of Washington has kindly determined as probably *Coleothrips 3-fasciata* Fitch. Fields infested by it have a reddish, wilted look and often mature comparatively little of their seed. No remedy can be suggested in this case.

Thrips, n. s.—The 'white blast' of market onions is the most serious disease to which onions in the field have been subject this year, and has been reported from numerous localities and observed in all the onion districts which have been visited. The injury gives the field a white appearance which starts in one or more spots and spreads in all directions. The onions themselves are stunted in their growth, the leaves dying more or less completely according to the severity of the attack, becoming water soaked at the base if the weather is at all wet, inducing decay and generally injuring the keeping quality of the bulbs. The insect which produces this result has been determined by Mr. Pergande as an undescribed species of *Thrips*, an insect allied to that producing the rust of oats above mentioned. A similar insect, very probably the same species, is described by Mr. Shipley (Kew Gardens Bulletin of Miscellaneous Information, No. 10, 1887, p. 18) in his studies of the onion diseases in Bermuda, but was not injurious to any extent according to his statement. Should it become so he suggests a treatment with sulphate of iron; but it seems probable that ordinary kerosene emulsion would be very effectual against this insect, which, from its habit of congregating in the angles between the leaves, would be readily and effectually reached by the solution, a trial of which is strongly recommended.

LABORATORY APPARATUS.

Here follows an account of several pieces of apparatus devised at this Station and proved by lengthened experience to be satisfactory. They represent a part of the work of the Station, and it is believed that full descriptions of them will be helpful to others engaged in agricultural investigation. This paper is accordingly technical in its character and is prepared especially for the use of agricultural chemists.

Hydrogen Generator.

A full supply of some inert gas is necessary in agricultural chemical laboratories for making moisture determinations with accuracy. Hydrogen by reason of its rapidity of diffusion and the ease of obtaining it in a state of comparative purity has decided advantages over any other gas. The ordinary Kipp generator and other portable apparatus do not supply enough gas nor sufficient pressure for this use.

The accompanying figures 1, 2 and 3 represent an apparatus made by Prof. S. W. Johnson and Dr. T. B. Osborne which has been in use for about three years at this Station with most satisfactory results. The principle of its construction is the same as of the Kipp generator. The three vessels *A*, *B* and *C*, Fig. 1, are of stone ware and were bought of Messrs. Eimer & Amend of New York. *A* is No. 8456 of their catalogue, "Woulff's Bottle of best German acid-proof stone ware," capacity 8 gallons. *B* is No. 5954*a*, "Chlorine apparatus of acid-proof stone ware, with ground air tight cover," capacity 20 gallons, and the perforated inside vessel, *C* is No. 5954*b*. *B* should be ordered with "outlet near the bottom and ground-in stop cock." The stone ware basket *C* within *B* is perforated with many ½ inch holes. In the bottom of *C* is placed a layer of coarse quartz gravel four or five inches deep. On this are laid 100 pounds of zinc spelter—broken ingots—as shown in the figure. The acid-reservoir *A* stands on a bracket shelf covered with sheet lead, directly above *B* so that any leakage may fall into the sink *M* below. The three necks of *A* are closed with rubber stoppers, the central one provided with a glycerine valve, seen in the figure, which admits air and hinders the escape of acid fumes. The pressure of gas is regulated by the height of the reservoir *A*. In our arrangement, a

Fig. 1.

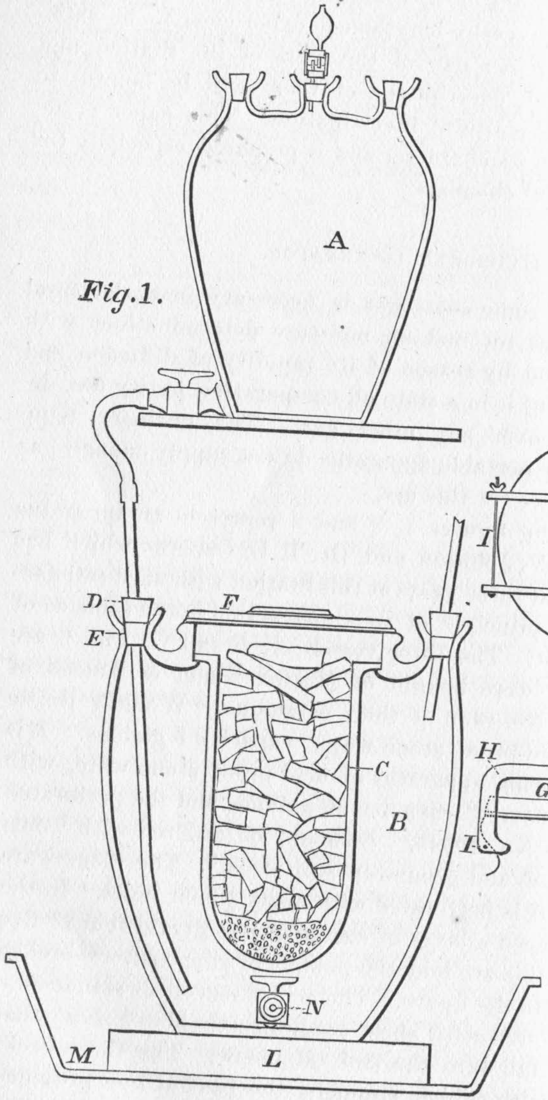


Fig. 2.

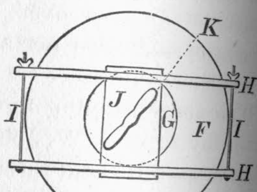
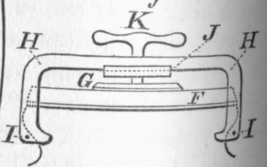


Fig. 3.



distance of only $3\frac{1}{4}$ feet between the bottoms of *A* and *B* was available and this has proved sufficient. *A* is connected with *B* by a stout glass tube one inch in diameter, which goes nearly to the bottom of *B*. It is joined to the stop cock of *A* by a tight-fitting piece of rubber hose which has been thoroughly soaked in a mixture of melted paraffine and vaseline. To enter *B* this tube passes loosely through a wooden collar, *D*, about 3 inches long and tightly through a rubber stopper, *E*, which is driven well down into the tubulure. The collar and stopper are securely tied down by stout copper wire to the neck of the tubulure. This fastening is not shown in the figure. The cup-shaped cavity above the stopper is finally filled with a melted mixture of paraffine and vaseline [having when cold the consistency of soft lard] so as to completely cover the rubber. The leaden exit tube of $\frac{1}{2}$ inch bore for the hydrogen gas shown on the opposite side of *B* is similarly secured. It is carried some 20 feet to a table in the laboratory on the floor above, where it is provided with a very carefully ground brass stop cock. In this way perfectly gas-tight joints capable of resisting the pressure of the apparatus are obtained without difficulty. The cover of *B*, see sectional drawings, Figs. 2 and 3, is made of cast iron $\frac{3}{4}$ inch thick in order to sustain the strain of the heavy clamps required to hold it in place. The earthen ware cover furnished with the jar was found to be too weak. Beneath the cover *F* which is planed to a true surface is a thick sheet of soft vulcanized rubber thoroughly impregnated with the melted paraffine-vaseline mixture. Above *F* is an iron disc *G* about six inches in diameter, separated from *F* by a rubber disc to equalize pressure. Two steel clamps *H H* tied together by iron screw-bolts, *I I* to keep them in position, rest on a wrought iron plate $\frac{1}{2}$ inch thick *J* whose ends are turned up as indicated in Fig. 3. Through the center of *J* passes the screw *K* $\frac{1}{2}$ inch thick with a transverse handle. The end of the screw bears upon the disc *G*. The ends of the clamps embrace the stout flange about the mouth of the stone-ware vessel and are well fitted to its contour.

The sheet rubber beneath the cover *F* serves not only to pack the joint but also to protect the iron from corrosion by the acid in the vessel beneath. The vessel *B* rests on a large fire brick *L* soaked in melted paraffine and this in turn stands in a heavy iron sink *M* well painted with asphalt. This iron sink (for which one of acid-proof stone-ware might perhaps be advantageously substituted), is bedded in mortar on a low brick platform on the cellar floor and its outlet is trapped into the drain.

The use of hydrochloric acid so diluted with water that it scarcely fumes [specific gravity 1.11] avoids the crystallization of zinc-salts in the apparatus. To charge this generator the stop cock of *A* is opened and acid is poured in till the vessel is three-fourths filled. When by use the acid is exhausted, the cock *N* is opened, the zinc chloride solution discharged into the sink and fresh acid is supplied through one of the tubulures in *A*.

Since setting up the apparatus about three years ago the vessel *B* has never been opened and the charge of zinc is apparently far from being exhausted. It was to avoid the trouble and expense of frequent attention that this apparatus was constructed and the greatest care was exercised to make it gas-tight and durable.

Gas Desiccator.

This apparatus was designed by Prof. S. W. Johnson, Director of this Station, primarily for drying hydrogen to be used in determining water in vegetable products. It consists of nine parts, wholly of glass, viz: the waste-acid jar *a*, fig. 4 and ground glass stopper *b*, the U-tube *h* with its accessory parts, the acid bulbs *l l*, the cocks *m* and the caps *q q*. The apparatus was made in Germany to order by Messrs. Eimer & Amend and cost, duty free, between $6.00 and $7.00. *a* is a cylindrical jar 5¼ inches in diameter and 5½ inches high, having a tubulure with ground glass stopper *b* for emptying the waste acid. The U-tube is fitted to *a* by a hollow ground glass stopper. Immediately above this is a trap whose construction is sufficiently plain from the figure. When acid trickles into this trap it rises in the outer bulb *d* and passing through *e* rises equally in the inner bulb till the level is above the top of the tube *f g* through which it discharges into *a*. The U-tube *h h* is 8 inches high from *f* to *s* and 1 inch in diameter, *i* and *i* are ingress and egress tubes. Each acid bulb *l* is fitted to the U-tube by the hollow ground-glass stopper *j*. In each stopper is a single perforation which by turning the bulb may be brought to coincide with the tubes *i* and *i* and so admit gas to the U-tube. This is shown on the right of the figure. The gas is shut off by turning each bulb slightly. Through *l* passes a glass rod *m* enlarged and flattened at *p* for convenience in turning. The lower part of this rod is enlarged and carefully ground to make a

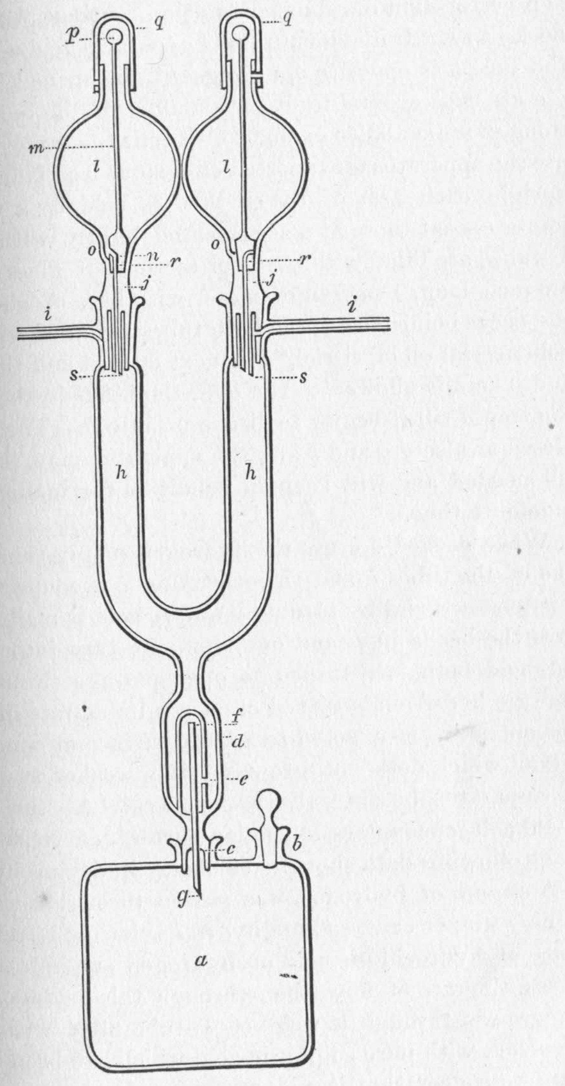


Fig. 4.

tight-stopper at and above *r* except at one point *o* where the wall of the acid bulb is expanded a little. In this section of the stopper is a perforation *n*. The perforation continues through the bulb-neck *j* to *s*. It is evident that if *l* contains acid and *p* is turned till the hole *n* is opposite *o*, passage will be opened between *l* and *h*. *q q* are caps ground to fit the shoulder of the bulbs with perforations as indicated to exclude or admit the atmospheric air. For use the apparatus is supported on a stout iron lamp-stand to whose upright each arm of the U-tube is held by a clamp. All the joints except those at *o* are smeared lightly with vaseline. The U-tubes are filled with beads or sections of glass tube about $\frac{1}{4}$ of an inch long, $\frac{1}{4}$ inch in diameter with bore of about $\frac{1}{8}$ inch. All the cocks being closed, the bulb tubes are filled with the strongest commercial oil of vitriol,* *b* is next opened and then by turning *p* and *p* acid is allowed to run over the beads in the U-tube and fill the trap *d* till it begins to discharge into *a*. The cocks are again closed as also *q q* and *b* and the apparatus may then be set aside till needed and will keep in condition for immediate use for an indefinite time.

When needed for use the hydrogen supply tube is joined with one of the tubes *i*, and the other tube *i* is connected as required, *b* is loosened and by turning *p* and *p*, acid is made to drop slowly over the beads in *h* and out from the trap into *a*. Next, both the acid bulbs are turned to open passage through the U-tube and the hydrogen is turned on at a suitable rate of flow. As the gas enters it is exposed to a large surface of concentrated oil of vitriol which does not grow sensibly weaker as in other forms of apparatus, because always renewed. As the gas leaves the U-tube it encounters a similar current of fresh oil of vitriol. The following data show its efficiency in drying hydrogen.

A stream of hydrogen was passed through a wash bottle containing 40 per cent. sodium hydrate solution, to retain a possible trace of hydrochloric acid or hydrogen sulphide and also to indicate the rate of flow, then through this drying apparatus, and afterwards through a weighed U-tube filled with broken glass, drenched with pure sulphuric acid which had been boiled in platinum to concentrate it and contained 94.17 per cent. of H_2SO_4. This was slightly stronger than the acid used in the drying apparatus at the time. Hydrogen was passed through the apparatus at a measured rate while each of the bulbs of the drying tubes delivered a certain number of drops of oil of vitriol per minute. The results of several experiments, in which the weight of the U-tube remained fairly constant within the ordinary limits of error, are given in the following table:

No. of experiments.	Rate of flow of hydrogen. No. of minutes per liter.	No. of liters of hydrogen passed.	Flow of oil of vitriol in apparatus. No. of drops per minute.	Time of experiment in minutes.	Gain or loss of weight of U-tube in grams.
1	$5\frac{2}{3}$	5.3	18–20	30	.0000
2	$4\frac{1}{6}$	7.2	18–20	30	+.0003
3	$4\frac{1}{6}$	14.4	18–20	60	+.0003
4	$4\frac{1}{2}$	13.3	11–12	60	−.0005
5	$3\frac{1}{2}$	8.5	6– 7	30	−.0009
6	$3\frac{1}{2}$	8.5	6– 7	30	−.0001
7	$2\frac{1}{2}$	24.0	5– 8	60	.0000

* We now use an acid of 97 per cent. H_2SO_4, which we have obtained from the Fairfield Chemical Co., 71 Wall St., N. Y., for two cents a pound by the carboy.

Apparatus for Drying in Hydrogen.

This apparatus was devised by Mr. A. L. Winton of this Station, and has been in use for a year and a half. A in fig. 5 is a rectangular copper boiler 9 inches long, 9 inches wide and 7 inches deep, supported by iron legs. B is a stopcock, through which the tank can be emptied, and which carries a glass gauge for showing the water level, attached by a rubber stopper. Through the short tube C a thermometer may be introduced. D is a copper tube connecting with a block tin worm inside the condenser tank E, which is 9 inches long, 5 inches wide and 4 inches deep, and is held 3 inches above the boiler by copper supports. When in use, cold water is supplied to this condenser to prevent loss by evaporation from the boiler. Eight copper tubes G, arranged as in the figure, pass through the boiler horizontally. They are $\frac{9}{16}$ inch inside diameter and as long as the width of the boiler, 9 inches, and their open ends are soldered flush with the sides of the latter. The copper brackets F support the metal tubes I, through which hydrogen is supplied.

Fig. 6 shows four of the eight glass drying tubes G, attached by rubber connectors H to the copper tube I, and ready for insertion into the tubes G of fig. 5. These glass tubes, each numbered and provided with numbered cork stoppers, have the shape shown in the figure. They are 8 inches long and about $\frac{1}{2}$ inch in outside diameter. For use, a small cotton plug closes the throat of the tube at J, two grams of the finely pulverized, air-dry material in which a water determination is to be made, are weighed on a watch glass and poured in through a funnel, or weighed in directly from a weighing tube, another small cotton

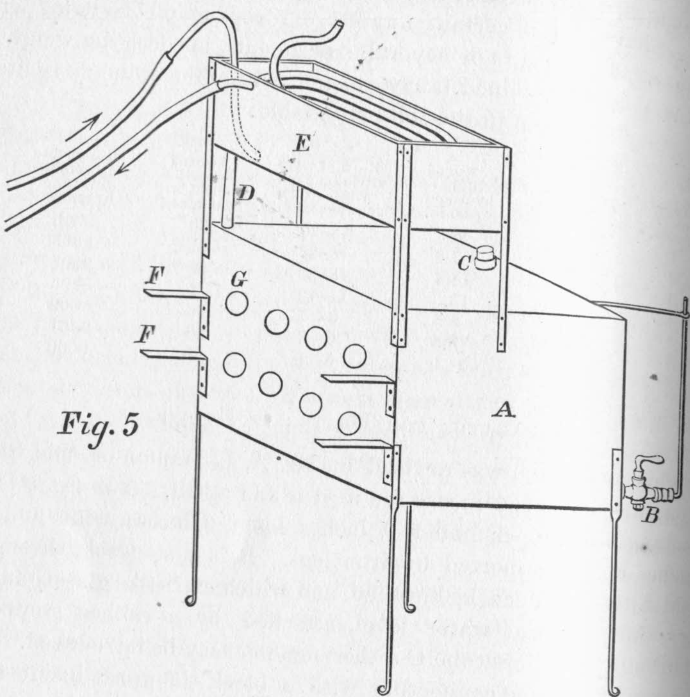


Fig. 5

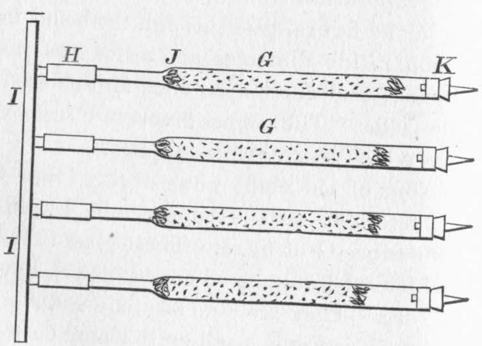


Fig. 6.

plug is inserted and the stoppers are put in place. The tubes are wiped and in 20 minutes can be weighed. They are then fitted with stoppers K, carrying glass tubes which are drawn out to a fine opening and are connected by rubber with copper tubes I. These tubes are closed at one end and have an inside diameter of $\frac{1}{4}$ inch with offsets of the same diameter as the glass tubes. A three-way glass tube with rubber connectors joins two of these copper tubes to each other and to the hydrogen supply. At first the tubes are so placed that the jets do not project beyond the side of the boiler; otherwise the moisture will condense in them. A slow current of dry hydrogen displaces the air, and after most of the moisture is gone, the gas jets are made to project and the gas lighted to show that it is passing through all the tubes. If the pressure is sufficient there will be no difficulty in distributing the hydrogen. The boiler, filled to G, with water, to which salt may be added if necessary to raise the boiling point to 100° C. is heated by a gasburner. The material is dried till repeated weighings demonstrate that the weight remains constant. From three to five hours have been found sufficient in most cases. We have practiced replacing the hydrogen in the tubes at the close of the operation by perfectly dry air before weighing.

Aliquotimeter.

The apparatus here described was made by Mr. Winton with special reference to the routine work of fertilizer analysis. To determine total phosphoric acid, $2\frac{1}{2}$ or 5 grams of the phosphate, after ignition with magnesium nitrate, are brought into a half liter flask* and dissolved in hydrochloric or nitric acid. It is then necessary to make the volume of solution 500^{cc}, to pass it through a dry filter and measure off 100^{cc} for the determination. If the number of determinations is large, these operations are very tedious, when hand-pipettes are used, the least agreeable part of the work being the continued use of the mouth in filling and rinsing the pipette. A funnel and a flask are also required for each determination, thus adding considerably to the work of dish-washing. For accurate work a pipette should never be emptied by blowing into it and should be held perfectly still

* Messrs. Whitall & Tatum of N. Y., supply half liter flasks accurately graduated, in which solutions can be boiled. By their use one transference of the solution can be avoided.

while the liquid is running out, points which are sometimes disregarded, but which with the apparatus here described do not tax the operator's attention.

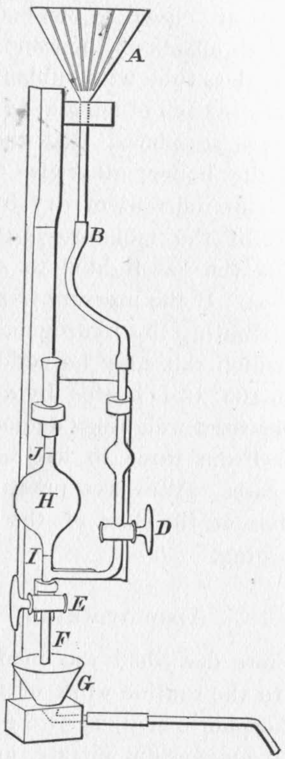


Fig. 7.

In fig. 7, H represents a pipette properly graduated to deliver 100^{cc} when the surface of the liquid falls from the mark J to I by opening the stop cock E. Below I is a branch tube having a stop cock with $\frac{1}{8}$-in. bore, D, and a small bulb which prevents bubbles of air from being carried down the tube. To this tube by the rubber at B is attached a funnel A. The apparatus is mounted on a wooden support, partly shown in the figure.

