STATE OF CONNECTICUT

EIGHTEENTH ANNUAL REPORT

— OF —

The Connecticut Agricultural Experiment Station

For 1894

Printed by Order of the General Assembly

The publications of this Station are sent free to every citizen of Connecticut who applies for them. Address, The Conn. Agricultural Experiment Station, New Haven, Conn.

NEW HAVEN:
THE TUTTLE, MOREHOUSE & TAYLOR PRESS.
1895

CORRECTIONS.

The Index to the Report of this Station for 1893 is defective under the letter V, p. 331.

Following is the corrected index for that letter:—

Vaccinium Oxycoccus	267
Valuation, Explanations concerning	11
" of Bone in 1893	25
" of Fertilizers, how obtained	14
" meaning of	12
" of Home-mixed Fertilizers	56
" of Mixed Fertilizers	14
" of Nitrogenous Superphosphates in 1893	41
" of Special Fertilizers in 1893	52
" of Mill Feeds	245
" Uses of	15
Vegetation Experiments, Description of Method	230
with Fertilizers	226
Verbena, Diseases of	284
Vermicularia circinans	273
subeffigurata	263
Viola odorata	284
Violet, Diseases of	284
Vitis	270

The following corrections are to be made in the Report of 1894.

Page 6. At the beginning of the list of manufacturers who have complied with the fertilizer law, insert: G. B. Alderman, Suffield, Special Potato Fertilizer.

Page 45. Eighth line from the bottom, erase the words: "as muriate." The sample **4430** of Shoemaker's Swift-Sure Superphosphate, as shown by the analysis on page 39, contains 3.88 per cent. of potash calculated as sulphate and .59 per cent. calculated as muriate.

OFFICERS AND STAFF FOR 1894.

STATE BOARD OF CONTROL.

Ex-officio.

His Excellency LUZON B. MORRIS, *President.*

	Term expires.
Appointed by Connecticut State Agricultural Society:	
Hon. E. H. HYDE, Stafford, *Vice-President.*	July 1, 1897
Appointed by Board of Trustees of Wesleyan University:	
Prof. W. O. ATWATER, Middletown.	1897
Appointed by Governor and Senate:	
EDWIN HOYT, New Canaan.	1895
JAMES H. WEBB, Hamden.	1896
Appointed by Board of Agriculture:	
T. S. GOLD, West Cornwall.	1895
Appointed by Governing Board of Sheffield Scientific School:	
W. H. BREWER, New Haven, *Secretary and Treasurer.*	1896
Ex-officio.	
S. W. JOHNSON, New Haven, *Director.*	

Executive Committee.

Station Staff.

Chemists.

S. W. JOHNSON, *Director.*
E. H. JENKINS, Ph.D., *Vice-Dir.*
A. L. WINTON, Ph.B.
T. B. OSBORNE, Ph.D.
A. W. OGDEN, Ph.B.
W. R. JOHNSTON, Ph.B.*
G. F. CAMPBELL, Ph.B.†

Mycologist.

WILLIAM C. STURGIS, Ph.D.

Horticulturist.

W. E. BRITTON, B.S.

Grass Gardener.

JAMES B. OLCOTT, South Manchester.

Stenographer and Clerk.

Miss C. S. GREEN.

In charge of Buildings and Grounds.

CHARLES J. RICE.

Laboratory Helpers.

HUGO LANGE. JULIUS KORN.

Sampling Agents.

DENNIS FENN, Milford. M. H. PARKER, So. Coventry.

* Till Aug. 1.

† From Oct. 15.

Notice as to Bulletins.

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others, as far as the limited editions permit.

Applications should be renewed annually before January 1st.

The matter of all the Bulletins of this Station, in so far as it is new or of permanent value, will be made part of the Annual Report of the Director.

Bulletins earlier than No. 71 and Nos. 83, 93, 100, 101, 102, 106, 109, 111 and 118, are exhausted and cannot be supplied.

Notice as to Supply of Station Reports.

The Station has no supply of its Annual Reports for the years 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1887, 1891, and 1893.

The Annual Report of this Station, printed at State expense, is by law limited to an edition of 12,000 copies, of which 5,000 copies are bound with the Annual Report of the Connecticut State Board of Agriculture, and distributed by the Secretary of the Board, T. S. Gold, West Cornwall, Conn.

After exchanging with other Experiment Stations and Agricultural Journals, the Reports remaining at the disposal of the Station will be sent to Citizens of Connecticut who shall seasonably apply for them, and to others as long as the supply lasts.

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, moulds, blights, mildews, useful or injurious insects, etc., and to give information on various subjects of Agricultural Science, for the use and advantage of the citizens of Connecticut.

The Station does not undertake sanitary analyses of water.

The Station makes analyses of Fertilizers, Seed-Tests, 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 private use of individuals is charged for at moderate rates. The Station undertakes 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 immediate general interest are published in Bulletins, copies of which are sent to each Post Office in this State, and to every citizen of the State who applies for them. The results of all the work of the Station are 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.*

☞ Letters sent to individual officers are liable to remain unanswered in case the officer addressed is absent. All communications therefore should be directed simply to the

AGRICULTURAL EXPERIMENT STATION,

NEW HAVEN, CONN.

☞ Station Grounds, Laboratories and Office are on Suburban st., between Whitney avenue and Prospect st., 1⅛ miles north of City Hall. Suburban st. may be reached by Whitney ave. electric cars, which leave the corner of Chapel and Church sts. four times hourly, viz: on the striking of the clock and at intervals of fifteen 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.

☞ The Grass Garden, in charge of Mr. James B. Olcott, is near South Manchester and may be reached by A. Gardner's regular Passenger Express starting at 9 A. M. and 1 P. M. from Cheney's Store, So. Manchester, or starting at 10 A. M. and 4 P. M. from Burnside, where connection is made by electric car with Hartford.

CONTENTS.

	Page
Corrections	ii
Officers and Staff of the Station	iii
Notices as to Bulletins and Reports	iv
Announcement	v
Table of Contents	vii
Report of the Treasurer	xi
Report of the Board of Control	xiii
Report of Station Work	1
Fertilizers	1
The Connecticut Fertilizer Law	1
Act Concerning Commercial Fertilizers	3
Observance of the Fertilizer Law	6
Collecting and Sampling of Fertilizers	11
Explanations concerning Analysis and Valuation	12
Trade Values of Fertilizing Elements	15
Valuation of Mixed Fertilizers	16
Classification of Fertilizers Analyzed	18
Raw Materials containing Nitrogen	19
Nitrate of Soda	19
Sulphate of Ammonia	19
Dried Blood	20
Ground Horn and Hoof	20
Cotton Seed Meal	20
Castor Pomace	23
Gluten Feed	23
Raw Materials containing Phosphoric Acid	24
Odorless Phosphate	24
Dissolved Bone Black	25
Dissolved Rock Phosphate	25
Raw Materials containing Potash	26
High Grade Sulphate of Potash	26
Double Sulphate of Potash and Magnesia	26
Muriate of Potash	27
Raw Materials containing Nitrogen and Phosphoric Acid	28
Bone Manures	28
Tankage	31
Dry Ground Fish	33
Mixed Fertilizers	33
Bone and Potash	33
Nitrogenous Superphosphates and Guanos	35
Special Manures	45
Home Mixtures	59

	Page
Fertilizers :—	
Miscellaneous Fertilizers and Manures	59
Cotton Hull Ashes	59
Unleached Wood Ashes	64
Lime Kiln Ashes	64
Saltpeter Waste	64
Sheep Manure	65
Waste Material from Enameling Iron	65
Review of the Fertilizer Market	66
Quantity of Commercial Fertilizers sold in Connecticut	72
On Methods to Determine Availability of Organic Nitrogen	73
Vegetation Experiments	73
Description of Method and Apparatus	74
Results of Vegetation Experiments	83
Data regarding Fertilizers and Crops	83
Influence of Water-content of soil on the Crops,	87
Effects on Crops of Soil Extract in the Artificial Soil	89
Effects of different Quantities of Phosphoric Acid and Potash on Crop Production	91
Relative Availability of Nitrogen in Raw Materials	94
in various Preparations of Leather	100
in various Mixed Fertilizers	102
Relative Solubility of Nitrogen in Pepsin Solution	105
Relative Solubility of Nitrogen by Putrefaction	109
Fire-Blight	113
Fire-Blight of Plum Trees	117
Experiments on the Prevention of Potato Scab	118
Scab upon Turnips	126
Notes on the "Early Blight" of Potatoes	127
Experiments on the Treatment of Pear Scab	135
Miscellaneous Notes on Fungi	137
Some Injurious Insects	139
Notes on Some Leaf Miners	143
The Proteids of the Rye Kernel	147
A. Proteids soluble in Water	149
B. Proteids soluble in Saline Solutions	155
C. Proteids soluble in Alcohol	156
D. Proteids soluble only in dilute Alkalies	163
Quantities of the different Proteids in the Rye Kernel	164
The Proteids of Barley	165
Proteids soluble in Water	167
Soluble in Sodium Chloride Solution	170
Soluble in Dilute Alcohol	173
Insoluble in Water, Saline Solutions and Alcohol	189
Conclusion	189
The Chemical Nature of Diastase	192
Work done for the Dairy Commissioner	208

	Page
The Babcock Method of Finding Amount of Butter-fat in Milk and Cream	209
Directions for Weighing	209
Sampling	210
Preserving Samples	211
Apparatus for Making the Test	211
Directions for Making the Test	213
The Babcock Test as a Basis for Payment in Cream-GatheringCreameries	214
Defects of the Space System	215
Method of Payment according to Butter-Fat	217
Apparatus for Sampling and Weighing Cream	217
Instructions for Sampling and Weighing Cream	219
The Composite Sample	222
Apparatus for Testing Cream	223
Making the Test	226
Book-keeping of the Babcock Test System	231
Records of Five Connecticut Creameries on Babcock System	231
Comparison of Space and Babcock Systems at Six Creameries	233
Observations on the Growth of Maize continuously on Same Land	245
Gross Yield	246
Dry Matter of Crops	247
Yield of Each Food Ingredient	248
Composition of Field Cured Crops	250
Composition of Dry Matter of Kernels and Stover	251
Enrichment or Impoverishment of Land by Seven Years Cropping	252
Yield of Dry Matter and Shelled Corn per Acre for Seven Years	253
Experiments in Growing Tobacco with Different Fertilizers	254
Final Report on Fermented Crops of 1893	254
Shrinkage in Fermentation	254
Report of Expert on Quality of	255
Discussion of Quality of	265
Comparative Fire-holding Capacity	266
Effect of Cotton Seed Meal and Castor Pomace as Fertilizers	268
Effect of Linseed Meal, Fish, Nitrate of Soda, Various Potash Salts as Fertilizers	269
Report on Experiments of 1894	270
Notes on Rainfall, Soil Moisture and Temperature	271
Fertilizers Applied	272
Harvesting, Curing, Stripping and Sorting	278
Weights of Pole-cured Leaves	279
Per cents of the Four Different Grades	280
Comparative Fire-holding Capacity	280
Number of Pole-cured Leaves to Pound	281
Discussion of Results	282

REPORT OF THE TREASURER.

WM. H. BREWER, IN ACCOUNT WITH THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING SEPTEMBER 30TH, 1894.

RECEIPTS.

	Oct. 1893 to June 1894	July to Sept. 1894.	Total.
State Appropriation	$6,000.00	$2,000 00	$8,000.00
United States Appropriation	5,625 00	1,875.00	7,500.00
Analysis Fees due last year rec'd this year	231.89	80.00	311.89
Analysis Fees of this year	4,510.00	157.04	4,667.04
Miscellaneous Receipts	374 55	8.40	382.95
Total Receipts	$16,741.44	$4,120.44	$20,861.88

EXPENDITURES.

	State Acc't	U. S. Acc't.	Total.
Salaries*	$4,839.50	$4,950.00	$9,789.50
" †	1,307.50	1,825.00	3,132.50
Labor†	88.75		88.75
Publications*	170.35	134.22	304.57
" †	5.44		5.44
Postage*	66.78		66.78
" †	60.18		60.18
Stationery*	96.42		96.42
" †	16.32		16.32
Freight and Express†	11.79		11.79
Coal*	13.00		13.00
" †	547.25		547.25
Gas†	230.85		230.85
" †	34.20		34.20
Water*	147.00		147.00
Laboratory Expenses*	1,459.36	29.74	1,489.10
Chemicals†	6.20	32.38	38.58
Laboratory Supplies†	15.77		15.77
Field Experiments*		50.58	50.58
" " †	20.00		20.00
Tobacco Experiments*	175.69		175.69
" " †	267.87		267.87
Dairy Tests*		52.51	52.51
Grass Garden*	200.00	400.00	600.00
" " †	200.00		200.00
Turf Collection†	500.00		500.00
Mycological Expenses*	19.57	7.95	27.52
Miscellaneous Supplies†	61.78		61.78

* For the 9 months, Oct , 1893 to June, 1894, inclusive.
† For the 3 months, July to September, 1894, inclusive.

	State Acc't.	U. S. Acc't.	Total.
Fertilizers†		$17.62	$17.62
Feeding Stuffs†	$23.15		23.15
Library*	287.14		287.14
" †	37.80		37.80
Tools and Machinery†	58.90		58.90
Office Supplies*	59.42		59.42
Furniture†	34.05		34.05
Scientific Apparatus†	35.95		35.95
Traveling Expenses of the Board*	7.51		7.51
" " " " †	22.69		22.69
" " of the Staff†	100.58		100.58
Unclassified Sundries*	299.45		299.45
Contingent Expenses†	3.85		3.85
Telephone*	75.25		75.25
" †	25.25		25.25
Collecting Fertilizers*	320.13		320.13
Insurance*	67.50		67.50
The Establishment Growers, Repairs, etc.*	322.37		322.37
New Greenhouse*	495.52		495.52
" " †	373.54		373.54
Improvement on Buildings†	64.02		64.02
Repairs†	68.11		68.11
	$13,343.75	$7,500.00	$20.843.75
Balance to New Account			18.13
			$20,861.88

The accounts of the treasurer were duly audited December 11th, 1894 by the State Auditors of Public Account.

As in previous years the Analysis Fees of fertilizers known to have been on sale after May 1st and subject to the law concerning commercial fertilizers, coming into the hands of the treasurer after closing the above account, will be credited to the next year's account.

Beginning with July 1st, 1894, all the Agricultural Experiment Stations receiving appropriations from the United States are required to make their treasurer's reports to the Secretary of Agriculture of the United States instead of to the Secretary of the Treasury as heretofore. Said reports must hereafter be made in accordance with schedules prepared by the Department of Agriculture and for the fiscal year used by the general Government.

The treasurer of this station will hereafter be required to make reports for two different fiscal years, that of the United States which ends June 30th, and that of the State which ends Sept. 30th. I have therefore prepared this report for our State fiscal year giving the amounts for nine and three months respectively, that its agreement with that to be made to the Secretary of Agriculture next year may be obvious.

WM. H. BREWER, *Treasurer.*

* For the 9 months, Oct., 1893 to June, 1894, inclusive.

† For the 3 months, July to September, 1894, inclusive.

REPORT OF THE BOARD OF CONTROL.

To his Excellency, Luzon B. Morris, Governor of Connecticut:

The Board of Control of the Connecticut Agricultural Experiment Station, herewith submits its report for the year ending October 31st, 1894.

In executing the provisions of the State Fertilizer Law, Messrs. Dennis Fenn and M. H. Parker the agents of this Station have visited seventy-eight towns and villages and have drawn four hundred and fifty-six samples, representing one hundred and fifty-six distinct brands of commercial fertilizers.

In the chemical laboratory of the Station, Messrs. Winton and Ogden, with the aid of Mr. Lange, have made three hundred and thirty-one analyses of commercial fertilizers, manures and manurial waste-products. The results of these analyses have been prepared for publication by Dr. Jenkins, are now in the printer's hands and with other appropriate matter will form Part I of the Eighteenth Annual Report.

In continuation of work begun at this Station in 1885—on the relative availability to growing plants of the various forms of organic nitrogen found in fertilizers and on proposed methods for estimating this availability there have been made this year, one hundred and fifty vegetation experiments, for which Indian corn was grown in pots of artificial soil and supplied with nitrogen from different fertilizers whose relative value as regards their nitrogen, it was thus sought to determine. Eleven articles representing the materials most used in the fertilizer manufacture, were also examined with respect to the solubility of their nitrogen in pepsin solution and under putrefaction. These investigations taken together, furnish a comparison of the three methods of estimating the availability of organic nitrogen.

This investigation is the joint work of the Director and Vice-Director aided by Messrs. Britton, Winton, Ogden and Lange.

A considerable number of feeding stuffs have been analyzed in behalf of purchasers.

On behalf of the State Dairy Commissioner twenty-three samples

of suspected butter and five samples of molasses have been tested by Dr. Jenkins, and in twelve cases expert evidence has been furnished by him in court.

More than two hundred samples of milk and cream have been chemically examined, chiefly to determine butter-fat.

Eighteen nearly complete analyses of milk have been made at the request of milk dealers and the fact of adulteration established in several of the samples.

An extended study has been made of the method of paying for cream, which is at present most commonly used in this State, and of the arrangements which creameries must make in order to adopt the more equitable system of paying patrons according to the butter-fat contained in the cream, as determined by the Babcock test. On request of creamery superintendents, eleven creameries have been visited, in some cases a considerable number of times, to explain and illustrate the working of the new system in all particulars, from the sampling of the cream by the cream-gatherer, to the final monthly calculation of payments and incidentally several hundred tests of milk and cream have been made at the creameries.

As a result of this work, six cream-gathering and two milk-gathering creameries have adopted and are now successfully using the system of payment just referred to.

All this work on feeding stuffs, milk and cream, has been most efficiently performed by Messrs. Winton and Ogden.

The work of Dr. W. C. Sturgis, Mycologist, may be briefly summarized as follows:

A critical study has been made in both the botanical laboratory and the field of the so-called "Early blight" of potatoes.

The value of the treatment of seed potatoes with corrosive sublimate solution just previous to planting, for the prevention of Potato Scab, has been tested in coöperation with Mr. Walter H. Olcott in a field experiment at South Manchester.

Experiments on the treatment of the Pear "Scab" in the orchard of Mr. A. E. Plant, of Branford, begun two years ago, have been continued this year.

The bacterial disease known as "fire blight," which does very considerable damage in this State, has been studied in the botanical laboratory.

Some work has also been done, as opportunity presented, upon other plant diseases, chiefly those of the peach, apple and quince.

During the year Dr. Osborne has carried his investigations on the proteids contained in the seeds of Rye and Barley as far as is practicable at present, and the results of these studies are now ready for publication. He has also made good progress in an investigation of Diastase, that ferment of the cereal grains which transforms starch into sugar, and his preliminary paper on this subject is now ready to be printed. In this work he has been assisted by Mr. Johnston and Mr. Campbell.

The field-work of the Station except as already noted has been in the charge of the Vice-Director, as follows:—

The field experiment on the continuous growth of maize on the same land, begun in 1888, has been carried on this year as before at the farm of Mr. J. H. Webb, of Hamden.

In coöperation with Messrs. S. D. Woodruff & Sons, of Orange, a field experiment has been conducted for testing the effect of nitrate of soda in forcing the tomato crop, but owing to the dry weather has given no results.

The field experiments on the influence of different fertilizers on quality and quantity of the tobacco crop, have been prosecuted on the same plan as last year, in conjunction with the Connecticut Tobacco Experiment Co., at Poquonock.

With the coöperation of Prof. Milton Whitney, formerly of this Station and now Chief of the Division of Agricultural Soils, U. S. Department of Agriculture (which furnished the appropriate meteorological instruments), observations of rainfall, maximum and minimum soil-temperatures and maximum and minimum air-temperatures (by radiation thermometers), were daily made at the Poquonock Tobacco Station. Moisture was also determined in samples of soil taken on five different plots of the tobacco field each day from the time the tobacco plants were set till they were harvested. These samples securely packed, were daily sent by mail to New Haven for this examination which was made by Dr. Jenkins.

In the spring of 1894, a vegetation house, twenty-seven feet long by nineteen wide, was built on the Station grounds, with special reference to experiments on the growth of plants in pots during the summer season. Its construction and uses will be described on subsequent pages.

A forcing house, forty feet long by sixteen feet wide, has just been finished, to be used for experiments with fertilizers applied to winter crops, under glass.

On seventeen days, one or two and sometimes three of the Station Staff have been engaged in attendance at meetings of Granges, Farmers' Institutes, and various other public gatherings of dairymen, orchardists, etc. where they demonstrated the Babcock milk-test, gave addresses and answered questions.

Three Bulletins have been issued during the year, containing in the aggregate seventy octavo pages.

Bulletin No. 118, on the "Literature of Fungous Diseases; a Provisional Bibliography, etc.," by Dr. W. C. Sturgis, issued in March 1894, was made a part of the 17th Annual Report as its preparation had been mostly accomplished during or before the time covered by that Report, and to save the very considerable expense of reprinting.

Bulletin No. 117 on "The Babcock method of determining fat in milk and milk products," published in January, and Bulletin No. 119, on "The Babcock Test as a basis for Payment in Cream-gathering Creameries," issued in May last, have been rewritten to include the results of further work and form part of this Annual Report.

The Station Staff has been increased during the year, by the appointment of a horticulturist. Mr. W. E. Britton, a graduate of the New Hampshire Agricultural and Mechanical College, and a graduate student of horticulture in Cornell University, entered on the duties of this position, on the first of May, 1894.

Mr. W. R. Johnston left the station on the first of August. The place thus made vacant was filled on the fifteenth of October, by Mr. George F. Campbell.

A detailed account of the investigations above referred to, will be found in the Reports of the Station Staff, which are now in preparation.

All of which is respectfully submitted.

WM. H. BREWER, *Secretary.*

New Haven, Conn., November 1st, 1894.

REPORT OF STATION WORK.

A general statement of the lines of work followed by the Station Staff during the past year and of the results attained is to be found on previous pages, in the Report of the Board of Control.

The following pages present a full and detailed account of the operations of the Station within the twelvemonth ending October 31, 1894.

In the discussion of commercial fertilizers it is found advisable to reprint, annually, certain statements regarding the fertilizer law and the analysis and valuation of fertilizers, to answer questions which are constantly addressed to the Station on these subjects.

THE FERTILIZER LAW OF CONNECTICUT.

The General Assembly at its Session in 1893 passed an act, Chapter CLXXII, amending the fertilizer law previously in force in Connecticut.

The attention of all concerned is called to the following copy of the General Statutes of the State regarding fertilizers which embodies the amendments and is the law now in force.

Copies of the law may be had on application to the Station. Attention is specially called to the following requirements.

1. In case of *all* fertilizers or manures, except stable manure and the products of local manufacturers of less value than ten dollars a 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 has provided labels or statements and has paid the fee. Sections 4005 and 4007.

The Station understands "the fertilizing ingredients" to be those whose determination in an analysis is necessary for a valuation, and which are generally Nitrogen, Phosphoric acid and Potash. The analysis-fees in case of any fertilizer will therefore usually 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 the case of every commercial fertilizer*, 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, Section 4006.

A statement of the per cent. 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.

The percentage of 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 and 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 4008.

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 4013 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 4013, 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.

ACTS CONCERNING COMMERCIAL FERTILIZERS.

Chapter CCLIII of the General Statutes of Connecticut as amended by Chapter CLXXII of the Acts of the General Assembly, Session of 1893.

SECTION 4005. Every person or company who shall sell, offer, or expose for sale, in this State, any commercial fertilizer or manure except stable manure, and the products of local manufacturers of less value than ten dollars a ton, shall affix conspicuously to every package thereof a plainly printed statement clearly and truly certifying the number of net pounds of fertilizer in the package, the name, brand, or trade-mark under which the fertilizer is sold, the name and address of the manufacturer, the place of manufacture and the chemical composition of the fertilizer, expressed in the terms and manner approved and usually employed by the Connecticut Agricultural Experiment Station.

If any such fertilizer be sold in bulk, such printed statement shall accompany every lot and parcel sold, offered, or exposed for sale.

SEC. 4006. Before any commercial fertilizer is sold, offered, or exposed for sale, the manufacturer, importer, or person who causes it to be sold, or offered for sale, within this State shall file with the director of the Connecticut Agricultural Experiment Station two certified copies of the statement prescribed in section 4005, and shall deposit with said director a sealed glass jar or bottle containing not less than one pound of the fertilizer, accompanied by an affidavit that it is a fair average sample thereof.

SEC. 4007. The manufacturer, importer, agent, or seller of any commercial fertilizer shall pay on or before May 1, annually, to the director of the Connecticut Agricultural Experiment Sta-

tion, an analysis fee of ten dollars for each of the fertilizing ingredients contained or claimed to exist in said fertilizer: *provided*, that when the manufacturer or importer shall have paid the fee herein required for any person acting as agent or seller for such manufacturer or importer, such agent or seller shall not be required to pay the fee prescribed in this section.

SEC. 4008. Every person in this State who sells, or acts as local agent for the sale of any commercial fertilizer of whatever kind or price, shall annually, or at the time of becoming such seller or agent, report to the director of the Connecticut Agricultural Experiment Station his name and brand of said fertilizer, with the name and address of the manufacturer, importer, or party from whom such fertilizer was obtained, and shall, on demand of the director of the Connecticut Agricultural Experiment Station, deliver to said director a sample suitable for analysis of any such fertilizer or manure then and there sold or offered for sale by said seller or agent.

SEC. 4009. No person or party shall sell, offer, or expose for sale, in this state any pulverized leather, raw, steamed, roasted, or in any form, as a fertilizer or as an ingredient of any fertilizer or manure, without explicit printed certificate of the fact, such certificate to be conspicuously affixed to every package of such fertilizer or manure, and to accompany every parcel or lot of the same.

SEC. 4010. Every manufacturer of fish guano, or fertilizers of which the principal ingredient is fish or fish-mass from which the oil has been extracted, shall, before manufacturing or heating the same, and within thirty-six hours from the time such fish or mass has been delivered to him, treat the same with sulphuric acid or other chemical, approved by the director of said experiment station, in such quantity as to arrest decomposition: *provided, however*, that in lieu of such treatment such manufacturers may provide a means for consuming all smoke and vapors arising from such fertilizers during the process of manufacture.

SEC. 4011. Any person violating any provision of the foregoing sections of this chapter shall be fined one hundred dollars for the first offence, and two hundred dollars for each subsequent violation.

SEC. 4012. This chapter shall not affect parties manufacturing, importing, or purchasing fertilizers for their own private use, and not to sell in this State.

SEC. 4013. The director of the Connecticut Agricultural Experiment Station shall pay the analysis-fees received by him into the treasury of the station, and shall cause one or more analyses of each fertilizer to be made and published annually. Said director is hereby authorized, in person or by deputy, to take samples for analysis from any lot or package of manure or fertilizer which may be in the possession of any dealer.

SEC. 4014. The director of the Connecticut Agricultural Experiment Station shall, from time to time, as bulletins of said station may be issued, mail or cause to be mailed two copies, at least, of such bulletins to each post-office in the State.

OBSERVANCE OF THE FERTILIZER LAW.

Here follows an alphabetical list of the MANUFACTURERS who have paid Analysis Fees as required by the Fertilizer Law, and the names or brands of the Fertilizers for which Fees have been paid by them for the year ending May, 1895.

Firm.	*Brand of Fertilizer.*
Armour Packing Co., Kansas City, Mo.	Fine Ground Beef Bone. Fruit, Vegetable and Tobacco Special.
Baker, H. J. & Bro., 93 William St., New York City.	Tobacco Manure. Onion Manure. Potato Manure. Corn Manure. A. A. Ammoniated Superphosphate. Harvest Home Phosphate. Castor Pomace. Pure Ground Raw Bone.
Bowker Fertilizer Co., 43 Chatham St, Boston, Mass.	Stockbridge Special Tobacco Manure. " " Grain Manure. " " Grass Top-Dressing and Forage Crop Manure. Stockbridge Special Potato and Vegetable Manure. Bowker's Hill and Drill Phosphate. " Farm and Garden Phosphate or Ammoniated Bone Fertilizer. " Potato Manure. " Tobacco Grower. " Sure Crop Bone Phosphate.
Bradley Fertilizer Co., 92 State St., Boston, Mass.	Bradley's Superphosphate. " Potato Manure. " Complete Manure for Potatoes and Vegetables. " Complete Manure for Top Dressing Grass and Grain. " Complete Manure for Corn and Grain. " Pure Fine Ground Bone. " Circle Brand Ground Bone and Potash. " Fish and Potash, Anchor Brand. " Fish and Potash, Triangle A Brand. " B. D. Sea Fowl Guano. " Original Coe's Superphosphate. " Farmer's New Method Fertilizer. " High Grade Tobacco Manure. "
Buckingham, C., Southport, Conn.	A No. 1 Fertilizer.
Chicopee Guano Co., 140 Maiden Lane, New York City.	Chicopee Potato Manure. Farmer's Reliable

Firm.	*Brand of Fertilizer.*
Clark's Cove Fertilizer Co., Farlow Building, State St., Boston, Mass.	Great Planet "A." King Philip Guano. Potato and Tobacco Fertilizer. Bay State Fertilizer. Bay State Fertilizer G. G.
Cleveland Linseed Oil Co., Cleveland, Ohio.	Connecticut Wrapper Fertilizer, "Pinney Formula."
Coe Co., The E. Frank, 133–135 Front St., New York City.	High Grade Potato Fertilizer. High Grade Ammoniated Superphosphate. Ground Bone and Potash. Special Tobacco Fertilizer, N. E. Brand. Gold Brand Excelsior. Fish and Potash. Alkaline Bone.
Cooper's Glue Factory, Peter, 17 Burling Slip, New York City.	Bone Dust.
Crocker Fertilizer and Chemical Co., Buffalo, New York.	Crocker's Ammoniated Bone Superphosphate. " Potato, Hop and Tobacco Phosphate. " Special Conn. Tobacco Manure. " Pure Ground Bone. " Ground Bone Meal. " New Rival Ammoniated Bone Superphosphate. " Vegetable Bone Superphosphate. " Ammoniated Wheat and Corn Phosphate. " Ammoniated Practical Superphosphate. " Special Potato Manure.
Cumberland Bone Phosphate Co., Boston, Mass.	Cumberland Superphosphate. " Potato Fertilizer.
Danbury Fertilizer Co., Danbury, Conn.	Bone Meal. Nameless Fertilizer. Potato Manure.
Darling Fertilizer Co., The L. B, Pawtucket, R. I.	Darling's Wheat and Corn Fertilizer. " Animal Fertilizer. " Fine Ground Bone. " Extra Bone Phosphate. " Potato and Root Crop Manure. " Tobacco Grower.
Downes & Griffin, Birmingham, Conn.	Ground Bone.
Ellsworth, F., Hartford, Conn.	Shoemaker's Swift Sure Superphosphate. " " " Bone Meal. Collier Castor Pomace.