For use, D and E being closed, the solution to be measured is poured on a plain filter, contained in the funnel. When the solution has filled the funnel, D is opened and the pipette H filled. Next D is closed and E opened, and to rinse the apparatus, the solution is run off through G to the sink. E is again closed, D is opened and the pipette filled to the mark J. Next, D being closed, 100^{cc} are drawn off through F into the beaker for precipitation. The filter and contents are removed and the same operations are repeated with the next solution. The waste-funnel is mounted in a block of wood with which it is pushed aside when the aliquot is drawn into a beaker.

To secure rapid filtration in the funnel A, a number of slender glass rods are disposed radially within it. They may be kept equidistant and in proper position by ligatures of thin platinum wire. Folded filters are very liable to be broken, but might doubtless be used if supported at the vertex by a platinum cone.

Apparatus for Determining Nitrogen by the Method of Kjeldahl.

1. The substance to be analyzed is weighed into long necked pear-shaped digesting flasks whose transverse diameter is about 3 inches. Ten of these are firmly supported in a portable box or frame of light wood (not figured) carrying two horizontal shelves 21 inches long, 8 inches wide and 6 inches apart, the lower one having two rows of $2\frac{1}{4}$ inch holes over which the flasks rest, the upper shelf being divided lengthwise into three sections. Of these the two outer ones are fixed to the frame: they are 2 inches wide and each has on its inner edge five notches of about 1 inch depth which engage the necks of the flasks. The third movable section, 4 inches wide, when put in place secures the flasks in a nearly vertical position.

2. The sulphuric acid is measured into the digesting flasks by help of the arrangement *a*, *b*, *c* shown at the right in figure 8. The H_2SO_4 reservoir *a* of 4 liters capacity is supported on a shelf. It is closed by a rubber stopper through which pass two glass tubes. One of these communicates with the exterior air through an oil of vitriol trap to exclude ammonia. The other is a syphon whose short arm (erroneously figured) reaches to the bottom of *a*, and whose long arm is provided with a cock, and connects by a rubber stopper with the measuring cylinder *b*. Except when *b* is in actual use, the upper lateral cock is kept closed. The delivery tube must be rinsed with a little acid just before using to remove any absorbed ammonia. When *b* is not in use, the small beaker *d*, supported by a hinged wire, is brought under *c*

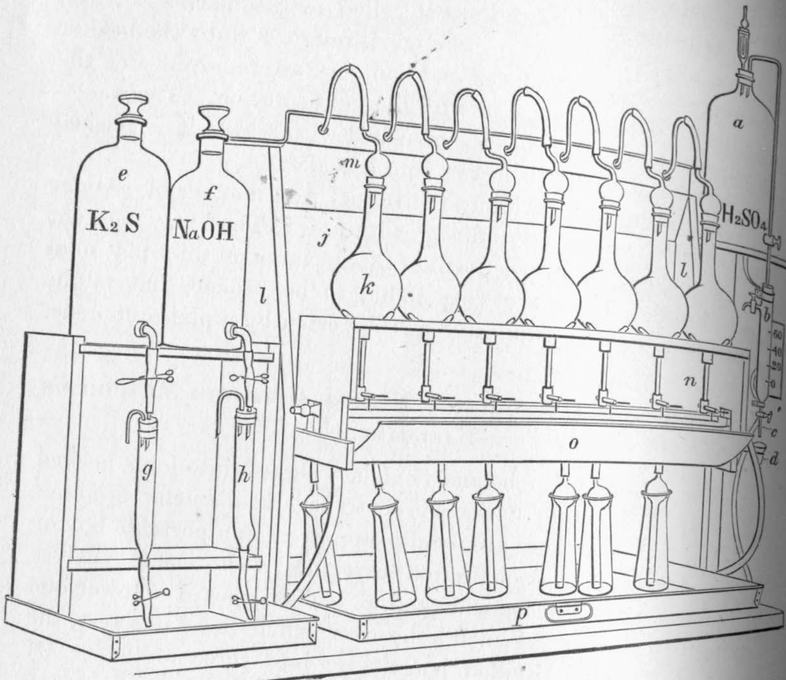


Fig. 8.

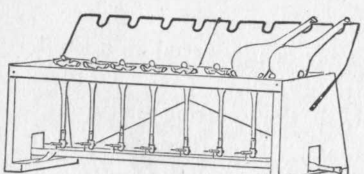


Fig. 9.

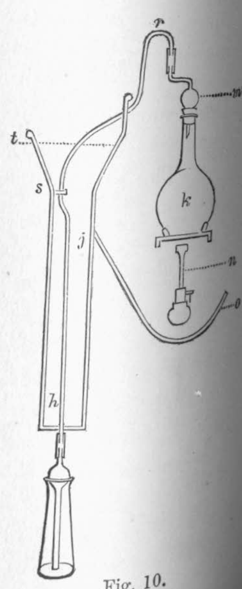


Fig. 10.

to catch the drip. The cylinder *b* is secured to the vertical edge of a fixed wooden support by means of tin-plate clamps and wood-screws.

3. The digestion flasks charged with acid and mercuric oxide are next placed on the lamp stand, fig. 9, which is made of stout sheet iron. The ends as seen in cut, measure 6 inches high, 6 inches wide at top and 7½ inches at bottom. Each end is made from a piece of iron so large that by turning its edges at right angles and cutting away the overlapping corners, a flange is made 2 inches wide at bottom and 1 inch wide on the top and sides. Each end is notched below to admit the long gas tube which bears the Bunsen burners. An iron sheet 13 inches wide and (for 8 flasks), 37 inches long is bent lengthwise at nearly right angles one inch from one edge and again at about 6 inches from the other edge to form a top, a back and a narrow front to the stand. This piece of metal is finally riveted to the inch flanges of the end pieces above described.

Before bending however, 8 holes are cut in the top section as follows :—Draw a line 4 inches from and parallel to the edge of the unbent plate, and from centers 4½ inches apart on this line, describe 8 equidistant circles of 3½ inches diameter ; next mark 12 equidistant points on the circumference of each circle, and from alternate points as centers draw semicircles of ⅝ inches radius within the large circles. Now cut away the metal of the large circles except so much as the small semicircles include, and bend upwards at right angles three alternate tongues, thus made, for each aperture. The necks of the flasks are supported at proper inclination by a small iron rod bent and riveted as shown in the figure. The iron ends of the stand are screwed by the bottom flange upon pine strips each 7½ by 2 by 1 inch, and the gaspipe carrying the lamps is secured to these strips by clamps or bands of sheet iron. The flasks are heated over the naked flame of Bunsen burners arranged like those of the Erlenmeyer combustion furnace. The burners are either widened out funnel-shape at the top and covered with short wire gauze caps, or longer cylindrical gauze caps are supported upon ordinary burners so that the top of the caps is ½ inch above the burner. By either arrangement the flames may be turned very low without risk of striking down or becoming smoky.

4. When the digestion is completed and after treatment with permanganate the solutions are transferred to distilling flasks of

about 600^{cc}. capacity, k, fig. 8. To each flask is added 25^{cc}. of K_2S solution from the bottle e by help of the measuring cylinder g, which swings freely by its rubber connections. From f a slight excess of NaOH solution [50%] is introduced and after adding a few pieces of granulated zinc and, to prevent foaming, a bit of paraffine, the flasks are mounted as shown in figures 8 and 10. Each flask is fitted with a rubber stopper carrying a spray-trap, m. This is a bulbed tube bent twice at right angles having a diameter of ½ inch and bore of ⅜ inch; the diameter of the bulb is 1½ inches. The spray-trap is joined by a rubber connector to the block tin-condensing tube r fig. 10, which has a bore of ⅛ inch and a total length of 32 inches. This condensing tube passes vertically through an open tank made of sheet copper, j, and is firmly soldered into the bottom of the same but is supported above by simply passing through holes in the upper rim of the tank and in a narrow horizontal shelf at s, fig. 10. The dimensions of the tank with 7 condensing tubes are, length 32 inches, depth from t 16 inches, width at top 6 inches, at base 3 inches. The tank was widened at the top with a view to its use with ice in hot weather for alcohol estimations, etc. For ammonia-distillations simply, ice is never required and a tank of much less capacity is sufficient. Cold water is supplied at one end through a syphon, one leg of which is connected with a service pipe, the other reaching to the bottom of the tank. A short efflux tube of ½ inch bore is soldered into the other end of the tank at the level of t. The flasks are heated by gauze-capped Bunsen burners n and are supported on an iron shelf quite similar to that represented in fig. 9.

The distillates are received in so-called precipitating jars of about 7 inches height. The tin condensing tubes which project underneath some three inches are joined by rubber connections to bulbed tubes which should be somewhat shorter than shown in figure 8 so as to just dip into the standard acid in the jars. These tubes are of ¾ in. caliber at the widest, except the bulbs which are about 1¾ inches in diameter. The bulbs serve as covers for the jars and assist to prevent loss of their contents either by spirting or regurgitation.

5. The tank when full of water requires a substantial support which consists of two uprights, l l, fig. 8, cut from a pine board. Each upright at the base and for half its height is 12 inches wide, at top 6 inches wide and is 27 inches high. At 11 in. from the table the base of the tank rests upon a pine shelf with holes for the projecting tin tubes. This shelf is supported by transverse battens 18 in. long secured to the uprights and which project in front to support the lamp-stand. The uprights are kept in position by means of 4 brass rods of about ⅛ inch diameter fitted with screw, nut and washer at each end. These rods traverse the uprights close to the tank, two on its opposite sides below near h and two above near the level of s. The nuts being screwed on tightly, bind the whole firmly together.

To protect the table and distillate from injury in case a distilling flask should break, the galvanized iron screen o, fig. 10 is employed. The lower part of this is made into a trough by suitable end pieces and at the bottom is connected with the sink by a rubber tube seen at the left in fig. 8. A half hour's distillation is sufficient to completely expel ammonia from the distilling flasks and condenser tubes. When in constant use the tank should be emptied once a week and steam blown through the condenser tubes to remove paraffine deposited in them. Glass condensing tubes are objectionable since as is well known they always yield more or less alkali to hot water or steam.

The spray-traps which were devised by Dr. Osborne are at once effectual and simple and we have repeatedly filled distilling flasks more than half full of water to which 50^{cc}. of NaOH solution was added, with granulated zinc, and boiled as fast as the full heat of the lamps would allow for half an hour and found in the distillates alkali equivalent to but 4 to 5 one-hundredths of one per cent of nitrogen reckoned on one gram of substance. When the rate of boiling is not excessive the error caused by the spray carried over is inappreciable. In a working day of seven hours one operator with one distilling apparatus and two digestion stands, can make 30 to 35 nitrogen determinations in feeding stuffs. In fertilizers fewer determinations can be made because a longer time is usually consumed in the digestions with sulphuric acid.

Drying Oven.

A fully representative sample of maize stalks, coarse grasses or other forage plants can only be secured by gathering a large quantity of the material from all parts of the field, plot or mow. This must then be so subdivided that it can be thoroughly intermixed so as to yield finally an average portion not too large to be ground to a fine meal suitable for analysis.

Fresh material containing from 30 to 80 per cent. of water may be cut by machinery or hand into pieces from ½ to 1 inch long, and, after thorough mixing, a fraction of the whole taken for drying. This is then dried, rough ground, and a weighed fraction of it again taken to be pulverized for analysis. Owing to the labor involved in handling the bulky material the temptation is strong to draw samples as small as may be. This always involves danger of making the sample unrepresentative and thus vitiating the results of further work. Without a fair sample the best analysis has little or no value.

A capacious drying apparatus and a mill run by a steam or gas engine makes it possible to handle large samples conveniently and greatly diminishes the risks of sampling. Every laboratory needs a large drying oven which may be left to the care of laboratory helpers without danger of damage to its contents. It must dry quickly, for slow drying is favorable to loss by fermentation; the heat, however, must not be sufficient to "cook" the samples, i. e. to disintegrate starch grains or coagulate albuminoids.

Not having live steam at our disposal the oven herewith described was constructed and has given satisfaction for the last two years. It is built in the basement of the laboratory against a broad chimney-stack which forms its rear wall, and consists of a brick-work base containing the heating apparatus and a wooden superstructure which carries the trays in which the material to be dried is spread. The full details of the carpentry cannot well be given but are simple and can be readily planned by any practical joiner. The sketch, fig. 11, will give an idea of the construction. The brick base is 32 inches high, 5 feet 6 inches long and 34 inches from front to back, outside measurement. The opening, or fire-door at the end, see fig. 11, is 18 inches wide and is closed by an asbestos board ⅜ inch thick, having a wooden base and handle on the outside. The brick-work is 4 inches thick except at the right of the fire-door where an 8-inch pier is built. In front two bricks are left out of the lower course and one brick also on the end opposite the fire-door. These are the openings of short brick flues laid on the floor which deliver cold air directly under the smoke pipe within. These openings may be closed with brick when desired. Within this enclosure stands a small cast-iron laundry stove for anthracite or coke, known in trade as "Sweetmeat No. 1." Its widest diameter is about 17 inches and its body is about 16 inches high. To save space the stove without

its legs is bedded in mortar on the floor. It is placed as near as possible to the fire-door so that coal can be conveniently supplied and ashes removed. The smoke pipe leading from stove to chimney flue is about 16 feet long and traverses the brick enclo-

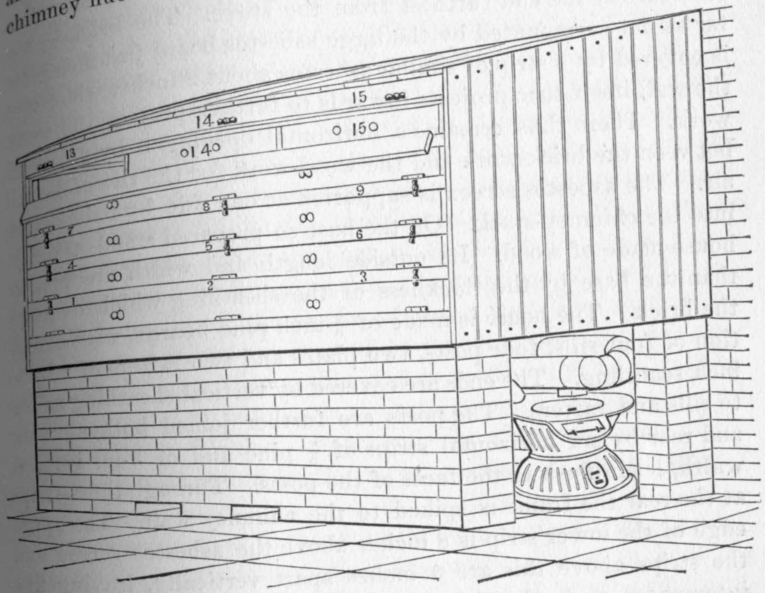


Fig. 11.

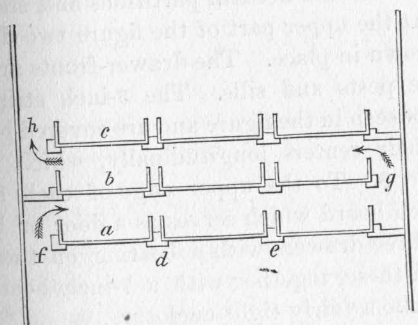


Fig. 12.

sure back and forth four times in parallel lengths (the second and third lengths being under the first and fourth), and enters the flue by a fifth short length near the fire-door. The first, fourth and fifth lengths of pipe are seen in the figure. This pipe has eleven elbows.

A screen of asbestos board $\frac{3}{8}$ of an inch thick, 4 feet 9 inches long and 34 inches wide is laid over this brick structure, covering the wall at the fire-door end, to protect the wood-work above from too intense heat. Heated air must therefore pass into the super-structure at the end furthest from the stove. The brick wall so far as not surmounted by the large asbestos board just mentioned is covered by a strip of similar asbestos about 2 inches wider than the wall itself that projects inwards to further protect the wood-work. There thus remains a horizontal opening 3 by 28 inches between the brick-work and the wood-work for the rise of heated air. The asbestos screen is supported at one side by nails driven into the chimney-stack. On the base so prepared stands the dry-house made of wood. Its outside length and width are greater than the base by the thickness of the sheathing which overlaps the brick. The house is made of $\frac{7}{8}$-inch pine boards, with exception of four sills, four posts, two plates and two rafters of 2 by 3-inch scantling. The ends are covered by vertical sheathing nailed to sills and rafters. The posts are further joined both at front and rear by six horizontal strips of $\frac{7}{8}$ pine and of 3-in. vertical width, let in flush to the faces of the posts. Through these strips at the rear the frame is spiked to the chimney wall. The upper edge of the lower strip is 8 inches above the asbestos screen and the strips above this are 3 inches apart vertically, leaving five interspaces, each of which gives room for three drawers as shown in fig. 11, for which the needful partitions and slides are suitably framed in. At the upper part of the figure two drawers, Nos. 14 and 15, are shown in place. The drawer-fronts are flush with the outside of the posts and sills. The 3-inch strips between the drawers are not seen in the figure and are covered by $1\frac{1}{2}$-inch strips nailed over their centers longitudinally, which in the cut are numbered 1 to 9. To the upper edge of each $1\frac{1}{2}$-inch strip is hinged a $4\frac{1}{2}$-inch board which serves as a door or lid to shut over the fronts of three drawers with a bearing on the drawer-frames all around, and these, together with a 7-inch board nailed on at the bottom, make a fairly tight enclosure.

The drawers or trays are each $20\frac{1}{4}$ inches wide and 34 inches long from front to rear, outside measurement. The drawer-frames are made $2\frac{1}{2}$ inches deep and the bottoms are galvanized iron netting of $\frac{1}{4}$-inch mesh secured underneath by $\frac{3}{8}$-inch strips nailed on through the netting, making a total depth of 3 inches. Two 1-inch augur holes 3 inches apart, at the middle of the drawer-front, serve as a "pull." The fifteen trays have an aggregate area of over 60 square feet and about $12\frac{1}{2}$ cubic feet content.

The interior arrangement is shown in section by fig. 12 [not to scale]. Supposing the trays all to be filled with substance to be dried resting on sheets of thin paper that completely cover the netting bottoms, the hot air rising [at the rear end of the horizontal asbestos screen placed between the brick-work and the wood-work] enters *f*, the end-space between the sheathing and the slide on which drawer *a* runs, thence it is made to pass over all the drawers in succession, its course being indicated by the arrows [alternate end-spaces, which have a horizontal measurement of 2 by 28 inches, being closed for that purpose] and finally enters the chimney just under the roof of the dry-house by a 6-inch hole that opens directly into a flue, adjoining and warmed by, the flue which carries off the smoke of the stove. The roof of the dry-house is a movable cover of battened sheathing which rests on the plates and rafters and is kept in position by the sheathing at the ends, and by notches in the rafters which engage the ends of the battens. We find it best to block up the lower edge of the cover an inch or so and let the moisture-laden air escape directly into the room.

Thermometers kept in the trays for hours while fire was burning in the stove, their bulbs being immersed in sand to hold the temperature during observations, gave the following readings in degrees Centigrade:

	12 M.	1 P. M.	3 P. M.	4 P. M.	5 P. M.
Tray No. 1	50°	46°	48°	43°	42°
" " 3	51°	50°	50°	45°	44°
" " 5	50°	46°	46°	43°	41°
" " 12	46°	40°	42°	38°	42°

Apparatus for Determining Nitric Acid.

This modification of the Schulze-Tiemann apparatus, devised by Dr. Osborne, is much more convenient for rapid work than the original. The flask *a*, Fig. 13, of about 150 c. c. capacity and of glass so thick, that it will sustain the full atmospheric pressure, is provided with a doubly perforated stopper carrying the funnel tube *b*, closed by the pinchcock *c*. The glass exit tube *d* is joined by stout rubber tubing to the three way tube *e*, as shown in the figure. One branch of this tube has a short rubber tube attached which may be closed by the pinchcock *n*. The other branch is connected by glass and rubber tubing with the bulb *f*, which in turn is joined to the 100 c. c. burette *g*. This burette is surrounded by a water jacket so that the gas in it may be easily cooled to a constant temperature by a stream of water. The tip of the burette passes through a rubber stopper in a glass tube *h*, which forms a small reservoir for caustic soda solution used to wash the gas at the close of the operation. A second glass tube

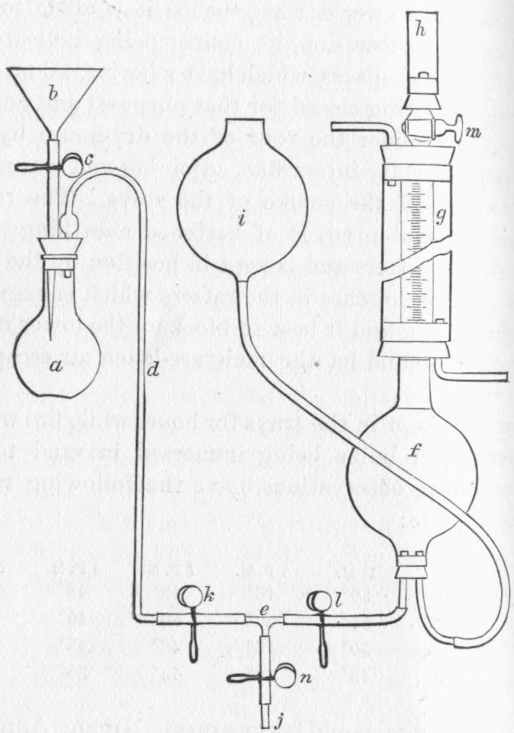


Fig. 13.

enters the bottom of the bulb *f*, and is connected by a long rubber tube to the bulb *i*, which contains a ten per cent. caustic soda solution. The substance for analysis is placed in the flask *a*, if necessary enough sodium carbonate is added to make the reaction neutral or alkaline and the flask is then two-thirds filled with freshly boiled water and the stopper inserted. The contents are then boiled down to a small volume, the steam escaping through *j*, the clamps *k* and *n* being open and *l* closed. In the mean time

the burette is filled with freshly boiled caustic soda solution by filling the bulb *i*, and raising it until the solution runs from the burette into *h*. The stopcock *m* is then closed and *i* about half filled with soda solution. When the contents of *a* have been boiled to a small volume the lamp is removed and the clamp *k* is closed and *l* opened. The soda solution will then run out through *j*, filling the tubes; *j* is then closed and *k* opened carefully. The diminishing pressure in *a*, due to cooling, will cause the soda solution to rise in the tube *d*. When it has risen an inch or two *k* is closed and by cautiously opening *c* ferrous chloride solution is run from the funnel *b* into *a*, followed by hydrochloric acid. The clamp *c* is then closed and the lamp replaced under *a*. By opening the clamp *k* from time to time the pressure in the flask *a* can be ascertained. As soon as the solution in the tube *d* begins to fall, *k* is left open and the gas from *a* passes through the tubes into *f* and into the burette. In the meantime the bulb *i* is placed in a position below *g* in order to diminish the pressure within the burette. While collecting the gas, water is kept running through the jacket and is allowed to flow over *f*, thereby keeping the solution cool. When the gas has ceased to come off, *h* is filled with the soda solution and by opening *m* the contents are allowed to run slowly into the burette so as to wash the interior surface of the latter and remove any trace of carbonic or hydrochloric acids which it might contain. The cock *m* is then closed, the bulb *i* is raised to bring the surfaces of the solution in the bulb and in the burette to the same level and the volume of gas read. If after a few minutes the reading is unchanged the gas has been cooled sufficiently.