Firm.	*Brand of Fertilizer.*
Frisbee Co., L. F., Hartford, Conn.	Bone Meal.
Great Eastern Fertilizer Co., Rutland, Vermont.	Great Eastern General Fertilizer for Grass and Grain. Great Eastern Vegetable, Vine and Tobacco. Great Eastern General for Oats, Buckwheat and Seeding down. Great Eastern General Soluble Bone and Potash Fertilizer.
Kelsey, E. R., Branford, Conn.	Bone, Fish and Potash.
Lister's Agricultural Chemical Works, Newark, N. J.	Celebrated Ground Bone. Ammoniated Dissolved Bone. Potato Fertilizer. Standard Superphosphate. Success Fertilizer.
Mapes Formula and Peruvian Guano Co., 143 Liberty St., New York City.	Complete Manure for Light Soils. " " " General Use. " " "A" Brand. Potato Manure. Tobacco Starter. Fruit and Vine Manure. Grass and Grain Spring Top Dressing. Corn Manure. Fine Dissolved Bone. Tobacco Manure, Wrapper Brand.
Miller, Geo. W., Middlefield, Conn.	Ground Bone. Flour of Bone Phosphate.
National Fertilizer Co., Bridgeport, Conn.	Chittenden's Complete Fertilizer. " Ammoniated Bone Phosphate. " Fish and Potash. " Ground Bone.
Nuhn, Frederick, Waterbury, Conn.	Self-Recommending Fertilizer.
Olds & Whipple, Hartford, Conn.	Red Seal Castor Pomace. O. & W. Special Phosphate.
Peck Bros., Northfield, Conn.	Pure Ground Bone.
Plumb & Winton, Bridgeport, Conn.	Ground Bone.
Preston Fertilizer Co., Greenpoint, L. I.	Onion Fertilizer. Potato Fertilizer. Ammoniated Bone Superphosphate.
Quinnipiack Rendering Co., Meriden, Conn.	Pure Ground Bone.

Firm.	*Brand of Fertilizer.*
Quinnipiac Co., 92 State St., Boston, Mass.	Quinnipiac Phosphate. " Potato Manure. " Market Garden Manure. " Ammoniated Dissolved Bone. " Fish and Potash, Crossed Fishes Brand. " Fish and Potash, Plain Brand. " Pine Island Phosphate. " Havana Tobacco Fertilizer. " Grass Fertilizer. " Corn Manure. " Bone Meal. " Dry Ground Fish. Tankage. Muriate of Potash. Sulphate of Potash. Nitrate of Soda. Sulphate of Ammonia. Dissolved Bone Black.
Read Fertilizer Co., Box 3121, New York City.	Read's Standard. High Grade Farmer's Friend. Fish and Potash. Vegetable and Vine.
Reese, J. S. & Co., Baltimore, Md.	Reese's Potato Special. " New England Favorite.
Rogers & Hubbard Co., Middletown, Conn.	Pure Ground Raw Knuckle Bone Flour. Pure Ground Raw Knuckle Bone Meal. Strictly Pure Fine Bone. Fertilizer for Oats and Top Dressing. Soluble Potato Manure. Soluble Tobacco Manure. Grass and Grain Fertilizer. Fairchild's Formula for Corn and General Crops.
Rogers Mfg. Co., Rockfall, Conn.	Pure Ground Bone. Grass and Grain Fertilizer. Soluble Potato and General Crops. High Grade Fertilizer for Oats and Top Dressing. Complete Fertilizer. High Grade Corn Fertilizer.
Sanderson, L., New Haven, Conn.	Old Reliable Superphosphate. Formula A. (Complete). Pulverized Bone and Meat. Blood, Bone and Meat. Fine Ground Bone. Muriate of Potash. High Grade Sulphate of Potash. Regular Sulphate of Potash. Nitrate of Soda. Sulphate of Ammonia. Dissolved Bone Black.

Firm.	*Brand of Fertilizer.*
Soluble Pacific Guano Co., Boston, Mass.	Pacific Guano. Potato Manure. High Grade General Fertilizer.
Standard Fertilizer Co., Farlow Building, State St., Boston, Mass.	Standard Superphosphate. Standard Complete Manure. Standard Potato and Tobacco Fertilizer.
Walker, Stratman & Co., Pittsburgh, Pa.	Potato Special. Tobacco Special. Banner Fertilizer. Four Fold Fertilizer.
Walton & Whann Co., Wilmington, Delaware.	Diamond Soluble Bone and Potash. Peerless Potato Manure.
Wheeler, M. E. & Co., Rutland, Vermont.	Potato Manure. Corn Fertilizer. Electrical Dissolved Bone. Grass and Oats Fertilizer.
Wilcox, Leander, Mystic, Conn.	Potato, Onion and Tobacco Manure. Ammoniated Bone Phosphate. Complete Bone Superphosphate. High Grade Fish and Potash.
Wilkinson & Co., 54 William St., New York City.	Economical Bone Fertilizer.
Williams & Clark Fertilizer Co., 81 Fulton St., New York City.	Americus Ammoniated Bone Superphosphate. " Potato Phosphate. " High Grade Special. " Pure Bone Meal. " Fine Wrapper Tobacco Grower. " Corn Phosphate. " Potato and Tobacco Fertilizer. " Grass Manure. " Fish and Potash. Royal Bone Phosphate.

COLLECTION AND SAMPLING OF FERTILIZERS.

During the year 310 samples of commercial fertilizers and manurial waste-products have been analyzed. A classified list of them is given on page 18.

On a few of these samples analyses were made for private parties and charged for accordingly. A few samples also were analyzed at request of other Experiment Stations in order to compare and test analytical methods. Results of the examination of all the samples, with these exceptions, are given in detail in the following pages.

During April, May and June, Messrs. Dennis Fenn of Milford, and M. H. Parker of South Coventry agents of this Station, visited seventy-eight towns and villages in Connecticut and drew 456 samples representing 166 distinct brands of commercial fertilizers.

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.

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 coöperation 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 strict accordance with the Station's Instructions for Sampling, and must*

also be 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, before the results are published.

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.*

The Elements of Fertilizers.

The three chemical elements whose compounds chiefly give value, both commercial and agricultural, to fertilizers are Nitrogen, Phosphorus and Potassium. The other elements found in fertilizers, viz: Sodium, Calcium, Magnesium, Iron, Silicon, Sulphur, Chlorine, Carbon, Hydrogen and Oxygen, which are necessary or advantageous to the growth of vegetation are either so abundant in the soil or may be so cheaply supplied to crops, that they do not considerably affect either the value or cost of high-priced commercial fertilizers.

Nitrogen in fertilizers is, on the whole, the least abundant of their valuable elements and is, therefore, their most costly ingredient.

Free Nitrogen is universally abundant, making up nearly four-fifths of the common air, and appears to be assimilable, with aid of certain bacteria, by leguminous plants (the clovers, alfalfa, peas, beans, lentils, esparsette, lupins, vetches, lathyrus, peanut, yellow locust, honey locust, etc.), and by a few non-leguminous plants, carrying root-nodules, viz: the Oleasters (*Eleagnus*), the Alders (*Alnus*), and a single family of coniferous trees (*Podocarpus*), but not at all, according to present evidence, by the cereals or other field and garden crops.

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

* Prepared and revised by the Director.

active as fertilizers; others as found in leather and peat, are comparatively slow in their effect on vegetation, unless these matters are chemically disintegrated. Since organic nitrogen may readily take the form of ammonia it has been termed *potential ammonia*.

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 exists in the form of phosphates, usually those of calcium, iron and aluminum, or in case of "superphosphates," to some extent in the form of free phosphoric acid.

Water-Soluble Phosphoric acid is phosphoric acid (or a phosphate) that freely dissolves in water. It is the characteristic ingredient of superphosphates, in which it is produced, by acting on "insoluble" or ("citrate soluble") phosphates, with diluted sulphuric acid. Once well incorporated with the soil, it gradually "reverts" and becomes insoluble, or very slightly soluble in water.

Citrate-soluble Phosphoric acid signifies the phosphoric acid (of various phosphates) that is freely taken up by a hot strong solution of neutral ammonium citrate, which solution is therefore used in analysis to determine its quantity. The designation *citrate-soluble* is synonymous with the less explicit terms *reverted*, *reduced* and *precipitated*, which all imply phosphoric acid that was once easily soluble in water, but from chemical change has become insoluble in that liquid.

Recent investigation tends to show that water-soluble and citrate-soluble phosphoric acid are on the whole about equally valuable as plant food, and of nearly equal commercial value. In some cases, indeed, the water-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 insoluble both in water and in hot solution of neutral ammonium citrate. The phosphoric acid of Canadian "Apatite," of South Carolina and Florida "Rock Phosphate" and of similar dense mineral phosphates, as well as that of "bone-ash" and "bone-black" is mostly insoluble in this sense, and in the majority of cases, gives no visible good results when these substances, in the usual ground state, are applied to crops. They contain however a small proportion of citrate-soluble phosphoric acid and sometimes, when they are reduced to extremely fine dust (floats) or are applied in large quantities, especially on "sour soils" or in conjunction with abundance of decaying vegetable matter (humus), they operate as efficient fertilizers.

Available Phosphoric acid is an expression properly employed in general, to signify phosphoric acid in any form, or phosphates of any kind that serve to nourish vegetation. In the soil phosphoric acid and all phosphates, whatever their solubilities as defined in the foregoing par-

agraphs, are more or less freely and extensively available to growing plants. Great abundance of "insoluble" phosphoric acid may serve crops equally well with great solubility of a small supply, especially when the soil and the crop carry with them conditions highly favorable to the assimilation of plant food.

In Commercial Fertilizers, "available phosphoric acid" is frequently understood to be the sum total of the "water-soluble" and the "citrate-soluble," with exclusion of the "insoluble."

The "insoluble phosphoric acid" in a commercial fertilizer costing $20 to $50 per ton has very little or no value to the purchaser, because the quantity of it which can commonly go upon an acre of land has no perceptible effect on the crop and because its presence in the fertilizer excludes an equal percentage of more needful and much more valuable ingredients.

In Raw Bone the phosphoric acid (calcium phosphate) is nearly insoluble, because of the animal matter of the bones, which envelops it; but when the animal matter decays in the soil, or when it is disintegrated by boiling or steaming, the phosphate mostly remains in an available form. The phosphoric acid of "Basic-Slag" and of "Grand Cayman's Phosphate" is in some soils as freely taken up by crops as water-soluble phosphoric acid, but in other soils is much less available than the latter.

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 form of muriate (potassium chloride). In unleached wood-ashes it exists mainly as potassium carbonate.

VALUATION OF FERTILIZERS.

The valuation of a fertilizer as practised at this station, consists in calculating the *retail Trade-value* or *cash-cost* (in raw material 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, for their trade-value exclusively 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.

TRADE-VALUE OF FERTILIZER ELEMENTS, FOR 1894.*

The average Trade-values or retail costs in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid and potash in raw materials and chemicals, as found in New England, New York and New Jersey markets during 1894, were as follows:

	Cts. per lb.
Nitrogen in ammonia salts	19
nitrates	14½
Organic nitrogen in dry and fine ground fish, meat and blood	18½
in cotton seed meal and castor pomace	15
in fine bone and tankage	16½
in fine-medium bone and tankage	15
in medium bone and tankage	12
in coarser bone and tankage	7
in hair, horn shavings and coarse fish scrap	7
Phosphoric acid, water-soluble	6
citrate-soluble†	5½
of dry ground fine fish, bone and tankage	5½
of fine-medium bone and tankage	4½
of medium bone and tankage	3
of coarse bone and tankage	2
of fine ground fish, cotton seed meal, castor pomace and wood ashes	5
of mixed fertilizers insoluble in ammonium citrate	2
Potash as high-grade sulphate and in forms free from muriate (or chlorides)	5¼
as muriate	4⅓

The foregoing are, as nearly as can be estimated, the 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

* Adopted at a conference of representatives of the Connecticut, Massachusetts, New Jersey and Rhode Island Stations held in March, 1894.

† Dissolved from 2 grams of the fertilizer, 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.

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 Superphosphates,
Azotin,	Dry Ground Fish,
Ammonite,	Bones and Tankage,

Ground South Carolina Rock.

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, 18½ cents.

Insoluble Phosphoric Acid is reckoned at 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 5½ cents per pound.

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. The 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 1894 the average selling price of Ammoniated Superphosphates and Guanos was $32.93 per ton, the average valuation was $23.30, and the difference $9.63, an advance of 41.3 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 $38.13, the average valuation $28.62 and the difference $9.51 or 33.2 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.

Uses and Limitations of Fertilizer Valuation.

The uses of the "Valuation" are two-fold :

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 valuation 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 in some cases analysis cannot discriminate positively between the active and the inert forms of nitrogen, 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-value 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 the 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.

Agricultural Value of Fertilizers.

The Agricultural Value of a fertilizer is measured by the benefits received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad, general rule, it is true that ground bone 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.

RAW MATERIALS.

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

Nitrate of Soda	5
Sulphate of Ammonia	2
Dried Blood	1
Ground Horn and Hoof	1
Leather	5
Cotton Seed Meal	16
Castor Pomace	3
Gluten Feed	1

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

Dicalcic Phosphate	1
Basic Slag or Odorless Phosphate	1
Concentrated Phosphate	1
Dissolved Bone Black	3
Dissolved Rock Phosphate	1

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

High Grade Sulphate of Potash	3
Double Sulphate of Potash and Magnesia	3
Muriate of Potash	4

4. *Containing Nitrogen and Phosphoric Acid.*

Bone Manures	26
Tankage	17
Dry Ground Fish	9

MIXED FERTILIZERS.

Bone and Potash	11
Nitrogenous Superphosphates and Guanos	76
Special Manures	102
Home Mixtures	7

MISCELLANEOUS.

Cotton Hull Ashes	17
Unleached Wood Ashes	10
Lime Kiln Ashes	1
Saltpeter Waste	2
Sheep Manure	1
Waste from Enameling of Iron	1
	331

DESCRIPTION AND ANALYSES OF FERTLIZERS.*

I. RAW MATERIALS CHIEFLY VALUABLE FOR NITROGEN.

NITRATE OF SODA OR SODIUM NITRATE.

Nitrate of Soda is mined in Chili and purified there before shipment. It contains about 16 per cent. of nitrogen, equivalent to 97 per cent. of pure sodium nitrate. The usual guarantee is "96 per cent." of sodium nitrate, equivalent to 15.8 per cent. of nitrogen.

4155. Bought by J. Norris Barnes, Yalesville.

4168. From stock of L. Sanderson, New Haven.

4314. From stock of Olds & Whipple.

4380. Sampled from stock of J. C. Lincoln, Berlin, by J. C. Lincoln. Bought of Bowker Fertilizer Co.

4456. Purchased by Station and dried before analysis.

ANALYSES.

	4155	4168	4314	4380	4456
Moisture	1.79	1.77	1.50	2.80	.42
Insoluble in water	.27	.16	.16	.18	.18
Sodium Chloride (Salt)	.83	.69	.38	.69	.66
Sodium Sulphate	.48	.43	.16	.30	.39
Sodium Nitrate	96.63	96.95	97.80	96.03	98.35
	100.00	100.00	100.00	100.00	100.00
Equivalent Nitrogen	15.94	16.00	16.14	15.84	16.20
Cost per ton	$	50.00	55.00	49.00	....
Nitrogen costs cents per pound		15.6	17.0	15.4	

SULPHATE OF AMMONIA, OR AMMONIUM SULPHATE.

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 94–97 per cent. of ammonium sulphate. 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.

* This chapter, pages 19–65, has been prepared for publication by Dr. Jenkins. The analyses of Fertilizers have been made by Messrs. Winton and Ogden with the constant assistance of Mr. Lange.

4418. Sampled and sent by the Quinnipiac Co., Boston.
4422. Sampled and sent by L. Sanderson, New Haven.

ANALYSES.

	4418	4422
Nitrogen	21.13	20.50
Equivalent Ammonia	25.65	24.88
Retail price per ton	----	$80.00
Nitrogen costs cents per pound	----	19.5

DRIED BLOOD.

This consists of slaughter-house blood which has been dried by superheated steam or hot air. It is a finely pulverized, nearly odorless substance, red or dark red in color, and rich in nitrogen that is quickly available to vegetation.

A single sample, **4457** purchased for vegetation experiments contained 13.20 per cent. of nitrogen.

GROUND HORN AND HOOF.

We are informed that this material is made in Chicago from horns and hoofs that are steamed under high pressure, which makes them brittle, so that they can be ground to a fine powder.

A single sample, **4458** obtained for vegetation experiments contained 15.59 per cent. of nitrogen.

COTTON SEED MEAL.

This material is of two kinds which are known in trade respectively as undecorticated and decorticated. In their manufacture cotton seed is first ginned to remove most of the fiber, then passed through a "linter" to take off the short fiber or lint remaining, then through machines which break and separate the hulls. The hulled seed is ground and the oil 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. In case of undecorticated meal the hulls and the ground-press cake are mixed together.

4226. Stock of Smith, Northam & Co., Hartford, sampled and sent by Eugene Brown, Poquonock.

4287. Stock of Smith, Northam & Co., Hartford, sampled and sent by H. H. Austin, Suffield.

4164. Stock of H. K. Brainard, Thompsonville, sampled and sent by C. D. Woodworth, Thompsonville.

4212. Stock of Olds & Whipple, Hartford, sampled and sent by Eugene Brown, Poquonock.

4143 and **4144.** Samples of two lots of meal made by the Charlotte Oil and Fertilizer Co., Charlotte, N. C., sampled from stock of J. F. Hyde, Hampton, by C. A. Hammond, Elliot.

4321. Stock of L. Sanderson, New Haven, sampled and sent by F. C. Root, Suffield, from a car lot bought by J. H. Van Gelder, Suffield.

4297. Stock of Olds & Whipple, Hartford, sampled and sent by E. J. Wells, E. Windsor Hill.

4289. Stock of R. A. Parker, Warehouse Point, sampled and sent by J. B. Noble, E. Windsor Hill.

4227. Stock of Olds & Whipple, Hartford, sampled by E. J. Wells, E. Windsor Hill.

4288. Stock of W. W. Cooper, Suffield, sampled and sent by H. H. Austin, Suffield.

4199. Stock of Coles & Weeks, Middletown, sampled and sent by J. M. Hubbard, Middletown.

4301. Bought of H. J. Baker & Bro., sampled and sent by E. A. Wildman, New Milford.

This is undecorticated, whence the low content of nitrogen.

4340. Stock of Olds & Whipple, sampled and sent by E. S. Clark, Hartford.

4358. Stock bought of Edward Austin, by H. N. Loomis, Suffield, sampled and sent by F. C. Root.

4359. Stock bought of Edward Austin by H. A. Sheldon, Suffield, sampled and sent by F. C. Root.

The prices quoted in the table represent average *retail* rates. In many cases car lots were bought at from $24.25 to $24.75 per ton at the purchaser's freight station.

The undecorticated **4301,** even at wholesale rates, is not as economical to buy as the hulled meal at retail prices.

Attention is again called to the merits of Cotton Seed Meal as a fertilizer. It is the cheapest supply of available organic nitrogen now in market. Experience demonstrates that it is very prompt to act and quite odorless.

Its use as a fertilizer seems to be mostly confined at present to tobacco, but it is equally valuable for other crops and at present rates, deserves to be used extensively, to replace the higher priced nitrogen of dried blood, tankage and ground bone.

ANALYSES OF COTTON SEED MEAL.

	4226	4287	4164	4212	4143	4144	4321	4297	4289	4227	4288	4199	4301	4310	4358	4359
Nitrogen	7.78	7.62	7.30	7.35	7.27	7.13	7.39	7.39	7.31	7.31	7.27	7.18	4.21	6.98	7.23	7.43
Phosphoric Acid	3.13	2.94	3.13	2.62	2.60	2.87	2.27	2.25	2.26	2.25	2.30	2.48	2.17	----	----	----
Potash	1.84	1.68	1.92	1.94	1.91	1.98	1.70	1.78	1.65	1.69	1.68	1.86	1.62	----	----	----
Cost per ton	$26.50	26.50	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.50	27.00	17.50*	----	----	----
Nitrogen costs per pound† cents	13.8	14.3	14.3	14.5	14.6	14.7	14 9	14.9	15.1	15.1	15.4	15.7	16.2	----	----	----

* Wholesale, car lots.

† Allowing 5 cents per pound for phosphoric acid and 5¼ cents per pound for potash.

CASTOR POMACE.

This is the ground residue of castor beans from which castor oil has been extracted. An excellent fertilizer, but is extremely poisonous to animals which often eat it greedily when the opportunity offers.

4306. Red Seal Castor Pomace, made by the Red Seal Castor Oil Co., St. Louis, Mo., sampled from stock of Olds & Whipple, Hartford.

4204. Collier Castor Pomace, sampled from stock of F. Ellsworth, Hartford.

4213. Baker & Bro's. Castor Pomace, made by H. J. Baker & Bro., N. Y., sampled by W. H. Olcott, So. Manchester, from stock of W. L. Buckland, Burnside.

ANALYSES.

	4306	4204	4213
Nitrogen	5.59	5.40	5.34
Phosphoric Acid	1.69	1.51	1.39
Potash	1.89	.98	.93
Cost per ton	$24.00	24.00	24.00
Nitrogen costs per pound*	19.1	19.9	20.2

Castor Pomace is regarded by some growers as the very best source of nitrogen for the tobacco crop. They are therefore quite willing to pay a special price for nitrogen in this form. On any other crop there can be no economy in using castor pomace when cotton-seed nitrogen can be bought for four or five cents less per pound.

1570 pounds of cotton seed meal contain as much nitrogen as 2000 pounds of castor pomace and now cost $3.20 less.

In the tests made in 1892 by this Station coöperating with the Conn. Tobacco Experiment Company, wrapper-tobacco grown with aid of castor pomace did not differ either in quality or yield from that manured with cotton seed meal, using equal amounts of nitrogen.

GLUTEN FEED.

This is a residue from the glucose manufacture much used as feed.

* Allowing 5 cents per pound for phosphoric acid and 5¼ cents per pound for potash.

A sample, **4455,** was sent by H. J. Lathrop of Suffield, with inquiry as to its value as a fertilizer for tobacco.

The sample contained 3.06 per cent. of nitrogen, but no considerable quantities of potash and phosphoric acid.

At the price given, $16 to $17 per ton, the pound of nitrogen costs 26 cents, while in cotton seed meal it costs little more than half as much.

II. Raw Materials of High Grade Containing Phosphoric Acid as the Chief Valuable Ingredient.

Odorless Phosphate.*

4200. Bought of Allison, Stroup & Co., N. Y. city., general agents. Sampled and sent by J. M. Hubbard, Middletown. Cost $19 per ton in car lots.

This material, a by-product of the steel manufacture, contains 21.58 per cent. of phosphoric acid of which 6.42 per cent. is soluble in ammonium citrate.

"Odorless phosphate" contains, besides 20 per cent. or more of phosphoric acid, some 45 to 50 per cent. of lime, 10 of oxide of iron, 5 to 7 of silica and smaller quantities of manganese, alumina and magnesia.

That the phosphoric acid of "odorless phosphate" is so readily available as to make its use profitable under some conditions has been abundantly proved by experience in this country and abroad.

Wagner, from the results of carefully conducted vegetation experiments concluded, that two parts of phosphoric acid in the form of *very finely ground* basic slag have the same crop-producing power *in the first year* as one part of water-soluble phosphoric acid of a superphosphate. When the slag is not extremely fine its fertilizing value is very much less than this.

That is 100 pounds of dissolved bone black and 148 pounds of basic slag, will, on land which is deficient in phosphates, produce about the same crop-increase in the season following the application.

But this statement can only be roughly true in a general sense. The comparative effect of basic slag and plain superphosphates depends largely on the quality of the soil and the kind of crop.

* Also known as Basic Slag, Thomas Slag or Thomas-Gilchrist Slag.

In general basic slag will have its best effect on moist soils rich in humus and on crops, like corn, which have a long period of growth. It is recommended for orchards and for grass land before seeding down.

In the reports of this Station for 1887, 1888 and 1889 are recorded the results of field trials with imported basic slag (costing but $12.50 per ton) which illustrate its value as a fertilizer.

At the price now quoted, phosphoric acid in this article costs about 4.4 cents per pound *in car lots.*

This is somewhat more than half the price of water-soluble phosphoric acid in dissolved bone black.

Attention is also called to the analysis given below, No. 4152, of dissolved So. Carolina rock, the price of which was exceptionally low, but whose water-soluble phosphoric acid costs little more than half as much as the phosphoric acid of the basic slag of which two-thirds is insoluble both in water and ammonium citrate.

Dissolved Bone Black and Dissolved Rock Phosphate.

Dissolved Bone Black.

Bone Black, made by subjecting bone to a red heat without access of air, is used in sugar refineries to decolorize sugar solutions. The waste bone black dried, and treated with oil of vitriol makes a "superphosphate" of high grade which does not cake together on standing, but remains as a fine powder suitable for application to the land.

4171. Stock of L. Sanderson, New Haven.

4315. Stock of D. Moriarty, Yalesville, agent of Quinnipiac Co., of Boston.

Dissolved Rock Phosphate or Acid Rock.

4152. This material, made by treating the mineral phosphates mined in So. Carolina and Florida with oil of vitriol, is the most common source of the phosphoric acid of factory-mixed fertilizers.

The per cent. of phosphoric acid in a fertilizer multiplied by 2.18 gives the amount of tricalcium phosphate or so-called "bone phosphate," which figures in commercial transactions and signifies not that the phosphate is in the form of bone, but is reckoned on the same basis in accordance with trade usage.

4152. Bought in Carteret, N. J., by J. Norris Barnes, Yalesville. The price is exceptionally low even for car lots.

ANALYSES.

	4171	4315	4152
Water-soluble phosphoric acid	17.17	14.51	10.78
Citrate-soluble or reverted phosphoric acid	.23	.37	3.51
Insoluble phosphoric acid	.08	.00	1.42
Total phosphoric acid	17.48	14.88	15.71
Cost per ton	$26.00	24.00	12.00*
Water-soluble phosphoric acid costs cents per pound	7.4	8.2	3.5

This material, which should contain 12–14 per cent. of soluble and reverted phosphoric acid, is apt to cake on keeping, but if mixed promptly with sufficient cotton-seed meal, tankage, or other organic matter, there is no difficulty in handling it.

III. Raw Materials of High Grade containing Potash.

High Grade Sulphate of Potash.

This chemical should contain over 90 per cent. of pure potassium sulphate (sulphate of potash) or about fifty per cent. of potassium oxide the same quantity as is supplied by muriate, and should be nearly free from chlorine.

Two samples, **4337** and **4381,** sent to the Station as "High grade Sulphate of Potash," proved to be cotton hull ashes! The analyses of these goods will be found with the others of cotton hull ashes.

4169. From L. Sanderson, New Haven.

4286. Sampled by H. H. Austin, Suffield, from stock purchased by him.

[For analyses see table on page 27.]

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 25.9–27.0 per cent. of potassium oxide. Besides some 46–50 per cent. of potassium sulphate it contains over 30 per cent. of magnesium sulphate, chlorine equivalent to 3 per cent. of common salt, a little sodium and calcium sulphates, with varying quantities of moisture.

* In car lots.

4170. From L. Sanderson, New Haven.

4295. Sampled and sent by E. J. Wells, East Windsor Hill, from stock of Olds & Whipple, Hartford, agents of Quinnipiac Co., Boston.

4420. Sampled and sent by the Quinnipiac Co., Boston.

[For analyses see the following table.]

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 potassium oxide.

4151. Sampled by J. Norris Barnes, Yalesville, from a supply bought in New York.

4175. Stock of L. Sanderson, New Haven.

4292. Sampled by E. C. Warner, Fair Haven, from goods purchased of L. Sanderson, New Haven.

4419. Sampled and sent by the Quinnipiac Co., Boston.

ANALYSES.

	4169	4286	4170	4295	4420	4151	4175	4292	4419
Potassium oxide soluble in water	48.96	49.68	26.47	27.34	32.35	56.65	49.07	52.02	44.96
Equivalent sulphate of potash	90.58	91.91	48.96	50.57	59.84	----	----	----	----
Equivalent muriate of potash	----	----	----	----	----	89.50	77.52	82.19	71.03
Cost per ton	$55.00	51.00	30.00	30.00	----	37.80*	42.50	42.50	----
Potassium oxide costs cents per pound	5.6	5.1	5.7	5.5	----		4.3	4.1	----

The average cost of potassium oxide (potash) in the form of high grade sulphate is not far from 5½ cents, its cost in the double sulphate of potash and magnesia is about the same. Potash in the form of muriate is about one and one-quarter cents per pound cheaper.

For all crops except tobacco, sugar beets and possibly potatoes, muriate of potash is altogether the most economical source of supply.

* f. o. b., New York.

If muriate is applied in moderate quantity in the fall or very early spring to potato land no damage to the quality or productiveness of the crop need be feared.

IV. Raw Materials containing Nitrogen and Phosphoric Acid.

Bone Manures.

The terms "Bone Dust," "Ground Bone," "Bone Meal" and "Bone" applied to fertilizers, sometimes signify material made from dry, clean and pure bones; 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 to recover grease, and are then dried and sometimes 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.

The method adopted for the valuation of bone manures, which takes account of their mechanical condition as well as chemical composition is fully explained on page 16.

1. *Sampled by Station agents.*

On following pages are tabulated eighteen analyses of this class. The last sample **4184** is a mixture of bone and salts of which the latter were perhaps added to dry and preserve the former.

Excluding 4184 from the calculation, the average cost of the seventeen samples of bone manure was $33.59 and the average valuation $32.01.

The valuation during this year has therefore been rather lower than is justified by the market prices.

Bone Manures Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.	Valuation per Ton.	Percentage Dif. between Cost and Valuation.	Chemical Analysis.		Mechanical Analysis.		
							Nitrogen.	Phos. Acid.	Finer than		Coarser than ½ inch.
									1/10 inch.	⅛ inch.	½ inch.
4185	Pure Ground Raw Bone.	H. J. Baker & Bro., 93 William St., N. Y. City.	C. O. Jelliff & Co., Southport.	$30.00	$34.13	Valuation exceeds cost. 12.1	3.54	23.28	65	22	13	--
4271	Bone Meal.	Danbury Fertilizer Co., Danbury.	S. D. Woodruff & Sons, Orange.	29.00	32.96	12.0	3.89	22.94	40	42	18	--
4210	Fine Ground Beef Bone.	Armour Packing Co., Kansas City, Kansas.	F. C. Vibert, Hockanum.	33.00	34.87	5.3	3.66	24.20	59	26	15	--
4207	The Rogers & Hubbard Co's Strictly Pure Fine Bone.	The Rogers & Hubbard Co., Middletown.	Marshall Porter, Hebron.	30.00	31.26	4.0	3.95	22.16	47	24	22	7
4319	Ground Bone Meal.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	J. C. Lincoln, Berlin.	32.00	33.30	3.9	2.47	27.12	55	27	15	3
4173	Ground Bone.	L. Sanderson, New Haven.	Manufacturer.	33.00	34.22	3.5	2.62	27.08	61	23	13	3
4208	Swift Sure Bone Meal.	M. L. Shoemaker & Co., Philadelphia, Pa.	F. Ellsworth, Hartford.	40.00	41.28	3.1	6.10	22.06	62	31	7	-
						Cost exceeds Valuation.						
4273	The Rogers & Hubbard Co's Pure Raw Knuckle Bone Meal.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	38.00 } 42.00 }	37.25	2.0	3.98	25.88	52	35	13	--
4313	The Rogers & Hubbard Co's Pure Raw Knuckle Bone Flour.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	40.00	38.94	2.7	4.07	25.94	56	42	2	--
4211	Fine Ground Bone.	Bradley Fertilizer Co., 92 State St., Boston, Mass.	H. H. Davenport, Pomfret.	31.00 } 32.00 }	29.94	3.5	3.13	21.03	58	25	17	--
			A. C. Sternberg, Hartford.	29.00 }								
			J. F. Elwood, Greens Farms.	35.00	33.25	5.2	2.26	26.11	66	24	10	--
4183	Fine Ground Bone.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	S. W. Bray, Milford.	30.00	26.62	12.6	4.43	21.79	26	17	28	29
4317	Ground Bone.	Downs & Griffin, Birmingham	Manufacturer.	34.00	29.25	16.2	3.03	20.76	57	25	18	--
4312	Pure Bone Meal.	Quinnipiac Co., 92 State St., Boston, Mass.	J. W. Gardner, Cromwell.	36.00	30.56	17.8	2.82	22.45	60	25	14	1
4378	Americus Brand Bone Meal.	Williams & Clark Fertilizer Co., 81 Fulton St., N. Y. City.	D. B. Wilson, Waterbury.	40.00	33.03	21.1	4.18	25.20	36	28	27	9
4318	Pure Ground Bone.	Crocker Fertilizer Co., Buffalo, N. Y.	J. F. Holmes, Ridgefield.	30.00	22.82	31.4	4.25	21.52	7	19	38	36
4267	Pure Ground Bone.	Peck Bros., Northfield.	D. B. Wilson, Waterbury.	30.00	20.47	46.5	4.21	23 36	9	9	15	67
4311	Ground Bone.	Quinnipiac Rendering Co., Meriden.	Manufacturer.	30.00	20.29	47.8	1.87	17.76	47	19	14	20
4184	Celebrated Ground Bone.	Lister's Agricultural Chemical Works, Newark, N. J.	A. N. Clark, Milford.									

2. *Sampled by manufacturers; and* 3. *Sampled by consumers.*

Sample **4228** deposited at the Station by the manufacturer in compliance with the law, was analyzed to meet the requirement of the law which calls for an annual analysis of each brand. The sampling agents of the station did not succeed in finding this brand on sale in the State.

The other samples described below were sent in by private parties and this Station is not responsible for the accuracy of the sampling. The Station holds however in each case a written certificate that the sample was drawn in accordance with its printed instructions.

2. *Sampled by manufacturers.*

4228. Bone Meal made by the L. T. Frisbee Co., Hartford.

3. *Sampled by consumers.*

4153. Bone bought in New York by J. Norris Barnes, Yalesville. Sample drawn by him.

4158. Chittenden's Ground Bone. Sold by National Fertilizer Co. Bridgeport. Sampled and sent by T. J. Stroud, Shaker Station.

4296. Bone bought of Olds & Whipple, Hartford. Sampled and sent by E. J. Wells, E. Windsor Hill.

4448 and **4449.** Bone bought of H. K. Brainard, Thompsonville, said to be from H. J. Baker & Bro. N. Y.

4448. Sampled and sent by T. J. Stroud, Shaker Station.

4449. Sampled and sent by Sumner F. Sikes, Suffield.

MECHANICAL ANALYSES.

	4228	4153	4158	4296	4448	4449
Fine, smaller than $\frac{1}{50}$ inch	96	0	67	60	57	57
Fine medium, smaller than $\frac{1}{25}$ inch,	4	37	20	23	42	42
Medium, smaller than $\frac{1}{12}$ inch	0	60	11	16	1	1
Coarse, larger than $\frac{1}{12}$ inch	0	3	2	1	0	0
	100	100	100	100	100	100

CHEMICAL ANALYSES.

Nitrogen	2.53	4.10	2.78	2.82	3.72	3.80
Phosphoric acid	26.80	24.78	26.00	22.43	21.11	21.30
Cost per ton	$----	22.50*	----	33.00	----	32.00
Valuation per ton	$37.59	28.11	34.36	30.36	33.15	33.60

* Car lot.

Sample No. **4209** was reported by the sampling agent to have been drawn from stock of G. S. Butler, Cromwell, labelled The Rogers & Hubbard Co's. Strictly Pure Fine Bone.

The Rogers & Hubbard Co. object that the analysis does not represent the composition of the brand named, see No. **4207** in the table page 29, and that there is probably some mistake about the sample.

The analysis of Sample No. **4375,** Pure Fine Ground Bone made by the Rogers Manufacturing Co. Rockfall, sent by the manufacturers, is objected to by them because the sample is coarser than the average of their ground bone. For these reasons the two analyses are not included in the foregoing Table.

MECHANICAL ANALYSES.

	4209	4375
Fine, smaller than $\frac{1}{50}$ inch	49	21
Fine medium, smaller than $\frac{1}{25}$ inch	40	30
Medium, smaller than $\frac{1}{12}$ inch	11	40
Coarse, larger than $\frac{1}{12}$ inch	0	9
	100	100

CHEMICAL ANALYSES.

Nitrogen	3.60	4.23
Phosphoric acid	25.80	21.74
Cost per ton	$30.00	----
Valuation per ton	$36.02	$28.20

TANKAGE.

This name is applied to the sediment remaining in tanks where meat scrap and bone are cooked with water to separate the fat. After boiling or steaming, the fat rises to the surface and is removed, the soup is run off, and the settlings at the bottom are dried and sold as tankage.

Sampled by Station Agent.

4123. Made by C. H. Davis & Co. Norwich.

4172. Pulverized Bone and Meat. Stock of L. Sanderson, New Haven.

4174. Blood, Bone and Meat. Stock of L. Sanderson, New Haven.

4252. Bone Fertilizer. Made by Plumb & Winton, Bridgeport.

4316. Bone Tankage. Made by Geo. F. Taylor & Brush, New York City.

MECHANICAL ANALYSES.

	4123	4172	4174	4252	4316
Fine, smaller than $\frac{1}{50}$ inch	30	71	63	64	53
Fine medium, smaller than $\frac{1}{25}$ inch	32	19	20	22	19
Medium, smaller than $\frac{1}{12}$ inch	20	9	11	13	18
Coarse, larger than $\frac{1}{12}$ inch	18	1	6	1	10
	100	100	100	100	100

CHEMICAL ANALYSES.

Nitrogen	4.92	3.79	5.29	5.40	6.27
Phosphoric acid	15.03	24.03	17.49	18.04	17.47
Valuation per ton	$25.47	36.24	32.88	34.48	33.88
Cost per ton	$20.00	35.00	35.00	30.00	21.90*

Sampled by manufacturer or consumers.

4421. Tankage sold and sampled by the Quinnipiac Co., Boston.

4426. Bone Tankage. Sold and sampled by C. Buckingham, Southport.

4070. Acidified Tankage bought and sampled by Geo. Butler, Cromwell.

4154. Tankage made by the Meriden Provision Co., Meriden. Sampled by J. Norris Barnes, Yalesville.

4298. Bone and Meat. Stock of A. Pouleur, Windsor. Sampled and sent by E. J. Wells, E. Windsor Hill.

MECHANICAL ANALYSES.

	4421	4426	4070	4154	4298
Fine, smaller than $\frac{1}{50}$ inch	69	24	40	58	55
Fine medium, smaller than $\frac{1}{25}$ inch	20	27	32	15	18
Medium, smaller than $\frac{1}{12}$ inch	11	37	20	11	14
Coarse, larger than $\frac{1}{12}$ inch	0	12	8	16	13
	100	100	100	100	100

CHEMICAL ANALYSES AND VALUATIONS.

Nitrogen	5.67	4.57	4.55	5.89	2.88
Phosphoric acid	11.95	16.12	4.39†	13.24	25.10
Valuation per ton	$29.84	24.69	14.45	28.77	30.97

*Car lots.

† Of which 3.98 per cent. is soluble in water.

DRY GROUND FISH.

This material is often sprinkled with diluted oil of vitriol to hinder decay during drying, and the bones of the fish are as a result softened and to some extent dissolved.

4203. Pure Dry Fish Guano. Made by The Miles Fertilizer and Oil Co., Milford. Sampled by Station agent from stock of Olds & Whipple, Hartford.

4379. Dry Ground Fish. Sold by Quinnipiac Co. Boston. Sampled by Station agent from stock of D. C. Wood, Stratford.

4293. Dry Ground Fish. Made by Leander Wilcox, Mystic. Sampled and sent by H. H. Austin, Suffield.

ANALYSES.

	4203	4379	4293
Nitrogen as ammonia	.35	----	.27
Nitrogen, organic	8.55	7.97	8.96
Total nitrogen	**8.90**	**7.97**	**9.23**
Water-soluble phosphoric acid	.48	.52	.86
Citrate-soluble (reverted) phosphoric acid	5.50	5.08	4.26
Insoluble phosphoric acid	1.34	.90	2.36
Total phosphoric acid	**7.32**	**6.50**	**7.48**
Cost per ton	$38.00	38.00	35.00*
Valuation per ton	$40.14	36.06	40.84

MIXED FERTILIZERS.

BONE AND POTASH.

4377. Circle Brand Bone and Potash, made by Bradley Fertilizer Co., Boston, and sample furnished by them.

The samples named below were drawn by an agent of this Station.

4266. A1 Fertilizer, made by C. Buckingham, Southport. Stock of R. C. Wilcox, Guilford.

As the results of this analysis were unsatisfactory, Mr. Buckingham asked that another sample be drawn, which is **4427,** A1 Fertilizer, made by C. Buckingham, and drawn from stock at his warehouse.

4268. Self Recommending Fertilizer, made by F. Nuhn, Waterbury, sampled from stock of manufacturer.

4305. Square Brand Bone and Potash, made by Bowker Fertilizer Co., Boston, Mass., sampled from stock of D. B. Wilson, Waterbury.

*In car lots.

4428. Ground Bone and Potash, made by The E. F. Coe Co., N. Y. Stock of Wheeler & Howes, Bridgeport.

MECHANICAL ANALYSES.

	4377	4266	4427	4268	4305	4428
Fine, smaller than $\frac{1}{50}$ inch	54	60	52	48	63	57
Fine medium, smaller than $\frac{1}{25}$ inch	33	23	24	22	21	26
Medium, smaller than $\frac{1}{12}$ inch	13	13	18	17	13	15
Coarse, larger than $\frac{1}{12}$ inch	0	4	6	13	3	2
	100	100	100	100	100	100

CHEMICAL ANALYSES.

Nitrogen	2.32	4.45	4.57	3.75	1.76	2.10
Phosphoric acid	19.34	10.45	11.00	19.83	18.68	23.19
Potash	3.61	5.75*	5.94†	4.27	1.91	2.03‡
Cost per ton		$36.00	36.00	35.00	29.00	30.00
Valuation per ton	$28.16	29.50	29.71	31.92	25.27	30.75

4182. Was drawn from stock of Elmer S. Banks, Southport. It purported to be E. F. Coe's Bone and Potash.

It contained 1.35 per cent. of nitrogen, 18.04 per cent. of phosphoric acid and 2.48 per cent. of potash.

The manufacturer objected that this analysis did not at all represent the goods and requested that another sample be drawn and tested. The analysis of the second sample is given in the table above, No. **4428.**

The two following samples are called "bone and potash," but they are not stated to contain any nitrogen.

4382. Diamond Brand Bone and Potash, made by Walton, Whann & Co., Wilmington, Del. Stock of W. S. Hill, Southford.

4383. Bone and Potash, made by Great Eastern Fertilizer Co., Rutland, Vt. Stock of J. U. Sanders, North Stamford.

ANALYSES.

	4382	4383
Water-soluble phosphoric acid	11.42	6.56
Citrate-soluble (reverted) phosphoric acid	2.34	4.42
Insoluble phosphoric acid	.67	.33
Potash, as muriate	2.94	2.21
Valuation per ton	$19.19	14.85
Cost per ton	$25.00	30.00

* 5.03 per cent in form of sulphate.
† 5.01 per cent in form of sulphate.
‡ 1.73 per cent in form of sulphate.

The two following samples were drawn by C. J. Dewey, Buckland. They are said to represent two different lots of Bradley Fertilizer Co.'s Bone and Potash, Circle Brand, shipped direct to Mr. Dewey by the manufacturer.

MECHANICAL ANALYSES.

	4458	4459
Fine, smaller than $\frac{1}{50}$ inch	45	55
Fine medium, smaller than $\frac{1}{25}$ inch	18	27
Medium, smaller than $\frac{1}{12}$ inch	25	14
Coarse, larger than $\frac{1}{12}$ inch	12	4
	100	100

CHEMICAL ANALYSES.

Nitrogen	2.52	2.12
Phosphoric acid	11.77	12.67
Potash	2.46	2.48
Cost per ton	$33.00	33.00
Valuation per ton	$19.33	20.67

II. NITROGENOUS SUPERPHOSPHATES AND GUANOS.

Here are included those mixed fertilizers containing nitrogen, phosphoric acid and in most cases potash, which are not designed by their manufacturers for use on any special crop. "Special Manures" are noticed further on.

1. *Samples drawn by Station agents.*

In the tables on pages 38 to 43 are tabulated the analyses of fifty-three brands, made on samples collected by the Station agents.

THE GUARANTEES.

The law of Connecticut requires every package of fertilizer to bear a statement of the actual composition of the goods. This statement expresses the quantities of nitrogen, phosphoric acid and potash within certain limits, for instance "nitrogen 2–4 per cent."

If a fertilizer with such a guarantee actually contains 2 per cent. of nitrogen, it justifies the manufacturer's statement.

It is the lowest figures of the guarantee therefore that purchasers should regard.

Of the fifty-three brands here reported sixteen are below their minimum guarantee in respect of one ingredient, and two in respect of two ingredients. That is, more than one-fourth of all the nitrogenous superphosphates in our market contain less of one or of two ingredients than they are claimed to contain.

It is urged that an excess of one ingredient over the guarantee should be held to make good the deficiency of another. But with reasonable care and skill in the manufacture and in the sampling and analysis of the goods the actual analysis should not fall below the minimum guaranteed in any respect particularly when wide limits are allowed in the guarantees themselves.

Cost and Valuation.

Cost.

The method used to ascertain the retail cash price of the superphosphates is as follows:

The sampling agents inquire and note the price at the time each sample is drawn. The analysis when done is reported to each dealer from whom a sample was taken, with an enclosed postal card addressed to the Station, and a request to note on it whether the retail cash price is correctly given and to mail to the Station.

From the data thus obtained the average prices are computed.

Valuation.

The valuation has been computed in all cases in the usual manner as explained on page 16.

Percentage Difference given in the table shows the percentage excess of the cost price over the average retail cost of the nitrogen, phosphoric acid and potash contained in the fertilizer.

This information enables the purchaser to estimate the relative value of the different brands and the relative economy of buying mixed fertilizers or of procuring and compounding the materials needful for a fertilizer.

Which plan is preferable can only be determined by each individual farmer, who should know best what his soil and crops need and what his facilities for purchase and payment are.

In case a fertilizer has sold at two or more different prices, the *manufacturer's price*, when known has been used in calculating percentage difference.

Otherwise an *average, or nearly average price* forms the basis of comparison between cost and valuation. The price thus employed is printed in heavy-faced type.

The average cost of the nitrogenous superphosphates is $32.93. The average valuation is $23.30, and the percentage difference 41.3.

Last year the corresponding figures were :

Average cost $32.99, average valuation $23.48, percentage difference 40.5.

These valuations it must be remembered are based on the assumption that the nitrogen, phosphoric acid and potash in each fertilizer are readily available to farm crops. Chemical examination can show pretty conclusively whether this is true in respect of potash. There is less certainty regarding phosphoric acid, while chemical examination, as it is usually made, gives little or no clue as to the availability of the organic nitrogen of mixed goods. This Station has been for some years engaged in a study of methods for determining approximately the relative availability of nitrogen, and on subsequent pages is given a report of the work done during the past year on this point.

While various inferior or agriculturally worthless forms of nitrogen are in the market the main security of purchasers of mixed fertilizers is in dealing with firms which have an established reputation and in avoiding "cheap" goods offered by irresponsible parties.

NITROGENOUS SUPERPHOSPHATES AND GUANOS, SAMPLED BY THE STATION.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
4464	Pure Fine Bone Dissolved in Sulphuric Acid.	Mapes' Formula & Peruvian Guano Co., N. Y. City.	Mapes' Branch, Hartford.	**$32.00***
4309	Flour of Bone Phosphate.	George W. Miller, Middlefield.	Manufacturer.	**36.00**
4319	Nameless Phosphate.	Danbury Fertilizer Co., Danbury.	L. P. Russell, Orange.	**30.00**
4251	Ammoniated Bone Phosphate.	Preston Fertilizer Co., Greenpoint, L. I.	S. D. Woodruff & Sons, Orange.	**29.00**
4254	Bone, Fish and Potash.	E. R. Kelsey, Branford.	Wilson & Burr, Middletown.	**28.00**
4276	Complete Fertilizer.	Rogers Mfg. Co., Rockfall.	John Lewis. Willimantic.	30.00
			R. H. Tucker, Saybrook.	34.00
				32.00
4178	Formula A.	L. Sanderson, New Haven.	N. E. Smith & Son, Woodmont	----
			C. O. Jelliff & Co., Southport.	**36.00**
4348	Vegetable Bone Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	J. F. Holmes, Ridgefield.	44.00
			G. S. Butler, Cromwell.	**42.00**
4389	Fish and Potash.	National Fertilizer Co., Bridgeport.	Thomas Kirkham, Newington.	**30.00**
4232	A. A. Ammoniated Superphosphate.	H. J. Baker & Bro., 93 William St., N. Y. City.	D. N. Benton, Guilford.	34.00
			Saxton & Strong, Bristol.	36.00
				35.00
4430	Swift Sure Superphosphate.	M. L. Shoemaker & Co., Philadelphia, Pa.	F. Ellsworth, Hartford.	**38.00**
4224	Complete Manure, A Brand.	Mapes' Formula & Peruvian Guano Co., N. Y. City.	Wheeler & Howes, Bridgeport.	**35.00**
			Will. Foot, Branford.	33.50
			Mapes' Branch, Hartford.	35.00
			Manchester Elevator Co., Manchester.	37.00
			G. K. Nason, Willimantic.	37.00
4188	Complete Manure for General Use.	Mapes' F. & P. G. Co., N. Y. City.	Manchester Elevator Co., Manchester.	40.00
			G. K. Nason, Willimantic.	**38.00**
4179	Standard Phosphate.	Lister Bros., Newark, N. J.	A. N. Clark, Milford.	**32.00**
4386	High Grade General Fertilizer.	Soluble Pacific Guano Co., Boston, Mass.	R. H. Tucker, Saybrook	**39.00**
4364	Fish and Potash.	Leander Wilcox, Mystic.	Manufacturer.	**34.00**
4367	Olds & Whipple Special Phosphate.	Olds & Whipple, Hartford.	Olds & Whipple, Hartford.	**38.00**
4353	Success Phosphate.	Lister Bros., Newark, N. J.	W. H. Parmelee, Essex.	**28.00**
4181	Ammoniated Dissolved Bone.	Lister Bros., Newark, N. J.	A. N. Clark, Milford.	**30.00**
4390	Ammoniated Bone Phosphate.	National Fertilizer Co., Bridgeport.	T. H. Eldridge, Norwich.	34.00
			G. A. & H. B. Williams, East Hartford.	**31.00**
			E. B. Clark, Milford.	28.00
			Henry Child, Woodstock.	30.00

* The full-face figure is the one used in calculating the percentage difference.

ANALYSES.

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Found. As Muriate.	Found. Total.	Guaranteed.
$31.64	1.1	----	----	2.94	2.94	*2.1*	3.47	13.76	3.66	20.89	*12.0*	17.23	----	----	----	----
32.06	12.2	1.18	----	2.07	3.25	*3.0*	8.29	3.10	.66	12.05	*11.0*	11.39	----	8.18	8.18	*7.0*
26.47	13.3	----	----	3.62	3.62	*2.1*	----	7.26	3.38	10.64	*8.0*	7.26	----	4.15	4.15	*2.0*
25.38	14.2	----	.30	2.93	3.23	*2.5*	6.26	3.03	.61	9.90	*9.0*	9.29	----	.81	2.32	*2.0*
24.35	14.9	----	.89	2.63	3.52	*2.5*	3.84	2.49	.13	6.46	*5.0*	6.33	----	.59	3.74	*3.0*
26.95	18.7	.36	----	2.51	2.87	*2.6*	3.04	6.40	.54	9.98	*10.0*	9.44	----	.72	5.54	*5.0*
29.05	20.4	1.07	.16	2.58	3.81	*3.3*	4.74	2.77	1.89	9.40	*10.0*	7.51	*7.0*	1.20	6.16	*6.0*
33.38	25.8	.90	----	4.82	5.72	*5.0*	4.82	1.40	.29	6.51	*7.0*	6.22	*6.0*	6.11	6.11	*6.0*
23.66	26.7	----	----	2.64	2.64	*3.0*	4.86	3.11	1.64	9.61	*6.0*	7.97	----	4.42	4.42	*4.0*
27.55	27.0	.38	1.61	1.30	3.29	*2.5*	5.31	4.68	2.81	12.80	*10.0*	9.99	----	3.20	3.20	*2.0*
29.89	27.1	.84	----	2.04	2.88	*2.5*	7.10	5.53	1.76	14.39	*14.0*	12.63	*9.0*	.59	4.47	*4.0*
27.32	28.1	.74	.39	1.90	3.03	*2.5*	7.18	4.34	1.29	12.81	*12.0*	11.52	*10.0*	3.05	3.05	*2.5*
29.12	30.4	1.24	.51	1.97	3.72	*3.3*	4.66	5.28	1.51	11.45	*10.0*	9.94	*8.0*	4.76	4.76	*4.0*
24.17	32.3	----	.41	2.16	2.57	*2.3*	7.94	2.21	2.57	12.72	----	10.15	*10.0*	1.81	1.81	*1.5*
29.45	32.4	1.55	---	2.13	3.68	*3.3*	4.00	5.15	1.15	10.30	*9.0*	9.15	*8.0*	6.82	6.82	*7.0*
25.57	32.9	----	.27	3.48	3.75	*3.3*	3.49	2.56	.47	6.52	*6.0*	6.05	*5.0*	4.96	4.96	*4.0*
28.30	34.2	1.03	.74	1.59	3.36	*2.7*	5.09	6.67	1.61	13.37	*10.0*	11.76	*8.0*	1.00	2.55	*2.0*
20.32	37.7	----	----	1.49	1.49	*1.2*	8.53	1.80	1.95	12.28	----	10.33	*9.5*	1.32	1.91	*2.0*
21.52	39.4	----	.37	1.72	2.09	*1.8*	7.12	2.44	2.31	11.87	----	9.56	*9.0*	1.79	1.79	*1.5*
22.01	40.8	----	.20	2.11	2.31	*1.6*	2.96	6.85	.77	10.58	*9.0*	9.81	*7.0*	2.27	2.27	*2.0*

Nitrogenous Superphosphates and Guanos Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
4190	High Grade Ammoniated Bone Superphosphate.	The E. Frank Coe Co., 133 Front St., N. Y. City.	E. S. Banks, Southport.	$33 00
4361	Old Reliable Superphosphate.	L. Sanderson, New Haven.	J. O. Fox & Co., Putnam.	**32.00**
			A. B. Morse, Guilford.	**30.00**
4369	Ammoniated Dissolved Bone.	Quinnipiac Co., 92 State St., Boston, Mass.	J. F. Silliman, New Canaan.	**33.00**
4363	Ammoniated Bone Phosphate.	Leander Wilcox, Mystic.	Manufacturer.	34.00
			Browning & Gallup, New London.	**34.00**
4192	Bradley's Superphosphate.	Bradley Fertilizer Co., Boston, Mass.	J. F. Elwood, Greens Farms.	**35.00**
			H. H. Davenport, Pomfret.	34.00
			G. W. Carver & Son, Putnam.	34.00
			Quinnebaug Store, Danielsonville.	36.00
			J. A. Lewis, Willimantic.	35.00
			W. B. Martin, Rockville.	35.00
			Thomas Ryan, Thompson.	34.00
4237	Fish, Bone and Potash for General Gardening.	Read Fertilizer Co., Box 3121, N. Y. City.	W. Tillinghast, Plainfield.	**30.00**
4249	Fish and Potash, Plain Brand.	Quinnipiac Co., Boston, Mass.	J. W. Gardner, Cromwell.	30.00
			S. V. Osborn & Co., Branford.	32.00
				31.00
4217	Hill and Drill Phosphate.	Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	C. H. Bell, Portland.	37.00
			M. A. Covell, North Grosvenordale.	34.00
			F. Hallock & Co., Birmingham.	**35.00**
4194	Farmers' New Method Fertilizer.	Bradley Fertilizer Co., Boston, Mass.	Quinnebaug Store, Danielsonville.	34.00
			H. H. Davenport, Pomfret.	31.00
			J. A. Lewis, Willimantic.	30.00
			Thomas Ryan, Thompson.	31.00
			G. W. Carver & Son, Putnam.	33.00
				32.00
4368	Fish and Potash, Crossed Fishes Brand.	Quinnipiac Co., Boston, Mass.	D. W. Spencer, Centrebrook.	**36.00**
4253	Russell Coe's Phosphate.	National Fertilizer Co., Bridgeport.	Wilson & Burr, Middletown.	**30.00**
4233	Ammoniated Dissolved Bone.	Bowker Fertilizer Co., Boston, Mass.	E. B. Clark, Milford.	28.00
			M. A. Covell, North Grosvenordale.	**30.00**
4220	Alkaline Bone.	The E. Frank Coe Co., N. Y. City.	J. O. Fox & Co., Putnam.	28.00
			C. H Lounsbury, Seymour.	32.00
				30.00
4396	Fish and Potash.	Williams & Clark Fertilizer Co., N. Y. City.	F. C. Gould, Silver Lane.	**31.00**
4238	Fish and Potash.	The E. Frank Coe Co., N. Y. City.	W. T. Andrew, Orange.	28.00
			D. N. Clark, Shelton.	35.00
				32.00

Analyses—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Found. As Muriate.	Found. Total.	Guaranteed.
$22.72	40.8	....	.48	1.65	2.13	*2.0*	7.87	2.20	1.83	11.90	*9.0*	10.07	*9.0*	.41	2.14	*1.8*
21.17	41.7	....	.31	2.03	2.34	*1.6*	1.20	5.35	4.14	10.69	*10.0*	6.55	*8.0*	.94	3.45	*3.0*
23.13	42.6	....	....	2.03	2.03	*1.6*	4.59	6.35	3.03	13.97	*10.0*	10.94	*9.0*	.59	1.90	*2.0*
23.75	43.1	....	.39	2.54	2.93	*2.5*	3.50	3.04	.96	7.50	*7.0*	6.54	*6.0*	5.50	5.50	*5.0*
24.40	43.4	.51	.06	2.28	2.85	*2.3*	6.91	3.35	1.13	11.39	*11.0*	10.26	*9.0*	2.02	2.02	*1.5*
20.85	43.8	.76	....	2.01	2.77	*2.5*	2.64	2.30	.51	5.45	*5.0*	4.94	*4.0*	5.90	5.90	*4.0*
21.48	44.3	....	.20	2.42	2.62	*2.1*	4.27	2.84	.62	7.73	*6.0*	7.11	*4.0*	3.64	3.64	*4.0*
24.20	44.6	1.55	....	1.30	2.85	*2.5*	5.82	4.59	2.61	13.02	*12.0*	10.41	*9.0*	2.02	2.02	*2.0*
22.05	45.1	.50	....	1.77	2.27	*1.6*	5.97	3.32	1.48	10.77	*10.0*	9.29	*8.0*	2.93	2.93	*3.0*
24.77	45.3	....	.35	3.38	3.73	*3.3*	4.35	2.23	.40	6.98	*5.0*	6.58	*4.0*	3.44	3.44	*3.0*
20.39	47.1	....	....	2.39	2.39	*1.7*	2.16	5.64	2.31	10.11	*8.0*	7.80	*6.0*	2.04	2.04	*1.0*
20.37	47.2	1.13	....	1.22	2.35	*1.5*	3.84	4.26	4.63	12.73	*10.0*	8.10	*8.0*	1.59	1.59	*2.0*
20.15	48.8	....	.12	1.37	1.49	*1.0*	6.94	2.89	2.31	12.14	*11.0*	9.83	*9.0*	.53	2.16	*3.0*
20.82	48.8	....	.22	2.20	2.42	*2.5*	4.94	2.52	.43	7.89	*6.0*	7.46	*4.0*	3.30	3.30	*4.0*
21.46	49.1	....	....	2.64	2.64	*3.0*	2.29	4.26	2.70	9.25	*6.0*	6.55	*4.0*	3.52	3.52	*2.0*