With this apparatus the results obtained have been in every way satisfactory and the time reduced to a minimum. Thirty to forty minutes are commonly sufficient to complete a determination. Further, if it happens that the amount of nitrate present evolves more gas than the burette will hold the boiling may be suspended, the clamp *k* closed and the evolved gas measured. The burette is then filled with soda solution again and the remaining gas collected and measured. By using a flask strong enough to sustain a complete vacuum this can be done easily and without danger.

Gas Engine and Mill.

It may not be out of place to say that the Station has used an Otto gas engine of one and a quarter horse power for the last year and a half with very satisfactory results, in connection with the Excelsior Mill noticed in our Report for 1888, page 11.

The engine was first run on June 23d, 1888, and since that time all feeding stuffs analyzed here have been ground by its power. Many of the samples have been quite large, the ease of grinding rendering it less imperative to keep the samples small than when hand power was used.

The total consumption of gas up to Sept. 1st, 1889, was 6900 feet, costing $10.35. $2.55 have been spent for oil and $1.00 in repairs.

The first cost of the engine was	$290.00
Setting, with shafting, pulleys, belting, etc.	129.91
Excelsior Mill, duty free	50.00
Setting up and connecting same	31.40
	$501.31

FIELD EXPERIMENTS.

IN 1889.

I. On the Comparative Agricultural Value of Superphosphate and certain Natural or Raw Phosphates.

For the last three years the Station, with the coöperation of farmers in different parts of the State, has carried out field experiments designed to give information on this subject. The facts which suggested the experiments may here be again briefly stated.

The market price of phosphoric acid varies greatly according to the form in which it is bought. Thus it costs in dissolved bone black about 8 cents per pound, in dissolved South Carolina rock between 5 and 6 cents, in Bolivian guano between 4 and 5 cents and in Grand Cayman's phosphate and ground South Carolina rock 3 cents per pound.

That the more expensive forms are also the ones most quickly available to plants may readily be admitted, but it is a question whether the cost prices stand always in direct relation to the agricultural value; that is, on land deficient in phosphates will $5.00 per acre spent in buying dissolved bone black for instance yield a greater or less return in the long run, than the same money spent for South Carolina rock or other raw phosphates, seeing that more than twice as much phosphoric acid can be bought for the same money in some of the cheaper forms, as can be bought in dissolved bone black?

The fact that the farmers of this State annually spend from $275,000 to $300,000 for phosphoric acid alone, makes this question practical and important.

The general plan of these experiments has been to broadcast over the whole field under experiment, a liberal quantity of nitrogenous matter and potash salts, and to divide it then into seven or more plots of equal size. On one plot a quantity of Dissolved Bone Black was used which, it was believed, would not be in excess of the needs of a full crop, but rather slightly deficient. Two other plots with no phosphates served to show what the land could produce without the addition of phosphates. On single plots, each of the other phosphates was used in such quantity, that the cost of each was just equal to the cost of the dissolved bone black on the first plot. The comparative effects were measured by the weights of the crop produced.

Mr. W. I. Bartholomew's Experiment.

The data regarding the experiment field, soil, arrangement of plots, etc., have been fully given in the Station Reports for 1887, page 110, and 1888, page 112, and need not be repeated here. Last season, the field was planted to the same variety of corn for the third successive year, after plowing, broadcasting 320 pounds of muriate of potash and 100 pounds of sulphate of ammonia per acre and harrowing. No phosphates were applied, except as mentioned below, the object being to note the after-effects of the phosphates applied in 1887.

The details of the experiment are given in Mr. Bartholomew's written report to the Director.

"In making this the third year's report of the continued field experiment with phosphates, which was commenced in the season of 1887, to ascertain the comparative values of several phosphatic materials furnished by your Station, and carried on under the direction and observation of its officers, I have but little to remark in addition to the figures which give to you the weight of the ears of corn grown on each plot this season.

At planting time, the indications were favorable for a good crop. The corn came up well and met with no accident, save that a few hills were pulled by the crows. Sufficient plants were successfully replaced in these from a bed of plants raised for such contingency, and their growth was quite similar to the others.

Differences in the appearance of the several plots were quite manifest, although on all except plot G, the corn was small, and evidently needed nourishment of some kind. Plot G alone received a supply of dissolved bone black at this planting. It had no phosphate during the two previous years, and responded quickly to the application, and the crop at harvest was not only greater in weight, but superior in ripeness and soundness to that on the other plots.

On the 20th of June, as we were hoeing the corn, I sprinkled a small quantity of dissolved bone black about the roots of the plants on three cross sections of the plots, the width of these sections being one rod each (see diagram). In two weeks this produced a visible change in the appearance of the corn to which it was applied, and there was a decided increase in the crop from the parts receiving it.

In the early part of August, after a period of extremely wet weather, a rust or blight was noticeable on the leaves over the

whole field,* which seemed to check growth and to prevent the crop from maturing as fully as it otherwise would have done, and the husks adhered closely to many of the ears, causing them to mould.

As a paying crop, this was not a success, but as showing the lasting effects of the phosphates used, as well as the ready response given to a small quantity of available phosphoric acid, although applied late in the season, I think it interesting."

The accompanying diagram will make clear the plan of the experiment. The weights of the ears harvested are given for each plot, and for each consecutive fifty hills in each plot, in pounds.

These figures show that the field was somewhat more productive on the west side, but this did not injure the experiment as all the plots ran from east to west.

The cross sections, one rod wide, referred to by Mr. Bartholomew, where a little dissolved bone black was sprinkled about the roots of the corn at hoeing time, June 20, are indicated by the full-faced figures, and show the increased yield caused by it.

This experiment has now come to a conclusion as far as the corn crop is concerned. It is necessary that some other crop should take its place. The results of the three years' planting to corn may profitably be considered together.

Results.

If we call the average yield of plots C and F, which received no phosphate, 100 per cent., the yields of the other plots expressed in per cents, are as follows:—

Season of 1887.

	Sound ears.	Soft ears.	Stover.	Total crop.
No phosphate	100	100	100	100
A, Dissolved Bone Black	144	67	102	111
B, Grand Cayman's Phosphate	141	64	121	119
D, Thomas-Slag	140	57	107	110
E, South Carolina Rock	118	66	99	100

Season of 1888.

	Sound ears.	Soft ears.	Stover.	Total crop.
No phosphate	100	100	100	100
A, Dissolved Bone Black	111	77	112	106
B, Grand Cayman's Phosphate	137	73	125	121
D, Thomas-Slag	140	65	135	125
E, South Carolina Rock	127	80	118	115

* See page 170.

A, Dissolved Bone Black put on in 1887.

12 **17** 10 13 **21** 15 18 **22** 24 24

Total, 176 pounds.

B, Grand Cayman's Phosphate put on in 1887.

19 **29** 27 20 **26** 26 20 **26** 31 31

Total, 255 pounds.

C, No Phosphate put on.

17 **18** 11 13 **23** 15 21 **23** 22 20

Total, 183 pounds.

D, Thomas-Slag put on in 1887.

22 **32** 20 25 **27** 25 29 **31** 31 32

Total, 274 pounds.

E, South Carolina Rock put on in 1887.

21 **22** 21 16 **22** 17 23 **28** 28 28

Total, 226 pounds.

F, No Phosphate put on in 1887.

14 **19** 11 12 **20** 10 15 **23** 21 23

Total, 168 pounds.

G, Gypsum, put on in 1887. Dissolved Bone Black in 1889.

28 **32** 20 **29** 29 31 27 **32** 31 38

Total, 297 pounds.

The plots are 2 rods wide and 10 rods long and contain one-eighth of an acre each. The hills of corn are one-fifth of a rod apart each way and the outside hills are one-tenth of a rod from the edge of the plot. Between the plots are spaces one-fifth of a rod wide and in the middle of each space is a single row of potatoes. The whole ground under experiment is surrounded by a double row of potatoes.

	Season of 1889. Sound and soft ears.
No phosphate	100
A, Dissolved Bone Black	100
B, Grand Cayman's Phosphate	145
D, Thomas-Slag	156
E, South Carolina Rock	129

1. In 1887, the year in which the phosphates were applied, equal money values of Dissolved Bone Black, Grand Cayman's Phosphate and Thomas-Slag had approximately equal effects on the yield of the corn crop. An equal money value of ground South Carolina rock produced less than half as much increase of sound ears as the other phosphates and no increase at all of stover. That is, in that season and on that land $5.00 would have paid about equally well whether it was spent for Dissolved Bone Black, Grand Cayman's Phosphate or Thomas-Slag.

2. In 1888 no phosphates were applied. The effects of Grand Cayman's Phosphate and Thomas-Slag, however, were as pronounced as they were the year before, making as large or a larger percentage increase over the plots which had received no phosphate in 1887. South Carolina Rock made a considerably larger percentage increase than the year before, showing that it was slowly becoming available in the soil.

But while Grand Cayman's Phosphate and Thomas-Slag produced nearly 40 per cent. more of sound ears and 25 per cent. more of total crop than the no-phosphate plots, Dissolved Bone Black in 1888 yielded only 11 per cent. more of sound ears and 6 per cent. more of total crop than the no-phosphate plots.

That is, the seasons and the land being such as they were, $5.00, if invested in 1887 in Grand Cayman's Phosphate or Thomas-Slag would have yielded in 1887 as much income as if invested in Dissolved Bone Black, and in 1888 would have yielded a much larger income. These facts were explained last year by showing from the analysis of the crops, that where Dissolved Bone Black was applied in 1887 there was not quite sufficient phosphoric acid left in the soil from this application to meet the requirements of the crop for 1888; therefore, it is not surprising that the yield on plot A in 1888 is but little larger than on the plot which received no phosphate in either year.

		Phosphoric acid applied in 1887.	Phosphoric acid removed by crop in 1887.	1888.	Phosphoric acid remaining in the soil after the crop of 1888.
Dissolved Bone Black,	Plot A	40.6 lbs.	23.9	20.1	−3.4
Grand Cayman's Phosphate,	B	132.2	24.5	22.0	85.7
Thomas-Slag,	D	105.3	22.0	23.0	60.3
Ground S. C. Rock,	E	140.0	21.1	21.1	97.8

3. The yield of corn in 1889 was very small, as was anticipated. The stover was so damaged by continuous wet weather and blight, that it was not thought worth while to weigh it. We have therefore only the weights of the ears for comparison. From these it appears that the plot which had received Dissolved Bone Black in 1887 produced no more ears than the plots which received no phosphate then or since. This fertilizer had entirely spent itself in the two previous years. Grand Cayman's Phosphate and Thomas-Slag, however, produced 45 and 56 per cent. more corn than the no-phosphate plots, and S. C. Rock 29 per cent., a larger percentage increase, indeed, than either last year or the year before.

That is, to carry out the illustration, the investment made in Thomas-Slag, Grand Cayman's Phosphate and S. C. Rock in 1887 was still paying considerable dividends in 1889 while the investment in Dissolved Bone Black had ceased to yield any returns whatever.

On this particular piece of land and in these three seasons Thomas Slag and Grand Cayman's Phosphate have been more profitable than Dissolved Bone Black.

Mr. W. H. Yeomans' Experiments.

These are in part a continuation of the experiment begun last year and fully described in the Report for 1888, page 122, to which reference may be made for details as to the soil, arrangement of plots, method of planting, etc. Following are Mr. Yeomans' notes regarding the course of this continued experiment this year:

May 17, finished plowing.

May 23, 200 pounds sulphate of ammonia and 320 pounds of muriate of potash were spread upon the acre of land and thoroughly harrowed in. The weather having been favorable the soil was in excellent condition.

May 25, planted yellow Canada flint corn on all the plots which served for the experiment of last year.

These plots were separated from each other by a single row of potatoes as before, and received no phosphates this year.

June 1, the corn commenced to come up, presenting an even appearance.

June 9, the corn was about three inches high; all the plots looking about the same.

June 22–24, the corn was carefully hoed with no very noticeable difference in the appearance.

July 17, employed the horse hoe, although the ground was very wet, the weather having been unfavorable for nearly a fortnight.

Aug. 10, portions of the fodder are attacked by a rust. The stand on this series of plots is very uneven.

Aug. 30, plants on C and F of this series remain very small. The other plots of the series are not nearly as even in the stand of corn as last season.

Sept. 16, for the purpose of calculating to a basis of a full stand of corn of four stalks to each hill with 275 hills to each plot, which would give 1100 stalks to each plot, the stalks of the entire field were counted with the following result:

	Total number of stalks.	More, +, or less, −, stalks than a full stand.
A	1236	+136
B	981	−119
C	1031	− 69
D	956	−144
E	995	−105
F	1095	− 5
G	948	−152
H	1017	− 83

There was no lack of moisture during the growing season. The trouble this year was rather from its excess, which was so great as to prevent the necessary attention in cultivation. In the latter part of July and fore part of August one would sink into the water-soaked soil to a depth of two or three inches, it being literally mud.

Sept. 20, cut up the corn which was in fairly ripened condition; the grain of full ears being glazed over.

Oct. 5, commenced to husk; the fodder was bright and well cured.

Oct. 10, finished husking and weighed the crop.

The yield of corn and of stover reduced to a basis of 1100 stalks to a plot, 4 to a hill is as follows:—

Experiment of 1889.

Phosphate applied in 1888.	Sound Ears.	Soft Ears.	Total Ears.	Stover.	Total Crop.
A, Dissolved Bone Black, 16 pounds	11.6	24.7	36.3	99.8	136.1
B, Grand Cayman's Phosphate, 23 pounds	3.4	44.9	48.3	123.3	171.6
C, No-Phosphate	--	12.3	12.3	55.4	67.7
D, Thomas-Slag, 27½ pounds	5.8	55.2	61.0	127.7	188.7
E, South Carolina Rock, 34½ pounds	3.6	48.7	52.3	113.9	166.2
F, Nothing	--	14.8	14.8	50.2	65.0
G, Bolivian Guano, 27½ pounds	22.0	71.4	93.4	156.6	250.0
H, Double quantity Dissolved Bone Black	29.2	62.6	91.8	152.5	244.3

If we call the average yield of the no-phosphate plots, C and F, 100 per cent. the yields of the other plots will compare as follows:—

	Ears.		Stover.		Total Crop.	
	1888	1889	1888	1889	1888	1889
C and F, No-Phosphate	100	100	100	100	100	100
A, Dissolved Bone Black	567	268	275	189	373	205
B, Grand Cayman's Phosphate	312	359	160	233	211	259
D, Thomas-Slag	211	452	136	242	161	284
E, South Carolina Rock	191	388	136	216	155	250
G, Bolivian Guano	194	692	155	296	168	377
H, Double quantity Dissolved Bone Black	550	680	387	289	442	368

Excluding the plots which received no phosphate last year the yield of sound corn, soft corn, and total crop last year and this, are as follows:—

	Sound Ears.	Soft Ears.	Total Crop. Ears and Stover.
In 1888	1558.4	764.4	5156.8
In 1889	190.4	820.0	3084.8

Examination of these results shows that the yield of corn as far as ears is concerned was almost a failure this year and that the total crop was very small.

This was due to two causes: first the condition of the soil which in farm practice would have been heavily manured last year and this year put to some other crop than corn, and secondly to the excessive wetness of the season.

The most noticeable things in this experiment are,

1. The double quantity of Dissolved Bone Black applied last year has produced about as large a relative gain this year as last. Last year 16 pounds on plot A produced nearly as much corn as 32 pounds on plot H, which means that 16 pounds was all that the crop needed or could use last year. But the yields this year show that the extra 16 pounds remained available, and while the gain of ears on plot A this year was only 168 per cent., on plot H it was 580 per cent. over the no-phosphate plots.

2. Last year Dissolved Bone Black gave a much heavier yield than an equal money value of any other phosphate. This year it has yielded much less both of ears and stover than any other phosphate.

The probable explanation is that it contains much less phosphoric acid than either of the others, is quickly available and therefore spent itself largely last year. It is most likely that now it is entirely used up. But as has been shown in the discussion of Mr. Bartholomew's experiments, there is a considerable supply of phosphoric acid from each of the other phosphates still in the soil and becoming available as time goes on.

3. The most striking thing in the experiment of this year is the very large increase produced on the Bolivian Guano plot over the yield of the no-phosphate plots which is particularly noticeable in the ears. Whether this is due to the rapid disintegration and solution of the phosphate by a single season's exposure or to an effect on the soil produced by the large quantity of carbonate of lime contained in it, must be left for the present undecided.

4. The results of these experiments and those of Mr. Bartholomew *agree* in this that the larger part of the Dissolved Bone Black has been used up in a single year and that in the second year after application Thomas-Slag, Grand Cayman's Phosphate and South Carolina Rock even (Bolivian Guano was not included in Mr. Bartholomew's tests), have given considerably larger yields than Dissolved Bone Black.

The results *differ* from Mr. Bartholomew's in this: first that *in the first year* Dissolved Bone Black gave a much larger yield than any other phosphate and secondly, in consequence largely of the very small total crops in 1889, Dissolved Bone Black paid much better than any other phosphate, taking the two years together.

Had the land been "in better heart," to begin with, i. e. if the no-phosphate plots had produced something like as much this year as they did last the difference in profit between Dissolved Bone Black and the other phosphates would have been very much smaller.

Mr. Yeomans also repeated the experiment of 1888 on land adjacent to that occupied for the experiment just described. In 1888, plots A, B, C, D and E of this series were planted to potatoes with the use of Mapes' Potato Manure at the rate of 200 pounds per acre and plots F, G and H were cropped with buckwheat, receiving

Experiment of 1889.

Phosphate applied in 1888.	Sound Ears.	Soft Ears.	Total Ears.	Stover.	Total Crop.
A, Dissolved Bone Black, 16 pounds	11.6	24.7	36.3	99.8	136.1
B, Grand Cayman's Phosphate, 23 pounds	3.4	44.9	48.3	123.3	171.6
C, No-Phosphate	--	12.3	12.3	55.4	67.7
D, Thomas-Slag, 27½ pounds	5.8	55.2	61.0	127.7	188.7
E, South Carolina Rock, 34½ pounds	3.6	48.7	52.3	113.9	166.2
F, Nothing	--	14.8	14.8	50.2	65.0
G, Bolivian Guano, 27½ pounds	22.0	71.4	93.4	156.6	250.0
H, Double quantity Dissolved Bone Black	29.2	62.6	91.8	152.5	244.3

If we call the average yield of the no-phosphate plots, C and F, 100 per cent. the yields of the other plots will compare as follows:—

	Ears.		Stover.		Total Crop.	
	1888	**1889**	**1888**	**1889**	**1888**	**1889**
C and F, No-Phosphate	100	100	100	100	100	100
A, Dissolved Bone Black	567	268	275	189	373	205
B, Grand Cayman's Phosphate	312	359	160	233	211	259
D, Thomas-Slag	211	452	136	242	161	284
E, South Carolina Rock	191	388	136	216	155	250
G, Bolivian Guano	194	692	155	296	168	377
H, Double quantity Dissolved Bone Black	550	680	387	289	442	368

Excluding the plots which received no phosphate last year the yield of sound corn, soft corn, and total crop last year and this, are as follows:—

	Sound Ears.	Soft Ears.	Total Crop. Ears and Stover.
In 1888	1558.4	764.4	5156.8
In 1889	190.4	820.0	3084.8

Examination of these results shows that the yield of corn as far as ears is concerned was almost a failure this year and that the total crop was very small.

This was due to two causes: first the condition of the soil which in farm practice would have been heavily manured last year and this year put to some other crop than corn, and secondly to the excessive wetness of the season.

The most noticeable things in this experiment are,

1. The double quantity of Dissolved Bone Black applied last year has produced about as large a relative gain this year as last.

Last year 16 pounds on plot A produced nearly as much corn as 32 pounds on plot H, which means that 16 pounds was all that the crop needed or could use last year. But the yields this year show that the extra 16 pounds remained available, and while the gain of ears on plot A this year was only 168 per cent., on plot H it was 580 per cent. over the no-phosphate plots.

2. Last year Dissolved Bone Black gave a much heavier yield than an equal money value of any other phosphate. This year it has yielded much less both of ears and stover than any other phosphate.

The probable explanation is that it contains much less phosphoric acid than either of the others, is quickly available and therefore spent itself largely last year. It is most likely that now it is entirely used up. But as has been shown in the discussion of Mr. Bartholomew's experiments, there is a considerable supply of phosphoric acid from each of the other phosphates still in the soil and becoming available as time goes on.

3. The most striking thing in the experiment of this year is the very large increase produced on the Bolivian Guano plot over the yield of the no-phosphate plots which is particularly noticeable in the ears. Whether this is due to the rapid disintegration and solution of the phosphate by a single season's exposure or to an effect on the soil produced by the large quantity of carbonate of lime contained in it, must be left for the present undecided.

4. The results of these experiments and those of Mr. Bartholomew *agree* in this that the larger part of the Dissolved Bone Black has been used up in a single year and that in the second year after application Thomas-Slag, Grand Cayman's Phosphate and South Carolina Rock even (Bolivian Guano was not included in Mr. Bartholomew's tests), have given considerably larger yields than Dissolved Bone Black.

The results *differ* from Mr. Bartholomew's in this: first that *in the first year* Dissolved Bone Black gave a much larger yield than any other phosphate and secondly, in consequence largely of the very small total crops in 1889, Dissolved Bone Black paid much better than any other phosphate, taking the two years together.

Had the land been "in better heart," to begin with, i. e. if the no-phosphate plots had produced something like as much this year as they did last the difference in profit between Dissolved Bone Black and the other phosphates would have been very much smaller.

Mr. Yeomans also repeated the experiment of 1888 on land adjacent to that occupied for the experiment just described. In 1888, plots A, B, C, D and E of this series were planted to potatoes with the use of Mapes' Potato Manure at the rate of 200 pounds per acre and plots F, G and H were cropped with buckwheat, receiving the fertilizer named at the same rate as the other plots. These plots were plowed and fertilized on the same day with those in the other experiment. The phosphates applied were as follows:

Each plot is marked "No. 2" to distinguish it from the corresponding plot in the experiment already described.

A, No. 2, 16 pounds Dissolved Bone Black.
B, " 23 pounds Grand Cayman's Phosphate.
C, " No phosphate.
D, " 27½ pounds Thomas-Slag.
E, " 34½ pounds ground South Carolina Rock.
F, " No phosphate.
G, " 27½ pounds Bolivian Guano.
H, " 23 pounds Mona Island Phosphate.

These phosphates were applied in the hill. Plots F, G and H were planted May 25th. The weather prevented planting the other plots of the series till May 29th. The plots were hoed and cultivated at the same times as those already described.

The following observations are additional to those already given in the account of the first experiment.

June 22. Plot A No. 2 is very much ahead of all the others. H No. 2 is well advanced.

July 17. A No. 2 is much the largest, H No. 2 closely following. C and F No. 2 are larger than C and F of the other series.

Aug. 2. A No. 2 spindled out and ears setting. C No. 2 much larger than any other no-phosphate plot and nearly as large as B No. 2.

Aug. 30. C No. 2 nearly as good as B, D and E No. 2. F No. 2 is uneven and not as good as C No. 2.

The crop was cut and stacked, harvested and weighed at the same time with the other experiment.

A full stand of corn of 4 stalks to each hill would give 1100 stalks to each plot. The stalks were counted on the several plots with the following results:—

Plots.	Whole Number of stalks.	Less stalks than a full stand.
A, No. 2,	847	—253
B, "	863	—237
C, "	1002	— 98
D, "	883	—217
E, "	842	—258
F, "	706	—394
G, "	765	—335
H, "	842	—258

In the following table are given the yields of corn and of stover reduced to a basis of 1100 stalks to a plot, 4 to a hill. This reduction itself involves a certain error, for where there is less than the full stand of corn the production of the individual plants is relatively increased. To make no allowance for missing stalks, however, would occasion a much larger error.

Experiment No. 2, 1889.

Phosphate applied in 1889.	Sound ears.	Soft ears.	Total ears.	Stover.	Total crop.
A, No. 2, Dissolved Bone Black	176.6	41.6	218.2	251.9	470.1
B, " Grand Cayman's Phosphate,	28.2	95.6	123.8	123.6	247.4
C, " No-phosphate	8.8	50.5	59.3	143.7	203.0
D, " Thomas-Slag	59.8	78.5	138.3	168.2	306.5
E, " Ground So. Carolina Rock	30.0	83.0	113.0	156.8	269.8
F, " No-phosphate	9.3	40.5	49.8	96.6	146.4
G, " Bolivian Guano	7.2	50.3	57.5	125.1	182.6
H, " Mona Island Phosphate	3.9	60.7	64.6	146.3	210.9

If we call the average yield of the no-phosphate plots, C and F, 100 per cent., the yields of the other plots will compare as follows:—

	Ears.	Stover.	Total crop.
C and F, No-phosphate	100	100	100
A, Dissolved Bone Black	400	209	270
B, Grand Cayman's Phosphate	227	103	142
D, Thomas-Slag	254	140	176
E, Ground So. Carolina Rock	207	131	154
G, Bolivian Guano	106	104	104
H, Mona Island Phosphate	118	122	121

The yield of ears on the duplicate plots, C and F, is nearly enough alike, but the differences in stover are too large, 49 pounds. In consequence, a difference of 20 per cent. in the stover or 17 per cent. in the total crop cannot be ascribed to any thing but the lack of uniformity in the soil.

Results.—1. The total crop of sound corn is small, as was to be expected from the exhausted land which was purposely chosen as most likely to be suitable for the experiment. The largest yield was at the rate of 3532 pounds of sound ears to the acre, or, allowing one-fifth for cob and 50 lbs. to the bushel of new shelled corn, 56 bushels of shelled corn per acre and the next largest yield was scarcely 20 bushels.

2. The Dissolved Bone Black plot was the only one which produced more sound ears than soft ears.

3. The Dissolved Bone Black plot yielded four times as much ears and twice as much stover as the no-phosphate plots, $1\frac{3}{4}$ times as much ears as Thomas-Slag or Grand Cayman's Phosphate, and nearly twice as much as South Carolina Rock.

4. Bolivian Guano and Mona Island Phosphate made little increase of crop.

5. In general the results confirm those obtained by Mr. Yeomans last year and given in our Report for 1888.

On this exhausted land with a liberal application of nitrogenous matter and potash salts soluble phosphates have increased the corn crop most remarkably.

Mr. C. A. Sill's Experiments.

One quarter of the field used last year for a similar experiment, Report for 1888, p. 127, was planted to corn as before, after plowing and sowing the same quantity of nitrogenous matter and potash salts as were used on an equal area last year. No additional phosphates were used. The yield of ears and stover was as follows, from $\frac{1}{40}$-acre plots:—

Phosphates applied in 1888.	Ears.	Stover.	Total crop.
A, Dissolved Bone Black	72	115	187
B, Grand Cayman's Phosphate	83	125	208
C, No-phosphate	66½	130	196½
D, Thomas-Slag	69	110	179
E, South Carolina Rock	74	119	193
F, No-phosphate	60	115	175
G, Bolivian Guano	65	116	181

The results, in connection with those of last year, furnish no information regarding the relative agricultural value of the phosphates, because the land is not sufficiently deficient in assimilable phosphoric acid to be suited to this experiment.

In another part of Mr. Sill's farm a two-acre piece was selected for a phosphate experiment, which it was believed would show less inequality in the soil and respond more decidedly to phosphatic fertilizers. It was a level piece and can be best described as a "run-out pasture." No manure had been put on for a long time, and it had lain in grass for years, being pastured occasionally with sheep but now bore more weeds than grass. This piece of land was plowed, muriate of potash and sulphate of ammonia were evenly broadcast over it* at the rate of 640 pounds and 400 pounds respectively per acre, and after harrowing, was laid off

* Excepting plots I and J, which will be spoken of later.

into eighteen plots, each covering $\frac{1}{10}$ of an acre. One fifth of an acre was left in vacant spaces between the plots. The plan was to have duplicate plots for each phosphate, and four plots with no phosphate, so as to insure greater accuracy in the results.

The crop was planted, cultivated and harvested in the usual way. The stand of corn was very even and grew without accident. The arrangement of plots can best be understood by the following diagram which also shows the quantity of phosphates used.

Plot I received its share of the ammonia salts but no muriate of potash; plot J received muriate of potash but no ammonia salts.

The phosphates were put in the hill. The quantities represent the same money values.

The weights of the crops were as follows:

		Sound ears.	Soft ears.	Stover.	Total crop.
Potash alone,	J	34	30	208	272
Nitrogen alone,	I	139	21	306	466
Nitrogen and Potash, no-phosphate,	C1	177	23	234	434
" " " "	C2	187	18	210	415
" " " "	F1	246	10	229	485
" " " "	F2	168	15	239	422
" " " Dissolved Bone Black,	A1	254	18	246	518
" " " " "	A2	237	13	221	471
" " " Grand Cayman's,	B1	243	18	214	475
" " " " "	B2	211	24	243	478
" " " Thomas-Slag,	D1	225	17	208	450
" " " " "	D2	196	20	223	419
" " " So. Carolina Rock,	E1	294(?)	23	236	553
" " " " "	E2	195	13	209	417
" " " Bolivian Guano,	G1	222	28	242	492
" " " " "	G2	174	21	220	415
" " " Mona Island,	H1	210	32	214	456
" " " " "	H2	164	18	218	400

These results are evidently of little use for the purposes of our experiment, chiefly for the reasons that the land is not perfectly uniform in crop-producing power and that available phosphoric acid is not strikingly deficient in the soil, and hence the addition of more produces no decided increase of crop. Thus the highest yield from Bone Black was less than 7 per cent. more than the highest yield where no phosphate was applied, and the average yield of the two Dissolved Bone Black plots was less than 13 per cent. more than the average of the four no-phosphate plots.

J Received potash, but no phosphate nor nitrogen.	I Received nitrogen, but no phosphate nor potash.
A2 Dissolved Bone Black, 26 lbs.	B1 Grand Cayman's Phosphate, 37 lbs.
C2 No phosphate.	D1 Thomas-Slag, 45 lbs.
E2 Ground South Carolina Rock, 56 lbs.	C1 No phosphate.
G2 Bolivian Guano, 45 lbs.	H1 Mona Island Guano, 37 lbs.
B2 Grand Cayman's Phosphate, 37 lbs.	A1 Dissolved Bone Black, 26 lbs.
D2 Thomas-Slag, 45 lbs.	F1 No phosphate.
F2 No phosphate.	E1 Ground South Carolina Rock, 56 lbs.
H2 Mona Island Guano, 37 lbs.	G1 Bolivian Guano, 45 lbs.

It is clear too that potash is not the lacking element of plant food (compare the yield of I with those of C and F) but that at present this land would be most benefited by applications of nitrogenous matters. A liberal application of cotton seed meal or of nitrogen from some other cheap source, or, now that there is a great abundance of potash and phosphoric acid in the soil, a crop of clover or of cow peas turned under would be the most profitable way of enriching it. Possibly alfalfa could profitably be grown there.

In the Report for 1888 the following offer was made: "To any in the State who may wish to test the effect of raw phosphates on their land for themselves and will engage to follow the Station's directions for making the test and will report the results to the Station for general use, the Station will supply these phosphates so far as it is possible."

Mr. Doyle, of Harwinton, and Mr. Dean, of Falls Village, accepted this offer and the results of their experiments follow.

Mr. L. Doyle's Experiment.

A single experiment with potatoes was made by Mr. Lawrence Doyle, of Harwinton. The soil was a sandy loam. The plots were each $\frac{1}{10}$ acre. The fertilizer-chemicals and phosphates were the same as those used in the experiments above described. The seed was Early Rose, and the tubers would weigh from one-half to three-quarters of a pound apiece and were cut to two and three eyes.

Plowed April 23, planted May 8, phosphates applied May 14, cultivated and hoed twice. Applied Paris green three times. July 10 the blight appeared.

The yields were as follows:

A, Dissolved Bone Black, 26 pounds	466	pounds potatoes.
B, Grand Cayman's Phosphate, 37 pounds	408	" "
C, No-phosphate	322	" "
D, Thomas-Slag, 45 pounds	512	" "
E, South Carolina Rock, 56 pounds	356	" "
F, No-phosphate	226	" "
G, Bolivian Guano, 45 pounds	276	" "
H, double quantity Bone Black, 52 pounds	488	" "
J, No-phosphate	206	" "
K, Mona Island Phosphate, 37 pounds	250	" "

Each of these plots had four rows, 108 hills in each row and the hills were $3\frac{1}{2}$ feet apart each way.

A single row by the side of plot A received no fertilizer of any kind and yielded 60 pounds of potatoes, which is at the rate of 240 pounds to a plot of the same size of the others. It was noticed that the soil at the east end, plot A, was a dark loam and became somewhat lighter and more sandy toward the west side, plot K. The no-phosphate plots show also that the west side of the field was considerably the poorer in plant food and that a close comparison of the crops cannot properly be attempted. All the phosphatic applications evidently had some good effect, but the highest yield was from Thomas-Slag, D, which in this experiment appears to have been almost as readily available a source of phosphoric acid as Dissolved Bone Black itself.

Mr. M. H. Dean's Experiment.

Two experiments were carried out on different fields, one at Lime Rock in the river valley, the other on high land some two miles away. The former showed no marked effect from any phosphate and therefore receives no further notice. The results of the latter are here tabulated. 160 pounds of muriate of potash and 100 pounds of sulphate of ammonia were broadcast over the half acre, after plowing, and harrowed in. Half of each phosphate was broadcast on the $\frac{1}{20}$ acre plot assigned to it and harrowed in while the other half was put in the hill. The field was planted May 22, cut September 14–17, and harvested and weighed October 16.

On the north half of each plot was planted an 8-rowed yellow corn, on the south half a variety furnished by the Storrs School Station. Following are the weights obtained:

	North Half.			South Half.			Total.		Total Yield
	Good ears.	Soft ears.	Stover.	Good ears.	Soft ears.	Stover.	Ears.	Stover.	
A, Dissolved Bone Black	130	6	164	107	18	127	261	291	552
B, Grand Cayman's Phosphate	90	14	114	77	23	115	204	229	433
C, No-phosphate	75	17	102	53	23	94	168	196	364
D, Thomas-Slag	109	9	127	45	19	137	182	264	446
E, S. C. Rock	77	15	105	43	24	87	159	192	351
F, No-phosphate	69	20	103	30	26	82	145	185	330
G, Bolivian Guano	86	11	108	41	21	80	159	188	347
H, No-phosphate	67	22	108	45	27	95	161	203	364
I, Dissolved Bone Black	131	10	162	109	14	140	264	303	567
J, Mona Island Guano	95	13	133	82	20	130	210	263	473
4 sq. rods adjoining without fertilizer	62	19	101	---	--	---	(162)	(202)	(364)

The yield in almost every case is considerably larger on the northern half of each plot than on the south half.

The yield of ears and stover is fairly uniform on each of the three no-phosphate plots C, F and H.

If we call the average yield of these three plots 100 per cent. the comparative yields of the other plots will be as follows:

	Ears.	Stover.	Total crop.
No-phosphate plots	100	100	100
Dissolved Bone Black, 13 pounds	165	149	156
Grand Cayman's Phosphate, 18½ pounds	129	118	122
Thomas-Slag, 22½ pounds	115	135	126
South Carolina Rock, 18 pounds	100	98	100
Bolivian Guano, 21½ pounds	100	96	99
Double quantity Dissolved Bone Black, 26 pounds	167	155	161
Mona Island Guano	133	135	135
No fertilizer of any kind	102	104	104

Results.—1. Bolivian Guano and South Carolina Rock have produced absolutely no increase either in ears or stover over the no-phosphate plots.

2. Dissolved Bone Black has produced the highest yield, more than 50 per cent. larger than where no phosphate was applied.

3. Mona Island Guano ranks next to Dissolved Bone Black, while Thomas-Slag and Grand Cayman's Phosphate rank nearly alike and gave not quite half as large an increase over the yield of the no-phosphate plots as Dissolved Bone Black gave.

II.—The Effect of the Rate or Distance of Planting on the Quantity and Quality of the Maize Crop.

Field Trials of 1889.

On pages 9–48 of this Report are discussed the results of an experiment on this subject carried out in 1888 on the farm of the late Mr. J. J. Webb of Hamden.

This experiment has been in part repeated in 1889 in the same field. Mr. James H. Webb of New Haven very generously put this land at our disposal, as his father had done the year before, with the necessary help, teams and tools. We are also indebted to the foreman, Mr. Gage, for his coöperation and care in cultivating and harvesting the crop.

The details of planting, cultivation, cutting and harvesting were the same as the year before, where the contrary is not stated, and have been described on pages 11–15.

The plots used were those known last year as G, H, I, J, K, L (see page 12). The seed was White Edge Dent. The fertilizer was prepared in the same way as in 1888, used in the same quantity and the distance of planting was the same also.

The field was planted on May 17. The crop came up very evenly and when a few inches high was thinned to secure just the stand desired on the several plots. It grew without accident, was kept very clean of weeds and thoroughly cultivated, and was cut and stacked September 25. It was husked and weighed on October 31.

This experiment may be considered an exact duplicate of the experiment of the previous year on plots A, B, C, D, E, F, though grown not on the same but on an adjacent row of plots. To facilitate comparison therefore the plots in this last experiment will be designated by these same letters, A, B, C, etc.

RESULTS OF THE EXPERIMENT.

A. QUANTITY OF CROPS.

Effect of Distance of Planting on the Gross Yield and also on the Amount of Water-free Crop.

Table I which follows shows that while the gross yield constantly increased with the thickness of planting, the *dry matter* or nutritive substance of the crop increased with the thickness of planting up to a certain point (two stalks to a foot), and then decreased again with still closer planting, so that when the stalks stood more than two to a foot the increased gross yield was wholly water, and contained actually less nutritive matter than where the stand was one stalk to a foot. The experiment of 1888 gave the same results, see page 18.

Table I.—Weight of the Field-cured Crops; Gross Yield and Dry Matter.—Pounds per 1-20th Acre.

	Gross yield.	Dry Matter in Field-cured Crops.
Plot A, One stalk in four feet	168.	104.3
" B, " " two "	320.	201.6
" C, " " to a foot	457.5	307.2
" D, Two stalks " "	491.0	**317.6**
" E, Four " " "	522.0	297.2
" F, Eight " " "	**532.0**	260.3

Dry Matter in the Kernels, Cobs and Stover of the Water-free Crops.

Table II shows that the largest yield of kernels, as also of cobs, was grown where the stalks stood one to a foot, plot C, and the yields decreased rapidly where the seeding was either thicker or thinner. Thicker seeding yielded more stover and the maximum stover crop was on plot E, four stalks to a foot.—In 1888 the maximum yield of ears was on plot D, *two* stalks to a foot, and the closest planting, plot F, yielded most stover, see page 19.—No attempt was made this year to separate marketable ears from "nubbins." There were very few soft or moldy ears even where the planting was thickest. The ears on plots A, B and C were all fair and of good size, those on D were smaller but generally good, while all those on E and F were very small and largely misshapen—"hog corn."

Table II.—Total Yields of Water-free Kernels, Cobs and Stover.—Pounds per 1-20th Acre.

	Kernels.	Cobs.	Stover.
Plot A, One stalk in four feet	50.5	11.8	42.0
" B, " " two "	102.2	20.4	79.0
" C, " " to a foot	**145.3**	**32.1**	129.8
" D, Two stalks " "	105.4	21.1	191.1
" E, Four " " "	71.4	19.1	**206.7**
" F, Eight " " "	48.4	13.5	198.4

Percentage of Kernels, Cobs and Stover in the Water-free Crops.

The following table, Table III, is of per cents, and shows that the *proportion* of kernels was largest on the plot where the stalks stood one in two feet, i. e. with very thin planting, and that the proportion rapidly decreased when the stand was thicker than one to a foot. Naturally the *proportion* of stover to total crop was largest where the stand was closest. The same fact appeared in the experiment of the previous year (see page 21).

Table III.—Percentage Parts of the Water-free Crop.

	Kernels.	Cobs.	Stover.
Plot A, One stalk in four feet	48.4	**11.3**	40.3
" B, " " two "	**50.7**	10.1	39.2
" C, " " to a foot	47.3	10.4	42.3
" D, Two stalks " "	33.1	6.6	60.3
" E, Four " " "	24.0	6.4	69.6
" F, Eight " " "	18.6	5.1	**76.3**

B. CHEMICAL COMPOSITION OF THE CROPS.

PERCENTAGE COMPOSITION OF THE FIELD-CURED CROPS.

The following tables, Tables IV and V, show the composition of the field-cured crop and its parts. The water content of the crops being quite different, a better comparison of their chemical composition can be made by reducing the analyses to the basis of dry matter as is done further on. These tables furnish the data for this reduction and are here introduced simply as matter of record.

The crops on the plots A, B, C and D have *approximately* the same percentage of water, while those on E and F have a considerably higher percentage.

TABLE IV.—PERCENTAGE COMPOSITION OF THE FIELD-CURED CROPS.

	Water.	Ash.	Albuminoids (N. x 6.25).	Fiber.	Nitrogen free Extract.	Crude Fat.
A, One stalk in four feet	37.9	2.2	**5.4**	11.7	40.8	2.0
B, " " two "	37.1	2.1	5.0	11.6	42.0	**2.2**
C, " " to a foot	32.9	**2.3**	4.3	13.0	**45.4**	2.1
D, Two stalks " "	35.3	2.3	3.7	**15.5**	41.4	1.8
E, Four " " "	43.1	2.1	3.2	14.9	35.3	1.4
F, Eight " " "	**51.0**	2.1	2.9	13.9	28.9	1.2

TABLE V.—PERCENTAGE COMPOSITION OF THE SEPARATE PARTS OF THE FIELD-CURED CROPS.

	Water.	Ash.	Albuminoids.	Fiber.	Nitrogen free Extract.	Crude Fat.
KERNELS.						
A, One stalk in four feet	32.99	1.08	8.15	1.77	52.22	3.79
B, " " two "	33.52	1.04	7.76	1.52	52.28	3.88
C, " " to a foot	31.19	.93	5.78	1.57	57.03	3.50
D, Two stalks " "	28.91	.77	5.87	1.39	59.40	3.66
F, Four " " "	34.68	.72	5.20	1.39	54.73	3.28
F, Eight " " "	**39.28**	.69	5.28	1.35	50.45	2.95
COBS.						
A, One stalk in four feet	46.56	.78	1.13	17.54	33.65	.34
B, " " two "	37.48	.68	1.12	21.88	38.53	.31
C, " " to a foot	43.51	.93	1.08	20.39	33.71	.38
D, Two stalks " "	45.00	.91	1.33	18.57	33.95	.24
E, Four " " "	48.16	1.08	1.52	17.06	31.85	.33
F, Eight " " "	44.98	1.06	1.61	18.83	33.17	.35
STOVER.						
A, One stalk in four feet	40.54	3.91	3.91	20.31	30.54	.79
B, " " two "	40.89	3.82	2.92	20.73	30.92	.72
C, " " to a foot	31.53	4.22	3.56	23.66	36.10	.93
D, Two stalks " "	37.22	3.23	3.01	22.02	33.42	1.10
E, Four " " "	45.01	2.56	2.80	18.66	29.93	1.04
F, Eight " " "	**53.63**	2.46	2.52	15.92	24.53	.94

PERCENTAGE COMPOSITION OF THE DRY MATTER IN THE FIELD-CURED CROPS.

Table VI shows the percentage composition of the dry matter in the several crops and brings out the following facts:

Ash.—The per cent. of ash is practically the same in the crop of each plot except F. In 1888 it is nearly alike in all but A, which suggests that these two exceptions are accidental, due, perhaps, to unobserved errors in the work. See page 27.