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

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
4245	Soluble Pacific Guano.	Soluble Pacific Guano Co., Boston, Mass.	R. H. Tucker, Saybrook.	**$35.00**
			R. F. Woodford, Plainville.	35.00
			Saxton & Strong, Bristol.	36.00
4327	Harvest Home Phosphate.	H. J. Baker & Bro., N. Y. City.	S. J. Hall, Meriden.	**30.00**
4394	Bay State Fertilizer.	Clark's Cove Fertilizer Co., Boston, Mass.	Henry Fields, Newington.	38.00
			John Ballard, Thompson.	**35.00**
			E. White, Rockville.	38.00
4223	Quinnipiac Phosphate.	Quinnipiac Co., Boston, Mass.	J. W. Gardner, Cromwell.	34.50
			F.S. Bidwell, Windsor Locks.	35.00
			D. C. Wood, Stratford.	**35.00**
4346	Fish and Potash, Triangle A Brand.	Bradley Fertilizer Co., Boston, Mass.	A. H. Diamond & Son, Bristol.	**33.00**
4395	Bay State Fertilizer G. G.	Clark's Cove Fertilizer Co., Boston, Mass.	J. M. Burke, South Manchester.	**35.00**
4225	Americus Brand Ammoniated Bone Superphosphate.	Williams & Clark Fertilizer Co., New York City.	J. Bramfield, Portland.	**35.00**
			F. C. Gould, Silver Lane.	33.00
			H. K. Brainard, Thompsonville.	35.00
			Hale, Day & Co., South Manchester.	38.00
			W. B Martin, Rockville.	35.00
4307	New England Favorite.	John S. Reese & Co., Baltimore, Md.	John Gunn, Groton.	**36.00**
4240	Royal Bone Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	F. C. Gould, Silver Lane.	**28.50**
			Hale, Day & Co., South Manchester.	35.00
4248	Standard Phosphate.	Read Fertilizer Co., N. Y. City.	W. Tillinghast, Plainfield.	**30.00**
			J. H. Blackman, Stratford.	30.00
4260	Farmers' Reliable Phosphate.	Chicopee Guano Co., N. Y. City.	F. J. Newton, Branford.	30 00
			H. D. Archer, Southport.	36.00
				33.00
4191	New Rival Superphosphate.	Crocker Fertilizer Co., Buffalo, N. Y.	G. F. Kibbie, Tolland.	**31.00**
4258	Alkaline Guano.	Clark's Cove Fertilizer Co., Boston, Mass.	John S. Wells, Hebron.	31.00
			A. C. Innis, Stratford.	**30.00**
			J. M. Burke, South Manchester.	30.00
4370	Four Fold Brand.	Walker, Stratman & Co., Pittsburgh, Pa.	W. T. Dudley, Guilford.	**30.00**
4371	Vegetable, Vine and Fruit Manure.	Read Fertilizer Co., N. Y. City.	H. L. Foot, Brookfield Junction.	**38.00**
4244	Standard Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Arnold Warner, South Coventry.	**36.00**
4195	Sure Crop Phosphate.	Bowker Fertilizer Co., Boston, Mass.	W. Tillinghast, Plainfield.	30.00
			John A. Paine, Danielsonville	**28.00**
4241	Economical Fertilizer.	Wilkinson & Co., 52–54 William St., N. Y. City.	W. W. Peck, Woodbridge.	**32.00**

ANALYSES—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen.		Soluble.	Reverted.	Insoluble.	Total.		Available.		Found.		Guaranteed.
					Found.	Guaranteed.				Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	
$23.42	49.4	.23	....	2.30	2.53	*2.3*	4.77	5.76	1.33	11.86	*10.5*	10.53	*8.5*	1.83	1.83	*2.0*
20.06	49.5	....	.84	.92	1.76	*.9*	2.50	6.59	2.76	11.85	*8.0*	9.09	....	2.35	2.35	*2.0*
23.04	51.9	.68	....	2.04	2.72	*2.5*	5.39	4.28	1.15	10.82	*9.5*	9.67	*8.0*	2.09	2.09	*2.0*
22.98	52.3	.71	.08	1.85	2.64	*2.5*	4.90	4.98	1.63	11.51	*10.0*	9.88	*9.0*	1.96	1.96	*2.0*
21.58	52.9	....	.16	2.33	2.49	*2.0*	3.54	3.08	.83	7.45	*6.0*	6.62	*4.0*	4.87	4.87	*4.0*
22.88	52.9	....	.12	2.23	2.35	*1.9*	5.57	4.68	1.08	11.33	*10.0*	10.25	*8.5*	2.12	2.12	*2.0*
22.85	53.2	.74	....	1.92	2.66	*2.5*	5.92	3.51	1.47	10.90	*10.0*	9.43	*9.0*	2.28	2.28	*2.0*
23.40	53.8	....	.20	2.73	2.93	*2.5*	3.97	5.27	.94	10.18	*10.0*	9.24	*9.0*	1.78	1.78	*2.0*
17.76	60.4	....	....	1.33	1.33	*1.0*	5.31	3.71	1.36	10.38	*8.0*	9.02	*7.0*	2.06	2.06	*2.0*
18.43	62.7	....	....	1.14	1.14	*.8*	6.72	1.99	.69	9.40	*10.0*	8.71	*8.0*	4.09	4.09	*4.0*
19.86	66.1	....	....	1.95	1.95	*1.7*	5.82	2.89	1.75	10.46	*10.0*	8.71	*8.0*	1.98	1.98	*2.0*
18.55	67.1	....	....	1.40	1.40	*1.2*	6.05	3.47	1.47	10.99	*11.0*	9.52	*10.0*	1.89	1.89	*1.6*
17.83	68.2	....	....	1.49	1.49	*1.5*	3.49	4.72	1.59	9.80	*7.0*	8.21	*6.0*	2.56	2.56	*2.0*
17.58	70.6	....	....	1.47	1.47	*1.6*	4.66	3.59	3.07	11.32	*10.0*	8.25	*8.0*	1.52	1.52	*2.0*
22.02	72.5	.29	....	1.78	2.07	*1.6*	5.31	1.40	.31	7.02	*7.0*	6.71	*6.0*	7.29	7.29	*8.0*
20.66	74.2	.35	....	1.80	2.15	*2.0*	6.21	3.06	1.09	10.36	*10.0*	9.27	*8.0*	1.91	1.91	*2.0*
15.24	83.7	.69	....	.37	1.06	*.7*	2.18	6.19	3.20	11.57	*10.0*	8.37	*8.0*	1.04	1.25	*1.0*
14.22	125.0	....	....	1.08	1.08	*1.2*	4.80	1.52	.55	6.87	*6.0*	6.32	....	2.86	2.86	*3.0*

2. Sampled by the Manufacturers.

In the preceding table, page 44, are twelve analyses made on samples deposited with the Director of the Station by manufacturers in compliance with the requirements of the Fertilizer Law.

The brands named were not found in the Connecticut market by our sampling agents.

3. Sampled by the consumer.

A single analysis of a sample of this kind is given in the preceding table, page 44.

Protest was made by the manufacturers of the two brands named below because the analyses (first made and here given) did not represent the general quality of the goods. In case of Swift Sure Superphosphate it was possible to draw and analyze a second sample, with the results given in the table on page 39 No. **4430,** which are copied below for comparison.

4242. Complete Bone Phosphate, made by L. Wilcox, Mystic, sampled from stock of Browning & Gallup, New London.

4256. Swift Sure Superphosphate, made by L. Shoemaker & Co., Phila., sampled from stock of J. P. Barstow & Co., Norwich.

ANALYSES.

	4242	4256	4430
Nitrogen as nitrate	----	.70	.84
Nitrogen, organic	1.96	1.80	2.04
Total nitrogen	1.96	2.50	2.88
Water-soluble phosphoric acid	7.23	5.39	7.10
Citrate-soluble (reverted) phosphoric acid	2.90	4.96	5.53
Insoluble phosphoric acid	.68	4.39	1.76
Total phosphoric acid	10.81	14.74	14.39
Potash, as muriate	2.49	4.47	4.47
Valuation per ton	$21.63	26.40	29.89

III. SPECIAL MANURES.

1. *Sampled by Station Agent.*

For Analyses and Valuations see pages 46 *to* 53.

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

NITROGENOUS SUPERPHOSPHATES, GUANOS AND FERTILIZERS SAMPLED AND SENT BY THE MANUFACTURERS.

Station No.	Name or Brand.	Manufacturer.	Sampled by	Manufacturer's Price per Ton.	Valuation per Ton.	Percentage Diff. per Ton.	Nitrogen. Nitric Nitrogen.	Ammonic Nitrogen.	Organic Nitrogen.	Total. Found.	Total. Guaranteed.	Phosphoric Acid. Water-soluble.	Citrate-soluble (Reverted).	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.
4404	Fish and Potash, Anchor Brand.	Bradley Fertilizer Co.	Manufacturer.	$ --	$26.57	--	--	--	3.91	3.91	2.2	3 39	3.83	.87	8.09	5.0	7.22	3.0	3.74	3.0
4403	B. D. Sea Fowl Guano.	Bradley Fertilizer Co.	"	--	26.19	--	--	--	2.97	2.97	2.1	6.16	5.50	1.25	12 91	10.0	11.66	8.0	1.40	1.5
4402	Original Coe's Superphosphate.	Bradley Fertilizer Co.	"	--	23.48	--	.17	--	2.45	2.62	1.7	6.24	4.40	1.04	11.68	12.0	10.64	10.0	1.30	1.0
4408	Great Planet A Fertilizer.	Clark's Cove Fertilizer Co.	"	--	31.12	--	1.30	.22	2.18	3.70	3.3	4.53	5.07	1.08	10.68	9.0	9.60	8.0	7.77	7.0
4401	Gold Brand Excelsior Guano.	E. F. Coe Co.	"	--	24.72	--	--	.69	1.23	1 92	--	7.50	2.74	1.31	11.55	--	10.24	--	4.87	--
4406	Cumberland Superphosphate.	Cumberland Bone Phosphate Co.	"	--	23.78	--	.61	--	2.11	2 72	2.06	5.98	3.32	1.01	10.31	10.0	9.30	8.0	3.24	2.0
4414	Extra Bone Phosphate.	L. B. Darling Fertilizer Co.	"	--	24.17	--	.72	--	1.49	2.21	--	6.19	4.12	.62	10.93	--	10.31	--	4.84	--
4412	Pine Island Phosphate.	Quinnipiac Co.	"	--	23.53	--	.11	--	2.43	2.54	2.06	5.74	5.00	1.13	11.87	10.0	10.74	9.0	1.53	1.0
4411	Standard Complete Manure.	Standard Fertilizer Co.	"	--	30.87	--	1.24	.30	2.12	3.66	3.30	4.51	4 97	1.01	10.49	--	9.48	8.0	7.79	--
4399	Banner Fertilizer.	Walker, Stratman & Co.	"	--	21.23	--	--	--	2.69	2 69	2.0	5.71	3.16	.85	9.72	11.0	8.87	9.0	.68	1.0
4424	Ammoniated Bone Superphosphate.	Crocker Fertilizer Co.	"	--	23.32	--	--	--	2.49	2.49	2.9	7.38	3.43	.91	11.72	11.0	10.81	10.0	1.24	1.0
4425	Ammoniated Practical Superphosphate.	Crocker Fertilizer Co.	"	--	15.32	--	--	--	--	1.06	.82	4.29	4.20	1.34	9.83	9.0	8.49	8.0	1.21	1.0

NITROGENOUS FERTILIZER SAMPLED BY CONSUMER.

4294	Market Garden Manure.	Quinnipiac Co., Boston, Mass.	Josiah Hawkins, Southport, from stock of C. F. Godfrey.	--	$29.74	--	.86	.55	1.94	3.35	3.3	2.59	7.12	1.93	11.64	9.0	9.71	8.0	6.97	7.0

Special Manures Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' Cash Price per Ton.
4385	The Rogers & Hubbard Co.'s Soluble Tobacco Manure.	Rogers & Hubbard Co., Middletown.	T. S. Loomis, Windsor. G. S. Butler, Cromwell.	***42.00** 42.00
4355	Seeding Down Manure.	Mapes' Formula & Peruvian Guano Co., New York.	Mapes' Branch, Hartford.	**37.50**
4235	Special Fertilizer for Fruit, Vegetables and Tobacco.	Armour Packing Co., Kansas City, Kansas.	F. C. Vibert, Hockanum.	**35.00**
4272	Potato Manure.	Danbury Fertilizer Co., Danbury.	S. D. Woodruff & Sons, Orange. L. P. Russell, Orange.	**35.00** 35.00
4177	Fairchild's Formula for Corn and General Crops.	Rogers & Hubbard Co., Middletown.	F. T. Bradley, Saybrook.	**46.00**
4176	The Rogers & Hubbard Co.'s Soluble Potato Manure.	Rogers & Hubbard Co., Middletown.	F. T. Bradley, Saybrook.	**38.00**
4373	The Rogers & Hubbard Co.'s Fertilizer for Oats and Top Dressing.	Rogers & Hubbard Co., Middletown.	G. S. Butler, Cromwell.	**50.00**
4374	The Rogers & Hubbard Co.'s Grass and Grain Fertilizer.	Rogers & Hubbard Co., Middletown.	G. S. Butler, Cromwell.	**37.50**
4372	High Grade Corn Fertilizer.	The Rogers Mfg. Co., Rockfall.	W. H. Warner, Wethersfield.	**48.00**
4231	Onion Manure.	H. J. Baker & Bro., New York.	C. O. Jelliff & Co., Southport.	**39.00**
4250	Quinnipiac Havana Tobacco Fertilizer.	Quinnipiac Co., Boston, Mass.	J. W. Gardner, Cromwell.	**48.00**
4265	Soluble Potato and General Crop Manure.	The Rogers Mfg. Co., Rockfall.	R. H. Tucker, Saybrook. W. H. Warner, Wethersfield. F. Hallock, Birmingham.	39.00 **38.00** 38.00
4392	Wrapper Brand Tobacco Manure.	Mapes' F. & P. G. Co., New York.	Mapes' Branch, Hartford.	**48.00**
4350	Tobacco Grower.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	F. S. Bidwell, Windsor Locks.	**40.00**
4234	Potato Manure.	H. J. Baker & Bro., New York.	D. N. Benton, Guilford. C. O. Jelliff & Co., Southport. Saxton & Strong, Bristol.	**40.00** 38.00 41.00
4354	Tobacco Starter.	Mapes' F. & P. G. Co., New York.	Mapes' Branch, Hartford.	**35.00**
4325	Complete Manure for Corn and Grain.	Bradley Fertilizer Co., 92 State St., Boston, Mass.	M. Beach & Son, New Milford. Lewis & Judson, Stratford. Strong & Tanner, Winsted.	40.00 38.00 **38.00**
4216	Complete Manure for Light or Sandy Soils.	Mapes' F. & P. G. Co., New York City.	C. O. Jelliff & Co., Southport. Mapes' Branch, Hartford. G. K. Nason, Willimantic.	40.00 **42.00** 44.00
4236	Stockbridge Tobacco Manure.	Bowker Fertilizer Co., Boston, Mass.	H. K. Brainard, Thompsonville.	**50.00**

* Where several quotations are made the full-face figure indicates the one used in calculating the percentage difference.

Analyses.

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
					Total Nitrogen.					Total.		Available.		Found.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	Guaranteed.
$42.91	*2.1	1.15	.20	4 52	5.87	*5.0*	2.05	5.80	.25	8.10	*10.0*	7.85	----	.28	10.40	*10.0*
36.83	1.8	.99	.16	1.16	2.31	*2.5*	----	----	----	18.01	*18.0*	----	----	11.73	11.73	*10.0*
32.73	6.9	----	----	----	6.94	*7.4*	-- -	----	----	11.17	*9.16*	----	----	----	----	----
31.68	10.4	----	----	4.03	4.03	*2.9*	----	7.75	3.03	10.78	*8.0*	7.75	----	7.81	7.81	*7.0*
41.33	11.2	4.21	----	1.70	5.91	*5.5*	----	---	----	13.01	*12.0*	----	----	12.16	12.16	*12.5*
34.05	11.6	1.25	----	4.22	5.47	*5.0*	1.74	6.29	.85	8.88	*10.0*	8.03	----	.77	5.54	*5.0*
43.70	14.4	7.62	----	1.58	9.20	*8.8*	---	----	----	8.88	*7.9*	----	----	8.75	8.75	*8.4*
32.55	15.2	----	----	----	3.32	*2.5*	----	----	----	17.24	*16.0*	----	----	11.44	11.44	*12.5*
41.66	15.2	4.14	----	2.02	6.16	*5.5*	----	----	----	12.35	*13.0*	----	----	13.01	13.01	*14.0*
33.46	16.5	----	4.21	.51	4.72	*4.9*	4.05	1.00	.54	5.59	----	5.05	*4.5*	9.49	10.30	*9.0*
41.17	16.5	----	3.09	3.21	6.30	*5.8*	.42	3.66	1.10	5.18	*6.0*	4.08	*5.0*	.85	11.25	*10.0*
32.47	17.0	.69	----	3.06	3.75	*3.1*	2.40	6.26	.78	9.44	*10.0*	8.66	----	.77	8.75	*9.0*
40.99	17.1	1.50	2.96	1.85	6.31	*6.2*	.35	5.43	.19	5.97	*4.5*	5.78	----	1.28	11.68	*10.5*
34.09	17.3	----	.69	2.67	3.36	*4.9*	5.01	4.41	1.20	10.62	*10.0*	9.42	----	2.00	10.05	----
33.66	18.8	.46	2.15	1.57	4.18	*3.3*	3.44	2.52	2.18	8.14	----	5.96	*5.0*	4.61	10.73	*10.0*
29.26	19.6	.82	.43	1.90	3.15	*2.5*	6.85	5.41	.98	13.24	*12.0*	12.26	*8.0*	----	3.48	*2.5*
31.52	20.5	1.54	----	2.00	3.54	*3.3*	4.27	10.38	2.72	17.37	*13.0*	14.65	*12.0*	2.24	2.24	*3.0*
34.02	23.4	1.59	1.33	2.42	5.34	*4.9*	3.39	4.30	1.21	8.90	*8.0*	7.69	*6.0*	6.80	6.80	*6.0*
40.49	23.4	3.11	----	2.86	5.97	*5.8*	.58	5.90	4.75	11.23	*4.0*	6.48	----	.52	11.31	*10.0*

* Valuation exceeds cost.

Special Manures, Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' Cash Price per Ton.
4326	Tobacco Manure.	H. J. Baker & Bro., New York.	E. F. Hawley, Newtown.	**$42.50**
4222	Corn Manure.	Mapes' F. & P. G. Co., New York.	G. K. Nason, Willimantic.	41.00
			Mapes' Branch, Hartford.	**39.00**
			Will. Foot, Branford.	38.50
4391	Grass and Grain Spring Top Dressing.	Mapes' F. & P. G. Co., New York.	J. P. Barstow & Co., Norwich.	40.00
			Birdsey & Foster, Meriden.	40.00
			Southington Lumber & Feed Co.	40.00
			Mapes' Branch, Hartford.	**39.00**
			G. K. Nason, Willimantic.	40.00
4197	Stockbridge Top Dressing.	Bowker Fertilizer Co., Boston, Mass.	John A. Paine, Danielsonville.	40.00
			John Lewis, Willimantic.	**40.00**
4243	Potato, Onion and Tobacco Manure.	Leander Wilcox, Mystic.	Browning & Gallup, New London.	**36.00**
4219	Complete Manure for Potatoes and Vegetables.	Bradley Fertilizer Co., Boston, Mass.	J. F. Elwood, Greens Farms.	**38.00**
			Buckley & Hanmer, Wethersfield.	38.00
			Lewis F. Judson, Stratford.	38.00
			J. C. Lincoln, Berlin.	38.00
4310	Peerless Potato Manure.	Walton & Whann Co., Wilmington, Del.	W. S. Hill, Southford.	**38.00**
4221	Potato Manure.	Mapes' F. & P. G. Co., New York.	Wilson & Burr, Middletown.	42.00
			G. K. Nason, Willimantic.	43.00
			Manchester Elevator Co., Manchester.	43.00
			Mapes' Branch, Hartford.	**41.00**
			Wheeler & Howes, Bridgeport.	45 00
4384	High Grade Special for Potatoes, Tobacco, Onions and Cabbage.	Williams & Clark, 81 Fulton St., N. Y. City.	J. Bransfield, Portland.	40 00
			F. C. Gould, Silver Lane.	**39.00**
			Hale, Day & Co., South Manchester.	42.00
			S. D. Woodruff & Sons, Orange.	37.00
4180	Potato Manure.	Lister's Agricultural Chemical Works, Newark, N. J.	A. N. Clark, Milford.	**38.00**

Analyses.

Station No.	Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
						Total Nitrogen.					Total.		Available.		Found.		
			Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	Guaranteed.
4326	$34.28	23.9	- --	2.50	1.88	4.38	*4.5*	4.59	.83	.40	5.82	----	5.42	*3.5*	.49	10.78	*10.0*
4222	31.39	24.2	1.44	.60	1.92	3.96	*3.7*	5.95	3.93	1.40	11.28	*10.0*	9.88	*8.0*	6.46	6.46	*6.0*
4391	30.74	26.8	2.01	.88	1.90	4.79	*4.1*	3.71	4.09	.55	8.35	*7.0*	7.80	*5.0*	5.97	5.97	*5.0*
4197	31.47	27.1	3.11	----	2.02	5.13	*5.0*	2.90	3.71	3.07	9.68	*6.0*	6.61	*4.0*	6.88	6.88	*6.0*
4243	28.07	28.2	.76	.30	2.46	3.52	*3.3*	4.22	3.31	1.25	8.78	*8.0*	7.53	*7.0*	1.54	6.34	*6.0*
4219	29.30	29.6	1.50	.05	2.18	3.73	*3.7*	4.61	4.37	1.63	10.61	*9.0*	8.98	*8.0*	6.33	6.33	*6.0*
4310	29.28	29.7	1.60	.06	1.62	3.28	*3.3*	6.24	1.07	.30	7.61	*7.0*	7.31	----	10.70	10.70	*9.0*
4221	31.27	31.1	2.16	.46	1.31	3.93	*3.7*	4.50	3.83	1.00	9.33	*8.0*	8.33	*8.0*	.89	8.12	*6.0*
4384	29.38	32.7	1.32	----	2.20	3.52	*3.7*	3.68	5.70	1.14	10.52	*8.0*	9.38	*7.0*	6.95	6.95	*7.0*
4180	28.54	33.1	1.57	.29	1.83	3.69	*3.7*	6.30	1.86	.76	8.92	----	8.16	*7.5*	6.89	6.89	*7.0*

Special Manures, Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
4270	Corn Fertilizer.	M. E. Wheeler & Co., Rutland, Vermont.	P. Rourke, Orange. S. J. Peck, Woodbridge.	------ **$32.00**
4257	Special Phosphate for Potatoes.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	G. S. Butler, Cromwell. Will. Foot, Branford.	**40.00** 40.00
4351	Wheat and Corn Phosphate.	Darling Fertilizer Co., Pawtucket, R. I	Treat & Clark, Orange.	**32.00**
4196	Stockbridge Potato Manure.	Bowker Fertilizer Co., Boston, Mass.	A. M. Williams, Manchester. J. A. Lewis, Willimantic. M. A. Covell, No. Grosvenor Dale.	40.00 40.00 38.00 **39.00**
4255	Vegetable, Vine and Tobacco Fertilizer.	Great Eastern Fertilizer Co., Rutland, Vermont.	C. Grant, Buckland. G. L. Beach, Branford. S. C. Lewis, Stratford.	**33.00** 33.00 33.00
4187	Potato, Hop and Tobacco Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	G. F. Kibbie, Tolland. John S. Wells, Hebron.	35.00 **34.00**
4275	Potato and Root Crop Manure.	Darling Fertilizer Co., Pawtucket, R. I.	F. S. Bidwell, Windsor Locks. Treat & Clark, Orange. S. W. Bray, Milford.	**38.00** 37.00 40.00
4218	Stockbridge Corn Manure.	Bowker Fertilizer Co., Boston, Mass.	J. F. Hutchinson, Windsor. John A. Paine, Danielsonville. J. A. Lewis, Willimantic.	41.00 **40.00** 40.00
4269	High Grade Potato Manure.	M. E. Wheeler & Co., Rutland, Vermont.	S. J. Peck, Woodbridge.	**34.00**
4262	Tobacco Fertilizer.	Bradley Fertilizer Co., Boston, Mass.	M. Beach & Son, Milford. A. C. Sternberg, Hartford.	40.00 40.00
4247	Special Potato Manure.	J. S. Reese & Co., Baltimore, Md.	Donald Gunn, Groton.	**38.00**
4264	General Fertilizer for Grass and Grain.	Great Eastern Fertilizer Co., Rutland, Vt.	S. C. Lewis, Stratford. F. Morton, Rocky Hill. C. Grant, Buckland.	**33.00** 34.00 33.00
4261	Potato Manure.	Chicopee Guano Co., 140 Maiden Lane, N. Y. City.	H. D. Archer, Southport F. J. Newton, Branford.	38.00 35.00 **36.50**
4193	High Grade Potato Fertilizer.	E. Frank Coe Co., 133 Front St., N. Y. City.	E. S. Banks, Southport. J. O. Fox, Putnam.	**36.00**
4429	High Grade Potato Fertilizer.	E. Frank Coe Co., 133 Front St., N. Y. City.	I. W. Dennison & Co., Mystic.	**35.00**
4189	Ammoniated Wheat and Corn Phosphate.	Crocker Fertilizer Co., Buffalo, N. Y.	G. F. Kibbie, Tolland. John S. Wells, Hebron.	**33.00** 32.00
4366	Americus Potato and Tobacco Manure.	Williams & Clark Fertilizer Co., N. Y.	F. C. Gould, Silver Lane.	**33.00**

Analyses.

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Found. As Muriate.	Found. Total.	Guaranteed.
23.87	34.0	.80	---	2.52	3.32	*1.7*	6.56	1.80	.85	9.21	*9.0*	8.36	*8.0*	2.27	2.27	*2.0*
29.58	35.2	----	----	3.88	3.88	*3.7*	7.06	1.29	.30	8.65	*9.0*	8.35	*8.0*	5.79	5.79	*5.4*
23.44	36.5	----	----	2.15	2.15	*2.1*	5.76	4.91	2.25	12.92	*9.0*	10.67	----	2.52	2.52	*2.0*
28.49	36.8	2.04	----	1.52	3.56	*3.3*	6.19	2.50	1.86	10.55	*8.0*	8.69	*6.0*	6.70	6.70	*7.0*
23.59	39.8	.52	----	1.67	2.19	*2.1*	6.16	2.30	1.35	9.81	*9.0*	8.46	*8.0*	6.05	6 05	*6.0*
24.14	40.8	----	----	2.30	2.30	*2.0*	7.31	2.73	1.22	11.26	*11.0*	10.04	*10.0*	3.74	3.74	*3.3*
26.88	41.3	.37	.11	2.34	2.82	*2.9*	3.38	4.51	1.70	9.59	*10.0*	7.89	*6.0*	3.18	7.15	*7.0*
28.13	42.1	1.81	----	1.70	3.51	*3.3*	5.41	5.11	2.07	12.59	*10.0*	10.52	*8.0*	4.05	4.05	*4.0*
23.90	42.2	.25	----	1.94	2.19	*2.1*	5.52	2.99	1.89	10.40	*9.0*	8.51	*8.0*	5.91	5.91	*3.8*
27.76	44.0	1.29	----	2.25	3.54	*3.3*	4.48	4.52	1.68	10.68	*10.0*	9.0	*8.0*	5.19	5.19	*7.4*
26.33	44.3	----	.16	2.81	2.97	*3.0*	2.90	4.82	.97	8.69	*7.0*	7.72	*7.0*	6.83	6.83	*7.5*
22.86	44.3	.75	----	2.28	3.03	*2.9*	6.54	1.85	.86	9.25	*9.0*	8.39	*8.0*	2.23	2.23	*2.0*
25.01	45.9	.60	.16	2.20	2.96	*2.9*	5.68	2.17	1.45	9.30	*9.0*	7.85	*7.0*	5.25	5.25	*5.0*
24.29	48.2	----	.27	1.90	2.17	*2.0*	6.74	2 02	1.50	10.26	*10.0*	8.76	*8.0*	.65	5.15	*6.0*
----	----	----	----	----	----	----	----	----	----	----	----	----	----	.60	4.88	----
22.07	49.5	----	----	2.24	2.24	*2.0*	7.28	2.54	1.18	11.00	*11.0*	9.82	*10.0*	1.97	1.97	*1.6*
22.06	49.5	.35	----	1.89	2.24	*2.5*	7.17	2.12	.55	9.84	*9.0*	9.29	*8.0*	1.61	2.99	*3.0*

Special Manures, Sampled by the Station.—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' Cash Price per Ton.
4324	Complete Manure for Top Dressing Grass and Grain	Bradley Fertilizer Co., Boston, Mass.	F. S. Bidwell, Windsor Locks.	39.00
			J. F. Elwood, Greens Farms.	**38.00**
4393	Tobacco Grower.	Bowker Fertilizer Co., Boston, Mass.	M. McNamara, New Milford.	**39.00**
4246	Special Potato Manure.	Soluble Pacific Guano Co., Boston, Mass.	J. Bramfield, Portland.	**35.00**
			R. F. Woodford, Plainville.	35.00
4365	Americus Corn Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	W. B. Martin, Rockville.	**35.00**
4388	Potato Manure.	Quinnipiac Co., Boston, Mass.	S. V. Osborn & Co., Branford.	38.00
			J. W. Gardner, Cromwell.	35.00
			D. C. Wood, Stratford.	**36.00**
4239	Potato Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	Hale, Day & Co., So. Manchester.	38.00
			W. B. Martin, Rockville.	**35.00**
			F. C. Gould, Silver Lane.	33.00
			J. Bramfield, Portland.	35.00
			D. N. Benton, Guilford.	33.00
			H. K. Brainard, Thompsonville.	38.00
4387	Potato Manure.	Preston Fertilizer Co., Greenpoint, L. I.	W. J. Anderson, Danbury.	**38.00**
4259	Potato and Tobacco Fertilizer.	Clark's Cove Fertilizer Co., Boston, Mass.	J. M. Burke, So. Manchester	**37.00**
4198	Potato Manure.	Bradley Fertilizer Co., Boston, Mass.	J. F. Elwood, Greens Farms.	**36.00**
			Quinebaug Store, Danielsonville.	38.00
			H. H. Davenport, Pomfret.	35.00
			G. W. Carver & Son, Putnam.	36.00
			J. A. Lewis, Willimantic.	38.00
			Thomas Ryan, Thompson.	34.00
4347	Bay State Potato Manure.	Clark's Cove Fertilizer Co., Boston, Mass.	E. White, Rockville.	38.00
			John Ballard, Thompson.	**35.00**
4362	Potato and Tobacco Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Arnold Warner, So. Coventry.	**38.00**
4230	Potato Manure.	Bowker Fertilizer Co., Boston, Mass.	W. Tillinghast, Plainfield.	34.00
4352	Oats, Buckwheat, and Seeding Down Manure.	Great Eastern Fertilizer Co., Rutland, Vt.	P. Campbell, Sandy Hook.	**35.00**
			F. W. Button, Thompsonville.	----
4308	Potato Special.	Walker, Stratman & Co., Pittsburgh, Pa.	W. T. Dudley, Guilford.	**40.00**
4397	Grass and Oats Fertilizer.	M. E. Wheeler & Co., Rutland, Vt.	S. J. Peck, Woodbridge.	**28.00**