Albuminoids.—The highest per cent. of albuminoids was found where the planting was thinnest, showing that there the food product was the most "concentrated," concentration being measured by the nutritive ratio, i. e. the ratio between digestible albuminoids and digestible non-nitrogenous matter: fat, fibre and nitrogen-free extract. The per cent. of albuminoids quite regularly and rapidly decreased as the stand of maize was closer. In the previous year the result was the same. Between the thinnest and closest planting there was a difference of about 3 per cent. in the albuminoids. Where the maize stood one stalk in four feet in the rows, the crop, *pound for pound*, contained over one and a half times as much albuminoids as where the stalks stood eight to a foot in the rows.

Fiber.—The per cent. of fiber, both in 1888 and 1889, quite regularly increased as the stand grew closer, being largest on plot F.

Nitrogen-free Extract.—The per cent. was largest where the stand was one stalk to a foot, but not very different in the two plots on which the stand was thinner. The previous year two stalks to a foot produced the largest per cent., with rapid decrease where the stand was thinner.

Fat, or Ether Extract.—The per cent. was highest where the crop stood one stalk in two feet in the row and decreased with the closeness of the stand. The same was true in 1888.

TABLE VI.—PERCENTAGE COMPOSITION OF THE DRY MATTER IN THE FIELD-CURED CROPS.

	Ash.	Albuminoids. (N x6.25.)	Fiber.	Nitrogen-free Extract.	Crude Fat.
A, One stalk in four feet	3.6	**8.7**	18.8	65.7	3.2
B, " " two feet	3.3	7.9	18.4	66.9	**3.5**
C, " " to a foot	3.4	6.4	19.4	**67.7**	3.1
D, Two stalks to a foot	3.5	5.7	24.1	63.9	2.8
E, Four " "	3.7	5.6	26 4	61.8	2.5
F, Eight " "	**4.3**	5.9	**28.3**	59.0	2.5

Total Quantities of Water, Ash, Albuminoids, etc., Harvested from each Plot.

The following table, Table VII, calculated from those previously given, shows the actual yield of each food ingredient and the real value of each crop.

It appears that plot C, where the rate of planting was one stalk to a foot in the row,—the rows were four feet apart,—produced the most albuminoids, nitrogen-free extract and fat, therefore the most cattle food. Hence in this season, and on this land, that rate of planting was more profitable than any of the others, and the best *possible* rate would have been either this or a little closer, perhaps one stalk in ten inches.

Plot D yielded 10 pounds more of dry matter than C, but 16 pounds more of fiber and correspondingly less of the more valuable food ingredients.

Under the conditions of this experiment, to get as much real feed as was raised on an acre of maize planted one stalk to a foot in the row,—rows four feet apart,—would have required one and a third acres if planted at the rate of eight stalks to a foot in the row, and the handling of a ton and a half more of water in the crop when field-cured, to say nothing of the extra quantity handled at cutting time.

In 1888 "a stand of one plant to a foot produced more of every ingredient except fiber than a stand of four to a foot, so the rate which would have given the maximum yield was either two to a foot or between one and two to a foot." Page 30.

Table VII.—Total Production of each Food Ingredient of the Crop on each Plot.

Pounds per 1-20th Acre.

	Field-cured.	Dry Matter.	Water.	Ash.	Albuminoids. (N. x6.25)	Fiber.	Nitrogen-free Extract.	Fat.
A, One stalk in four feet	168.0	104.3	63.75	3.74	9.15	19.55	68.33	3.48
B, " " two "	320.0	201.6	118.40	6.92	16.20	37.17	134.28	7.03
C, " " to a foot --	457.5	307.2	150.29	10.40	**19.67**	59.83	**207.78**	**9.46**
D, Two stalks " --	491.0	**317.6**	173.43	11.32	18.37	76.22	202.80	8.86
E, Four " " --	522.0	297.2	224.84	10.81	16.76	**77.95**	184.03	7.61
F, Eight " " --	**532.0**	260.3	**271.75**	**11.33**	15.38	73.80	153.28	6.46

Comparative Development of the Individual Maize Plant.

The largest yield of the three most valuable food ingredients, as the last table shows, was from plot C, where the rate of planting was one stalk to a foot. There were on this plot 544 maize plants. Now, while the yield on plots A and B was considerably smaller the *number of plants* was likewise much smaller. To ascertain then the comparative productiveness of the *individual maize plant* the total production of each plot must be divided in each case by the number of plants on the plot. For convenience, these quotients have been multiplied by 1,000, and in the two following tables are stated the yield of 1,000 maize plants for each of the distances planted, omitting fractions of a pound.

From these tables it appears that a single maize plant produced most where the stand was thinnest, one stalk in four feet, plot A, i. e. where it had most room to grow in, though the difference is not large between this and B where the stand was twice as close. The production of the single plant is still further reduced when the number of stalks is again doubled, plot C, but as has been seen, this plot produced the maximum *total* yield, i. e. the decrease in the productiveness due to crowding the plants is much more than compensated by the greater number of plants raised. But when the number of plants is again doubled, the decrease of productiveness of the individual plants due to crowding is not compensated by the increase in the number of plants, and so the total crop is lessened. For the four rates of planting represented by plots C, D, E, and F, doubling the rate of planting in each case about halves the crop production *of a single* plant.

The same holds true for each single food ingredient of the crop. See also the discussion on pages 30–34.

Table VIII.—Comparative Development of the Maize Plant.

Pounds of Product from 1000 Seed Kernels for each of the Distances named.

	Field cured Total crop.	Water-free Total crop.	Water-free Kernels.	Water-free Cobs.	Water-free Stover.
A, One stalk in four feet --------	**1236**	**767**	371	**87**	**309**
B, " " two " --------	1176	741	**376**	75	290
C, " " to a foot --------	841	565	267	59	239
D, Two stalks " " --------	451	292	97	19	176
E, Four " " " --------	239	137	32	9	96
F, Eight " " " --------	122	60	11	3	46

TABLE IX.—COMPARATIVE DEVELOPMENT OF THE MAIZE PLANT.

Pounds of Ash, Albuminoids, etc., in 1000 plants, for each of the Distances named.

	Dry weight.	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
A, One stalk in four feet---	**767**	**27**	**67**	**144**	**502**	**27**
B, " " two " ---	741	25	59	137	495	25
C, " " to a foot---	564	19	35	110	382	18
D, Two stalks " " ---	292	10	17	70	186	9
E, Four " " " ---	137	5	8	36	84	4
F, Eight " " " ---	59	3	4	17	35	2

POUNDS OF NITROGEN, PHOSPHORIC ACID AND POTASH CONTAINED IN THE CROPS PER ACRE.

The following table, Table X, gives the pounds *per acre* of nitrogen, phosphoric acid and potash taken from the land by the crops on the several plots in 1889. With these data are also given for comparison the quantities of the ingredients mentioned which were removed from the corresponding plots of dent maize in 1888.*

TABLE X.—POUNDS OF NITROGEN, PHOSPHORIC ACID AND POTASH PUT ON IN FERTILIZERS AND REMOVED IN CROPS OF DENT CORN PER ACRE IN 1888 AND 1889.

	Nitrogen. Pounds.		Phosphoric Acid. Pounds.		Potash. Pounds.	
	1888.	1889.	1888.	1889.	1888.	1889.
Put on in the Fertilizer----	*45.1*	*45.1*	*107.2*	*107.2*	*77.8*	*77.8*
Taken off in the crop:						
A, One stalk in four feet--	57.3	29.2	21.2	14.0	49.9	23.0
B, " " two " --	89.9	51.8	36.9	27.7	48.6	39.8
C, " " to a foot--	94.0	63.0	38.5	29.9	48.5	51.7
D, Two stalks " " --	95.7	58.8	40.2	27.5	51.7	45.4
E, Four " " " --	75.3	53.6	34.1	22.2	41.5	40.3
F, Eight " " " --	67.8	49.2	27.2	17.1	34.7	44.0

The rates of planting on plots C and D—one stalk to a foot and two stalks to a foot—are nearest to general farm practice, and the average quantities of nitrogen, phosphoric acid and potash removed in 1889 by the crops on these plots, calculated to the acre would be—

* It should be kept in mind that the plots bearing dent maize in 1888 were not the same ones which bore it in 1889 but were adjacent to them. See page 219. These dent maize plots of 1889 bore flint maize in 1888, but as may be seen from page 35 the quantities of nitrogen, phosphoric acid and potash removed by the flint maize crop in 1888 were very nearly the same as those removed by the dent maize in the same year.

Nitrogen----------	60.9	pounds.
Phosphoric Acid----------	28 7	"
Potash----------	48.5	"

The total crop on these two plots in 1889 represents a production of 6248 pounds of dry matter per acre, or 2507 pounds of water-free kernels. It is usual, however, to measure crops rather by the bushels of shelled corn per acre. New corn dry enough to shell, contains about 20 per cent. of water and weighs about 50 pounds per struck bushel, so that this corn crop on plots C and D averaged about 63 bushels to the acre.

In 1888 the corresponding yield was 3124 pounds of dry sound shelled corn, or about 78 bushels of marketable shelled corn. Following are the quantities of the ingredients named contained in the two crops of white-edged Dent, ears and stover, of 1888 and 1889 *calculated to a yield of 75 bushels per acre.*

	1888.	1889.	Average.
Nitrogen,	91.2	72.5	81.8
Phosphoric Acid,	37.8	34.1	35.9
Potash,	48.2	57.7	52.9

The above are *average* figures designed to show the quantities of the ingredients named taken from the land by the ears and stover of a crop yielding 75 bushels of sound shelled corn per acre.

In the two years the *actual* yields of plots C and D were 141 bushels of shelled corn per acre, and the stover and shelled corn together took from an acre of land in these two crops the quantities of nitrogen, phosphoric acid and potash given below. There are also given the quantities of the same ingredients which were put on in the fertilizer during the two years.

	Nitrogen.	Phosphoric acid.	Potash.
Put on per acre in fertilizer during 2 years--	90.2	214.4	155.6
Taken off in crop " " --	155 7	68.1	98.6
Gain, +, or loss, —, to the land ------	—65.5	+146.3	+57.0

It appears that the soil has been drawn upon for 65 pounds of nitrogen, four fifths as much as is required for a full crop of corn. At the same time it has been enriched by as much phosphoric acid as four crops would take from it and by as much potash as a single crop requires.

This is the result of using a fertilizer containing 4.5 per cent. of nitrogen, 10.7 of phosphoric acid and 7.8 per cent. of potash at the rate of 1000 pounds per acre, *without* stable manure. In 1889 the yield of corn on the rest of the farm was said by Mr. Gage to be larger and better than in 1888; but on these plots it was smaller. This is to be explained by a relative deficiency of nitrogen in the soil of the plots.

Evaporation of Water during Field-curing.

At the time of cutting, three samples were drawn on plot C. One weighing 75 pounds was taken to the laboratory and analyzed, another weighing 75½ pounds was placed in a cool dry room and allowed to cure till harvest time, a third weighing 83½ pounds was left in the stack.

By an oversight this last sample was not separately weighed when the crop was harvested so the data for determining the changes in the corn during field-curing are missing.

The per cent. of water contained in the crop on plot C, as determined at the time of cutting was 59.35 per cent., at harvest time it was 32.9 per cent. The total weight of crop at the time of *cutting* was 15,114 pounds per acre, and at *harvest* 9,156 pounds per acre. If now we assume that there was no loss of dry substance by fermentation or otherwise during the curing, the difference, 5,958 pounds, is the water which evaporated during field-curing, nearly 3 tons per acre.

That the crop did not suffer any great loss from fermentation during field-curing may be inferred from the following table which shows the composition of the dry matter in the crop, at the time of cutting, Sept., at the time of harvesting after field-curing, Oct., and thirdly, when house-cured as above described.

	September. When cut.	October. When field-cured.	October. When house-cured
Ash	3.4	3.4	3.1
Albuminoids	6.6	6.4	6.5
Fiber	19.0	19.4	19.2
Nitrogen-free Extract	67.8	67.7	68.0
Fat	3.2	3.1	3.2
	100.0	100.0	100.0

Any considerable loss by fermentation would have decreased the percentage of nitrogen-free extract, and correspondingly increased the percentages of the other ingredients.

Comparison of the Crops of 1888 and 1889.

This experiment in its main features is a confirmation of the previous experiment already described, and there is little to be added to the discussion and general statements made in connection with that experiment.

Some comparisons of the crops of 1888 and 1889 are instructive. The two crops were raised in the same field, the land was fertilized in exactly the same way and the crops were treated alike. The crop of 1888 followed sod, that of 1889 followed a flint corn crop in 1888. The rainfall for the whole year 1889 was far above the average, but not greater than that of 1888. During the growing season, however, from May first to November first, a good deal more rain fell in 1889 than in 1888. But again, less rain fell in 1889 during May, August, September and October than in 1888. But in July, 1889, there was an almost unprecedented rainfall, and from June on, the humidity of the air was considerably greater in 1889 than in the year before. June and July, 1888, were exceptionally dry months. 1889 was also a warmer year than 1888. The fall of 1888 was very unfavorable to field-curing, but in 1889, in this vicinity at least, there was less rain during September and October and warmer weather than in the previous year, and the crop cured much better in the stack.

Water in the crops.

What difference the weather during October may make in the cost of harvesting—as well as in the keeping of the gathered crop—may be seen in table XI. which shows the weight of water per acre for each distance of planting contained in the two crops of 1888 and 1889, after field-curing, *and reckoned to an equal production of dry matter in the two years.*

Table XI.—Water in the Field-cured Maize Crops of 1888 and 1889—Pounds per Acre.

Rate of planting.	Crop of 1888.	Crop of 1889.
One stalk in four feet	5380	2175
" " two "	6470	3552
" " to a foot	7888	3607
Two stalks " "	6930	4335
Four " " "	7964	5620
Eight " " "	8270	7608

The table shows that with the same yield of dry matter in the two years there would have been from 662 pounds to 4281 pounds more of water to be handled in 1888 than in 1889, or with the average rate of planting, one to two stalks to a foot in the row, about 1¾ tons more of water per acre in 1888 than in 1889.

With the average rate of planting, plots C and D, the field-cured crop of 1888 had 49.12 per cent. of water, that of 1889, 15 per cent. less, 34.1 per cent.

Proportion of shelled corn.

The crop of 1889 produced a larger proportion of kernels than that of the previous year by about 2 per cent. on the average of all the plots. On the three plots which had the thinnest stand the average yield of kernels in 1888 was 42.4 per cent. of the whole yield, and in 1889, was 48.8 per cent. (See table X.)

Percentage composition of the dry matter of the crops in 1888 and 1889.

a. Ash.—Excluding a single result in each year [from A in 1888 and F in 1889] which was so different from all the others as to suggest the possibility of error, the ash percentage in 1888 was between 3.12 and 3.29, in 1889 between 3.3 and 3.7 which is a rather close agreement.

b. Albuminoids.—In 1888 the percentage was very considerably higher than in 1889. The maximum, minimum and average percentages in the two years were as follows:

	Maximum.	Minimum.	Average.
In 1888	10.05	5.80	7.82
In 1889	8.70	5.60	6.70

c. Fiber.—On the two plots which were most thinly planted there was a slightly smaller percentage of fiber in 1889 than in 1888, on the other plots the reverse was the case.

d. Nitrogen-free Extract.—Variations were observed the reverse of those noted in the case of fiber. The crops of the three plots most thinly planted had a larger percentage of nitrogen-free extract in 1889 than in 1888, with the other plots the reverse was the case.

e. Fat.—Differences in the percentages for the two years are not marked.

Total Production of each Food Ingredient.

The crops on all the plots and the yield of each food ingredient as well, were very considerably smaller in 1889 than in 1888.

The falling off of the crop in 1889 is not in the same ratio on all the plots. If we call the yield in 1888 in each case 100 per cent. the several yields in 1889 expressed in per cent. will be as follows:

A, One stalk in four feet	50.8	per cent.
B, " " " two "	66.6	"
C, " " to a foot	83.6	"
D, Two stalks "	79.6	"
E, Four " "	79.9	"
F, Eight " "	71.2	"

From this it appears that, compared with the crop of 1888, the two plots A and B, which were most thinly planted, suffered most in 1889 from the changed conditions of soil, light, heat and moisture, and next to these the plot where the stand was thickest. As compared with 1888 there was in 1889, 20 per cent. less of mineral matter or "ash," 24 per cent. less fiber, 27 per cent. less fat and nitrogen-free extract and 37 per cent. less albuminoids.

The fact that grasses differ very greatly from year to year in the proportion of albuminoids, even when cut at the same period of development as nearly as can be, has been shown by observations at the New York Station; and that grasses cut here in 1889 were strikingly poorer in albuminoids than the same species cut from the same land at the same stage of growth in 1888 will appear further on in this Report. The maize plant, which is also a grass, has shown a like variation in these two years.

It is evident that in calculating rations by the aid of tables of the average composition of feeds great allowance has to be made for differences of water content and also for variations in the dry matter itself, particularly in the percentage of albuminoids which are the most costly element in feeds.

III.—Influence of the Size and Method of Cutting Seed Potatoes on the Crop and on the Variety.

A series of experiments was begun in 1889 on this subject which it was expected would be carried on for a term of years. The early appearance of the potato blight ruined some of the experiments and very seriously damaged all of them. It is thought best, therefore, to defer reporting any of the results till further data are secured.

IV.—Eastern and Western Sweet Seed Corn.

Small samples of seed were sent to the Station in the spring of 1889 by Mr. E. B. Clark of Milford, for comparison. They were labeled as follows:

A,	Evergreen,	J. C. Morgan, Mich.
B,	"	E. B. Clark, Conn.
C,	"	F. T. Emerson, Nebraska.
D,	Early Crosby,	C. S. Clark, Ohio.
E,	" "	E. B. Clark, Conn.

The weight of 100 kernels of the seed in grams was as follows:

A, 20.7 B, 26.7 C, 25.3 D, 19.5 E, 27.0

The corn was planted on May 17 in good soil, well fertilized. The drills were four feet apart and the kernels were about 18 inches apart in the drills. July 18th the following notes were made: Plot A, uneven stand, tips of tassels just showing; B, taller, even stand, tassels just showing; C, same as B; D, small, uneven stand, tasselled fully; E, tassels fully out, very thrifty. D and E have many suckers which are cut off.

Sept. 24. Topped the corn on all the plots. A has 159 stalks, 168 ears; B has 159 stalks, 158 ears; C has 44 stalks, 54 ears; D has 118 stalks, 147 ears; E has 203 stalks, 177 ears. B has decidedly larger and better ears than A. No apparent difference in ripeness between A and B. C looks decidedly inferior to A and B. The quantity of seed planted was not the same in the several plots, but it germinated about equally well on all the plots.

October 31. Harvested the corn. The average weight of dry corn on one ear was as follows:

A, 3.5 oz. B, 3.8 oz. C, 4.0 oz. D, 3.0 oz. E, 3.5 oz.

The dry matter of the kernels had the following composition:

	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
A, Evergreen, Mich.	1.99	12.00	3.24	73.48	9.30
B, " Conn.	1.95	10.99	3.50	73.67	9.89
C, " Nebr.	2.28	12.19	3.12	72.83	9.58
D, Early Crosby, Ohio	1.88	13.88	2.54	71.86	9.84
E, " Conn.	2.07	14.60	2.67	70.74	9.92

GRASSES AND FORAGE.

Forage Plants of the Salt Marshes of Connecticut.

By A. L. Winton, Jr., Ph.B.

In 1884 the U. S. Department of Agriculture published a report on the tide marshes of the United States,* from which it appears that there are in Connecticut 34.79 square miles or 22,264 acres of "salt marsh" and 1.67 square miles or 1,069 acres of "swamp land" or fresh water tide marsh. We have been unable to ascertain what portions of this area lie in each of the several townships or counties which border on the sound and the larger rivers of the State. Through the kindness of Mr. A. B. Hill, city engineer of New Haven, we are however able to give the areas of marsh in and adjoining the town of New Haven, as follows:—

	Acres.
On easterly side of Harbor from Fort Hale to Grand Avenue Bridge	383
Quinnipiac River to North Haven or as far as salt marsh extends	3679
Mill River to Whitneyville Dam	434
West River salt marsh, below Congress Avenue	587
West River from Congress Avenue to Whalley Avenue	286
Total	5369

This does not include area of the rivers.

It appears that of the 23,300 acres of marsh, both salt and brackish, 5,369 or nearly one-fourth lie about New Haven.

The money value of the salt marshes in this State ranges from less than $10.00 per acre upwards according to the character of the land and its situation.

Care of the Marshes.—With the exception of a few acres of reclaimed marsh the only crop gathered from this large area is the so-called "salt hay" which varies greatly from place to place in the character of the herbage producing it, yields from one-half to two or more tons per acre and brings in market not more than from one-half to three-fourths as much per ton as upland hay. The marshes are neither manured nor tilled in any way by their owners. The only work spent on them besides harvesting the crop is making and maintaining the ditches and necessary bridges over the ditches and creeks. The sediment which settles from

*Miscellaneous Special Report No. 7, The Tide Marshes of the United States, by D. M. Nesbit, with contributions by the U. S. Coast and Geodetic Survey.

the water that overflows them during high tides, or, in the case of river marshes, during freshets, supplies the only fertilizer which they get and is a kind of natural sewage irrigation. The importance of ditching is well understood. On well ditched meadows the yield of hay is larger, and, owing to the firmness of the land, the crop is more easily harvested than on those where ditches are improperly constructed, neglected or wanting. Bare spots entirely devoid of vegetation, result from lack of care in keeping the ditches clear. The salt water remaining on the marshes after high tides and especially in a dry season, after concentrating by evaporation acts injuriously even on salt marsh plants.

Cutting and Curing the Hay.—The meadows are mowed anywhere from the middle of June to December. Although "Black-Grass," "Three-Square" and most of the other marsh plants, excepting, perhaps, "Red Salt Grass," yield a larger and better crop of hay the latter part of June or the first part of July than afterwards, still as a matter of fact few farmers cut salt hay till much later in the season. When the marshes are firm enough to bear it, the grass is cut with mowing machines. The horses' feet are often shod with "clods," which are stout pieces of board 7 by 9 inches square attached to their hoofs by means of irons fastened with bolts. Horses soon become accustomed to these clods and walk with little difficulty even on rather soft marsh. Generally it is practicable to cure the hay where it is cut, but where the meadows are so low as to be inundated at each tide it must be hauled to the upland for curing. Many hundred tons of the hay are annually stacked on the marshes. The latter plan is extensively practiced on the meadows about New Haven where each stack usually contains about a ton of hay and is raised a little above the marsh on a bunch of stakes driven into the ground.

Various Uses of the Hay.—The value of the hay for feeding varies greatly according to the kinds of plants which compose it as well as the time when it is cut. We have seen well-conditioned stock that have received none other than good salt marsh hay, while on the other hand some hay cut on the marshes is entirely unfit for feeding. The coarser kinds are only useful for litter and on some farms salt hay is used exclusively for this purpose. The hay from "Red Salt Grass" makes an excellent mulch which is particularly valued by strawberry growers, being quite free from any seeds which can prove troublesome. Salt hay is also largely used for packing crockery, etc.

The Vegetation on the Marshes.—Directly adjoining the Sound and along the rivers where the water is distinctly salt, the vegetation differs materially from that further up the rivers and creeks where the tide-water rises daily but is only brackish, being mixed with fresh water.

We will separately consider the most important grasses, sedges, rushes and other plants of the salt marshes proper, and those growing more remote from the salt water on what may be called the brackish marshes. Following up our river valleys as far as tide-water rises, we generally find all stages of transition from purely salt marshes to brackish marshes and thence to fresh water river meadows.

A. *Plants growing on the salt marshes proper.*—Black Grass, (*Juncus Gerardi*), Salt Grass, "Red Salt Grass, "Fox Salt" etc., (*Spartina juncea*), and Creek Sedge, (*Spartina stricta*, var. *glabra*), make up most of the vegetation of the marshes, and of these salt grass is the most abundant. They do not grow mixed together so thoroughly as upland grasses and clovers but the marshes generally have a patched appearance. Sometimes these patches have only a few square feet of surface and sometimes they cover quite large tracts, but each patch is made up chiefly of one of the three above named species. Those of Black Grass show some shade of brown, those of Salt Grass and Low Creek Sedge are green and all are bordered on the creeks and ditches by Tall Creek Sedge. On marshes often overflowed with salt water Black Grass is generally wanting. Besides the plants already mentioned, more or less Goose Grass (*Triglochin maritimum*), Marsh Rosemary (*Statice limonium*, var. *Carolinianum*), and Sea Club Rush (*Scirpus maritimus*), are scattered through the marshes, and in places Spike Grass (*Distichlis maritima*), and some other plants occur.

B. *Plants growing on the brackish marshes.*—On these marshes there is greater variety of vegetation. Besides a few species peculiar to such localities, some of the plants described under A, and a number of fresh water grasses and sedges occur. Only the more common species are here noted. We find on the marshes whose level is little if any below that of high water mark, the sedges, "Three-Square" (*Scirpus pungens*), Larger Three-Square (*Scirpus Olneyi*), and "Snip Snap" (*Eleocharis rostellata*), the grasses, Fiorin (*Agrostis alba*), Red Fescue (*Festuca rubra*), Wild Rye Grass (*Elymus Virginicus*), and more or less Black

Grass with Wild Oats (*Zizania aquatica*), and Cord-Grass (*Spartina cynosuroides*), on the low borders adjoining rivers and ditches. In places there are acres of Cat Tails (*Typha latifolia*), and here and there a clump of *Phragmites communis*. On the very low marshes that most of the time are submerged, Wild Oats and Cord Grass flourish.

During the season of 1889 samples of most of these grasses, sedges, etc., were taken at different stages of growth from the meadows, and also samples of hay made from them. These were analyzed and the results appear in the tables on pages 243–245. A brief popular description of each plant is also given, which may help in recognizing them.

Black Grass (*Juncus Gerardi*).—The popular name "Black Grass" is a misnomer since the plant is not a grass at all but one of the rushes; a group of plants more nearly related to the lilies than to the grasses. Indeed the flowers of Black Grass somewhat resemble diminutive lilies.

While most of the marsh plants have received very appropriate names, the terms "grass," "sedge," and "rush" have naturally been used rather loosely. Black Grass commonly grows from one to two feet high, the fertile stalks rising from the roots and bearing at the summit the flowers (which afterwards develop into the little round pods) on the ends of short stems (peduncles.) It blooms early in June and gets its growth by about the first of July. If it is cut at that time the yield on a good marsh will be from one and one-half to two tons per acre of excellent hay which compares favorably with hay from upland meadows. The aftermath if cut about the first of September will yield from one-half to one ton per acre of hay equal or superior in feeding value to the first crop.

The fruit is ripe about the first of August, each little pod containing numerous minute seeds of which (as we have reckoned from actual weighing), it takes about 800,000 to make an ounce. In the table are given twelve analyses, five on samples from Saybrook, one from Guilford, two from Mill River and four from Quinnipiac River, both the latter localities near New Haven. In every case the earlier cut grass is the richer in albuminoids—the most valuable food ingredient.

Salt Grass (*Spartina juncea*), variously known in this State as Red Salt-Grass, Fox Salt Grass, etc., is a true grass and the most important, agriculturally, of the four species of Spartina that

grow on our salt marshes. It attains about the same height as Black Grass (one to two feet), but is readily distinguished from the latter by its later development, its leafy stems and by its flower-heads which are one to five in number, each about one inch long and quite one-sided. The stalks are tough and wiry and bear about six narrow rolled-up leaves alternately arranged.

Salt Grass hay is inferior to that of Black Grass, but is still a good fodder if used in connection with upland hay. It is useful as a mulch and is the kind of "salt hay" sought after by strawberry growers for this purpose. It generally brings in the market about half the price of upland hay. In the table are five analyses of this species taken at different stages of growth.

Creek Sedge (*Spartina stricta*, var. *glabra*).—This species, which is not a sedge but a true grass, when it grows on the banks of the creeks and ditches becomes coarse and rank, reaching a height of six or eight feet by the first of August, when it blooms. But when it grows away from creeks and ditches it is low and stunted seldom rising to a height of two feet even when in bloom. The leaves of Creek Sedge are broad and smooth and the edges are free from saw-teeth. The five to twelve heads or spikes are pressed close together along the flowering stalk making what appears to be a single slender head about one foot long. Each spikelet is one-sided like the salt grass. The stunted form when cut for hay is said to be relished by cattle and the same is true of the ranker growth if cut before it becomes coarse and woody, but if allowed to stand too long is only suitable for litter. Five analyses are given in the table.

Spike Grass (*Distichlis maritima*, or *Brizopyrum spicatum* of Gray's Manual) grows on the marshes but in less abundance than the plants already described. Its long root-stalk and deep seated roots fit it for the sandy shores where it is usually found. Like Salt Grass it has a wiry stalk with abundant leaves and grows to the height of one to two feet, but it differs in having a single head which is not one-sided. An analysis is given below.

Sea Club Rush (*Scirpus maritimus*), is a sedge about one foot high which is often found on the marshes and bears a close bunch of heads which, soon after bloom, has the size of a hickory nut. The seeds by the last of June are juicy and palatable. When cut before there is danger of the seed dropping it makes a nutritious hay. One analysis is given in the table.

Goose-Grass or Greasy-Bog (*Triglochin maritimum*). This plant with its round succulent leaves and its flower stalks one to three feet high is widely distributed over the marshes. In early June it blossoms, and in the course of the summer ripens numerous oval fruit pods. Owing to its succulent nature it is seldom thoroughly dried in curing and feels greasy in the hay, hence the name Greasy-Bog. Two analyses are given below.

Three-Square (*Scirpus pungens*), is well described by its common name. The triangular stalk is from one to three feet high and near the summit bears the fruit heads in a close bunch. It is not peculiar to salt marshes, being very common on the borders of fresh-water rivers and ponds and in wet places generally. Many tons of Three-Square are cut annually for hay, and although rather coarse it has proved itself a valuable cattle food. Four analyses are given.

Larger Three-Square (*Scirpus Olneyi*), is a rarer plant but in places occurs in considerable abundance. A cross-section of a stem of Three-Square is sharply triangular, but a section of the Larger Three-Square is **Y**-shaped. See analysis.

Fiorin, (*Agrostis alba*). More or less Agrostis, generally a form like *A. alba*, grows luxuriantly near the ditches where the conditions are favorable for a thick stand. A method of handling the marshes so as to extend the growth of this most excellent grass would be welcome. Three analyses are given below.

Cord-Grass (*Spartina cynosuroides*). This coarse grass grows not only where the water is fresh or brackish but also, together with Creek Sedge, on muddy banks by the salt water. Before blooming it is readily distinguished from the latter by the rough saw-toothed edges of the leaves and afterwards by the spreading heads.

Snip-Snap, Two-Tail (*Eleocharis rostellata*). This, so far as we have observed, is the most common of several species of *Eleocharis* that grow on the marshes. The fertile plants consist of wiry stalks about a foot high with little oval heads on the summit, and remind one of large pins stuck in the turf. The sterile plants scattered among the latter bend over and take root at the apex of the leaf and appear like so many croquet wickets; hence the name "Two-Tail." As one walks through the marsh the feet catch in these wickets and they break with a snap—(Snip-Snap).

Wild-Rice (*Zizania aquatica*), also called Wild-Oats, Water-Oats, Blackbird-Oats and Indian Rice. This lordly grass growing from five to ten feet high is found on the river banks, often covering acres of marsh, apparently doing best where at high tide it is partly or completely submerged. It has long broad leaves and a much branched panicle one to two feet long. The lower branches of the panicle are spreading and bear the staminate flowers while the upper branches are almost erect and bear the bearded fertile flowers. It blossoms in midsummer.

Wild-Oats is a nutritious grass and it is said that cattle relish it. As the seeds when ripe drop with the least touch, it should be cut before there is danger of losing them. At Essex, on the Connecticut river, there are acres of Wild-Oats which make, as is well known to sportsmen, a favorite feeding place for rail and other birds. In the Northwest the Indians are said to gather large quantities of the seed for food. See analyses below.

Wild-Rye-Grass (*Elymus Virginicus*), has a head much resembling Rye. Another species of Elymus occurs commonly in Connecticut but has not been noticed on the marshes.

Cat-Tail (*Typha latifolia*), which grows in the brackish marsh is never used for feed but makes a good bedding.

Notes on the Analyses and Conclusions.

It appears from the table of analyses that in every case any given species contains a higher percentage of albuminoids, the most costly food ingredient, and generally also of fat which is next in value, when cut before or at the time of bloom than when it is cut at a later period of development. The same is known to be true of the grasses on upland meadows and the fact harmonizes with the belief of some farmers that hay should be cut at the time of bloom on salt marshes as well as on upland. Red Salt Grass (*Spartina juncea*), blooms quite late, in the latter part of July or early in August, and if growing by itself might perhaps profitably be left till that late date. But Black Grass in particular yields the best return if cut early, and then a second and lighter cutting may also be got—which is much richer both in albuminoids and fat. Compare analyses 10 and 11. In this vicinity, however, early cutting is the exception, and last year much of the grass stood till the middle of September.

The chief reason why the cutting of marsh hay is deferred so long is lack of time or help to secure it earlier. All upland hay is gathered first because it is generally considered to be superior. While it is not claimed that marsh hay is commonly as valuable as good upland hay, there is reason to believe that the best marsh grasses are generally undervalued as forage and partly so because they are rarely cut until they are over-ripe, have dropped their seed and lost their flavor.

While chemical analysis does not accurately show the relative feeding value of different grasses—that depends on the digestibility and palatability of the food as well as on its composition—yet it gives valuable indications.

The following statement shows the average percentage composition of mixed Timothy and Red-Top, 10 analyses; mixed meadow grasses, 11 analyses; compared with Black Grass cut when seed was in the milk or before, 4 analyses; Salt Grass, 4 analyses; and Creek Sedge, 5 analyses, all reduced to a water-free basis:

	Timothy and Red-Top.	Mixed Meadow grasses.	Black Grass, *Juncus Gerardi.*	Red Salt Grass, *Spartina juncea.*	Creek Sedge, *Spartina stricta.*
Ash	5.5	5.5	7.9	9.3	11.7
Albuminoids	7.4	7.6	9.2	6.0	7.2
Fiber	34.4	35.6	29.0	28.6	29.4
Nitrogen-free Extract	50.4	48.9	51.3	53.4	49.5
Fat	2.3	2.4	2.6	2.7	2.2
	100.0	100.0	100.0	100.0	100.0

These figures show that when cut in proper season Creek Sedge has practically the same percentage of albuminoids and fat as good meadow hay with less fiber or woody tissue. Black Grass may have $1\frac{3}{4}$ per cent. more albuminoids, a little more fat, and considerably less woody fiber than these meadow grasses. Black Grass in blossom is quite as soft and fine as the best meadow hay and has a pleasant odor and flavor.

Certain other of the coarser grasses, as Creek Sedge, Indian Rice, Cord Grass, etc., especially the two first named, if cut while young may make quite palatable food.

Another point to be noted is this: that all the marsh grasses which are used for feed or litter bring no inconsiderable quantities of plant-food from the rivers and sea to the manure heaps.

Following are two tables of ash analyses of certain grasses which are the basis of subsequent calculations.

In making the analyses the determinations of potash, soda and chlorine were most carefully repeated and controlled and are believed to be quite exact. Taking the average of these determinations we find the following quantities, in pounds, of nitrogen,

Composition of the Ash of Salt-Marsh Plants.

	Black Grass. *Juncus Gerardi.*		Salt Grass. *Spartina juncea.*		Three-Square. *Scirpus pungens.*		Creek Sedge. *Spartina stricta.* var. *glabra.*
	June 22. No. 4.	Aug. 7. No. 9.	July 13. No. 15.	Aug. 5. No. 16.	June 22. No. 27.	Aug. 12. No. 28.	Aug. 5. No. 19.
Silica and Earth	7.03	12.05	32.73	*40.08	24.22	40.93	14.65
Oxide of Iron and Alumina	1.10	2.30	4.66	3.85	.89	.94	1.37
Lime	3.70	4.00	1.68	2.92	2.84	2.56	3.53
Magnesia	5.36	5.26	4.04	5.36	3.38	1.50	4.00
Potash	45.75	22.18	6.51	10.45	22.30	12.92	12.51
Soda	10.88	21.79	25.06	22.92	16.38	15.87	31.64
Sulphuric Acid	5.77	5.63	4.47	5.33	10.76	11.64	2.85
Phosphoric Acid	4.41	3.27	2.30	4.30	3.50	2.23	4.36
Chlorine	20.66	30.37	23.95	6.17	20.30	14.74	32.41
	104.66	106.85	105.40	101.38	104.57	103.33	107.32
Deduct Oxygen equivalent to Chlorine	4.66	6.85	5.40	1.38	4.57	3.33	7.32
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent. of Ash in air-dry hay	5.80	7.01	12.19	5.78	8.59	8.56	8.48
Per cent. of salt in Ash reckoning soda as sodium chloride	20.50	41.09	47.25	43.20	30.87	29.90	59.64
Per cent. of salt in Ash reckoning chlorine as sodium chloride	34.09	50.11	39.52	10.18	33.50	24.32	53.48

Per Cent. of Nitrogen and Ash-Ingredients in the Hay of Salt-Marsh Plants.

	Black Grass. *Juncus Gerardi.*		Salt Grass. *Spartina juncea.*		Three-Square. *Scirpus pungens.*		Creek Sedge. *Spartina stricta.* var. *glabra.*
	June 22. No. 4.	Aug. 7. No. 9.	July 13. No. 15.	Aug. 5. No. 16.	June 22. No. 27.	Aug. 12. No. 28.	Aug. 5. No. 19.
Silica and Earth	.41	.84	3.99	2.31	2.07	3.49	1.24
Oxide of Iron and Alumina	.06	.16	.57	.22	.08	.08	.12
Lime	.21	.28	.21	.17	.24	.22	.31
Magnesia	.31	.37	.49	.31	.29	.13	.34
Potash	2.65	1.55	.79	.61	1.92	1.11	1.06
Soda	.63	1.53	3.06	1.32	1.41	1.36	2.68
Sulphuric Acid	.33	.40	.54	.31	.92	1.00	.24
Phosphoric Acid	.26	.23	.28	.25	.30	.19	.37
Chlorine	1.20	2.13	2.92	.36	1.75	1.26	2.74
	6.06	7.49	12.85	5.86	8.98	8.84	9.16
Deduct Oxygen equivalent to Chlorine	.26	.48	.66	.08	.39	.28	.62
	5.80	7.01	12.19	5.78	8.59	8 56	8.48
Nitrogen	1.19	1.18	1.04	.71	1.33	1.04	1.09
Probable per cent. of Salt (NaCl)	1.19	2.88	4.81	.59	2.65	2.08	4.55

* Of which 8.08 is silica soluble in dilute hydrochloric acid and 21.70 silica soluble in sodium carbonate solution.

phosphoric acid and potash in a ton of hay, of the kinds named, respectively.

	Black Grass.	Salt Grass.	Three Square.	Creek Sedge.
Nitrogen	23.8	17.4	23.8	21.8
Phosphoric Acid	5.0	5.4	5.0	7.4
Potash	42.0	14.0	30.2	21.2

Five tons of this hay contains as much of these fertilizing materials as are contained in a full crop of corn, including stover, from an acre of land.

It may be here remarked that the samples, as is usual with salt marsh hay, were more or less coated with mud and salt so that the quantities of silica and earth and of salt given in the analyses are larger than existed as actual constituents of the plants. Analyses of the clean plants would be of scientific interest but it was our object to ascertain the composition of the plants as cut in farm practice.

The percentage of adhering matters is extremely variable, depending on the situation of growth, the washing and spattering of rains and the overflowing of tides.

In the seven samples of which the analyses of the ash are given above the quantity of salt in a ton of hay varied from 12 to 90 pounds, the average being 54 pounds.

The question of reclaiming salt marsh and growing other farm crops on it need not here be discussed. It is believed that by proper ditching and earlier cutting our marshes may be made a good deal more profitable without changing the kind of vegetation now growing on them.

ANALYSES OF GRASSES AND OTHER FORAGE PLANTS GROWING ON TIDE MARSHES.

Number.	Name.	Locality.	Date of Cutting.	Stage of Growth.	Analyses. Water.	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract, Starch, Gum, etc.	Fat.	Analyses, Calculated Water-free. Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract, Starch, Gum, etc.	Fat.
1	Black Grass. *Juncus Gerardi.*	Saybrook.	1888. July 1	----------	6.74	6.61	8.62	27.74	48.14	2.15	7.08	9.24	29.76	51.62	2.30
2	" "	"	Sept. 1	----------	6.74	9.18	6.56	26.16	49.13	2.23	9.84	7.03	28.06	52.68	2.39
			1889.												
3	" "	"	June 22	In bloom.	8.15	7.96	9.20	25.37	46.61	2.71	8.68	10.02	27.64	50.71	2.95
4	" "	"	22	Seed in milk.	10.04	5.80	7.44	27.40	46.93	2.39	6.44	8.26	30.44	52.20	2.66
5	" "	"	Aug. 12	Seeds gone.	7.35	4.97	5.31	28.20	52.09	2.08	5.37	5.73	30.46	56.20	2.24
6	" "	Mill River Marsh, New Haven.	June 30	Seed in milk.	10.58	8.71	8.12	25.06	45.21	2.32	9.74	9.08	28.03	50.56	2.59
7	" "	" "	Sept. 27	Aftermath.	8.99	9.22	7.50	23.43	47.78	3.08	10.13	8.25	25.75	52.49	3.38
8	" "	Quinnipiac Marsh, New Haven.	July 20	Seed almost ripe.	9.94	7.93	7.75	24.10	47.38	2.90	8.80	8.60	26.74	52.64	3.22
9	" "	" "	Aug. 7	Seed very ripe.	9.51	7.01	7.37	24.41	48.84	2.86	7.74	8.15	26.97	53.98	3.16
10	" "	" "	Sept. 15	Seed gone.*	11.49	5.37	6.69	26.36	47.23	2.86	6.07	7.56	29.79	53.36	3.22
11	" "	" "	15	Second growth.†	11.63	8.78	11.62	20.44	44.32	3.21	9.94	13.14	23.12	50.17	3.63
12	" "	Guilford.	----------	----------	9.60	6.09	8.00	27.21	46.83	2.27	6.74	8.84	30.10	51.81	2.51
13	Red Salt Grass. *Spartina juncea.*	Saybrook.	1888.	----------	6.74	9.00	4.50	24.30	53.22	2.24	9.65	4.82	26.04	57.09	2.40
			1889.												
14	" "	"	June 22	Spikes not visible.‡	10.10	7.02	6.37	26.80	47.08	2.63	7.80	7.08	29.81	52.39	2.92
15	" "	Quinnipiac Marsh, New Haven.	July 13	In bloom.	9.22	12.19	6.50	26.14	43.64	2.31	13.43	7.15	28.79	48.09	2.54
16	" "	" "	Aug. 5	In seed.	9.01	5.78	4.44	27.18	51.09	2.50	6.35	4.88	29.87	56.15	2.75
17	" "	" "	Sept. 14	Seed gone.	8.15	5.08	4.13	26.72	53.17	2.75	5.54	4.49	29.11	57.87	2.99

* Grass dried and brown. † Grew up through the lodged first growth. ‡ Growth thick but low.