Analyses.—*Continued.*

Valuation per Ton.	Percentage Diff. between cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen.		Soluble.	Reverted.	Insoluble.	Total.		Available.		Found.		Guaranteed.
					Found.	Guaranteed.				Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	
25.30	50.1	5.20	----	----	5.20	*5.0*	2.35	3.97	1.01	7.33	*6.0*	6.32	*5.0*	.60	2.59	*2.5*
25.75	51.4	1.08	----	1.66	2.74	*2.5*	6.42	4.27	1.05	11.74	*9.0*	10.69	*7.0*	.44	3.54	*4.2*
22.44	55.9	.65	.13	1.83	2.61	*2.5*	2.72	4.24	2.03	8.99	*7.0*	6.96	*5.0*	5.07	5.07	*5.0*
22.66	57.2	.48	----	1.71	2.19	*2.1*	6.08	4.53	1.22	11.83	*10.5*	10.61	*9.0*	1.97	1.97	*1.5*
22.83	57.6	.81	.11	1.74	2.66	*2.5*	2.74	4.82	1.37	8.93	*7.0*	7.56	*6.0*	4.98	4.98	*5.0*
22.11	58.3	.83	----	1.75	2.58	*2.5*	3.81	3.12	1.50	8.43	*7.0*	6.93	*6.0*	5.13	5.13	*5.0*
23.53	61.4	----	.31	1.01	1.32	*3.3*	5.72	4.29	1.03	11.04	*8.0*	10.01	----	3.79	6.85	*7.0*
22.80	62.2	----	----	2.35	2.35	*2.1*	5.52	4.68	2.00	12.20	*9.0*	10.20	*8.0*	1.70	1.70	*3.0*
21.93	64.1	.99	----	1.63	2.62	*2.5*	4.64	2.47	1.03	8.14	*8.0*	7.11	*6.0*	4.81	4.81	*5.0*
21.26	64.6	1.17	----	1.45	2.62	*2.5*	3.60	2.86	.97	7.43	*7.0*	6.22	*6.0*	5.15	5.15	*5.0*
21.37	77.7	.71	----	1.44	2.15	*2.1*	5.49	3.94	1.60	11.03	*9.0*	9.43	*8.0*	2.69	2.69	*3.0*
18.90	79.8	.81	----	.99	1.80	*1.5*	3.54	5.24	2.80	11.58	----	8.78	*11.0*	1.96	1.96	*2.0*
18.10	93.3	----	----	1.12	1.12	*.8*	7.01	1.61	.58	9.20	*9.0*	8.62	*8.0*	3.94	3.94	*4.0*
19.88	101.2	----	.12	1.35	1.47	*2.4*	5.78	1.65	2.80	10.23	*12.0*	7.43	*10.0*	5.05	5.05	*5.4*
13.80	102.8	----	----	----	----	----	6.96	3.13	.50	10.59	*12.0*	10.09	*10.0*	2.01	2.01	*2.0*

Special Manures, Sampled by the Station.—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' Cash Price per Ton.
4324	Complete Manure for Top Dressing Grass and Grain	Bradley Fertilizer Co., Boston, Mass.	F. S. Bidwell, Windsor Locks.	39.00
			J. F. Elwood, Greens Farms.	**38.00**
4393	Tobacco Grower.	Bowker Fertilizer Co., Boston, Mass.	M. McNamara, New Milford.	**39.00**
4246	Special Potato Manure.	Soluble Pacific Guano Co., Boston, Mass.	J. Bramfield, Portland.	**35.00**
			R. F. Woodford, Plainville.	35.00
4365	Americus Corn Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	W. B. Martin, Rockville.	**35.00**
4388	Potato Manure.	Quinnipiac Co., Boston, Mass.	S. V. Osborn & Co., Branford.	38.00
			J. W. Gardner, Cromwell.	35.00
			D. C. Wood, Stratford.	**36.00**
4239	Potato Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	Hale, Day & Co., So. Manchester.	38.00
			W. B. Martin, Rockville.	**35.00**
			F. C. Gould, Silver Lane.	33.00
			J. Bramfield, Portland.	35.00
			D. N. Benton, Guilford.	33.00
			H. K. Brainard, Thompsonville.	38.00
4387	Potato Manure.	Preston Fertilizer Co., Greenpoint, L. I.	W. J. Anderson, Danbury.	**38.00**
4259	Potato and Tobacco Fertilizer.	Clark's Cove Fertilizer Co., Boston, Mass.	J. M. Burke, So. Manchester	**37.00**
4198	Potato Manure.	Bradley Fertilizer Co., Boston, Mass.	J. F. Elwood, Greens Farms.	**36.00**
			Quinebaug Store, Danielsonville.	38.00
			H. H. Davenport, Pomfret.	35.00
			G. W. Carver & Son, Putnam.	36.00
			J. A. Lewis, Willimantic.	38.00
			Thomas Ryan, Thompson.	34.00
4347	Bay State Potato Manure.	Clark's Cove Fertilizer Co., Boston, Mass.	E. White, Rockville.	38.00
			John Ballard, Thompson.	**35.00**
4362	Potato and Tobacco Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Arnold Warner, So. Coventry.	**38.00**
4230	Potato Manure.	Bowker Fertilizer Co., Boston, Mass.	W. Tillinghast, Plainfield.	34.00
4352	Oats, Buckwheat, and Seeding Down Manure.	Great Eastern Fertilizer Co., Rutland, Vt.	P. Campbell, Sandy Hook.	**35.00**
			F. W. Button, Thompsonville.	----
4308	Potato Special.	Walker, Stratman & Co., Pittsburgh, Pa.	W. T. Dudley, Guilford.	**40.00**
4397	Grass and Oats Fertilizer.	M. E. Wheeler & Co., Rutland, Vt.	S. J. Peck, Woodbridge.	**28.00**

Analyses.—*Continued.*

Valuation per Ton.	Percentage Diff. between cost and Valuation.	Nitrogen.					Phosphoric Acid.							Potash.		
		Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen.		Soluble.	Reverted.	Insoluble.	Total.		Available.		Found.		
					Found.	Guaranteed.				Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	Guaranteed.
25.30	50.1	5.20	----	----	5.20	*5.0*	2.35	3.97	1.01	7.33	*6.0*	6.32	*5.0*	.60	2.59	*2.5*
25.75	51.4	1.08	----	1.66	2.74	*2.5*	6.42	4.27	1.05	11.74	*9.0*	10.69	*7.0*	.44	3.54	*4.2*
22.44	55.9	.65	.13	1.83	2.61	*2.5*	2.72	4.24	2.03	8.99	*7.0*	6.96	*5.0*	5.07	5.07	*5.0*
22.66	57.2	.48	----	1.71	2.19	*2.1*	6.08	4.53	1.22	11.83	*10.5*	10.61	*9.0*	1.97	1.97	*1.5*
22.83	57.6	.81	.11	1.74	2.66	*2.5*	2.74	4.82	1.37	8.93	*7.0*	7.56	*6.0*	4.98	4.98	*5.0*
22.11	58.3	.83	----	1.75	2.58	*2.5*	3.81	3.12	1.50	8.43	*7.0*	6.93	*6.0*	5.13	5.13	*5.0*
23.53	61.4	----	.31	1.01	1.32	*3.3*	5.72	4.29	1.03	11.04	*8.0*	10.01	----	3.79	6.85	*7.0*
22.80	62.2	----	----	2.35	2.35	*2.1*	5.52	4.68	2.00	12.20	*9.0*	10.20	*8.0*	1.70	1.70	*3.0*
21.93	64.1	.99	----	1.63	2.62	*2.5*	4.64	2.47	1.03	8.14	*8.0*	7.11	*6.0*	4.81	4.81	*5.0*
21.26	64.6	1.17	----	1.45	2.62	*2.5*	3.60	2.86	.97	7.43	*7.0*	6.22	*6.0*	5.15	5.15	*5.0*
21.37	77.7	.71	----	1.44	2.15	*2.1*	5.49	3.94	1.60	11.03	*9.0*	9.43	*8.0*	2.69	2.69	*3.0*
18.90	79.8	.81	----	.99	1.80	*1.5*	3.54	5.24	2.80	11.58	----	8.78	*11.0*	1.96	1.96	*2.0*
18.10	93.3	----	----	1.12	1.12	*.8*	7.01	1.61	.58	9.20	*9.0*	8.62	*8.0*	3.94	3.94	*4.0*
19.88	101.2	----	.12	1.35	1.47	*2.4*	5.78	1.65	2.80	10.23	*12.0*	7.43	*10.0*	5.05	5.05	*5.4*
13.80	102.8	----	----	----	----	----	6.96	3.13	.50	10.59	*12.0*	10.09	*10.0*	2.01	2.01	*2.0*

Guarantees.

Of the sixty brands of Special Manures analyzed, twenty-six are quite below the manufacturer's minimum guarantee in respect of one ingredient, four are below in respect of two ingredients and one in respect of all three ingredients. Fully one half therefore are below the manufacturer's guarantee.

Cost, Valuation, and Percentage Difference.

The average cost per ton of the Special Manures has been $38.13. The average valuation, $28.62, and the percentage difference 33.2 per cent. Last year the corresponding figures were, average cost, $37.76, average valuation, $29.35, percentage difference, 28.6 per cent.

Analyses requiring Special Notice.

In the table, page 51 is an analysis of The E. Frank Coe Co's. High Grade Potato Manure, No. **4193.** The sample was drawn from Stock of E. S. Banks, Southport and J. O. Fox & Co., Putnam. Six per cent. of potash is guaranteed by the manufacturer. Protest was made that the sample analyzed, which contained only 5.15 per cent. of potash, did not represent the general quality of the goods. Potash was accordingly determined in another sample of the same brand, **4429,** drawn from Stock of I. W. Dennison & Co., Mystic.

The latter contained 4.88 per cent. of potash of which .60 was in form of muriate. This result confirms the previously made analysis and shows that the goods sold in Southport, Putnam and Mystic were below guarantee in respect to potash.

The "Chemical Compound Fertilizer" for Tobacco and for Corn.

Samples of fertilizers bearing the names given above have been sent to the Station by John Mason of Warehouse Point and A. D. Nooney of Suffield.

Mr. Mason states that orders for these fertilizers were solicited by a traveling agent and we are otherwise informed that the goods were shipped to the purchasers direct from Providence.

They were offered at the modest price of $50.00 per ton, the purchaser to delay payment till the crop was harvested and proved satisfactory.

It was represented that half a ton was enough to raise a crop of tobacco.

4300 and **4417** are samples of the Chemical Compound for tobacco, sampled from stock at the warehouse of F. S. Bidwell by John Mason, Warehouse Point and A. D. Nooney, Suffield.

4299 is a sample of the Chemical Compound for Corn, sampled by John Mason, Warehouse Point.

The statement of composition given on the tags which were attached to the packages were as follows:

	For Tobacco.	*For Corn.*
Nitrogen	4.21	1.46
Phosphoric acid soluble in the soil	15.75	16.36
Alkali	21.37	24.54

The tags are also marked from Mason, Chapin & Co. Importers of and Dealers in Dyestuffs, Chemicals, Paints, Oils, etc., Providence, R. I.

Following are the results of analyses of the samples:

	4300	**4417**	**4299**
Nitrogen in nitrates	4.03	3.56	1.47
Phosphoric acid soluble in water	.11	.22	.29
" " "reverted"	2.20	2.38	2.08
" " insoluble	11.51	10.08	13.70
" " total	13.82	12.68	16.07
Potash	none.	none.	none.
Valuation per ton	$18.84	17.23	12.38
Cost per ton	$50.00	50.00	50.00

Further knowledge of the composition of these fertilizers is given by the following complete analyses.

	Chemical Compound Fertilizer for Tobacco.	Chemical Compound Fertilizer for Corn.
	4300	**4299**
Sand and Silica	11.78	12.66
Oxide of Iron and Alumina	6.92	7.96
Lime	13.80	15.50
Magnesia	.16	.10
Potash	.00	.00
Soda	20.75	21.83
Carbonic Acid	10.22	14.13
Sulphuric Acid	.36	.29
Phosphoric Acid	13.82	16.07
Nitric Acid	15.52	5.62
Chlorine	.45	.25
Water by difference	6.22	5.59
	100.00	100.00

The Fertilizer for Tobacco consists of about 24 to 25 per cent. of nitrate of soda, and 20 per cent. of carbonate of soda mixed with some quite insoluble ground phosphate of iron and lime.

The Fertilizer for Corn consists of about 9 to 10 per cent. of nitrate of soda with correspondingly more carbonate of soda and ground phosphate.

The Tobacco Fertilizer is below the guarantee in respect to both nitrogen and phosphoric acid, the Corn Fertilizer in respect to phosphoric acid alone.

A mixture of 500 pounds of nitrate of soda, costing $12.50, 1200 pounds of basic slag costing $11.40 and 300 pounds of dry carbonate of soda, costing $6.00, total cost $29.90, would contain approximately the same quantities of nitrogen, phosphoric acid and soda and would have at least as great a crop-producing power as these fertilizers costing $50.00 per ton.

The only valuable fertilizing ingredients contained in these fertilizers viz: phosphoric acid and nitrogen could however be bought for not far from $20.00, so that the plant food in these goods costs more than twice as much as the farmer needs to pay for it.

It is claimed that the soda existing in these fertilizers as carbonate and nitrate is an efficient substitute for potash in the plant and in the soil. So far as the plant is concerned a large amount of the most refined investigation would appear to demonstrate conclusively that soda cannot in any sense or to any extent take the place of potash in plant-nutrition. Plants growing in presence of abundance of potash usually take up and contain more potash than they really need. This accidental or unnecessary

potash may indeed be replaced by soda but both may be withheld without detriment to the plant. Even the salt-worts and sea-weeds which usually grow in soils or water containing much sodium compounds, flourish equally well in absence of soda, but cannot exist in default of potash.

On the other hand soda may sometimes or often take the place of potash as a fertilizer. In such cases it operates indirectly not by entering itself into the crop as a needful food to the plants but by its action on the soil, making more rapidly available some other ingredient of the soil, it may be potash, or lime or nitrogen, which is there present but exists in a comparatively inert state. It is well established that the use of soda as a fertilizer has often increased crops, but experience shows that it is commonly an uncertain and unsafe application to land. In any case it does not enrich the soil or increase its stores of plant-food, but simply facilitates their solution, consumption and, it may easily be, their waste.

As a rule soils contain more soda than potash and the frequent use of soda in fertilizers tends to exhaust and impoverish the land. If soda is to be used it is most cheaply supplied in nitrate of soda, which by its nitrogen may easily return its entire cost leaving its soda in the soil as carbonate, and if more alkali is useful, lime is vastly cheaper than soda and not a whit less efficacious, is in fact, what soda is not, an essential element of plant-nutrition, as well as the safest and surest means of fluxing the inert plant-food of the soil and putting its hoarded capital into active circulation.

2. *Sampled by Manufacturers and* 3. *Sampled by Consumers.*

2. *Sampled by Manufacturers.*

These samples were sent to the Station in compliance with the terms of the Fertilizer Law and were analyzed because no samples of the brands named were found in market by our sampling agents:

In the same table of analyses with the above is included **4416** Crocker's Ammoniated Wheat and Corn Phosphate.

This analysis was objected to by the manufacturer on account of the low per cent. of nitrogen which he claims does not fairly represent the quality of this brand.

3. *Sampled by Consumers.*

These analyses are included with those of manufacturers in the following table:—

Station No.	Name or Brand.	Manufacturer.	Sampled by	Manufacturer's Price per Ton.	Valuation per Ton.	Percentage Diff.	Nitrogen. Nitric Nitrogen.	Ammonic Nitrogen.	Organic Nitrogen.	Total. Found.	Total. Guaranteed.	Phosphoric Acid. Water-soluble.	Citrate-soluble (Reverted.)	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.
4431	Special Potato Fertilizer.	G. B. Alderman, Suffield.	Manufacturer.	--	$30.03	--	.82	--	2.61	3.43	--	1.65	5.44	.60	7.69	--	7.09	--	9.47	--
4423	Connecticut Wrapper Fertilizer, Pinney Formula.	Cleveland Linseed Oil Co.	"	--	33.88	--	--	--	4 38	4.38	--	--	6 24	.30	6 54	--	6.24	--	10.18	--
4400	Special Tobacco Fertilizer, New England Brand.	E. Frank Coe Co., N. Y.	"	--	33.27	--	--	3.21	1.01	4.22	--	7.73	2.39	1.39	11.51	--	10.12	--	4.63	--
4415	Special Connecticut Tobacco Manure.	The Crocker Fertilizer and Chemical Co.	"	--	45.31	--	.62	--	6.50	7.12	*5.75*	5.84	.76	.13	6.73	*6.0*	6.60	*5.0*	11.11	*10.0*
4405	Potato Phosphate.	Cumberland Bone Phosphate Co., Boston, Mass.	"	--	24.85	--	.33	--	2.33	2.66	*2.06*	6.05	4.18	1.0	11.23	*11.0*	10.23	*9.0*	3.25	*3.0*
4413	Corn Manure.	QuinnipiacCo, Boston, Mass	"	--	26.01	--	.33	--	2.80	3.13	*2.06*	5.63	5.36	1.34	12 33	*10 0*	10.99	*9 0*	1.65	*1.5*
4409	Grass Manure.	Quinnipiac Co.	"	--	28.20	--	6.12	--	--	6.12	*3.91*	.22	6.10	1.23	7.55	*6.0*	6.32	*5.0*	2.90	*2.0*
4407	High Grade Fertilizer for Oats and Top Dressing.	Rogers Manufacturing Co., Rockfall, Conn.	"	--	37.11	--	1.86	--	3.21	5.07	--	3.33	6.40	.40	10.13	--	9.73	--	9.60	--
4398	Tobacco Special.	Walker, Straiman & Co, Pittsburgh, Pa.	"	--	24.47	--	--	--	2.48	2.48	--	7.35	2.24	.70	10.29	--	9.59	--	3.64	--
4410	Grass Manure.	Williams & Clark Fertilizer Co., N. Y. City.	"	--	28.14	--	6.14	--	--	6.14	*3.91*	.17	6.03	1.21	7.41	*6 0*	6.20	*5.0*	2.93	*2.0*
4416	Ammoniated Wheat and Corn Phosphate.	Crocker Fertilizer and Chemical Co.	"	--	20.88	--	--	--	1.83	1.83	*2 0*	7.07	3.31	.94	11.32	*11.0*	10.38	*10.0*	1.79	*1.0*

SPECIAL MANURES, SAMPLED AND SENT BY CONSUMERS.

Station No.	Name or Brand.	Manufacturer.	Sampled by	Manufacturer's Price per Ton.	Valuation per Ton.	Percentage Diff.	Nitrogen. Nitric Nitrogen.	Ammonic Nitrogen.	Organic Nitrogen.	Total. Found.	Total. Guaranteed.	Phosphoric Acid. Water-soluble.	Citrate-soluble (Reverted.)	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.
1160	Chittenden's Complete Grass Fertilizer.	National Fertilizer Co., Bridgeport, Ct.	T. J. Stroud, Shaker Station, Ct.	$36.00	$30.10	*19.6*	trace.	2.54	1.52	4.06	*4.1*	6.05	1.45	2.47	9.97	*8.0*	7.50	*6.0*	5.53	*5.0*
1214	Special Strawberry Manure.	Baker & Bro., N. Y. City.	W. H. Olcott, South Manchester, Ct.	42.50	27.71	*53.4*	--	2.13	1.10	3.23	*2.7*	4.50	1.89	1.50	7.89	--	6.39	*6.0*	8.14	*8.0*
1215	Fruit and Vine Manure.	Mapes F. & P. G. Co., N. Y. City.	W. H. Olcott, South Manchester.	38.00	29.68	*28.1*	.49	.31	1.82	2.62	*1 6*	4.96	2.78	.70	8.44	*7.0*	7.74	*5.0*	10.68	*11.0*
1453	Grass and Grain Fertilizer.	Leander Wilcox, Mystic.	Horatio Willard, Clinton	--	34.86	--	--	--	2.95	2.95	*2.5*	--	--	--	17.01*	*17.0*	--	--	13.38	*13.0*

* In form of Bone.

IV. HOME MIXTURES.

Here are included fertilizers which have been home-made from chemicals or raw materials bought of wholesale dealers. This method of preparing mixed fertilizers is steadily growing in favor, particularly with those who study most closely the special requirements of their particular soils and crops. The formulas by which the mixtures are made are first given, followed by the analyses, page 60.

FORMULAS.

	4328	4329	4330	4331	4332	4333	4334
	pounds.	pounds.	pounds.	pounds.	pounds.	pounds.	pounds.
Nitrate of Soda	----	100	300	200	200	200	100
Sulphate of Ammonia	50	----	200	----	----	----	----
Dried Blood	----	----	----	----	----	----	100
Blood, Bone and Meat	----	----	2000	500	1000	700	----
Tankage	600	650	----	----	----	----	----
Bone	----	150	500	600	----	300	1200
Dissolved Bone Black	700	800	2000	600	600	700	----
Double Sulphate of potash and magnesia	650	100	500	----	----	----	----
Muriate of Potash	----	200	500	200	200	100	500
	2000	2000	6000	2000	2000	2000	1900

The cost given in each case represents the regular retail price of the raw materials delivered at the purchasers' freight station with the addition of $2.00 per ton to cover the cost of mixing. The average cost of these seven home-mixtures including cost of mixing is $36.76 and the average valuation $31.70 per ton. The percentage difference between cost and valuation is 16.0. In factory-mixed fertilizers this percentage difference has been on the average 41.3 for nitrogenous superphosphates and 33.2 for special manures during the last season.

The average valuation of these home-mixtures is therefore very much nearer their cost price than is the case with factory-mixed goods.

Most of the materials for these home-mixtures were bought at prices considerably below the regular retail rates, but for this comparison regular retail rates are employed.

MISCELLANEOUS FERTILIZERS AND MANURES.

COTTON HULL ASHES.

In the table, page 62, are given analyses of 14 samples of Cotton Hull Ashes which show the usual variations of composition.

Analyses of Home Mixtures.

Station No.	Name or Brand	Made by	Sampled by	Cost per ton.	Valuation per Ton.	Percentage Dif.	Nitrogen.				Phosphoric Acid.				Potash.
							Nitric Nitrogen.	Ammonic Nitrogen.	Organic Nitrogen.	Total.	Water-soluble.	Citrate-soluble. (Reverted).	Insoluble.	Total.	Available.	
4328	For Potatoes.	E. E. Burwell, New Haven	E. E. Burwell.	$33.36	$25.81	29.2	----	.45	1.43	1.88	4.77	5.36	.68	10.81	10.13	7.14
4329	For Top-dressing Grass and Grain.	E. E. Burwell, New Haven.	E. E. Burwell.	34.52	28.67	20.5	.61	----	2.01	2.62	5.97	5.98	1.35	13.30	11.95	5.75
4330	For General Use.	N. D. Platt, Milford.	Station agent.	38.69	31.07	24.5	.71	trace	2.75	3.46	6.93	2.72	.38	10.03	9.65	7.85
4331	For Potatoes.	Dennis Fenn, Milford.	"	38.55	33.97	13.5	1.62	----	2.56	4.18	6.08	6.62	1.50	14.20	12.70	5.13
4332	For Potatoes.	Dennis Fenn, Milford.	"	37.40	32.81	14.0	1.44	----	3.17	4.61	5.81	4.40	.66	10.87	10.21	5.37
4333	For Potatoes.	Geo. F. Platt, Milford.	"	36.25	32.83	10.4	1.74	----	2.87	4.61	6.61	5.61	1.31	13.53	12.22	2.82
4334	For General Use.	R. H. Tucker, Saybrook.	"	38.55	36.73	4.9	.87	----	3.24	4.11	none	8.34	5.25	13.59	8.34	12.17

Sample **4202,** represented stock bought by Hermann Ude for $48.00 per ton. As the analysis showed the goods to be of very inferior quality, the seller agreed to take the Station valuation as the price.

Two samples were received at the Station from E. F. Brown, Berlin, who stated that they were from stock of J. C. Lincoln, Berlin, bearing tags marked "High Grade Sulphate of Potash, 90 to 95 per cent. sulphate potash."

These samples contained 22.09 and 24.98 per cent. of potash respectively, and were to all appearance cotton hull ashes.

A sample of Cotton Hull Ashes **4447,** sent by Olin Wheeler, Buckland, from stock bought of Olds & Whipple, Hartford, contained only 9.54 per cent. of potash, and 4.57 per cent. of phosphoric acid.

Messrs. Olds & Whipple being informed of the character of the goods took them back at once, and stated that the car lot would not be handled by them unless at a price corresponding to the valuation.

The price of "actual potash" in cotton hull ashes has ranged from 5.4 cents to 15.5 cents per pound, the average being 8.3 cents.

Formerly these ashes were one of the cheapest sources of available potash; they are now the most expensive source in market.

Analyses of Cotton Hull Ashes.

Station No.	Dealer or Purchaser.	Sampled by	Soluble Phosphoric Acid.	"Reverted" Phosphoric Acid.	Insoluble Phosphoric Acid.	Potash Soluble in Water.	Cost per ton.	Valuation per ton.	Potash costs per pound in cents.
4163	G. A. Douglass, Thompsonville	C. D. Woodworth, Thompsonville	.86	7.39	.67	25.80	$37.50	$35.23	5.4
4205	Olds & Whipple, Hartford	Griswold Bros. Tariffville	2.24	10 26	.22	27.94	45.00	43.41	5.5
4302	T. Soule & Co., New Milford	Station Agent	1.46	5.08	.34	28.36	40.00	37.26	5.7
4167	Olds & Whipple, Hartford	Station Agent	2.24	7.00	1.40	24.25	40.00	35.40	6.0
4304	Olds & Whipple, Hartford	Station Agent	2.24	6.40	.65	26.16	45.00	37.46	6.7
4320	W. S. Pinney, Suffield	Samuel Barr, Suffield	1.36	6.37	.68	25.26	45.00	35.43	7.1
4290	R. A. Parker, Warehouse Point	J. B. Noble, East Windsor Hill	.56	7.62	1.25	20.54	42.00	31.12	7.9
4206	Olds & Whipple, Hartford	Station Agent	trace	5.53	.27	18.54	40.00	25.68	9.1
4201	Edward Austin, Suffield	Arthur Sikes, Suffield	.59	7.17	.38	20.66	48.00	30.44	9.5
4291	I. Luther Spencer, Suffield	F. C. Root, West Suffield	.21	6.80	1.13	21.32	40.00	30.57	11.9
4357	Edward Austin & H. A. Sheldon	F. C. Root, West Suffield	trace	4.72	1.37	12.25	38.00	18.60	13.2
4356	Edward Austin	F. C. Root, West Suffield	trace	3.56	1.28	10.78	38.00	15.75	15.5
4202	I. Luther Spencer, Suffield	F. C. Root, West Suffield	none	8.77	1.37	13.38		24.25	
4148	J. H. Hale, So. Glastonbury	J. H. Hale, So. Glastonbury	.64	4.53	1.37	25.11		34.44	

Unleached Wood Ashes.

Station No.	Source.	Sampled and sent by	Potash Soluble in Water.	Phosphoric Acid.	Cost per ton in Car lots.
4166	Allison, Stroup & Co., New York City	J. E. Bishop, Clintonville	4.04	1.50	$11.50
4457	Allison, Stroup & Co., New York City	A. E. Atwater, Cheshire	4.70	1.28	10.50
4437	Allison, Stroup & Frost, New York City	L. S. Ellsworth, Simsbury	5.51	1.32	11.00
4186	Monroe, Lalor & Co., Oswego, N. Y.	Station Agent, from lot bought by J. F. Elwood, Greens Farms	6.20	1.34	11.50
4303	Monroe, Lalor & Co., Oswego, N. Y.	Station Agent, from lot bought by J. F. Holmes, Ridgefield	3.74	1.50	13.00
4322	F. R. Lalor, Dunnville, Ont., Canada	H. C. C. Miles, Milford	2.87	1.05	16.00*
4161	Bought in Canada	T. A. Stanley, New Britain	4.41	1.44	11.00
4450	H. K. Brainard, Thompsonville	Sumner F. Sikes, Suffield	5.43	1.50	12.00
4157	"Witch Hazel Extract Factory"	S. A. Smith, Clintonville	5.69	3.97	

* Retail, bagged.

Unleached Wood Ashes.

In the preceding table are given nine analyses of what purport to be unleached wood ashes.

The quantity of potash in **4322** is so small as to create suspicion that the ashes have been partially leached.

The high per cent. of phosphoric acid in **4157** is probably due to the fact that the ashes came from small twigs which contain considerably more phosphoric acid than older wood.

Lime Kiln Ashes.

A sample of this material, **4121,** sent by W. G. Atkins, Forestville, was partially analyzed with the following results :

Moisture	2.81
Sand and Soil	7.74
Lime	50.87
Phosphoric Acid	.53
Potash soluble in water	1.11
Total potash	2.02

This material contains about one per cent. of soluble potash.

As a fertilizer it ranks between ordinary unleached and leached ashes.

Saltpeter Waste.

Two samples of this waste, from the works of the Hazard Powder Co., Hazardville, were sent to the Station by T. J. Stroud, Shaker Station. The analyses are as follows :

	4071	4159
Nitrogen in Nitrates		6.39
Nitrogen, organic		.22
Total Nitrogen	5.07	6.61
Potash, as Nitrate and Sulphate		25.55
Potash as muriate		1.96
Total Potash	38.70	27.51
Chlorine		1.47

This is a waste from the purification of saltpeter or nitrate of potash, used in the manufacture of gunpowder, and as the analysis shows has very considerable value as a fertilizer, though its composition is variable.

Sheep Manure.

4442. This sample, sent by E. C. Ayer of Unionville, is stated to represent material dug from an abandoned sheep corral in the Southwest, disused because of the accumulation of dung.

Analysis.

Moisture	15.11
Nitrogen	1.37
Sand and Soil	48.29
Phosphoric Acid	1.60
Potash	1.87

This sheep manure has some value as a fertilizer, but would not pay for much transportation because nearly half its weight is due to sand.

Waste Material from the Enameling of Iron.

A sample of this material sent by Edwin Hoyt of New Canaan, with an inquiry as to its value, if any, was found to contain no nitrogen or phosphoric acid and only .26 per cent. of potash.

REVIEW OF THE FERTILIZER MARKET.

For the Year ending November 1st, 1894.

By E. H. Jenkins.

Nitrogen.

Nitric Nitrogen.

The *wholesale* New York quotations of nitrogen in nitrate of soda have fluctuated between 11.7 cents per pound in February and 14.4 cents in May, the average quotation for October, 1894, being 12.9 cents per pound.

The average wholesale quotation for the entire year has been 13.4 cents. The averages of the monthly quotations for the past few years have been as follows:

Year	1894.	1893.	1892.	1891.	1890.
Average quotation	13.0	12.7	12.1	12.9	11.5 cents.

The *retail* ton price of nitrogen in nitrate of soda in this State during the past season has been about 16 cents per pound.

Ammonic nitrogen.

The quotations of nitrogen in this form have ruled higher than ever before and are practically prohibitory on the use of sulphate of ammonia in profitable farming.

The *wholesale* New York price of nitrogen in this form has fluctuated between 16.4 cents and 18.5 cents per pound. The average of the monthly quotations for the past year has been 17.3 cents per pound.