Analyses of Grasses and other Forage Plants growing on Tide Marshes—*Continued.*

Number.	Name.	Locality.	Date of Cutting.	Stage of Growth.	Analyses. Water.	Analyses. Ash.	Analyses. Albuminoids.	Analyses. Fiber.	Analyses. Nitrogen-free Extract. Starch, Gum, etc.	Analyses. Fat.	Water-free. Ash.	Water-free. Albuminoids.	Water-free. Fiber.	Water-free. Nitrogen-free Extract. Starch, Gum, etc.	Water-free. Fat.
18	Creek Sedge. *Spartina stricta* var. *glabra.*	Quinnipiac Marsh, New Haven.	1889. July 5	Spikes not visible.	9.72	15.30	8.44	25.53	39.02	1.99	16.95	9.35	28.28	43.21	2.21
19	" "	" " "	Aug. 5	In bloom.	8.18	8.48	6.81	26.72	47.75	2.06	9.24	7.42	29.10	51.00	2.24
20	" "	Saybrook.	12	In bloom.*	7.37	8.33	4.00	27.28	51.25	1.77	9.00	4.32	29.46	55.31	1.91
21	" "	"	12	" †	8.13	11.85	6.06	27.70	44.02	2.24	12.87	6.58	30.14	47.98	2.43
22	" "	"	12	" ‡	8.25	9.66	7.62	27.39	44.90	2.18	10.52	8.30	29.83	48.98	2.37
23	Spike Grass.¶ *Distichlis maritima.*	Stratford.	31	"	9.22	6.99	5.44	26.38	49.42	2.55	7.70	5.99	29.05	54.46	2.80
24	Sea Club Rush. *Scirpus maritimus.*	Saybrook.	June 22	Soon after bloom.	11.24	7.98	9.19	24.75	43.99	2.85	8.98	10.36	27.84	49.62	3.20
25	Goose Grass. *Triglochin maritimum.*	"	22	Seed soft.§	7.16	10.98	11.37	25.13	42.01	3.35	11.84	12.25	27.08	45.23	3.60
26	" "	New Haven.	July 13	" ‖	9.02	6.29	8.12	36.31	37.57	2.69	6.92	8.93	39.90	41.29	2.96
27	Three Square. *Scirpus pungens.*	Saybrook.	June 22	Soon after bloom.	7.97	8.59	8.31	25.10	47.41	2.62	9.34	9.02	27.29	51.50	2.85
28	" "	"	Aug. 12	Seed dropping.	7.89	8.56	6.50	23.76	50.49	2.80	9.29	7.06	25.78	54.83	3.04
29	" "	Quinnipiac Marsh, New Haven.	July 13	Seed hard.	8.00	8.22	7.44	30.22	43.97	2.15	8.94	8.08	32.85	47.79	2.34
30	" "	Mill River Marsh, New Haven.	Aug. 5	Seed gone.	8.55	7.89	7.37	23.68	49.95	2.56	8.63	8.06	25.88	54.63	2.80

* Banks of a creek of brackish water, 6 feet high.
† Banks of a creek of salt water, 6 feet high.
‡ Near 20 and 21, but in the middle of the marsh, 1 foot high.
§ Leaves only.
‖ Stalks with green seed pods.
¶ *Brizopyrum spicatum* of Gray's Manual.

Analyses of Grasses and other Forage Plants growing on Tide Marshes—*Continued.*

Number.	Name.	Locality.	Date of Cutting.	Stage of Growth.	Analyses. Water.	Analyses. Ash.	Analyses. Albuminoids.	Analyses. Fiber.	Analyses. Nitrogen-free Extract. Starch, Gum, etc.	Analyses. Fat.	Water-free. Ash.	Water-free. Albuminoids.	Water-free. Fiber.	Water-free. Nitrogen-free Extract. Starch, Gum, etc.	Water-free. Fat.
31	Larger Three Square. *Scirpus Olneyi.*	Quinnipiac Marsh, New Haven.	1889. July 28	Soon after bloom.	9.53	8.24	10.06	25.14	45.25	1.78	9.11	11.12	27.79	50.01	1.97
32	White Bent or Fiorin. *Agrostis alba.*	Saybrook.	June 22	Before bloom.	7.68	6.73	9.38	26.47	47.48	2.26	7.28	10.18	28.68	51.41	2.45
33	" "	"	Aug. 12	Seed gone.	6.83	4.92	5.19	27.53	53.92	1.61	5.28	5.57	29.55	57.87	1.73
34	" "	Quinnipiac Marsh, New Haven.	June 28	In bloom.	9.08	8.64	8.69	24.48	46.65	2.46	9.52	9.57	26.94	51.28	2.69
35	Fresh-water Cord Grass. *Spartina cynosuroides.*	New Haven.*	Aug. 5	"	8.16	6.18	5.62	30.79	47.43	1.82	6.74	6.12	33.54	51.62	1.98
36	Snip Snap or Two Tail. *Eleocharis rostellata.*	Saybrook.	June 22	Soon after bloom.	8.67	9.47	9.32	24.61	45.51	2.42	10.37	10.21	26.96	49.81	2.65
37	" "	"	Aug. 12	Seed hard.	8.09	10.72	8.25	24.25	46.29	2.40	11.66	8.97	26.39	50.37	2.61
38	Wild Rice or Wild Oats. *Zizania aquatica.*	New Haven.†	July 13	Coming into bloom.	9.86	16.95	8.56	25.44	36.28	2.91	18.80	9.50	28.23	40.24	3.23
39	" "	" †	Aug. 5	In bloom.	8.23	14.25	7.12	31.06	37.29	2.05	15.52	7.76	33.84	40.65	2.23
40	Wild Rye Grass. *Elymus Virginicus.*	"	June 28	Before bloom.‡	6.87	7.09	7.62	32.01	44.36	2.05	7.62	8.18	34.37	47.53	2.20
41	Cat Tails. *Typha latifolia.*	"	July 13	§	10.77	5.78	7.00	33.68	39.75	3.02	6.37	7.85	37.76	44.64	3.38

* Banks of Mill River.
† In shallow water.
‡ 3 feet high.
§ Leaves only.

COMPARISON OF THE YIELD AND COMPOSITION OF CERTAIN GRASSES IN 1888 AND 1889.

By E. H. Jenkins.

In the Report for 1888, page 100, are described in detail certain plots of grass, each containing only a single species, from which the crops are to be annually gathered, each at the period of full bloom, weighed and analyzed. The weights and analyses of the crops for 1888 are also given in the Report for that year, p. 101.

In the early spring of 1889, as in the previous year, the dead aftermath grass was burned off, and a fertilizer made up of 150 pounds of nitrate of soda, 250 pounds tankage, 30 pounds muriate of potash and 125 pounds dissolved bone black was sown over the whole garden at the rate of 555 pounds to the acre. The same had been done the year before. The crop on each plot was cut at the time of full bloom as nearly as was possible. The continuous rains in June made it difficult to determine in all cases just when the grass was fully in bloom and also hindered in the cutting and weighing. It is believed that all the grasses were cut at a period a trifle more advanced than last year, but the difference was not great.

The following table contains the results obtained in 1889:

Name of Grass.	Plot.		Per cent. Nitrogen. Total.	Per cent. Nitrogen. Albuminoid.	Per cent. of Phosphoric Acid.	Per cent. of Potash.
Tall Red Top	E	Fresh.	.34	.29	.18	.72
		Water-free.	.79	.67	.43	1.68
Fine Bent	D	Fresh.	.43	.37	.21	.78
		Water-free.	1.06	.92	.52	1.94
June-grass	A	Fresh.	.39	.32	.18	.78
		Water-free.	1.18	1.00	.56	2.42
Wood Meadow-grass	C	Fresh.	.37	.36	.15	.74
		Water-free.	1.11	1.04	.45	2.21
Orchard-grass	I	Fresh.	.30	.26	.15	.79
		Water-free.	1.02	.86	.50	2.61
Tall Oat-grass	Z	Fresh.	.28	.21	.14	.76
		Water-free.	1.02	.77	.53	2.82
Yellow Oat-grass	Q	Fresh.	.30	.26	.13	.66
		Water-free.	1.02	.91	.46	2.31
Meadow Fescue	Y	Fresh.	.29	.24	.14	.62
		Water-free.	1.10	.91	.53	2.38
Sweet Vernal-grass	S	Fresh.	.37	.32	.16	.63
		Water-free.	1.42	1.26	.62	2.46

No extended discussion is desirable till further data can be presented.

The leading facts which appear from a comparison of the crops of 1888 and 1889 are these:

1. The weight of the water-free crops on three plots, D, E and Y, was less in 1889 than in 1888; but on the other six plots it was larger and the gross yield from them all was 7 per cent. larger in 1889 than in 1888.

2. In the water-free crops the percentage of ash did not exhibit very striking differences in the two years. The per cent. of fiber and of nitrogen-free extract was on the average considerably larger in 1889 than in 1888. The percentage of fat was smaller. Very striking, however, are the differences in albuminoids. In 1889 there was on the average, in the dry matter of these grasses 28 per cent. less albuminoids than in 1888. The minimum difference was 16 per cent., the maximum difference 40 per cent.

A similar though not so striking a difference in the percentage of albuminoids has already been noticed in the corn crops of the two years; see page 230.

This striking decrease of nitrogen in the crop of 1889 is to be explained by the facts that the fertilizer applied did not furnish nearly enough nitrogen to meet the requirements of the crop, and that nitrogen is known to be relatively deficient in our soil.

ON THE AWNED SEED OF AGROSTIS VULGARIS.

By E. H. Jenkins.

The species *Agrostis vulgaris* has at least two very distinct agricultural varieties well known to farmers in the eastern states and very likely elsewhere; one is the coarse red top, called by Gould *A. vulgaris*, *major*, the other, *A. vulgaris minor*, variously called fine bent, furze-top and Rhode Island bent. A popular description of these varieties by J. B. Olcott may be found in the Report of this Station for 1887, page 177.

Awns on the palets of coarse red-top are unknown, but in old pastures where fine bent grows abundantly, plants with awned palets are occasionally found. The awns are upwardly barbed, usually geniculate, attached very near the base of the palet. The plants which bear them do not differ strikingly in appearance from the others which are not awned.

An experiment was begun in 1888 to learn whether awned seed produces plants bearing *only* awned seed or a *larger proportion* of

Analyses of Grasses grown in 1889.

Name of Grass.	Plot.	When cut.	Average height of flower stalks in inches.	Weight of Crop in ounces.		Composition of the Crop. Per cent. Water.	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Crude Fat.
Tall Red-top. *Agrostis vulgaris, major*	E	June —	36	Fresh,	277	57.29	2.24	2.12	15.74	21.64	.97
				Water-free,	118		5.24	4.96	36.89	50.63	2.28
Fine Bent. *Agrostis vulgaris, minor*	D	—	26	Fresh,	186	59.71	2.93	2.67	13.29	20.51	.89
				Water-free,	75		7.28	6.64	33.00	50.88	2.20
June-grass. *Poa pratensis*	A	" 10	30	Fresh,	240	67.02	2.07	2.44	10.77	16.77	.93
				Water-free,	79		6.29	7.38	32.64	50.86	2.83
Wood Meadow-grass. *Poa nemoralis*	C	—	26	Fresh,	216	66.57	1.67	2.32	11.62	17.03	.79
				Water-free,	72		4.98	6.91	34.77	50.97	2.37
Orchard-grass. *Dactylis glomerata*	I	" 10	48	Fresh,	408	69.86	1.75	1.92	11.11	14.55	.81
				Water-free,	123		5.79	6.36	36.92	48.23	2.70
Tall Oat-grass. *Arrhenatherum avenaceum*	Z	" 10	60	Fresh,	400	72.62	1.60	1.74	9.70	13.73	.61
				Water-free,	109		5.84	6.35	35.47	50.11	2.23
Yellow Oat-grass. *Avena flavescens*	Q	—	40	Fresh,	292	70.11	1.71	1.91	10.06	15.46	.74
				Water-free,	87		5.74	6.40	33.67	51.70	2.49
Meadow Fescue. *Festuca pratensis*	Y	—	43	Fresh,	268	73.18	1.58	1.84	10.19	12.55	.66
				Water-free,	72		5.90	6.86	38.02	46.73	2.49
Sweet Vernal-grass. *Anthoxanthum odoratum*	S	" 10	25	Fresh,	196	74.41	1.55	2.29	7.68	13.10	.97
				Water-free,	50		6.06	8.93	30.00	51.22	3.79

awned seed than is produced by plants grown from seed destitute of awns.

A small lot of furze-top hay containing some awned seed was kindly sent to the Station by Mr. Charles Potter of Prudence Island, Providence, R. I., who makes a specialty of raising fine-bent seed. Seeds were picked from this sample and each one was separately examined to be sure that it was awned. These were planted on clean land in the spring of 1888, and made a good growth the first year, but did not blossom.

In 1889 the plants seeded fully. The whole crop was cut when the seed was ripe and each panicle was separately examined for awns. The results were as follows:

	No. of panicles fully awned.	No. of panicles with few awns.	No. of panicles with no awns.
Stool No. 1	9	0	0
" " 2	0	29	1
" " 3	35	6	5
" " 4	56	36	0
" " 5	191	18	0
" " 6	116	0	0
" " 7	52	15	0
" " 8	2	63	0
" " 9	4	41	0
	465	208	6

The panicles described as fully awned may have had a few seeds destitute of awns.

Comment on the results is reserved till further data have been gathered.

COMPARISON OF SOLVENTS FOR FAT IN FEEDING STUFFS.

By R. S. Curtiss, Ph.B.

The following experiments were made to compare ether, petroleum-benzine and chloroform in their action on feeding stuffs, particularly with reference to chlorophyl, which it has been claimed is not dissolved by petroleum-benzine. On this ground it has been proposed to substitute benzine for ether in the determination of fat. The ether here employed was purified and dried by standing over fused $CaCl_2$ for twenty-four hours or more with frequent shaking. It was then distilled from $CaCl_2$ on a water-bath. From the petroleum-benzine, which is known in trade as 76° B, two fractions were prepared. The fraction distilling from 53°–60° C. was redistilled and the portion coming off from this between 55°–60° C. was used in the experiments. Likewise the portion obtained in the first distillation from 63°–80° C. was redistilled and the fraction coming off at 75°–80° C. reserved for use. A third preparation was made from what is known as 80°–90° gasoline. This material has a nauseating odor which made it necessary to boil off the more volatile portions in the open air. The fraction distilling off between 45° and 50° C. was used in the experiments.

The chloroform operated with was Malinckrodt's, thoroughly dried over $CaCl_2$ and distilled. Its boiling point was between 60.5° and 61.5° C.

For comparing these solvents six substances were selected, viz:

No. 4, *Typha latifolia*, the common cat-tail.
No. 10, *Agrostis alba*, a meadow grass.
No. 38, *Juncus Gerardi*, a sedge cut late.
No. 39, *Juncus Gerardi*, the young aftermath.
No. 2662, Linseed meal, new process.
No. 2664, Gluten meal.

These samples, air dried when necessary, were finely ground. In all cases the extractions were made in duplicate on 2 grams of material, previously dried at 100° C. to constant weight, in a current of hydrogen. The extractions were carried on at or near the boiling points of the solvents, in the apparatus for continuous extraction, first described by the Director of this Station in 1875, and figured in the American Journal of Science for March, 1877, p. 196. When the extraction was interrupted as at night, the residues were protected from the possible absorption of moisture. The flasks containing the extracts were finally heated for three hours in an air-bath at 100° C., to remove the solvent, care being taken to displace all heavy vapors from the flasks during the drying. They were then allowed to cool in the air and weighed with counterpoise-flasks. The table on the following page shows the percentage of matter extracted from each of the materials, and the accompanying notes give further details regarding the action of the various solvents.

Ether.

On five of the samples single extractions were made, continuing for three hours, previous experiments having proved that this length of time was sufficient except with No. 39, which required more than eleven hours treatment for perfect extraction and even then the residue retained a distinct dark green color.

Another portion of No. 39 extracted continuously for eight hours, yielded 3.21 per cent., three hours additional treatment gave .31 per cent., and a third extraction yielded .07 per cent., making the total extract 3.59 per cent.

Gasoline distilled at 45°–50° C.

The first extraction lasting three hours, removed from linseed and gluten meal all which the solvent could take up. In all cases the extraction was complete in six hours. Chlorophyl appeared to be removed from the other samples as fully as by the use of ether.

Petroleum-benzine distilled at 55°–60° C.

The first extraction lasting three hours apparently removed all the chlorophyl of samples No. 4 and No. 38, while No. 39 still had a decided dark green color even after the second treatment. Except in two cases the extraction was practically complete at the end of three hours.

Petroleum-benzine distilled at 75°–80° C.

The extractions were nearly complete in three hours. The action on the coloring matter was apparently the same as noted in case of the other grades of benzine.

Extract, in Per cent. of Air-dry Material.

	First extraction, 3 hours.						Second extraction, 3 hours additional.¶					
	4	**10**	**38**	**39**	**2662**	**2664**	**4**	**10**	**38**	**39**	**2662**	**2664**
Ether	3.02	2.46	2.86	2.94*	2.63	16.11	----	----	----	----	----	----
Petroleum-benzine, 45°–50°	1.59	1.85	1.82	2.03	----	----	.12	.10	.14	.15	----	----
" 55°–60°	2.07	----	2.09†	2.53	2.27	15.81	.09	----	.02	.09‡	.30	.18
" 75°–80°	2.50	2.45	2.24	2.73	2.60	15.91	.04	.12	.08	.11	.20	.21
Chloroform	3.54§	3.55	3.40	3.75	----	----	.35‖	.26	.22	.38	----	----

* Difference between duplicates = 0.26 per cent.
† " " " = 0.14 "
‡ " " " = 0.19 "
§ " " " = 0.15 "
‖ " " " = 0.25 "
In all other cases the duplicate agreed to within 0.1 per cent.
¶ Second extraction with benzine, 55°–60° lasted 4½ hours.

Chloroform.

Six repetitions of the first extraction, fresh chloroform being used each time, were necessary to completely exhaust the samples.

Total Extract.

The total quantity of extract obtained with each solvent is given below in per cent. of air-dry substance.

	No. 4	No. 10	No. 38	No. 39	No. 2662	No. 2664
Ether	3.02	2.46	2.86	3.59	2.63	16.11
Petroleum dist. at 45°–50°	1.71	1.95	1.96	2.18	----	----
" " 55°–60°	2.16	----	2.11	2.62	2.57	16.05
" " 75°–80°	2.54	2.57	2.32	2.84	2.80	16.13
Chloroform	5.23*	4.78	4.21	5.57†	----	----

As was to be anticipated it is very difficult to remove the last portions of petroleum-benzine from the extracts before weighing. This solvent is a mixture of a large number of different hydrocarbons having widely different boiling points. The lighter portions on heating pass off with ease, but the heavier are held very obstinately by the extract so that to perfectly remove them probably requires a higher temperature than 100° C. and involves danger of decomposing the extracts themselves.

It appears from these results that petroleum-benzine and chloroform dissolve chlorophyl quite as readily as ether. In all cases but one, benzine extracted considerably less than ether, but it has yet to be shown that the benzine-extract any more nearly represents true fat than the ether-extract.

Petroleum-benzine is also especially unfit for use as a solvent in quantitative work for the reason that it is an indefinite and variable mixture of a number of solvents, which, as the above results indicate, have different solvent action on the dry matter of feeding stuffs.

* Disagreement between duplicate determinations = 1.06 p. c.
† " " " " = 0.20 "

THE DETERMINATION OF PHOSPHORIC ACID IN FERTILIZERS BY THE "CITRATE METHOD."

By S. W. Johnson and T. B. Osborne.

In the Report of this Station for 1880, page 103, are references to the literature of this subject previous to that date, and a detailed account of experiments, made by Mr. H. L. Wells,* at this Station, with the object of learning the sources of error in the "Citrate Method" of determining phosphoric acid. The summary of Prof. Wells' laborious and skillful research, involving 140 determinations of phosphoric acid, is as follows:

"The conditions which tend to introduce a plus error are these:

1. Excessive amount of magnesia mixture in the presence of citric acid.
2. Presence of calcium as sulphate or chloride.
3. Presence of ferric salts.

The circumstances which tend to make a minus error are:

1. Solvent action of ammonium citrate on $MgNH_4PO_4$.
2. Presence of aluminium salts in the solution.

The most serious error is likely to come from the solvent action of ammonium citrate, and it is to be avoided by increasing the amount of magnesia mixture as the amount of citrate increases, by moderate dilution, and when the amount of citrate is very large [23 grams as in the case of reverted P_2O_5 estimations] by increasing the amount of ammonia employed. In case of most fertilizers the presence of calcium salts nearly or entirely compensates for the solvent effect of the citrate."

The following quantities of reagents were used in the analyses of commercial fertilizers made by Mr. Wells.

"1. Bones and natural phosphates [20–30 per cent. P_2O_5]. Use 1 gram substance, 10–15 grams $\overline{Ci}$, 30–40 c. c. Mg. mixture, 350–400 c. c. solution, of which one quarter is ammonia of specific gravity 0.96.

2. Superphosphates, soluble P_2O_5, 1–2 grams substance, 5–10 grams $\overline{Ci}$, 20–30 c. c. Mg. mixture, 350 c. c. solution.

Reverted P_2O_5, 1–2 grams substance, 11½ or 23 grams $\overline{Ci}$, 40 c. c. Mg. mixture, and more ammonia than usual.

Insoluble P_2O_5, 2 grams substance, $\overline{Ci}$, etc., same as soluble."

Direct determinations of total phosphoric acid were made in thirty-eight commercial fertilizers of all the kinds then in our market, both by the molybdic and by the citrate methods.

In 14 of these cases the citrate method and in 19 the molybdic method gave the higher result. In 5 instances the results by the two methods were identical. In 5 cases the disagreement amounted to 0.2 per cent. or more; the differences being respectively 0.22, 0.31, 0.36, 0.40, and 0.42. The *average* difference between the two methods was 0.11.

In six comparative determinations of soluble phosphoric acid, the citrate method in all cases gave lower results than the molybdic method. The greatest difference was 0.30, the average difference, 0.13.

Since then the citrate method has been studied by others who appear to have generally overlooked Wells' work and to have repeated much of it with essentially the same results.* The fact that foreign chemists are now using this method is the occasion of giving it a more extended investigation. Wells was led to vary the conditions under which his determinations were made, according to the nature of the phosphate under examination. The volume of the solution in which ammonium magnesium phosphate was precipitated, for example, varied from 350 to 400 c. c. and the quantity of citric acid from 5 to 11½ grams. We have, on the contrary, endeavored to keep the conditions as nearly constant as possible in the following analyses.

Several determinations were first made nearly following a method described by J. H. Vogel (Chemiker Zeitung, Vol. XII, p. 86) as follows: "To 50 c. c. of a solution containing 0.5 gram of the phosphate are added 10 c. c. of a 50 per cent. solution of citric acid and after neutralizing with ammonia, 20 c. c. of magnesia-mixture and 10 or 12 c. c. of strong ammonia water, the solution being vigorously stirred. After standing two hours the precipitate is filtered off, ignited and weighed."

For the convenience of using the solutions at hand in the Station laboratory that had been prepared for the routine work of fertilizer analysis, the method as given by Vogel was varied by taking in case of soluble phosphoric acid, 0.4 grams of substance, and by using in all cases 100 c. c. of the solution of the material analyzed. Further the magnesia-mixture here employed contains twice as much ammonium chloride in the liter as that

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*Reference to recent literature is given in Zeitschr. für angew. Chemie, 1889, 702.

proposed by Märcker and used by the German chemists, its proportions otherwise being the same.

Below the composition of the two mixtures is contrasted:

MAGNESIA - MIXTURES.