The corresponding averages for 1893, 1892, 1891 and 1890, were 15.7 cents, 14.5, 15.6 and 16 cents respectively.

The *retail* cash price of nitrogen in this form within Conn. has been during the past season 19½ cents per pound.

Organic nitrogen.

The *wholesale* New York quotations for nitrogen in the form of high grade and low grade blood, azotin and tankage for each month in the year are shown in detail on page 71.

While in general not as high as in 1893 they have ruled higher than for some years previous to 1893. The nitrogen of red or high grade blood which was quoted during November 1893 at 16.6 cents per pound fell gradually to 12.6 cents per pound in July, but has rallied sharply since. The average quotation for October was 15.1 cents per pound. Azotin and low grade blood have followed much the same course.

Dried blood, azotin and concentrated tankage scarcely appear in our retail market and accordingly retail figures cannot be given. Bone and a low grade tankage are much used by farmers as a source of nitrogen. Tobacco growers alone seem to be alive to the fact that the nitrogen of cotton seed meal is a readily available and comparatively a very cheap form of organic nitrogen.

If available to the tobacco plant it must certainly be so to any of our farm crops.

The nitrogen of cotton seed meal has cost at retail in Conn. the past season, as is shown on page 22 from 13.8 to 15.7 cents per pound. In castor pomace it has cost from 19.1 to 20.2 cents.

Phosphatic materials.

Rough bone has been uniformly quoted through the year at $19.50 per ton and bone black at the same price till within the last three months when the latter has fallen to $18.25 per ton.

Ground bone has advanced from $22.25 early in the year to $22.75 and bone meal has remained steady at $23.75.

Ground Charleston rock quoted at $8.37½ in Nov. 1893, rose to $8.50 in February but fell in August to $8.31½, and to 8.12½ in September and October.

Sulphuric acid was quoted a little lower in Oct. 1894 than earlier in the year.

Acid phosphate, was quoted at 61¼ cents per unit till April, when it fell to 59½ and 60 cents, but in August rose again and in October was quoted at 62½ cents. At this figure its available phosphoric acid costs 3.12 cents per pound *at wholesale.*

The retail price in Conn. of available phosphoric acid in dissolved bone black has been from 7.4 to 8.2 cents per pound. Acid phosphate rock, though much cheaper is not in our retail market. See pages 25 and 26.

Potash.

Muriate of Potash.

The *wholesale* New York price of potash in this form which was 3.74 cents per pound in November, 1893, fell slightly till April when it rose to 3.84 and in May to 4.13 at which price, the highest in years, it has remained up to November, 1894.

It has been generally retailed in Conn. for about 4.1 to 4.3 cents per pound during the last season.

The Double Sulphate of Potash and Magnesia.

The *wholesale* New York price of potash in this form which was 4.33 cents per pound in November, 1893, rose to 5.04 cents per pound in May, which price, the highest in years, has held up to the date of this writing Nov. 1894.

Potash in this form has retailed in Conn. for 5.5 cents.

High Grade Sulphate of Potash.

The *wholesale* New York price of potash in this form which was 4.15 cents per pound in Nov. 1893 rose in May to 4.85 cents, at which price, the highest in years, it has since been quoted.

It has been sold at retail in Conn. for 5.6 cents per pound, the last season.

Kainit.

This article, which was quoted at $9.12\frac{1}{2}$ per ton in November, 1893, rose in price with other potassium salts and was quoted in July 1894, at $11.00 and this price rules at this writing, Nov. 1894.

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 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 an 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	4.00	cents per pound.	Nitrogen costs	19.5	cents per lb.
"	3.95	"	"	19.3	"
"	3.90	"	"	19.0	"
"	3.85	"	"	18.8	"
"	3.80	"	"	18.5	"
"	3.75	"	"	18.3	"
"	3.70	"	"	18.0	"
"	3.65	"	"	17.8	"
"	3.60	"	"	17.5	"
"	3.55	"	"	17.3	"
"	3.50	"	"	17.1	"
"	3.45	"	"	16.8	"
"	3.40	"	"	16.6	"

Commercial Nitrate of Soda averages 95 per cent. of pure sodium nitrate or 16.0 per cent. of nitrogen.

If quoted at	3.0	cents per pound,	Nitrogen costs	18.8	cents per lb.
"	2.9	"	"	18.2	"
"	2.8	"	"	17.5	"
	2.7	"	"	16.9	"

If quoted at	2.6	cents per pound,	Nitrogen costs	16.2	cents per lb.
"	2.5	"	"	15.6	"
"	2.4	"	"	15.0	"
"	2.3	"	"	14.4	"
"	2.2	"	"	13.8	"
"	2.1	"	"	13.2	"
"	2.0	"	"	12.5	"
"	1.9	"	"	11.9	"
"	1.8	"	"	11.3	"
"	1.7	"	"	10.6	"

Commercial Muriate of Potash and also High Grade (98 per cent.) Sulphate of Potash usually contain 50½ per cent. of "actual potash," or potassium oxide.

If quoted at	2.60	cents per lb.	Potassium Oxide 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 26½ per cent. of potassium oxide.

If quoted at	1.00	cents per lb.	Potassium Oxide costs	3.77	cents per lb.
"	1.05	"	"	3.96	"
"	1.10	"	"	4.15	"
"	1.15	"	"	4.34	"
"	1.20	"	"	4.53	"
"	1.25	"	"	4.72	"
"	1.30	"	"	4.90	"

The following table shows the fluctuations in the wholesale prices of a number of fertilizing materials in the New York market, since January, 1891. The price given for each month is the average of the four weekly quotations of that month. Sulphate of ammonia is assumed to contain 20.5 per cent. and nitrate of soda 16.0 per cent. nitrogen and muriate of potash 50½ per cent. of actual potash or 80 per cent. of pure salt.

Wholesale Prices of Fertilizing Materials.

		Cost of Nitrogen at wholesale in						Cost of Potash at wholesale in			
		Dried Blood.									
		Red. Cents per pound.	Black or low grade. Cents per pound.	Azotin or Ammonite. Cents per pound.	Concentrated Tankage. 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.
1891.	January	11.0	10.5	11.5	....	10.9	16.5	3.58	4.53	4.33	3.69
	February	12.0	11.0	11.5	....	12.5	16.5	3 58	4.53	4.33	3.69
	March	12 5	11.9	11.5	....	14.3	16.5	3.68	4.53	4.33	3.69
	April	12.4	12.0	11.5	....	14.4	16.5	3.68	4.53	4.33	3.69
	May	12.3	11.7	11.5	....	13.6	16 0	3 68	4.53	4.33	3.69
	June	12.3	11.7	11.5	....	13.2	15.5	3.68	4.53	4.33	3.69
	July	12.2	11.6	11.5	....	12.2	15 4	3.68	4.53	4.33	3.69
	August	12.3	11.8	11.5	....	11.3	15.4	3.68	4.53	4.33	3.69
	September	12.3	12.0	11.5	....	12.2	14.8	3.68	4 53	4.33	3.69
	October	12 3	12.0	11.5	....	13.6	14.7	3.68	4.53	4.33	3.69
	November	12.6	12.3	11.5	....	13.5	14.7	3.68	4.53	4.33	3.69
	December	12.4	12.1	11.5	....	13.3	14.7	3.63	4.63	4.41	3.69
1892.	January	12.2	11.5	11.5	....	12.9	14.7	3.62	4.79	4.45	3.69
	February	11.6	11.3	11.5	....	12.0	14.7	3.64	4.77	4.48	3.69
	March	11.5	11.0	11.2	....	12.1	14.7	3.71	4.77	4.48	3.69
	April	11.8	11.3	11 2	....	11.0	14.7	3.78	4.77	4.48	3.69
	May	12.0	11.5	11.2	....	10.5	14.7	3.78	4.77	4.48	3.69
	June	11.7	11.2	11.2	....	10.	14 7	3.78	4.77	4.48	3.69
	July	12.1	11.7	11.2	....	11.1	14.7	3.78	4.77	4.48	3.69
	August	12.3	12.1	11.2	....	11.7	14.7	3.78	4.77	4.48	3.60
	September	12.4	12.0	12.0	....	12.4	14.2	3.78	4.77	4.48	3.30
	October	13.0	12.6	12.6	....	12.9	14.0	3.78	4.77	4 48	3.30
	November	14.1	13.8	13.7	....	13.7	14.0	3.78	4.77	4.48	3.30
	December	14.6	14.2	14.8	....	13.7	14.0	3.78	4.77	4.48	3.30
1893.	January	16.2	15.8	15.9	12.3	13.8	14.0	3.51	4.25	4.70	3.33
	February	18.5	18.0	17.9	15.7	14.1	14.0	3.56	4.32	4.16	3.09
	March	20.0	19.8	19.6	19.3	14.7	15.6	3.56	4.32	4.16	3.09
	April	18.0	17.7	18.1	19.3	14.6	17.1	3.56	4.32	4.16	3.09
	May	16.2	15 4	16.4	18.3	13.0	17.1	3.56	4.32	4.16	3.09
	June	14 5	14.0	14.8	14.2	11.0	15.9	3.75	4.32	4.16	3.09
	July	13.7	13.1	13.7	14.2	11.1	14.9	3.75	4.32	4.16	3.09
	August	13.5	12.1	13.9	14.2	11.4	15.6	3.75	4.25	4.16	3.09
	September	12.5	12.2	13.2	14.2	11.6	15.9	3.75	4.32	4.16	3.09
	October	16.2	15.3	15.3	17 1	11.9	16.4	3 75	4.32	4.16	3.09
	November	16.6	15.7	16.6	16.3	11.7	16.4	3.74	4.33	4.15	3.09
	December	16.1	15.3	16.1	16.3	11.3	16 4	3.74	4.33	4.15	3.09
1894.	January	15.9	14.7	16.0	15.9	12.0	16.7	3.58	4.30	4.18	3.09
	February	15.9	15.2	15.9	15.4	11.7	18.4	3.71	4.44	4.28	3.09
	March	15.5	14 6	15.5	15.4	13.0	18.5	3.71	4.44	4.28	3.09
	April	14.5	13.9	14.2	13.3	14.0	17.6	3.84	4.54	4.39	2.98
	May	14.5	13.8	14.2	12.2	14.4	16.7	4.13	5.04	4.85	3.00
	June	13.2	12 6	13 1	12.2	14.3	16.7	4.13	5.04	4.85	3.00
	July	12.6	12.6	12.9	12.2	13.8	16 8	4.13	5.04	4 85	3.00
	August	13.3	12.6	13.3	12 3	13.7	17.7	4.13	5.04	4.85	3.09
	September	15.7	14.5	15.4	12.3	13.5	18.2	4.13	5.04	4.85	3.12
	October	15.1	14.4	15.2	12.4	12.9	17.5	4.13	5.04	4.85	3.12

THE QUANTITY OF COMMERCIAL FERTILIZERS ANNUALLY SOLD IN CONNECTICUT.

In November last a letter was sent to each manufacturer whose goods were entered for sale in this State asking for a statement of his total sales during the year ending Nov. 1, 1894, and stating that the replies would be held as strictly confidential. More than two-thirds of the manufacturers furnished the facts asked for.

The sales reported and a conservative estimate of the sales of those who did not report make it clear that the total amount of commercial fertilizers sold within the State annually cannot be less than 22,500 tons. If thirty dollars per ton is an average price, the total annual outlay for commercial fertilizers in this State is $675,000.

A similar estimate made in 1887 gave a total of 16,700 tons, costing $500,000. (Report for 1887, p. 182.)

This statement covers only factory-mixed goods, bone, mixtures of bone and salts, and fertilizer chemicals, all of which are handled by manufacturers of mixed goods. It does not, however, by any means show the total quantity of fertilizers used in the State.

It does not, for instance, include unleached wood ashes, a favorite fertilizer with fruit growers, cotton hull ashes or tobacco stems, and only a small part of the cotton seed meal which is used in the tobacco growing region in very large amount. It is impossible to estimate how much of the materials above named are annually bought.

ON METHODS TO DETERMINE THE AVAILABILITY OF ORGANIC NITROGEN IN FERTILIZERS.

By S. W. Johnson and E. H. Jenkins.

(Summaries of results and the conclusions drawn from them will be found on pages *88*, *90*, *93*, *96*, *102*, *103*, *107*, *111*.)

CONTENTS.

	Page
Introductory	73
I. Vegetation Experiments	74
General Scope of the Experiments of 1894	74
Description of Method and Apparatus	74
Vegetation House	75
Water Supply	76
Pots	76
Artificial Soil	77
Fertilizer Ingredients	77
Seed	78
Filling and planting the Pots	78
Care of Experiments during Growth	79
Determination of Dry Weight of Crops and Nitrogen in them	81
Results of Vegetation Experiments:—	83
Data of the Crops harvested	83
Influence of Water-Content of Soil on Crop Production	87
Effects of Addition of Soil or Soil Extract to the Pots	89
Are the Food Ingredients, other than Nitrogen, present in Excess of the Crop Requirements?	90
Relative Availability of Nitrogen in certain Raw Materials commonly used in Fertilizers	94
Relative Availability of Nitrogen in Various Preparations of Leather	100
Relative Availability of "Organic" Nitrogen in Mixed Fertilizers	102
II. On the Relative Solubility in "Pepsin Solution" of Nitrogen in certain Nitrogenous Matters	105
Raw Materials commonly used in Fertilizers	105
Mixed Fertilizers	108
III. On the Relative Solubility by Putrefaction of the Nitrogen of certain Fertilizers	109

The work described in this paper is a continuation of what has been done by this Station on the same subject in former years of which account has been given in the following articles:—On Methods of Testing the Agricultural Value of Nitrogen in Mixed Fertilizers, Report of this Station, for 1885, pp. 115–132; On the Agricultural Value of Horn Dust and of Horn and Hoof, Report for 1886, pp. 80–89; Methods to Determine the Availability of Organic Nitrogen in Fertilizers, Report for 1893, pp. 218–237.

The work of the present year has chiefly consisted of vegetation experiments carried on in pots, following in the main the method which has been so admirably perfected by Prof. Wagner of Darmstadt.

Further tests have also been made of the solubility of various organic forms of nitrogen in pepsin-hydrochloric acid and under putrefaction; and their results are compared with the results on the relative availability of the nitrogen as shown by vegetation experiments.

I. VEGETATION EXPERIMENTS.

Mr. W. E. Britton, Horticulturist to this Station, has had entire charge of the preparation of the seed and the artificial soil, filling the pots and caring for the crops through the whole period of growth and the success of the work is largely due to his patience and skill.

The chemical work involved has been done by the Station chemists, Messrs. Winton and Ogden.

General Scope of the Experiments of 1894.

1. Study has been made of the requirements of the maize plant with special reference to the proper supply of plant food and water when grown in pots under the conditions of our work.

2. The following materials have been compared in respect to the availability of their nitrogen, viz: nitrate of soda, dried blood, fish scrap, tankage, ground horn and hoof, cotton-seed meal, linseed meal, castor pomace, leather raw, roasted, steamed and acidified with oil of vitriol.

3. It was also sought to test the availability of organic nitrogen in twenty-seven brands of commercial fertilizers, found in the Connecticut market.

Description of the Apparatus and Method.

In some cases two, in others four, pots were used to test each form of nitrogenous matter.

These pots were filled with an artificial soil to which were added all the elements of plant food in excess of the crop requirements, excepting nitrogen.

The nitrogenous matter was added in such quantity as to supply either 0.8, 1.6, 2.4 or 3.2 grams of nitrogen.

The availability of the nitrogen was determined by the weight of the water-free crop produced and by the quantity of nitrogen taken up by the crop.

The "crop" does not include the roots as it is impossible to separate them satisfactorily from the artificial soil.

The crops, of course, can be used as a measure of availability of nitrogen only when it is certain that the nitrogen of the fertilizer is deficient relatively to the other elements of plant food.

As we have found the apparatus and materials used to be well adapted to the purpose and as we plan to do further work with the same, a full description of them is here given.

The Vegetation House.—This house, 27 feet long by 19 feet wide and 15 feet from sills to peak, was built essentially as respects constructive details after the model designed by Prof. L. H. Bailey of the Cornell Experiment Station which is figured and described in American Gardening for February, 1893, p. 95.

Considerable modifications have been made, however, to suit the structure to its special uses. As it is designed only for summer use, no heating apparatus is provided, but ample means for ventilation have been secured. Besides a glazed door at each end, eight feet by three feet seven inches, and glazed ventilators at both sides of the ridge running the whole length of the house, which are two feet wide and are opened and closed readily by an apparatus made by Hitchings & Co., of New York, there are between the glass and the sills, four wooden ventilators on each side of the house, two of them two feet two wide by seven feet two long, and two others, two feet two by four feet eight inches. On each end are also two wooden ventilators two feet two by three feet six inches. All these ventilators are hung by hinges on the upper edges and open outwards.

Fine wire netting is fastened over all the ventilating openings within to exclude insects without interfering with the movement of the ventilators. Protection from grasshoppers and crickets is especially necessary. Wire netting doors make it possible also to leave the sash doors open for ventilation when desired. The construction is nearly as slight as is consistent with safety and offers very little obstruction to sunlight.

The ridge of the house and the three benches on which the pots stand run nearly north and south.

Observations were made through the season at 9 A. M., 12 M. and 5 P. M. to determine how much the temperature in the shade

within the house differed from the air temperature in the shade without.

At the times of ten single observations the temperature within the house was lower than without, but at all other times of observation the reverse was the case.

The greatest observed difference of temperature was ten degrees Fahr.

The greatest difference between the mean of the three daily observations without and within the house was 7.3 degrees Fahr.

The average daily difference was 3.6 degrees Fahr.

Water Supply.—In one corner of this vegetation house was placed a circular tank 23 inches in diameter and 39 inches deep made of heavy "galvanized" iron and painted inside with asphalt. A battery of Pasteur-Chamberland filters, attached to the city water service pipes supplied very pure water which was stored in this tank for use in the experiment.

The general appearance and arrangement of the house are shown in the accompanying plates.

Plate I shows the appearance of the house seen from the southwest. The ventilators at the sides and in the peak and the sash doors in the ends, are all opened, the netting doors being closed. It was not found necessary to use the ventilators in the ends of the building during the season.

The iron pipes which support the sash bars and give rigidity to the structure are seen within. The arrangement of these supports is described in Prof. Bailey's paper already referred to.

Plate II shows the interior plan. A and B are the north and south end doors. C, D and E, are the three benches which carry the vegetation pots. Table C is 21 feet long by $3\frac{3}{4}$ feet wide, table D $19\frac{1}{3}$ feet long by 3 feet 2 inches wide, and table E is 23 feet long by $3\frac{3}{4}$ feet wide. The tops of these benches are 16 inches above the level of the top of the sills and 15 inches below the level of the glass in the sides of the building. F is the water tank and H a faucet from which with rubber hose water may be drawn for watering the floor and tables when desired.

Pots.—The pots used were made of "galvanized" iron, wired on the upper edge. They were eight inches in diameter, twelve inches deep, the bottom slightly concave, and in the center of the bottom was a hole with a collar $\frac{3}{4}$ of an inch in diameter, which could be closed with a rubber stopper. Each pot was supported on three iron legs, so that the lowest point of the collar

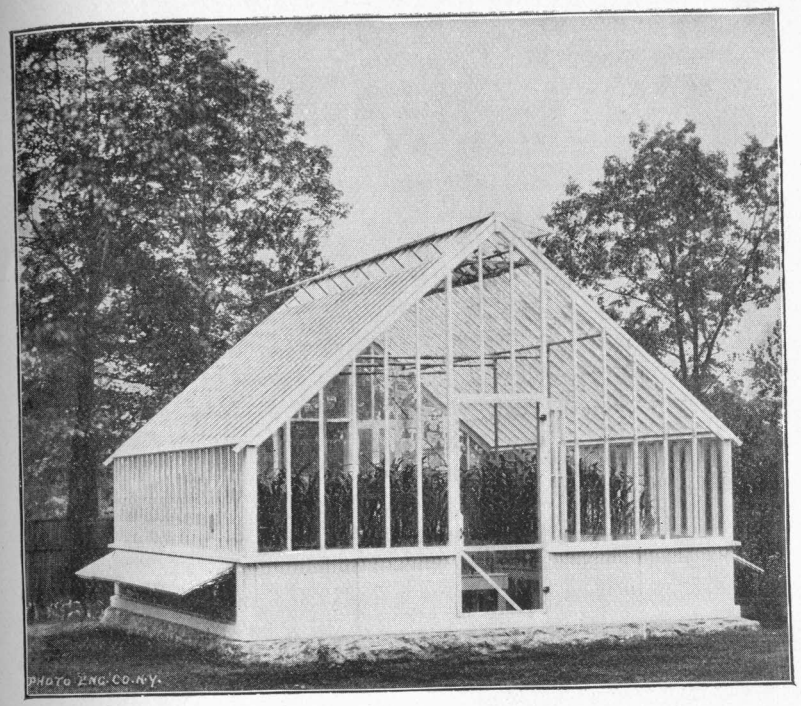


PLATE I. Vegetation House.

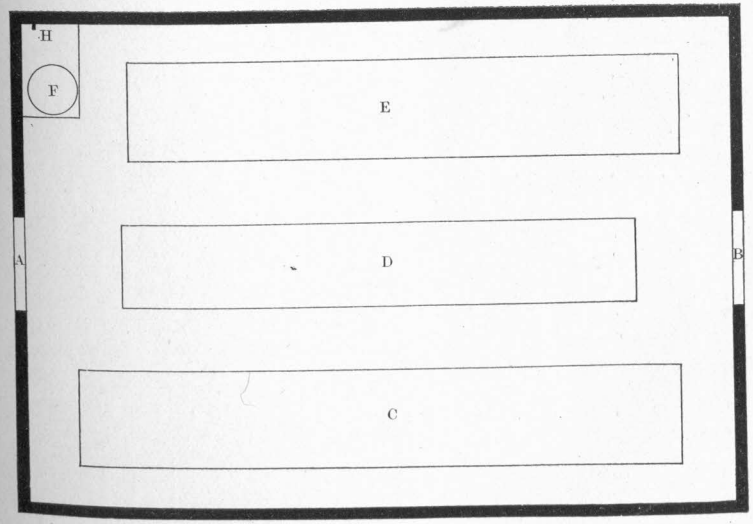


PLATE II. Interior Plan of Vegetation House.

referred to was two and a half inches above the platform on which the pot stood. The general appearance of the pots may be seen by reference to the plates facing page 104.

The Artificial Soil consisted of sifted anthracite coal ashes, to which three per cent. of peat moss had been added. This peat moss, we are informed is imported for stable bedding. It was sifted, and only that part was used which passed a sieve with about six meshes to the inch. This peat has a slight acid reaction and on digestion with water continued to give up acid for 48 hours. The total quantity thus extracted per gram of peat moss, neutralizes about .1144 grams of barium hydrate. Distilled with magnesia, four grams yielded a bare trace of ammonia. The peat moss contains $\frac{64}{100}$ of one per cent. of nitrogen. The coal ashes, fresh from the Station steam heater, were sifted through a wire sieve having square meshes, four to the inch. The ashes were perfectly neutral in reaction, and contained $\frac{6}{100}$ of one per cent. of nitrogen.

For the experiments of 1893, described in the Report for that year, p. 230, a mixture of five p. c. peat moss and 95 p. c. coal ashes was used as soil. Observations then made indicated that a smaller proportion of peat would give physical conditions quite as favorable to vegetation and led us to reduce the quantity this year to three per cent.

Fertilizer Ingredients.

Besides nitrogen, which was supplied in different forms and varying quantities, there was added to the soil of every pot a definite quantity of calcium carbonate, potassium sulphate, dicalcium phosphate and "concentrated phosphate."

The complete analyses of these materials follow:

TABLE I. ANALYSES OF FERTILIZERS USED IN THE EXPERIMENTS.

	Calcium Carbonate.	Potassium Sulphate.	Dicalcium Phosphate.	"Concentrated" Phosphate.
Sand and Silica	- -	.36	----	6.26
Oxide of iron and alumina	----	.70	----	38.37
Lime (CaO)	53.18	.55	35.49	.30
Magnesia	.90	2.88	----	.12
Potash (K_2O)	----	46.30	----	----
Soda	----	.59	----	.42
Phosphoric Acid (P_2O_5)	----	----	42.36	45.61
Sulphuric Acid (SO_3)	----	43.34	----	.21
Chlorine	----	1.80	----	trace
Carbonic Acid (CO_2)	43.82	----	----	----
Water	2.10	3.44	22.15	8.85
	100.00	99.96	100.00	100.14

With the exception of Nos. 36 to 49, both inclusive, the soil of every pot received 15 grams of calcium carbonate, 4.4 grams of potassium sulphate, 1.5 grams of dicalcium phosphate and 1.2 grams of concentrated phosphate.

Hence, with the exceptions noted above, the soil of each pot received, in addition to what plant food the ashes themselves contained, the following quantities of mineral ingredients :

Potash (K_2O)	2.04	grams.
Soda	.03	"
Lime (CaO)	8 54	"
Magnesia (MgO)	.27	"
Oxide of iron and alumina	.49	"
Phosphoric Acid (P_2O_5)	1.18	"
Sulphuric Acid (SO_3)	1.91	"
Chlorine	.08	"

The object of adding calcium carbonate was to maintain in the soil the mild alkalinity essential to the process of nitrification.

Seed.—The seed maize used was Hickox Improved Sweet Corn, raised in Milford, Conn. about nine miles from the Station.

By means of concentrated sugar solutions at a temperature of 24°C. there were separated those kernels which had an apparent specific gravity between 1.246 and 1.216.

After these were thoroughly and rapidly washed and air dried the separate kernels were weighed, reserving for experiment only those which weighed between .290 and .320 gram each, this being about the medium weight.

This work was deemed necessary in order to secure plants of equal vigor and fairly comparable. Unfortunately the seed corn of 1893 was of poor quality and the plants were not altogether satisfactory.

Filling and planting Vegetation Pots.—After thorough washing and drying, each pot was fitted with a piece of wire gauze over the hole in the bottom and with a glass tube of about $\frac{1}{3}$ inch bore, reaching to the bottom of the pot and projecting about $\frac{1}{2}$ inch above its upper rim. Washed fine quartz gravel was poured in, till the weight of the pot and contents was exactly 2721 grams (6 pounds). The layer of gravel was from $\frac{1}{2}$ to $\frac{3}{4}$ inch deep in the shallowest part.

Into each pot were next poured 4536 grams (ten pounds) of the artificial soil which had been thoroughly intermixed by hand with

the fertilizers already referred to, and with the weighed amount of organic nitrogen designed for that pot, the whole charge being pressed down to the same level in all the pots.

To each pot was then added 1446 grams (3 pounds and 3 ounces) of water which represented about 40 per cent. of the water-holding capacity of the soil.

The maize seed after soaking twelve hours in water was placed in a germinating apparatus.

On the 15th and 16th of June as the maize sprouted, three healthy looking seedlings were placed in each pot on the surface of the soil and equidistant from each other.

They were covered with 340 grams (12 ounces) of the mixture of peat and ashes which buried the seeds about three-quarters of an inch deep.

To 150 grams of rich garden soil were added 1500 c.c. of water and the whole shaken together. After the sand, etc., had settled, 15 c.c. of the turbid, supernatant liquid were added to each of the pots excepting Nos. 28 to 35 both inclusive. It was intended in this way to make more certain of the presence of nitrifying organisms within the soil.

On June 19th nearly all the plants had come up and the pots were removed to the vegetation house.

Care of the Experiments during Growth.

By frequent weighing and watering the water content of the soil in all the pots, excepting Nos. 14 to 21, both inclusive, was kept between 30 and 50 per cent. of the water-holding capacity of the soil. In vegetation experiments with natural soils a much higher percentage is adopted, but because the water-holding capacity of this artificial soil is greater than that of ordinary natural soils the lower figure was thought to be adequate. The relative position of the pots was changed from time to time in order to equalize as far as possible their exposure to light and heat.

In spite of the care exercised in selecting seed it immediately appeared that a part of the seedlings were incapable of growth.

On June 26, one plant was missing in each of the following pots. Nos. 1, 13, 24, 66, 72, 81, 96, 103, 115, 129, 145, 149. Two plants were missing in pots 21 and 26. The decaying seeds were removed and new ones planted which in all cases lived.

On July 2, one plant in No. 127 appeared as if badly burned. One plant in pot 134 was badly diseased, made no growth and was removed.

Each of the following pots had one, more or less abnormal, stunted plant; Nos. 1, 7, 23, 36, 47, 51, 114, 126, 130 and 134. Some of these afterwards grew to good size but never equaled the others in the same pot. It was noted that where a single plant was feeble and small another in the same pot would grow to be correspondingly larger, as if it took to itself the nitrogen which the other did not appropriate.

On July 18th, it was thought that the pots were standing too close to permit full development of all the plants. The foliage of the plants in certain pots was becoming pale green as if light were deficient. Those pots which had the larger supply of nitrogen, Nos. 7, 8, 12, 13, 24, 25, 26, 27, 104, 105, 108, 109, 112, 113, 116, 117, 125, 126, 130, 141, were therefore removed to a green house used in last year's experiments.

July 23d, those plants which received the smallest quantities of nitrogen, within a few days became very appreciably lighter in color, as if this date marked the time when nitrogen-hunger, or more properly nitrogen-starvation had set in.

On July 20, 4.9535 grams of nitrate of soda, equivalent to .8 gram nitrogen were added to pots 11 and 13.

July 30, the first staminate flower appeared, in pot 30.

Aug. 1. The tips of leaves were brown and dry on many plants among those which had received least nitrogen.

Aug. 2. By accident one plant in pot 116 was broken off close to the ground.

Aug. 11. Nearly all the plants which received the smallest quantity of nitrogen had very light green foliage, in sharp contrast with the others and were evidently suffering for lack of nitrogen. There were staminate flowers on two-thirds of the plants.

Aug. 13. Pistillate flowers first appeared on the plants of pots 12 and 26.

Aug. 16. The following pots were sent to the laboratory for harvest and chemical examination of the crops: Nos. 3, 51, 53, 55, 57, 59, 62, 64, 66, 68, 70, 72, 74, 76, 79, 81, 83, 85, 87, 89, 93, 95, 97, 98, 100, 118, 119, 121, 135, 138, 142, 146.

Aug. 17. The pots which were removed on July 18th were brought back to the vegetation house.

Aug. 28. The following pots were sent to the laboratory for harvest and chemical examination of the crops: Nos. 50, 52, 54, 56, 58, 60, 63, 65, 67, 69, 71, 73, 75, 77, 78, 80, 82, 84, 86, 88, 91, 92.

Aug. 27 to 31, all the pistillate flowers were pollinated by hand daily.

Sept. 18. All the pots remaining in the vegetation house were sent to the laboratory for harvest and chemical examination of the crops.

None of these plants reached normal size or development because in all cases there was a deficiency of nitrogen or of other elements of plant food.