	German Experiment Stations.	United States Experiment Stations.
$MgCl_2 6H_2O$	110 gm.	110 gm.
NH_4Cl	140 "	280 "
NH_3, sp. gr. .96	700 c. c.	700 c. c.
H_2O	1300 "	1300 "
Volume	2000 "	2000 "

Following are the per cent. results obtained compared with those by the molybdic method:

TOTAL PHOSPHORIC ACID.

Station Number.	Determined by the Citrate Method.	Molybdate Method.	Difference.
2314	11.19	11.26	— .07
2324	12.33	12.54	— .21
2328	11.14	11.13	+ .01
2377	9.68	9.94	— .26
2382	10.53	10.50	+ .03
2392	8.37	8.57	— .20

SOLUBLE PHOSPHORIC ACID.

2814	8.11	8.44	— .33
2318	6.69	6.88	— .19
2324	7.60	8.06	— .46
2328	4.68	5.09	— .41
2377	4.16	4.34	— .18
2392	7.54	7.57	— .03

The citrate method, it is seen, gave generally a less amount than the molybdic, the average deficiency being about .20 and the greatest .46. The deficiency is greatest with soluble phosphoric acid.

The following modification of the method was then tried and in most cases the results proved to be satisfactory. The volume of the solution of the phosphate was in all cases 100 c. c. and this was mixed with 10 c. c. of a 50 per cent. solution of citric acid. After neutralizing with ammonia, 50 c. c. of U. S. magnesia-mixture was slowly added with constant stirring and when the precipitate had separated, 30 c. c. of concentrated ammonia water

was poured in. After two hours the precipitate was filtered on a Gooch crucible, ignited and weighed. If the sample analyzed had more than 10 per cent. of phosphoric acid one gram of it was commonly used for the determination. If less than 10 per cent., two grams were usually employed. In the case of ashes containing soluble silica this substance was first separated.

The percentages, or their averages, thus obtained on a variety of materials are shown in the following Table, compared with the figures got by the molybdate method. Certain phosphates, as Thomas Slag and Keystone Concentrated Phosphate, containing much iron or aluminium failed to be precipitated sufficiently and with them satisfactory results were in no case secured. They are not included in the table:

BONE.

Station Number.	Phosphoric Acid. By Citrate method.	By Molybdate method.	The Citrate method gave more (+), or less (−), than the Molybdate method.
2362	23.57—23.51	23.50—	+ .04
2364	21.49—21.50	21.43—21.49	+ .03
2369	18.40—18.43	18.37—18.59	— .06
2424	27.40—27.59	27.50—27.87	— .18
2426	21.74	21.82	— .08
2430	21.49	21.44—21.39	— .07
2431	21.98	21.82	+ .16
2435	25.79	25.61	+ .18
2436	22.82	22.78	+ .04
2440	23.00—23.16	22.99	+ .09
2441	21.41	22.41—22.31	+ .05
2452	18.26—18.29	18 58—18.52	— .27
2614	18.52	18.50	+ .02

BONE AND CHEMICALS.

2412	20.93—21.02	20.94—21.02	.00
2432	15.67	15.81	— .14
2433	14.57	14.69	— .12

SUPERPHOSPHATES.

Total P_2O_5.

No. 2	14.84	14.80	+ .04
No. 3	10.51	10.61	— .10
2394	10.44—10.46	10.44—10.50	— .02
2415	11.85	12.20	+ .35
2428	17.06	16.95	+ .11
2447	19.23—19.29—19.37	18.96—19.04	+ .33
2451	15.85	15.76	+ .11
2455	8.78	8.81	— .03
2456	12.64—12.72	12.22—12.32	+ .41

Station Number.	Phosphoric Acid. By Citrate method.	Phosphoric Acid. By Molybdate method.	The Citrate method gave more (+), or less (−), than the Molybdate method.
2457	8.76	8.83	− .07
2458	11.67	11.68	− .01
2608	10.59	10.61−10.75	− .09
2613	7.94	8.02	− .08
2615	8.93	9.02−9.12	− .14
2616	8.49	8.57	− .08
2617	6.50	6.52	− .02
	Soluble P_2O_5.		
No. 3	6.85	6.83	+ .02
2394	8.62	8.59	+ .03
2428	16.90	16.99	− .09
2447	13.39	13.26	+ .13
2451	15.46	15.59	− .13
2608	7.60	7.55	+ .05
2613	6.74	6.77	− .03
2615	6.94	6.96	− .02
2616	6.35	6.40	− .05
2617	5.42	5.65	− .23
	Insoluble P_2O_5.		
No. 2	1.46	1.45	+ .01
No. 3	1.62	1.67	− .05
2394	.68	.65	+ .03
2415	3.78	3.65−3.77	+ .07
2447	1.85	1.63	+ .22
	Reverted P_2O_5.		
No. 2	2.58	2.39	+ .19
No. 3	1.92	2.11	− .19
2447	3.97	3.93	+ .04
	COTTON HULL ASHES.		
	Total P_2O_5.		
2408	8.75	8.59	+ .16
2409	8.75	8.77	− .02
2410	8.82	8.90	− .08
2453	10.23	10.26	− .03
2454	3.72	3.54	+ .18
	Soluble P_2O_5.		
2408	.67	.68	− .01
2409	.44	.48	− .04
	COTTON SEED MEAL.		
2421	2.71	2.68	+ .03
2449	2.56	2.56	.00
2450	2.70	2.74	− .04

Station Number.	Phosphoric Acid. By Citrate method.	Phosphoric Acid. By Molybdate method.	The Citrate method gave more (+), or less (−), than the Molybdate method.
	CASTOR POMACE.		
2439	2.35	2.38	− .03
	TANKAGE.		
2442	2.29	2.29	.00
2618	8.84	8.94	− .10
	BONE CHAR.		
2437	18.52	18.56	− .04
	PHOSPHATIC GUANO OR ROCK.		
No. 1	22.53	22.43	+ .10
Mona Island	31.46−31.49	31.30	+ .18
Bolivian	17.35−17.38 17.42	17.09−17.13 17.14−17.24	+ .23
Gr. Cayman's Phosphate	25.84−25.85 26.01−26.11 26.12−25.82	26.12−26.18	− .19
So. Carolina Rock	25.61 25.72 25.49	25.53	+ .08

Of the sixty-seven determinations* by the citrate method but three differ from the molybdate method by more than 0.3 and but four others by more than 0.2 p. c. The greatest difference is 0.41, the average difference is 0.09 p. c. In 30 cases the citrate method gave 0.117 p. c. more, on the average, than the molybdate; in 33 cases, 0.079 p. c. less.

On the whole these results are strikingly similar to those obtained in 1880 by Wells. It will be observed in the ten cases where duplicates were made by each of the two methods that those by the citric process agree together rather more closely than those by the molybdic method. Only in case of Grand Cayman's has the difference between two citrate determinations on the same sample amounted to 0.3 p. c.

The process thus found so satisfactory with a large number of fertilizers gave trouble when applied in the same manner to Thomas-Slag and Keystone Concentrated Phosphate, as is seen from the following statement of the results of repeated trials:

* Or averages, in case duplicate determinations were made. It should be noted that these analyses were made rapidly as a part of the routine work of the Station, and without any special painstaking for the purpose of securing agreement.

The determinations in Thomas-Slag and Keystone Concentrated Phosphate were made each on 0.5 or 1 gm. of substance in 50 or 100cc. of either a nitro-hydrochloric or a sulphuric solution and by use both of the U. S. and of the German magnesia-mixture. The sulphuric solutions were obtained as directed by the German Experiment Stations' method, viz: by "heating 10 gm. of Slag in 50cc. of conc. sulphuric acid until white fumes appear for some time." (Versuchs Stationen, xxxv, 438). See page 262. The estimations marked O. are by Osborne.

1 gives the percentages obtained at first, by the process which had served for the estimations reported on pages 257–9. The low and irregular results appear to be due to insufficient stirring or standing of the liquids before filtration. They were, however, it is believed, obtained by treatment similar in these respects to that practised with the determinations tabulated on pages 257–9 and may emphasize the necessity of diligent and prolonged agitation when applying the citrate method to iron and aluminium phosphates. The highest result is 0·8 p. c. less than was obtained in **7** where the conditions differed simply by a double quantity of ammonium citrate and greater experience of the value of stirring.

2 is like the official method of the German Experiment Stations with the single difference that from the use of the U. S. magnesia-mixture the solution contained 1.75 gm. more of NH_4Cl. The solutions were quite cold before precipitation, and perhaps were insufficiently stirred.

3 was planned to follow exactly the German Experiment Stations' method. The free NH_3 is reckoned as 30 p. c. strength for convenience of comparison, but in following the method NH_3 of 10 p. c. was actually used according to the instructions (Versuchs Stationen, xxxv, 439). The 0.33 p. c. gain over **2** is possibly due to precipitation from warmer solutions and better stirring.

4 and **5** are by the German Experiment Stations' method with respective additions of 10cc. and 15cc. of NH_3 of 30 p. c., and in **5** of a double amount of magnesia-mixture with thorough agitation.

6 gives the same result as **4** and **5**, the quantity of substance taken as well as that of magnesia and free NH_3 being one-half as great.

A, B, and C, made by Messrs. Winton and Curtiss, with thorough stirring, confirm **4, 5, 6** and **7** and show that closely accordant results are obtained by different analysts, each working independently on different solutions and with two solvents.

The remaining determinations illustrate the effect of increasing relatively the amounts of magnesia-mixture or reducing that of citric acid, and especially show the influence of a great excess of ammonia, the results being carried up from 19.1 to 19.5 p. c.

7 is a duplicate of **5** except for being made on an aquaregia instead of oil of vitriol solution and more dilute.

8 as to conditions, differs from **6** by having half as much citrate and double the amount of magnesia and free ammonia; the phosphoric acid is raised 0.24 p. c.

9 and **10** finally, were obtained by the use of 5 gms. citric acid and a large quantity (75 cc.) of free NH_3. Two of the results in **9** are lower than the others probably because the beakers were too small to safely admit of sufficient stirring. The higher figures of **9** are in close agreement with those of **10.**

It now remains to consider the results of our work on the Keystone Concentrated Phosphate, a highly aluminous product containing but little calcium. See page 263.

11 and **12**, the first trials made, are probably low because not stirred sufficiently.

The remaining results certainly are not deficient on this account as no pains was spared to ensure superabundant agitation. They exhibit an extreme difference of 0.85 p. c. without giving any positive clue to the conditions which produce such variations. The highest figures generally accompany large excess of NH_3 or small volumes of solution, but duplicates made under the same conditions so far as can be specified, (F), and even by the same operator (**13, 17**) differ by 0. 25 to 0.40 p. c.

We had intended to give here the data for comparing the citrate method with the molybdic method in case of Thomas-Slag and Keystone Phosphate, but notwithstanding we have made many determinations and have many results by the molybdic method, we are as yet uncertain what is the true percentage of phosphoric acid in these substances and have to defer the consideration of that point to a future publication.

To further examine the sources of error involved in this method, several of the ignited and weighed precipitates from determinations by the citrate method, were subjected to partial analysis as follows: The precipitate was dissolved from the Gooch crucible by hot dilute hydrochloric acid and the residue, consist-

ESTIMATIONS OF PHOSPHORIC ACID IN THOMAS SLAG BY THE CITRATE METHOD.

	Substance taken.	Solvent.	Aliquot.	$\overline{Ci}$.	Mg. mixt. U. S.	Free NH_3 of 30 p. c.	Total volume.	P_2O_5 found.	Average P_2O_5 found.
1..........O.	1 gram	aqua regia	100 cc.	5 grams	50 cc.	30 cc.	200 cc.	{ 18.28, 16.39 / 15.80, 17.16 }	16.91
2..........O.	1 "	oil-vitriol	50 "	10 "	25 "	15 "	190 "	18.40, 18.59	18.50
3..........O.	1 "	"	" "	" "	25* "	" "	190 "	{ 18.72, 18.82 / 18.85, 18.91 }	18.83
4..........O.	1 "	"	" "	" "	" "	25 "	" "	18.91	18.91
5..........O.	1 "	"	" "	" "	50 "	30 "	160 "	18.94, 18.94	18.94
6..........O.	½ "	aqua regia	" "	" "	25 "	15 "	190 "	18.94	18.94
A..........W. & C.	1 "	oil-vitriol	" "	" "	50 "	30 "	200 "	19.03, 18.85	18.94
B..........W. & C.	1 "	aqua regia	" "	" "	25* "	15 "	190 "	18.91, 18.95	18.95
C..........W.	1 "	"	" "	" "	25* "	" "	175 "	19.01	19.01
7..........O.	1 "	"	100 "	" "	50 "	30 "	210 "	19.14, 19.05	19.10
8..........O.	½ "	"	" "	5 "	" "	" "	190 "	{ 19.17, 19.17 / 19.20, 19.17 }	19.18
9..........O.	1 "	"	" "	" "	" "	75 "	260 "	{ 19.49, 19.42 / 18.91, 19.10 }	19.23
D..........W. & C.	1 "	oil-vitriol	50 "	" "	" "	" "	230 "	19.27, 19.23	19.25
10..........O.	1 "	"	" "	" "	" "	" "	215 "	19.47, 19.55	19.51

* German magnesia-mixture.

ESTIMATIONS OF PHOSPHORIC ACID IN KEYSTONE CONCENTRATED PHOSPHATE BY THE CITRATE METHOD.

	Substance taken.	Solvent.	Aliquot.	$\overline{Ci}$.	Mg. mixt. U. S.	Free NH_3 of 30 p. c.	Total volume.	P_2O_5 found.	Average P_2O_5 found.
11..........O.	½ gram	aqua regia	50 cc.	10 grams	25 cc.	15 cc.	190 cc.	42.71, 42.53	42.62
12..........O.	1 "	"	100 "	" "	50 "	30 "	210 "	43.39, 42.69	43.04
E..........W. & C.	½ "	"	50 "	" "	" "	100 "	270 "	45.48, 45.47	45.48
13..........O.	½ "	"	" "	5 "	" "	75 "	195 "	{ 45.80, 45.57 / 45.89, }	45.75
14..........O.	1 "	"	100 "	" "	" "	100 "	270 "	45.79,	45.79
15..........O.	½ "	"	50 "	" "	" "	" "	220 "	46.02, 46.14	46.08
16..........O.	1 "	"	100 "	" "	" "	150 "	320 "	46.18,	46.18
17†..........O.	½ "	"	" "	" "	" "	75 "	245 "	{ 46.14, 46.33 / 46.40, }	46.29
F..........W. & C.	½ "	"	50 "	" "	" "	100 "	235 "	46.08, 46.32	46.20
G..........W. & C.	½ "	"	" "	" "	" "	150 "	285 "	46.12, 46.32	46.22

† To this was added 0.5 gm. pure fused $CaCl_2$.

ing of carbon and silica, was washed with water, dried at 100° C. and weighed. The loss of weight on subsequent ignition gave the quantity of carbon. The incombustible residue was reckoned as silica. The acid filtrate was boiled for some time to convert pyrophosphoric acid into orthophosphoric acid, and after cooling was carefully neutralized with ammonia. A few drops of acetic acid were added and after standing twelve hours in the cold any ferric or aluminic phosphate which had separated was filtered out, ignited and weighed. In this filtrate lime was precipitated in the cold by ammonium oxalate; after filtration the calcium oxalate was dissolved in hydrochloric acid and reprecipitated hot with excess of ammonium oxalate from a slightly acid solution and weighed as CaO. The two filtrates were united and made strongly ammoniacal to precipitate ammonium magnesium phosphate. A preliminary experiment showed that the filtrate after this precipitation contained both magnesia and phosphoric acid, the latter not having been rendered tribasic by the treatment with hydrochloric acid. The filtrate from the ammonium-magnesium phosphate was therefore precipitated by addition of magnesia mixture, and the second smaller amount of magnesium pyrophosphate stated in the analyses is the quantity thus obtained. Any excess of magnesia in the original precipitate therefore could not be determined by this plan of procedure, and with some unconverted pyro-phosphoric acid must have contributed to the "loss."

ANALYSES OF IGNITED CITRATE PRECIPITATES.

	Pure Bone. 2362. gm.	p. c.	Superphosphate. 2394. gm.	p. c.
Carbon	.0015	.41	.0006	.19
Silica	.0000	—	.0004	.12
Calcium oxide	.0094	2.59	.0068	2.13
Magnesium pyrophosphate	.3387	93.61	.3002	94.28
" "	.0068	1.88	.0057	1.79
Loss	.0054	1.51	.0047	1.49
	.3618	100.00	.3184	100.00

	Grand Cayman's Phosphate. gm.	p. c.	South Carolina Rock. gm.	p. c.
Carbon	.0018	.44	.0006	.15
Silica	.0016	.40	.0004	.10
Calcium oxide	.0083	2.05	.0129	3.21
Ferric and aluminic phosphate	.0029	.71	.0014	.35
Magnesium pyrophosphate	.3809	94.40	.3762	93.58
" "	.0051	1.26	.0088	2.19
Loss	.0029	.74	.0017	.42
	.4035	100.00	.4020	100.00

	Bolivian Guano. gm.	p. c.	Dissolved Bone Black. 2182. gm.	p. c.
Carbon	.0013	.48	.0007	.27
Silica	.0006	.24	.0005	.19
Calcium oxide	.0108	3.95	.0053	2.05
Ferric and aluminic phosphates	—	—	.0008	.31
Magnesium pyrophosphate	.2473	91.22	.2460	95.21
"	.0102	3.76	.0068	2.62
Loss	.0009	.35		
	.2711	100.00	.2601	100.65

The total magnesium pyrophosphate recovered from these precipitates was 95.49, 96.07, 95.66, 95.77, 94.98, 97.83 p. c., respectively. The highest percentage it will be noticed is from an analysis which somewhat overruns 100 p. c. The precipitates yielded an average of 96 p. c. of magnesium pyrophosphate, 2.7 p. c. of lime, and 1.3 p. c. of magnesia (?) carbon, silica, and iron and aluminium phosphates.

Considering that the foregoing analyses were made with but 0.25 to 0.4 gm. of substance which had been ignited upon and dissolved out of asbestos, their agreement is such as to show that the precipitate is nearly constant in composition whether salts of calcium or those of iron and aluminium preponderate in the solution from which it is thrown down. From the Grand Cayman's, rich in iron and aluminium, but little more of these metals enters the precipitate than from Carolina Rock or Bone Black.

Herzfeld and Feuerlein and also Reitmair consider that the incomplete precipitation of phosphoric acid is ordinarily due to a soluble ammonium-magnesium phospho-citrate which is not completely decomposed by excess of magnesia, and the compensation comes from precipitation of ammonium-calcium phosphate of composition similar to that of the ammonium-magnesium phosphate.

Grupe and Tollens have, however, shown that the ignited precipitate probably contains orthophosphoric acid and conclude that the calcium is present in part at least as tricalcic phosphate. Petermann states that "basic magnesium citrate" is liable to deposit with the precipitate when it stands too long (48 hours) before filtering, and Grupe and Tollens are probably correct in their belief that in all cases trimagnesic citrate, and where lime is present tricalcic citrate, is thrown down since the ignited precipitate gives evidence of the presence of magnesium oxide and calcium oxide or carbonate, while citric acid is indicated by the carbonization of the precipitate on ignition.

In the Station Report for 1880, p. 103, is written as follows with regard to the citrate method as then elaborated by Mr. Wells: "The method is in our opinion quite accurate enough for the analysis of fertilizers, and is now regularly employed for that purpose in the Station, since its use saves much time and labor." When that paragraph was written it had been determined to use thenceforward during the year 1881, in all fertilizer analyses, the citrate method for one and the molybdic method for another of the duplicate determinations which are invariably made, and in that year a considerable number of fertilizers were so analyzed with good results. It was, however, found in case of a few fertilizers presumed or known to contain iron or alumina in considerable quantities, that the two methods could not be brought to give agreeing percentages and the use of the citrate method was accordingly discontinued as it was then impossible to devote further time to its investigation.

Referring to the analyses given on pages 257–9 we find among the "superphosphates," the two samples which differed most largely in the per cent. of phosphoric acid obtained by the molybdic and citric methods.

No. 2415 yielded 0.35 p. c. less and No. 2456 0.41 p. c. more of phosphoric acid by the citric method than by the molybdic. The samples contained respectively 12.20 and 12.27 p. c. of phosphoric acid, so that in these extreme cases the full range of error was 0.75 p. c. of the samples and 6.13 p. c. of the phosphoric acid.

It is evident that a mode of procedure which admits, though but rarely, of such discrepancies cannot be safely employed by an Experiment Station, when as is the case in this country, the chemists employed by brokers and manufacturers and by other Experiment Stations are accustomed to rely upon the molybdic method as the standard.

In France the citrate process appears to have been considerably employed and for ten years or more, we believe, it has been an official method of the Belgian Experiment Stations. The citrate method found little favor in Germany until in 1888 it was adopted for the analysis of Thomas-Slag by the Associated Agricultural Experiment Stations of the German Empire at their congress at Wiesbaden in September, 1888. The process thus sanctioned

differs slightly from that of Vogel which has been referred to on page 255.

It is our impression that in Belgium and Germany, in some instances, experiment stations and manufacturers have mutually agreed to use and abide by the citrate method applied according to carefully defined instructions, and they undoubtedly find very great advantage in so doing, for the errors of the method are commonly quite small and in the long run balance each other, being about as often on the plus as on the minus side, while as respects ease and rapidity of working and economy of reagents the citrate method is greatly superior, so that its results cost but perhaps one-third as much as those by the molybdic method.

The subjoined comparison of the modifications of the citrate method used or alluded to in this paper is given for convenience of reference.

	For Phosphates with little Fe and Al.		For Thomas-Slag.	
	Wells.	Osborne.	Vogel.	Ger. Exp. St.
Substance	1 gm.	0.5–1 gm.	0.5	1 gm.
Volume of aliquot	100 c. c.	100 c. c.	50 c. c.	50 c. c.
Citric acid	10–15 gm.	5 gm.	5 gm.	10 gm.
Magnesia mixture	30–40 c. c.	50 c. c.	20 c. c.	25 c. c.
Additional NH_4Cl		3.5 gm.		
Volume of 10 % Ammonia	90–100 c. c.	90 c. c.*	110 c. c.†	90 c. c.
Total volume of liquid	350–400 c. c.	190 c. c.	110 c. c.	190 c. c.

* 30 c. c. ammonia of 30 %. † 10–12 c. c. strong ammonia.

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