In each of thirty-eight of the crops there were one or more ears, in all cases small or abortive. The following statement gives the number of ears which contained kernels of corn.

The crops in the following pots each had one seed-bearing ear: 5, 6, 8, 12, 13, 15, 17, 23, 24, 33, 104, 106, 107, 117, 124, 128, 130, 148.

Each of the following carried two seed-bearing ears:—1, 7, 9, 10, 11, 19, 21, 25, 27, 29, 30, 105, 108, 109, 113, 126, 141.

The following had each three ears with seed:—26, 112, 125.

In pots 29 and 108 both ears were on one plant.

Determination of Dry Weight of Crops and of Nitrogen in them.

The crops were harvested as soon as they were brought to the laboratory. The three plants from each pot were cut off close to the surface of the soil; then cut into small pieces about half an inch long, and dried in a large drying oven at a temperature below 100° C. After drying, each crop was ground without any mechanical loss in a feed mill and allowed to stand exposed to the air for twenty-four hours. It was then weighed on a chemical balance, sensitive to a fraction of a milligram, and securely bottled.

Duplicate portions of the air-dry material (two grams in each), contained in weighing bottles were dried to constant weight at a temperature of 100° C.

From the result was calculated the weight of the water-free crop.

Nitrogen was also determined in duplicate portions.

In the following table, and preliminary to a discussion of the results of these vegetation experiments, are given all the data regarding the nitrogen supply and the quantities of water-free substance and of nitrogen harvested.

The following explanations are referred to by small numerals in their appropriate places in the table.

[1] The nitrogen was added August 6th. At that time the appearance of the crop was like that of crops in pots 2, 3, and 4.

[2] .8 gram nitrogen added at planting time and .8 on July 20.

[3] .8 gram nitrogen was added at planting, and .8 on July 20 and also on Aug. 6th.

[4] The water in the pot was kept between 80 and 60 per cent. of the water-holding capacity of the soil. See p. 87.

[5] The water in the pot was kept between 70 and 50 per cent. of the water-holding capacity of the soil. See p. 87.

[6] The water in the pot was kept between 60 and 40 per cent. of the water-holding capacity of the soil. See p. 87.

[7] The water in the pot was kept between 80 and 40 per cent. of the water-holding capacity of the soil. See p. 87.

[8] No soil extract was added to the soil.

[9] 100 grams of garden soil were added to the soil.

[10] Normal quantity phosphoric acid, ½ normal quantity of potash.

[11] " " " " ¾ " " "

[12] " " " " 1¼ " " "

[13] " " " " 1½ " " "

[14] " " potash, ½ normal quantity phosphoric acid.

[15] " " " ¾ " " " "

[16] " " " 1¼ " " " "

[17] " " " 1.7 " " " "

[18] 1½ normal quantity potash, 1.7 normal quantity of phosphoric acid.

[19] 1¼ " " " and " " " "

[20] 1½ " " " and " " " "

[21] Normal quantity potash, 1¼ " " " "

[22] " " " 1.7 " " " "

[23] 1½ normal quantity potash, 1.7 " " " "

The data given in this table may now be discussed in detail.

The basis of comparison of the crops and of the nitrogen in them is the *increase of crop* and of assimilated nitrogen produced by the several fertilizers over what was produced on the artificial soil without any nitrogenous fertilizer (pots 2, 3, and 4). This for brevity is referred to in the following discussion as "Crop Increase," and "Nitrogen Increase."

TABLE II.—VEGETATION EXPERIMENTS OF 1894. DATA REGARDING FERTILIZERS AND CROPS HARVESTED.

No. of Pot.	Nitrogen supplied		The Crop.			The Nitrogen in the Crop.			
	In form of	Quantity of nitrogen supplied. (grams.)	Weight of air-dry Crop* (exclusive of roots). (grams.)	Weight of water-free Crop. (grams.)	Increase of Crop over Crop of Pots 2, 3 and 4. (grams.)	Per cent. of nitrogen in the air-dry Crop.	Total nitrogen of Crop (exclusive of roots). (grams.)	Increase of nitrogen of Crop over that of Crop in Pots 2, 3 and 4.	Of 100 parts of nitrogen in the fertilizer there were recovered in the Crop. (parts.)
1	----------	.8 [1]	35.49	32.76	29.60	1.31	.465	.448	----
2	----------	none	3.54	3.23	------	.48	.017	-----	----
3	----------	none	2.90	2.60	------	.52	.015	-----	----
4	----------	none	3.91	3.64	------	.46	.018	-----	----
5	Ground Horn and Hoof	.8	82.97	74.01	70.85	.37	.307	.290	36.3
6	" " " "	1.6	130.42	118.92	115.76	.43	.561	.544	33.3
7	" " " "	2.4	140.90	128.89	125.73	.72	1.015	.998	41.6
8	" " " "	3.2	143.63	132.38	129.22	.89	1.278	1.261	39.4
9	Nitrate of Soda	.8	109.70	99.88	96.72	.35	.384	.367	45.9
10	" "	1.6	154.77	140.87	137.71	.56	.867	.850	53.2
11	" "	.8+.8 [2]	144.86	131.94	128.78	.55	.797	.780	48.8
12	" "	2.4	116.57	107.18	104.02	1.18	1.376	1.359	56.6
13	" "	.8+.8+.8 [3]	124.43	113.42	110.26	1.23	1.531	1.514	63.1
14	Dried Blood	.8 [4]	88.29	80.01	76.85	.37	.327	.310	38.8
15	" "	1.6 [4]	164 22	151.44	148.28	.38	.624	.607	38.0
16	" "	.8 [5]	104 89	96.66	93.50	.34	.357	.340	42.6
17	" "	1.6 [5]	160.95	145.03	141.97	.37	.596	.579	36.2
18	" "	.8 [6]	92 44	85.75	82.59	.37	.342	.325	40.7
19	" "	1.6 [6]	136 39	124.14	120.98	.44	.600	.583	36.5
20	" "	.8 [7]	100.57	91.95	88.79	.37	.372	.355	44.5
21	" "	1.6 [7]	142.35	131.68	128.52	.42	.598	.581	36.4
22	Dried Blood	.8	85.63	76.56	73.40	.39	.334	.317	39.7
23	" "	1.6	143.87	129.48	126.32	.42	.604	.587	36.7
24	" "	2.4	150.09	135.48	132.32	.62	.931	.914	38.1
25	" "	2.4	155.98	141.29	138.13	.65	1.030	1.013	42.2
26	" "	3.2	141.43	130.12	126.96	.91	1.287	1.270	40.2
27	" "	3.2	170.40	153.35	150.19	.74	1.261	1.244	38.7
28	Dried Blood	.8 [8]	87.47	79.71	76.55	.35	.306	.289	38.3
29	" "	1.6 [8]	147.28	136.81	123.65	.45	.663	.646	41.4
30	" "	2.4 [8]	150.52	138.58	135.42	.66	.993	.976	41.6
31	Dried Blood	.8 [9]	80.57	73.31	70.15	.44	.354	.337	44.3
32	" "	1.6 [9]	129 94	117.83	114.67	.42	.546	.529	34.1
33	" "	2.4 [9]	160.53	146.93	143.77	.65	1.043	1.026	43.5
34	" "	none [9]	6.25	5.70	2.54	.36	.023	.006	----
35	" "	none [9]	3.73	3.42	.26	.42	.016	-----	----
36	Dried Blood	1.6 [10]	131.48	120.45	117.29	.40	.526	.509	32.9
37	" "	1.6 [11]	128.73	118.64	115.48	.41	.528	.511	33.0
38	" "	1.6 [12]	123.43	112.83	109.67	.46	.568	.551	35.5
39	" "	1.6 [13]	140.21	127.69	124.53	.40	.561	.544	35.1

TABLE II.—VEGETATION EXPERIMENTS OF 1894. DATA REGARDING FERTILIZERS AND CROPS HARVESTED.—*Continued.*

No. of Pot.	Nitrogen supplied		The Crop.			The Nitrogen in the Crop.			
	In form of	Quantity of nitrogen supplied. (grams.)	Weight of air-dry Crop (exclusive of roots). (grams.)	Weight of water-free Crop. (grams.)	Increase of Crop over Crop of Pots 2, 3 and 4. (grams.)	Per cent. of nitrogen in the air-dry Crop.	Total nitrogen of Crop (exclusive of roots). (grams.)	Increase of nitrogen of Crop over that of Crop in Pots 2, 3 and 4.	Of 100 parts of nitrogen in the fertilizer there were recovered in the Crop. (parts.)
40	Dried Blood	1.6[14]	122.68	110.19	107.03	.42	.515	.498	32.2
41	" "	1.6[15]	139.75	128 93	125.77	.40	.559	.542	34.9
42	" "	1.6[16]	135.41	125.92	122.76	.43	.582	.565	36.4
43	" "	1.6[17]	143.75	132.54	129.38	.45	.647	.630	40.4
44	Dried Blood	1.6[18]	134.83	121.97	118.81	.41	.553	.536	34.6
45	" "	1.6[19]	91.84	82.68	79.52	.35	.321	.304	20.1
46	" "	1.6[20]	98.94	90.56	87.40	.32	.317	.300	19.4
47	Dried Blood	1.6[21]	82.80	75.74	72.58	.42	.348	.331	21.7
48	" "	1.6[22]	92.92	85.07	81.91	.35	.325	.308	20.3
49	" "	1.6[23]	97.87	89.85	86.69	.34	.333	.316	20.8
50	I Commercial Mixed Fertilizer	1.6	114.12	101.81	98.65	.37	.422	.405	26.4
51	II " " "	.8	55.32	50.59	47.43	.41	.227	.210	26.0
52	II " " "	1.6	121.42	107.99	104.83	.36	.437	.420	27.3
53	III " " "	.8	66.47	61.08	57.92	.39	.259	.242	32.4
54	III " " "	1.6	134.65	118.57	115.41	.39	.525	.508	32.8
55	IV " " "	.8	65.84	60.19	57.03	.40	.263	.246	32.9
56	IV " " "	1.6	114.88	101 99	98.83	.43	.494	.477	30 9
57	V " " "	.8	54.30	49.50	46.34	.41	.220	.203	27.5
58	V " " "	1.6	113.44	99.90	96.74	.38	.431	.414	27.0
59	VI " " "	.8	66.27	61.03	57 87	.39	.259	.242	32.4
60	VI " " "	1.6	126.55	111.17	108.01	.42	.531	.514	33.2
61	VII " " "	1.6	102.70	90.79	87.63	.39	.401	.384	25.0
62	VIII " " "	.8	54,63	49.64	46.48	.53	.290	.273	36.2
63	VIII " " "	1.6	130.54	112.03	108.87	.39	.509	.382	31.8
64	IX " " "	.8	69.46	63.69	60.53	.43	.295	278	36.9
65	IX " " "	1.6	147.31	127.63	124.47	.38	.560	.543	35.0
66	X " " "	.8	65.65	60.71	57.55	.44	.289	.272	36.1
67	X " " "	1.6	146.91	129.84	126.68	.38	.558	.541	34.9
68	XI " " "	.8	50.23	45.84	42.68	.44	.221	.204	27 6
69	XI " " "	1.6	109.90	98 69	95.53	.38	.418	.401	26.1
70	XII " " "	.8	51.72	47.07	43.91	.42	.217	.200	27.1
71	XII " " "	1.6	107.80	93.25	90.09	.36	.388	.371	24.2
72	XIII " " "	.8	67.22	61.66	58.50	.41	.276	.259	34.5
73	XIII " " "	1.6	156 39	137.09	133.93	.39	.610	.593	38.1
74	XIV " " "	.8	59.04	54.37	51.21	.38	.224	.207	28.0
75	XIV " " "	1.6	118.88	103.23	100.07	.38	.452	.435	28.2
76	XV " " "	.8	65.22	59.03	55.87	.43	.280	.263	35 0
77	XV " " "	1.6	133.23	115.87	112.71	.40	.533	.516	33.3
78	XVI " " "	1.6	75.42	64.72	61.56	.38	.287	.270	18.0
79	XVII " " "	.8	82.89	75.62	72.46	.43	.356	.339	44.5
80	XVII " " "	1.6	145.49	128.76	125.60	.39	.568	.551	35.0
81	XVIII " " "	.8	40.96	37.61	34.45	.46	.188	.171	23.5
82	XVIII " " "	1.6	106.20	91.94	88.78	.37	.393	.376	24.6

TABLE II.—VEGETATION EXPERIMENTS OF 1894. DATA REGARDING FERTILIZERS AND CROPS HARVESTED.—*Continued.*

No. of Pot.	Nitrogen supplied		The Crop.			The Nitrogen in the Crop.			
	In form of	Quantity of nitrogen supplied. (grams.)	Weight of air-dry Crop (exclusive of roots). (grams.)	Weight of water-free Crop. (grams.)	Increase of Crop over Crop of Pots 2, 3 and 4. (grams.)	Per cent. of nitrogen in the air-dry Crop.	Total nitrogen of Crop (exclusive of roots). (grams.)	Increase of nitrogen of Crop over that of Crop in Pots 2, 3 and 4.	Of 100 parts of nitrogen in the fertilizer there were recovered in the crop. (parts.)
83	XIX Commercial Mix'd Fertilizer	.8	56.98	52.33	49.17	.44	.251	.234	31.4
84	XIX " " "	1.6	138.76	122.66	119.50	.41	.569	.552	35.6
85	XX " " "	.8	70.23	63.91	60.75	.39	.274	.257	34.2
86	XX " " "	1.6	127.50	110.51	107.35	.42	.536	.519	33.5
87	XXI " " "	.8	64.70	59.53	56.37	.44	.285	.268	35.6
88	XXI " " "	1.6	132.75	116.13	112.97	.39	.518	.501	32.4
89	XXII " " "	.8	71.09	64.45	61.29	.40	.284	.267	35.5
90	XXII " " "	1.6	141.80	125.29	122.13	.39	.553	.536	34.6
91	XXIII " " "	1.6	100 33	86.65	83.49	.37	.371	.354	23.2
92	XXIV " " "	1.6	109.65	96.99	93.83	.34	.373	.356	23.3
93	XXV " " "	.8	52.73	48.34	45.18	.42	.222	.205	27.8
94	XXV " " "	1.6	123.71	108.51	105.35	.36	.445	.428	27.8
95	XXVI " " "	.8	63.59	58.41	55.25	.46	.293	.276	36.6
96	XXVI " " "	1.6	128.37	115.26	112.10	.41	.526	.509	32.9
97	XXVII " " "	.8	45.88	41.82	38.66	.43	.197	.180	24.6
98	XXVIII " " "	.8	65.61	59.61	56.45	.42	.276	.259	34.5
99	XXVIII " " "	1.6	123.27	109.83	106.67	.40	.493	.476	30.8
100	XXIX " " "	.8	68.17	62,31	59.15	.39	.266	.249	33.2
101	XXIX " " "	1.6	141.38	124.26	121.10	.45	.636	.619	39.7
102	A. Castor Pomace	.8	95.38	86.99	83.83	.33	.315	.298	39.3
103	" " "	1.6	107.40	97.84	94.68	.47	.505	.488	31.6
104	" " "	2.4	136.93	127.04	123.88	.69	.945	.928	39.0
105	" " "	3.2	115.98	107.49	104.33	.99	1.148	1.131	32.8
106	B. Castor Pomace	.8	89.97	83.48	80.32	.39	.351	.334	43.9
107	" " "	1.6	151.13	140.10	136.94	.45	.680	.663	42.5
108	" " "	2.4	153.28	140.91	137.75	.79	1.211	1.194	50.5
109	" " "	3.2	166.53	155.17	152.01	.90	1.499	1.482	46.8
110	Cotton Seed Meal	.8	82.45	74.81	71.65	.40	.330	.313	41.2
111	" " "	1.6	125.37	116.36	113.20	.47	.589	.572	36.8
112	" " "	2.4	152.21	140.23	137.07	.74	1.126	1.109	47.0
113	" " "	3.2	156.37	143.55	140.39	.74	1.157	1.140	36.1
114	Dry Ground Fish	.8	80.20	73.21	70.05	.37	.297	.280	37.1
115	" " "	1.6	123.38	114.74	111.58	.43	.531	.514	33.2
116	" " "	2.4	114.74	109.12	105.96	.81	.929	.912	38.7
117	" " "	3.2	145.47	132.60	129.44	.73	1.062	1.045	33.2
118	XXX Comm'cial Mixed Fertilizer	------	2.79	2.55	-----	.78	.022	.005	---
119	XXXI " " "	.8	90.25	81.89	78.73	.41	.366	.349	45.8
120	XXXI " " "	1.6	149.83	133.02	129.86	.46	.689	.672	43.1
121	XXXII " " "	.8	60.52	55.25	52.09	.45	.272	.255	34.0
122	XXXII " " "	1.6	138.26	124.49	121.33	.39	.539	.522	33.7

TABLE II.—VEGETATION EXPERIMENTS OF 1894. DATA REGARDING FERTILIZERS AND CROPS HARVESTED.—*Continued.*

No. of Pot.	Nitrogen supplied		The Crop.			The Nitrogen in the Crop.			
	In form of	Quantity of nitrogen supplied. (grams.)	Weight of air-dry Crop (exclusive of roots). (grams.)	Weight of water-free Crop. (grams.)	Increase of Crop over Crop of Pots 2, 3 and 4. (grams.)	Per cent of nitrogen in the air-dry Crop.	Total nitrogen of Crop (exclusive of roots). (grams.)	Increase of nitrogen of Crop over that of Crop in Pots 2, 3 and 4.	Of 100 parts of nitrogen in the fertilizer there were recovered in the Crop. (parts.)
123	Tankage	.8	72.22	65.35	62.19	.39	.282	.265	35.2
124	"	1.6	137.29	125.20	122.04	.43	.590	.573	36.9
125	"	2.4	124.90	114 61	110.45	.82	1.024	1.007	42.7
126	"	3.2	99.70	92.09	88.93	1.08	1.077	1.060	34.0
127	Linseed Meal	.8	84.50	81.31	78.15	.39	.330	.313	41.2
128	" "	1.6	127.07	116.27	113.11	.50	.635	.618	39.7
129	" "	2.4	139.75	129.58	126.42	.54	.755	.738	31.5
130	" "	3.2	124.48	114.93	111.77	.73	.909	.892	28.1
131	XXXIII Com'cial Mix'd Fertilizer	.8	74.44	68.09	64 93	.35	.261	.244	32.6
132	XXXIV " " "	.8	85.87	78.16	75.00	.39	.335	.318	41.9
133	Home Mixed Fertilizer	.8	87.43	80.37	77.21	.37	.324	.307	40 5
134	" " "	.8	89.00	80.94	77.78	.33	.294	.277	36.8
135	Raw Leather	.8	2.48	2.26	-----	.55	.014	----	1.7
136	" "	1.6	1.96	1.78	-----	.45	.009	----	0.5
137	Dissolved Leather	.8	83.16	73.26	70.10	.37	.308	.291	38.5
138	Garbage and Leather	.8	27.83	25.67	22.51	.50	.139	.122	17.4
139	" " "	1.6	73.72	65.26	62.10	.35	.258	.241	16.1
140	" " "	2.4	94.07	86.16	83.00	.35	.329	.312	13.7
141	" " "	3.2	103.84	95.69	92.53	.54	.561	.544	17.5
142	Steamed Leather	.8	10.34	9.48	6 32	.46	.047	.030	5.9
143	" "	1.6	14.21	12.89	9.73	.37	.053	.036	3.3
144	" "	2.4	27.60	24.16	21.00	.32	.088	.071	3.7
145	" "	3.2	28.91	26.38	23.22	.40	.116	.099	3.6
146	Roasted Leather	.8	8.20	7.40	4.24	.49	.040	.023	5.0
147	" "	1.6	17.25	15.19	12.03	.41	.071	.054	4.4
148	Dried Blood	1.6	106.38	97.79	94.63	.43	.457	.440	28.6
149	" "	1.6	135.35	124.40	121.24	.37	.501	.484	31.3

INFLUENCE OF THE WATER CONTENT OF THE SOIL DURING GROWTH, ON CROP PRODUCTION.

(Pots 14, 16, 18, 22, 20 and 15, 17, 19, 23, 21.)

The "water-holding capacity of the soil" was determined as follows:

Each pot when filled for experiment held 4876 grams ($10\frac{3}{4}$ pounds) of artificial soil.

Water was poured on the surface of the soil of a single pot till the soil was saturated and water ran off through the drainage tube. When the draining ceased, the pot and contents were weighed.

It appeared that the 4876 grams of soil would hold 3892 grams ($8\frac{57}{100}$ pounds) of water.

In following paragraphs, for brevity, the water supply is described as "80 to 60 per cent." etc. This signifies that the pot referred to never contained more than 80 per cent. nor less than 60 per cent. of 3892 grams of water, i. e., its water-content never exceeded 3113 grams (110 ounces) nor fell below 2335 grams (82 ounces).

The pot was placed on the scales from day to day and whenever its weight showed that it contained but 82 ounces of water enough was added to bring the amount up to 110 ounces.

About one-half of this water was carefully distributed over the surface of the soil and the remainder was poured through the tube to the bottom of the pot.

The results of the observations on the Water Content of the Soil may be tabulated for comparison as follows:

TABLE III.—INFLUENCE OF WATER SUPPLY ON CROP PRODUCTION.

NITROGEN SUPPLY, .8 GRAM IN DRIED BLOOD.

No. of Pot.	Water Supply,	Crop Increase. grams.	Nitrogen Increase. gram.
14	80—60 per cent.	76.9	.310
16	70—50 "	93.5	.340
18	60—40 "	82.6	.325
22	50—30 "	73.4	.317
20	80—40 "	88.8	.355

NITROGEN SUPPLY, 1.6 GRAMS IN DRIED BLOOD.

15	80—60 per cent.	148.3	.607
17	70—50 "	141.9	.579
19	60—40 "	121.0	.583
23	50—30 "	126.3	.587
21	80—40 "	128.5	.581

With .8 gram of nitrogen the largest crop increase was secured when the quantity of water in the soil was kept between 70 and 50 per cent. More water, 80-60 per cent. produced less crop. Less water, 60 to 40 per cent. and 50 to 30 per cent. also lessened production. When the water was allowed to fluctuate between 80 and 40 per cent. the crop was a little less than when between 70 to 50 per cent. of water was used.

The same is true of the nitrogen increase, except that the largest quantity was in the crop which received from 80 to 40 per cent. of water.

From 50 to 60 per cent. of water or else from 80 to 40 per cent. would seem to have been the quantity most favorable, with .8 gram of nitrogen in dried blood.

When 1.6 grams of nitrogen in form of blood were applied, the largest crop and the largest quantity of nitrogen was got with 80 to 60 per cent. of water. Somewhat less crop increase was got, with a water content of 70 to 50 per cent.; but 60 to 40, 50 to 30, and 80 to 40 per cent. gave decidedly less crop. It is noteworthy however that the quantity of nitrogen in these crops was nearly the same, despite the fluctuations in the water content of the soil and in the weights of crop.

With 1.6 grams of blood nitrogen, 80-60 per cent. of water appears necessary to secure the maximum effect. With smaller quantities of water however nearly the same amount of nitrogen entered the crop, but dry substance was found in less proportion.

These observations indicate that the quantity of water used in the other experiments of this year (50 to 30 per cent.) may not have been enough to bring the nitrogen of the fertilizers to its full efficiency in crop production.

They also indicate that as the nitrogen supply is increased (the quantities used were .8, 1.6, 2.4, and 3.2) the efficiency of the nitrogen in crop production may have been more and more seriously diminished by deficiency of water.

They further show that a reduction of yield on account of the deficiency of water is not necessarily followed by a reduction in the quantity of nitrogen in the crop.

Where more than .8 gram of nitrogen were used as fertilizer, deductions based on CROP INCREASE are unsafe, because it is probable that the water supply was not in excess of crop requirement.

Where more than 1.6 grams of nitrogen were used as fertilizer, deductions based on NITROGEN INCREASE are probably unsafe.

WAS GARDEN SOIL OR ITS EXTRACT HELPFUL TO THE ASSIMILATION OF ORGANIC NITROGEN?

(Pots 22, 28, 31, 23, 29, 32, 24, 25, 30, 33, 34, 35.)

To all the pots, except 28, 29, 30, 31, 32, 33, 34, 35, a definite quantity of water extract of garden soil as described on page 79 was added to ensure a supply of the microbes found in cultivated ground and so possibly to promote decay and nitrification.

To determine whether this addition was advantageous the following comparisons were made.

Pots 22, 23, 24, 25 received the soil extract just referred to.

Pots 28, 29, 30, received no soil extract.

To each of the pots 31, 32, 33, 34 and 35 were added 100 grams of rich garden soil.

Pots 34 and 35 received no additional nitrogen but to all the others nitrogen was supplied in the form of Dried Blood.

TABLE IV.—EFFECTS OF ADDING GARDEN SOIL OR SOIL EXTRACT TO THE ARTIFICIAL SOIL.

The arrangement of the series and the results obtained are given below.

Pot.	Quantity of Blood Nitrogen.	Addition.	Crop Increase. grams.	Crop increase. Per ct.	Nitrogen in Crop increase. grams.	Nitrogen in Crop increase. Per ct.
22	.8 gram.	Soil Extract.	73.4	100*	.317	100*
28	.8 "	Nothing.	76.6	104	.289	91
31	.8 "	100 grams garden soil.	70.2	95	.337	106
23	1.6 "	Soil Extract.	126.3	100*	.587	100*
29	1.6 "	Nothing.	123.7	98	.646	110
32	1.6 "	100 grams garden soil.	114.7	90	.529	90
24	2.4 "	Soil Extract.	132.3	100*	.914	100*
25	2.4 "	" "	138.1		1.013	
30	2.4 "	Nothing.	135.4	100	.976	101
33	2.4 "	100 grams garden soil.	143.8	106	1.026	106
34	none	" "	2.5		.006	
35	none	" "	.3		none	

* Taken as 100 because used in most of the experiments.

With a nitrogen supply of .8 gram the pot without soil or soil extract gave the largest crop increase and that with addition of garden soil, the smallest. The extremes were nine per cent. apart.

The pot with added garden soil showed the largest nitrogen increase, that with nothing added, least. Extreme difference 15 per cent.

When 1.6 grams of nitrogen were supplied the pot that received soil extract had the largest crop increase, the one with added garden soil the smallest. The extremes were ten per cent. apart.

The pot with no soil extract had the largest nitrogen increase, that with added garden soil, the least. Extreme difference 20 per cent.

When 2.4 grams of nitrogen were employed two pots were treated with soil extract.

The crops in these two pots differed in amount by 5 per cent. The amount of the nitrogen differed by 11 per cent.

The results of the three series of experiments are contradictory and the differences are probably within the limits of experimental error. They cannot therefore be regarded as significant.

The crop increase produced by 100 grams of garden soil above is shown to be trifling.

The experiments have not established that the nitrogen of dried blood was made any more available by the admixture of soil extract or of garden earth with the artificial soil.

The results have no bearing on the question whether nitrification is a necessary preliminary to the assimilation of organic nitrogen by the plant.

They only indicate that no artificial inoculation with soil-microbes was necessary to insure assimilation of nitrogen in the culture-trials here described.

Are the Quantities of other Plant Food, Especially Phosphoric Acid and Potash in Excess of the Requirements of the Plants?

(Pots Nos. 22, 45, 46, 47, 48, 49, 36, 37, 23, 38, 39, 40, 41, 23, 42, 43, 44.)

If so, then the crop, so far as the supply of plant food is concerned, is limited only by the quantity of nitrogen which is available.

If however the ingredients named are not in excess, the crop is limited in part by lack of them and the weight of crop is no longer a measure of the availability of the nitrogen.

On this point we have two series of experiments; in the first of which .8 gram of nitrogen in dried blood were used, and in the second 1.6 grams.

By "normal" quantity of potash (K_2O) is meant 2.04 grams the amount used in all the experiments of 1894 with the exceptions presently to be noted.

The "normal" quantity of phosphoric acid (P_2O_5) (also used in all the experiments of 1894 with the exceptions noted here) was 1.18 grams.*

The results of the first series, in which .8 gram nitrogen were used are as follows:

Table V.—Effects of Different Quantities of Phosphoric Acid and Potash, on Crop Production.

				Crop increase.		Nitrogen.	
				grams.	p. c.	gram.	p. c.
Pot 22,	Normal phosphoric acid,	Normal potash,		73.4	100	.317	100
45,	"	"	1¼ "	79.5	109	.304	96
46,	"	"	1½ "	87.4	119	.300	94
47, 1¼	Normal phosphoric acid,	Normal potash,		72.6	99	.331	104
48, 1.7	"	"		81.9	111	.308	97
49, 1.7	"	"	1½ "	86.7	118	.316	99

A study of these results shows that when potash was present in one fourth more than "normal" quantity as in pot 45, there was a crop-increase of 9 per cent. Potash in one-half more than normal quantity, (pot 46) made a further crop-increase of 10 per cent. The first crop-increase is perhaps within the limits of error but the second, taken with the first, indicates that with more potash the crops would have been larger.

Phosphoric acid was plainly in excess. The observed gain in pot 48 is nearly within the limits of error and the gain in pot 49 is accounted for fully by the extra potash present.

The nitrogen-increase, however, was not affected by either potash or phosphoric acid in excess of the normal quantities.

It appears that potash was not in relative excess when used in "normal" quantity *judging from the total crop increase*, but that with 0.8 gram of nitrogen in the fertilizer the total nitrogen of the crop is a fair measure of the availability of the nitrogen of the fertilizer.

* See page 78.

The results of the second series, with 1.6 grams of nitrogen are as follows :

TABLE VI.—EFFECTS OF DIFFERENT QUANTITIES OF PHOSPHORIC ACID AND POTASH ON CROP PRODUCTION.

							Crop increase.		Nitrogen.	
							grams.	per cent.	gram.	per cent.
Pot 23	normal	phos.	acid,		normal	potash,	126.3	100	.587	100
36	"	"	"	½	"	"	117.3	93	.509	87
37	"	"	"	¾	"	"	115.5	91	.511	87
38	"	"	"	1¼	"	"	109.7	87	.551	94
39	"	"	"	1½	"	"	124.5	98	.544	92
40	½ normal	phos.	acid,		normal	potash,	107.0	85	.498	85
41	¾ "	"	"		"	"	125.8	99	.542	92
42	1¼ "	"	"		"	"	122.8	97	.565	96
43	1.7 "	"	"		"	"	129.4	102	.630	107
44	1.7 "	"	"	1½	"	"	118.8	94	.536	91

In these tests neither less potash than the normal quantity, nor more than the normal, produced any striking difference in the quantity of crop. The cause of the smaller crop in pot 38 as compared with the crops in 37 and 39 does not appear.

Less potash than the normal quantity, was attended with less assimilation of nitrogen while increase of potash above normal did not increase the nitrogen of the crop.

One half the normal quantity of phosphoric acid in the fertilizer gave less crop-increase and less nitrogen-increase than normal while increase of the phosphoric acid of the fertilizer above normal made no appreciable change either in quantity of crop or crop-nitrogen. When *both* potash and phosphoric acid of the fertilizer were increased above normal (pot 44), no increase of crop or crop-nitrogen followed.

The "normal" potash supply was shown to be too small for maximum crop production in the cases where .8 gram of nitrogen were used, but where 1.6 grams of nitrogen were present the normal amount of potash does not appear deficient. It is hardly conceivable that potash should be relatively deficient with the less quantity of nitrogen, but not deficient with a larger quantity, unless the effect of the larger quantity of nitrogen is limited by some other factor.

Now it has been already shown on page 89 in studying the relations of water to crop production that when 1.6 grams of nitrogen in form of blood were used with the quantity of water

which was supplied to the pots now under discussion, the crop production, *but not the crop-nitrogen*, was limited by the water.

The water was not in excess of the crop requirements.

This furnishes the explanation of the results here given.

When .8 gram nitrogen was supplied, the water supply was in excess of the crop requirements and the "normal" potash ration was slightly deficient for maximum crop production.

When 1.6 grams nitrogen were supplied, the water supply was slightly deficient, the nitrogen consequently did not come to its full working in crop production and therefore the "normal" potash ration was not the factor which limited production.

The experiments above described are preliminary to those which form the main subject of this paper.

Their object is to determine whether the supply of plant food and of water has been so chosen that both are in relative excess and how far the differences in weight of crops observed in the experiments to be described later may justly be attributed to the quality and quantity of the nitrogen supply.

These results may be summarized as follows :

1. The inoculation of the artificial soil with either soil extract or garden soil was without effect and therefore unnecessary.

2. FOR THE ASSIMILATION OF NITROGEN the "normal" water supply was sufficient or in excess when .8 gram or 1.6 grams nitrogen were used in the fertilizer. There are no data to demonstrate whether with 2.4 or 3.2 grams of nitrogen, the water supply was deficient.

3. FOR MAXIMUM CROP PRODUCTION, the water supply was probably scarcely sufficient when .8 gram. nitrogen were used and was no doubt somewhat deficient when 1.6 grams nitrogen were employed.

4. FOR THE ASSIMILATION OF NITROGEN the "normal" quantity of potash was certainly in excess of the plant requirements when .8 gram nitrogen were used in the fertilizer and was probably also in excess when 1.6 grams nitrogen were present.

5. FOR MAXIMUM CROP PRODUCTION potash was deficient in all cases.

6. In the following experiments no conclusions as to the availability of nitrogen are safe where more than 1.6 grams of nitrogen were used in the fertilizer.

7. The quantity of nitrogen taken up by the crop is a fairer measure of its availability than the total weight of the crop.

The Relative Availability of Nitrogen in certain Raw Materials commonly used in Fertilizers.

(Pots 5, 6, 7, 8, 9, 10, 11, 12, 13, 22, 23, 24, 25, 26, 27, 102 to 117 (both inclusive) and 123 to 130 (both inclusive).

The nitrogenous matters used in these experiments were the following:

Commercial nitrate of soda, slightly dried to facilitate grinding and weighing and containing 16.15 per cent. of nitrogen.

Dried Blood, bought from a dealer in fertilizers, which contained 13.2 per cent. nitrogen.

Castor Pomace, A, a ground residue left after the removal of oil from the castor bean (*Ricinus*). The sample contained 5.4 per cent. of nitrogen.

Castor Pomace, B, another sample, containing 5.56 per cent. of nitrogen.

Cotton Seed Meal. Bright yellow meal from the Conn. market, containing 7.38 per cent. of nitrogen.

Dry Ground Fish, containing 9.34 per cent. of nitrogen.

Ground Horn and Hoof from Chicago. See description on page 20, containing 15.59 per cent. of nitrogen.

Tankage, bought in New Haven, which contained 4.17 per cent. of nitrogen.

Linseed Meal, used extensively in this State as a cattle food but also, among tobacco growers, as a fertilizer. It contained 5.75 per cent. of nitrogen.

All of the above materials were pulverized to pass circular holes $\frac{1}{50}$ inch in diameter.

For the most part four pots were devoted to tests of each material and each was used in such quantity as supplied .8, 1.6, 2.4 and 3.2 grams of nitrogen to the four pots respectively.

The quantities of other plant food supplied are given on page 78.

Nitrate of soda is taken as the standard of comparison.

The following table shows the amount of crop increase (over the crop in pots which received no nitrogen) obtained by the use of .8 gram of nitrogen in the nitrogenous matters named and also the amount of nitrogen increase; both being expressed in grams.

The last two columns give the relative crop and nitrogen increase, as compared with the increase obtained from nitrate of soda which is called 100 per cent.

Table VII.—Comparative Availability of Nitrogen in Various Fertilizers.

Crop Increase with .8 gram Nitrogen.

Pot.	Source of Nitrogen.	Crop Increase. grams.	Nitrogen Increase. gram.	Relative Crop Increase when Nitrate = 100 p. c. Crop. per cent.	Relative Crop Increase when Nitrate = 100 p. c. Nitrogen. per cent.
9	Nitrate of Soda	96.7	.367	100	100
22	Dried Blood	73.4	.317	75.9	86.4
102	Castor Pomace A	83.8	.298	86.7	81.2
106	Castor Pomace B	80.3	.334	83.0	91.0
110	Cotton Seed Meal	71.7	.313	74.1	85.3
114	Dry Fish	70.1	.280	72.5	76.3
5	Horn and Hoof	70.9	.290	73.3	79.0
123	Tankage	62.2	.265	64.3	72.2
127	Linseed Meal	78.2	.313	80.8	85.3

In Table VIII are given the corresponding experiments made with the double quantity of nitrogen, 1.6 grams.

Table VIII.—Comparative Availability of Nitrogen in Various Fertilizers.

Crop Increase with 1.6 grams Nitrogen.

Pot.	Source of Nitrogen.	Crop Increase.	Nitrogen Increase.	Relative Crop Increase when Nitrate = 100 p. c. Crop.	Relative Crop Increase when Nitrate = 100 p. c. Nitrogen.
10	Nitrate	137.7	.850	100	100
23	Dried Blood	126.3	.587	91.8	69.1
103	Castor Pomace A	94.7	.488	68.7	57.5
107	Castor Pomace B	136.9	.663	99.4	78.0
111	Cotton Seed Meal	113.2	.572	82.2	67.3
115	Dry Fish	111.6	.514	81.0	60.5
6	Horn and Hoof	115.8	.544	84.0	63.9
124	Tankage	122.0	.573	88.6	67.4
128	Linseed Meal	113.1	.618	82.1	72.7

We may now inquire what conclusions are justified regarding the availability of nitrogen in the various forms here under experiment.

The most accurate data are probably those of Table VII with the smaller quantity of nitrogen.

Regarding the *total crop increase* produced, it appears that the two kinds of Castor Pomace gave 86.7 and 83 per cent. of the crop which nitrate of soda gave, and larger crops than any of the other fertilizers.

Linseed Meal ranked next, and but little below the Castor Pomace, 80.8 per cent.

Then followed Dried Blood 75.9, Cotton Seed Meal 74.1, Horn and Hoof 73.3, Dry Fish 72.5 per cent.

Tankage is at the foot of the list, producing only 64.3 per cent. of the crop produced by nitrate of soda used in equivalent quantity.

Regarding in the next place the *nitrogen increase* it appears that next to nitrate came Castor Pomace B, 91.0 per cent.

Next, and nearly alike, were Dried Blood (86.4), Cotton Seed Meal (85.3) and Linseed Meal (85.3).

Somewhat below these ranked Castor Pomace A, 81.2 per cent., and Horn and Hoof, 79.0 per cent.

Then followed Dry Fish, 76.3 per cent. and last of all Tankage of whose nitrogen only 72.2 per cent. had been assimilated as compared with that yielded by nitrate of soda.

As appears from the conclusions on page 93 the only other data, which can fairly be used in discussing the relative value of nitrogen in these materials are the yields of nitrogen from those crops raised with the double quantity of this element.

An examination of these figures given in Table VIII, page 95, shows that Castor Pomace B, ranked next to Nitrate of Soda in respect of the assimilation of its nitrogen by the crop, 78 per cent.

Considerably below this was the availability of nitrogen in Linseed Meal 72.7, and Dried Blood 69.1.

A little lower ranked Tankage 67.4, and Cotton Seed Meal 67.3. Next lower was Horn and Hoof 63. 9, Fish 60.5, and last of all the Castor Pomace A 57.5.

The indications of these three sets of figures are sufficiently alike to warrant averaging the per cents. found, to obtain a general numerical expression of the result of the tests.

Such an average shows that under the conditions of this experiment, of the organic forms of Nitrogen, Castor Pomace B was the most available, 85 per cent., when nitrate of soda equals 100 per cent. Somewhat less available was the nitrogen of Linseed Meal, 80.0 and of Blood 77 per cent.

Next came Cotton Seed Meal, 76, Castor Pomace A, 74, and Horn and Hoof, 72 per cent.

Last came Dry Fish, 70, and Tankage, 68.0 per cent.

Extended discussion of these results is reserved till the tests have been repeated under varying conditions.

There are two or three particulars however to which attention may be called at the present time.

It is noteworthy that the nitrogen of one sample of Castor Pomace was very much more available than that of the other.

The reason of this difference it has not yet been possible to discover.

The nitrogen of Dry Fish and Tankage had a lower availability in these experiments than that of blood and the vegetable nitrogenous matters, rather lower indeed than horn and hoof. This is quite contrary to the popular estimate of the relative value of dried fish. It is generally regarded as one of the most active forms of nitrogen. Perhaps the same is true of tankage. This sample of tankage contained 4.17 per cent. of nitrogen and was therefore a "bone tankage" differing little in composition from ground bone and had undoubtedly been subjected to cooking and drying at a temperature of about 212° Fahr.

It will be noticed in Table IX, given on page 100, that Wagner finds from three years' experiments that the nitrogen of both blood and castor pomace is more fully available than that of either fish guano, steamed bone meal or "flesh meal;"—results which in general are confirmed by these trials.

These facts remind us of the insolubility or slowness of solution of dry ground fish and tankage in pepsin solution as contrasted with dried blood and raw bone; Report for 1893, pp. 220 and 222. Also Report for 1885, pp. 124–127. (Note the higher solubility of fresh-cooked menhaden, Fish No. 1598, Report 1885, page 123 and conclusion on page 126.)

It appears that some animal matters which yield gelatine (glue), viz: those of bone, of tendon, cartilage, hide, and the various intestinal membranes, are rendered less soluble and digestible by cooking or steaming; while others, constituting wool, hair, horn and hoof are made more soluble or digestible by cooking or steaming. In case of the former, the glue produced by the action of hot water or steam, makes a solution which impregnates the undissolved matter, and when the whole is dried fills the pores and covers and cements together the particles with a material which is quite insoluble in water of ordinary temperature so that the porosity of the whole mass is greatly diminished. In consequence of this, the material when steamed and dried dis-

solves less readily, decays much more slowly,—is less "available" to plants—than it was in its fresh or raw condition.

These remarks, of course, do not apply to processes which remove the glue quite completely from the material before drying. On the other hand, in case of wool, hair, horn and hoof, heating or steaming at the temperature usually employed produces no glue which may afterwards lessen porosity, but destroys the toughness and elasticity of these materials. Before steaming they are pulverized with the greatest difficulty; after steaming they are brittle and readily reduced to a fine powder. Thus the same process which makes fish and tankage less easy to pulverize, slower to dissolve, digest and decay, and less available to plants, makes horn and hoof, hair and wool, more easily pulverizable, quicker to decay and more available as plant food.

In the Report of this Station for 1886, page 88, is described a vegetation experiment on the agricultural value of horn shavings and horn and hoof. In this test, oats were grown in pots filled with a natural soil.

The outcome of that experiment is stated as follows: "The results are too irregular to justify any fine conclusions, but the average increase both of dry matter and of nitrogen is seen to be twice as much in the case of blood-nitrogen as in that of horn-nitrogen." . . . . "In these experiments both horn and hoof and horn shavings proved to be of very inferior value as fertilizers in comparison with dried blood."

In the experiments of this year, on the contrary, the nitrogen of ground horn and hoof was nearly as effective as that of dried blood.

In the experiments of 1886 the availability of blood-nitrogen was to that of horn-nitrogen as 100 to 46½. In the experiments of 1894 the relation was 100 to 93. There are two considerations which may fully explain this seeming discrepancy.

In 1886 the crop raised was oats; the time of growth was from May 3d to July 28th, a period of 79 days; and the temperature during the time of growth was comparatively low.

In 1894 the crop raised was maize; the time of growth was from June 16th to Aug. 28th, a period of 73 days; and the temperature during growth was exceptionally high.

While the time of growth was about the same for the two crops that time in the case of corn fell in the very warmest part of summer, while the oats grew in much cooler weather, and presumably the putrefactive and nitrifying processes within the soil were very much less active than six weeks later, at the time when the maize crop was most rapidly growing.

The other fact which explains the differences noted between the the availability of the nitrogen of horn and hoof in 1886 and in 1894 is that the character of the material used in the two series of experiments was quite different.

The horn and hoof samples used in the tests of 1886 were turnings from factories, raw or unsteamed and extremely hard to pulverize.

The firm who furnished the horn and hoof used in the tests of 1893 stated that it had been steamed. It was, at all events, a brittle material, totally different in texture from the other and very easily ground to a fine powder.

While the horn and hoof was ground to pass a $\frac{1}{50}$ inch mesh for both series of experiments it is quite certain that the preparation used in 1893 was on the whole much finer than the other and probably for this reason was more quickly decomposed and rendered available to plants.

Before leaving this subject we may cite the results of vegetation experiments made by Wagner* on the relative availability of nitrogen in various fertilizer materials.

The crops under experiment were summer rye, with flax following, summer wheat, and carrots. The tests were made on small plots of ground.

Expressing the nitrogen increase obtained by use of nitrate of soda as 100, the relative increase from the other materials was as follows:

* Die Stickstoffdüngung der Landwirtschaftl. Kulturpflanzen, 246.

TABLE IX.—RESULTS OF WAGNER'S EXPERIMENTS. THE RELATIVE AVAILABILITY OF VARIOUS FORMS OF ORGANIC NITROGENOUS MATTER.

	In experiment of the first year.	Average of first and second year's experiment.	Average of first, second and third year's experiment.
Nitrate of Soda	100	100	100
Sulphate of Ammonia	85	74	88
Peruvian Guano	84	88	80
Blood Meal	67	67	69
Castor Pomace	62	65	67
Green Crop Manure	62	60	68
Horn Meal	63	61	63
Fish Guano	51	59	64
Steamed Bone Meal	42	53	61
Flesh Meal	44	47	54
Wool Dust	27	28	33
Stable Manure	11	16	32
Leather Meal	13	12	20

The experiments made in *pots* with oats, carrots and summer rye gave results not essentially different from these.

Wagner says in discussing the figures above given: "Of course these statements of value can only represent approximately the availability of these nitrogenous matters in comparison with nitrate of soda. It would be foolish to attempt a numerical expression which should be absolutely correct in all cases.

Under conditions more favorable to the decay and nitrification of organic matters, than prevailed in our tests,—if the soil is richer in humus or lime, lighter, warmer, etc., or if a crop is grown, which has a longer period of growth and with it a greater capacity for assimilating nitrogen—then the above figures will be somewhat higher, and on the other hand (under less favorable conditions), lower."

THE RELATIVE AVAILABILITY OF NITROGEN IN VARIOUS PREPARATIONS OF LEATHER.

A considerable number of methods have been tried in this country and abroad to destroy the tannic acid and render the nitrogen of leather available to plants.

A bibliography of this subject up to date, prepared by Dr. J. B. Lindsey of the Massachusetts Station, may be found in Agricultural Science, Vol. VII, No. 2, p. 50.

As various preparations of leather are to be had in our markets at comparatively low rates, the following experiments were made

to test the effect of roasting, steaming and acidulating leather on the availability of its nitrogen.

The preparations used were as follows:—

1. Leather and garbage. This material, which is fine and easily pulverized, contains a considerable proportion of leather, but we have no precise information regarding its source or method of manufacture. It was purchased for us from a broker. The sample contained 7.26 per cent. of nitrogen.

2. Raw leather (hemlock-tanned, sole leather chips) ground to a fine powder, which contained 6.61 per cent. of nitrogen.

3. Roasted leather, made from the same raw leather by powdering and heating in an air bath at 240° C. for four hours. It contained 10.24 per cent. of nitrogen.

4. Steamed leather, prepared from the same raw leather, by heating over water in the autoclave for $1\frac{3}{4}$ hours at a pressure of 58 pounds to the square inch. It formed a gummy mass which after drying at 100° C. in a water bath became friable, and contained 7.11 per cent. of nitrogen.

5. Dissolved leather, obtained as follows: To 36 parts of hot oil of vitriol, free from nitrogen, were gradually added, with constant stirring, 32 parts of pulverized raw leather, like No. 2 above mentioned. This was more than the acid would at once blacken. The mass was rubbed thoroughly together and heated till fumes of sulphurous acid began to appear. The acid was then nearly neutralized with carbonate of lime and the mixture was dried on the water bath till it became friable. It contained 2.07 per cent. of nitrogen and gave no reaction for tannic acid when tested in the usual way with iron-salt.

TABLE X.—COMPARATIVE AVAILABILITY OF NITROGEN IN VARIOUS PREPARATIONS OF LEATHER.

Pot No.		Quantity of Nitrogen in Fertilizer.	Crop Increase.	Nitrogen Increase.	Relative Crop Increase when Nitrate = 100 per cent.	Relative Nitrogen Increase when Nitrate = 100 per cent.
9	Nitrate of Soda	.8	96.72	.367	100	100
10	" "	1.6	137.71	.850	100	100
138	Leather and Garbage	.8	22 51	.122	23.3	33.2
139	" " "	1.6	62.10	.240	45.1	28.3
135	Raw Leather	.8	none	none	none	none
136	" "	1.6	none	none	none	none
142	Steamed Leather	.8	6.32	.030	6.5	8.1
143	" "	1.6	9.73	.036	7.0	4.2
146	Roasted Leather	.8	4.24	.023	4.4	6.3
147	" "	1.6	12.03	.054	8.8	6.3
137	Dissolved Leather	.8	70.10	.291	72.5	79.3

It appears that raw leather finely pulverized was absolutely inert under the conditions of this experiment, that steamed and roasted leather were so slowly available as to be nearly worthless but that the nitrogen of leather which had been heated with more than its own weight of oil of vitriol was as available as that of dry fish or horn and hoof. This last result, of a single test, needs confirmation.

The nitrogen in the mixture of leather and garbage was less than half as available as that of fish, or horn and hoof.

The Availability of the "Organic" Nitrogen of Mixed Fertilizers.

Under the general name of "animal matter" a considerable number of inferior or perhaps nearly worthless nitrogenous manufacturing wastes are now offered to makers of commercial fertilizers. Very often nothing can be learned regarding their nature, or fertilizing value. Some of them moreover can be mixed with dried blood or with tankage in considerable quantity without betraying their presence on casual examination.

It is an important question whether any considerable amount of this suspicious material enters into our market in mixed goods.

In 1893 this Station tested every mixed fertilizer that came into the laboratory, by determining how soluble its organic nitrogenous matter was in water and pepsin-hydrochloric acid.* The result of this study was follows :

"Of the 125 brands of mixed fertilizers examined, this method accordingly finds that 105 were above suspicion, 12 were near the danger line, and 8 were to be suspected of containing some comparatively worthless form of organic nitrogen. The method cannot at present do more than create a strong presumption for or against the quality of the goods."

It was decided this year to test if possible the value of the organic nitrogen of certain mixed fertilizers by practical pot cultures.

For this purpose it was needful to separate the organic nitrogen from accompanying nitrates and ammonia salts as well as from fully soluble phosphates, potash, etc.

This was accomplished by washing with water as follows: 250 grams of each fertilizer were shaken in a fruit jar with 300^{cc} of cold water and after standing some time 200^{cc} of the liquid were poured off through a paper filter, 200^{cc} of water were added to

* Rept. Conn. Exp't. Station, 1893, 223.

the residue in the jar, shaken, let stand until nearly clear and poured off as before. This process was repeated six times.

The residue was then brought on the filter and washed sufficiently to collect all the solid particles. The residue was then dried, separated from the filter, weighed, ground and sifted to pass circular holes $\frac{1}{25}$ inch in diameter.

Nitrogen was determined in this washed residue as well as in the original material.

It is therefore possible to compute the quantity of organic nitrogen which was undissolved by water during the washing process.

Of the thirty-nine mixed fertilizers tested, the proportion of organic nitrogen undissolved by washing with cold water was

In 1 case	more than			95	per cent.
" 7 cases	between	85	and	90	"
" 5 "	"	80	"	85	"
" 6 "	"	75	"	80	"
" 4 "	"	70	"	75	"
" 7 "	"	65	"	70	"
" 5 "	"	60	"	65	"
" 3 "	"	60	"	40	"
" 1 "	less than			40	"

It appears then that in washing, a considerable portion of the organic nitrogen has in most cases been dissolved.

The vegetation tests are therefore made only *on that portion of the organic nitrogen which was undissolved by cold water.*

Certain preliminary experiments had indicated that the solubility of the organic nitrogen was not nearly so great as it proved to be in many cases. The results are accordingly less valuable than was expected.

The general result of the vegetation test made with twenty-seven mixed fertilizers is as follows:

In fifteen of the fertilizers, the part of the organic nitrogen which was undissolved by cold water appeared to be rather less available than that of dried blood.

If the availability of nitrogen in nitrate of soda is called 100, and of that of Blood 77, then the availability of the nitrogen of these fifteen fertilizers is between 60 and 70.

In one other case the relative nitrogen availability was							78	.0	
" two others	"	"	"	"	between		55	and	60
" four	"	"	"	"	"	"	50	"	55
" two	"	"	"	"	"	"	45	"	50
" two	"	"	"	"	"	"	40	"	45
" one	"	"	"	"	"	"	35	"	40

While it is true that this statement refers only to a portion of the organic nitrogen,—the part which was undissolved by cold water,—it is nevertheless evident that there are very decided differences in the availability to plants as well as in the solubility in water of the organic nitrogen of mixed fertilizers. These differences we believe can only be demonstrated by vegetation experiments made in general like those here described.

Field tests, as usually conducted are quite unfit for this purpose, however useful they may be in other ways.

In future experiments it is hoped that the entire organic nitrogen of mixed fertilizers may be practically tested in pot culture. Further discussion of the results of the present year is therefore reserved.

In concluding the account of our vegetation experiments it may be well to supplement the description, by a few illustrations.

The accompanying plates, III, IV, V and VI, show the appearance of five cultures at four different periods of growth.

Pot 9 received at planting time, June 17, .8 gram (12 grains) of nitrogen in form of nitrate of soda while the other pots 1, 2, 3 and 4 had no nitrogen except what came from the seed, and the very small quantity which the artificial soil supplied. In all other respects the soil of the five pots was fertilized in the same manner.

The first picture, Plate III, was taken July 20th.

No. 9 had reached a height of about 57 inches, the foliage was dark green and the whole appearance very thrifty. Nos. 1, 2, 3 and 4 were about 14 inches high, the leaves were yellowish or reddish, growth was at a standstill, and as new leaves developed, the old ones withered.

On August 6th, there was added to the soil of No. 1, .8 gram of nitrogen in form of nitrate of soda.

Within four days the color of the foliage improved and on August 16th, the second picture was taken, Plate IV. It is quite evident here that new growth has begun, and that the plant which showed most strength appropriates the nitrogen supply most promptly and effectively under the changed conditions. The other three plants have made no appreciable growth.

The next two pictures Plates V and VI show the appearance of this series on Aug. 28 and Sept. 18. In the meantime the crop of pot 3 had been harvested.

The plants in pot 1 made good growth, though of course greatly

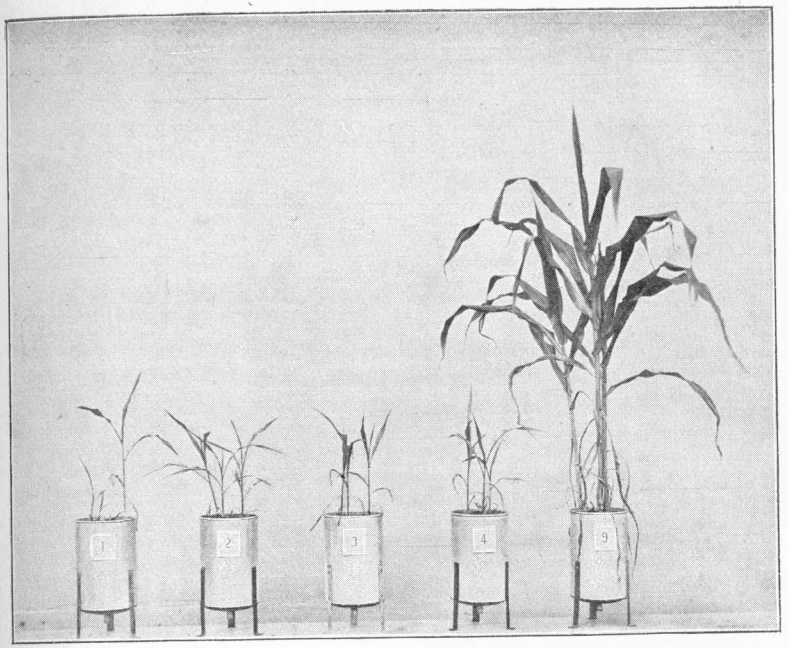


PLATE III. Effects of Nitrate of Soda.

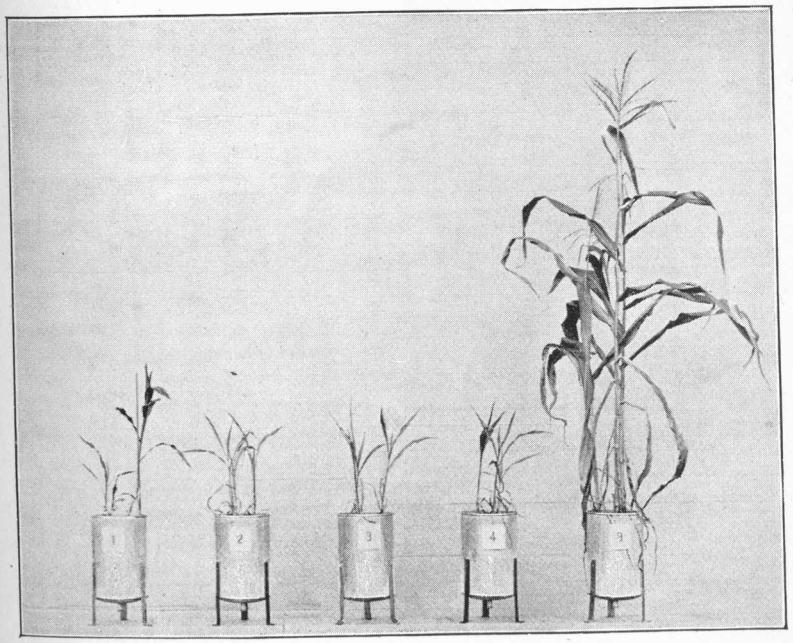


PLATE IV. Effects of Nitrate of Soda.

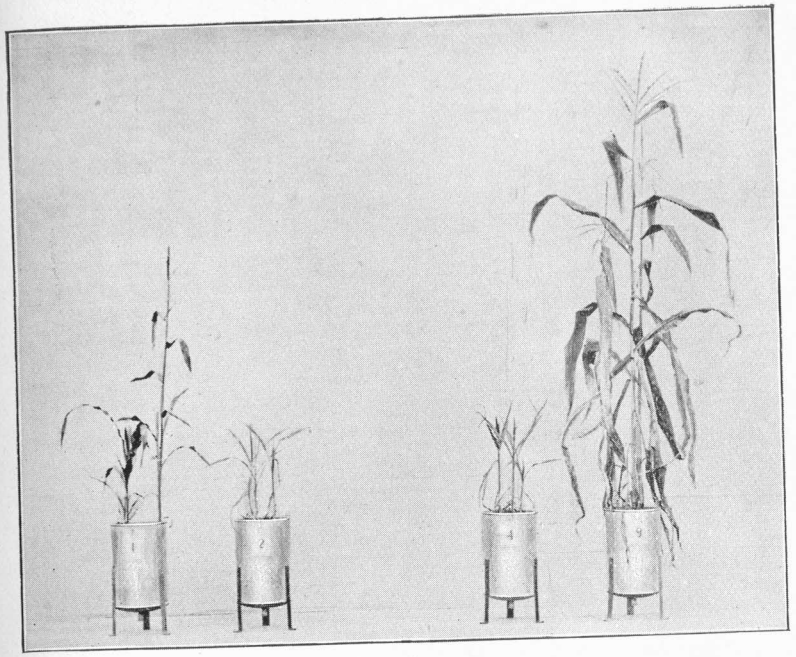


PLATE V. Effects of Nitrate of Soda.

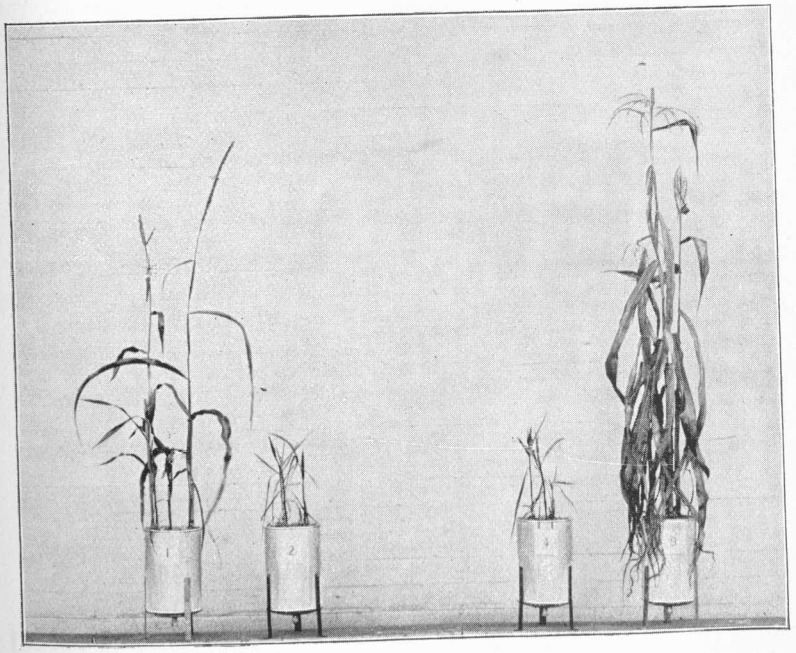


PLATE VI. Effects of Nitrate of Soda.

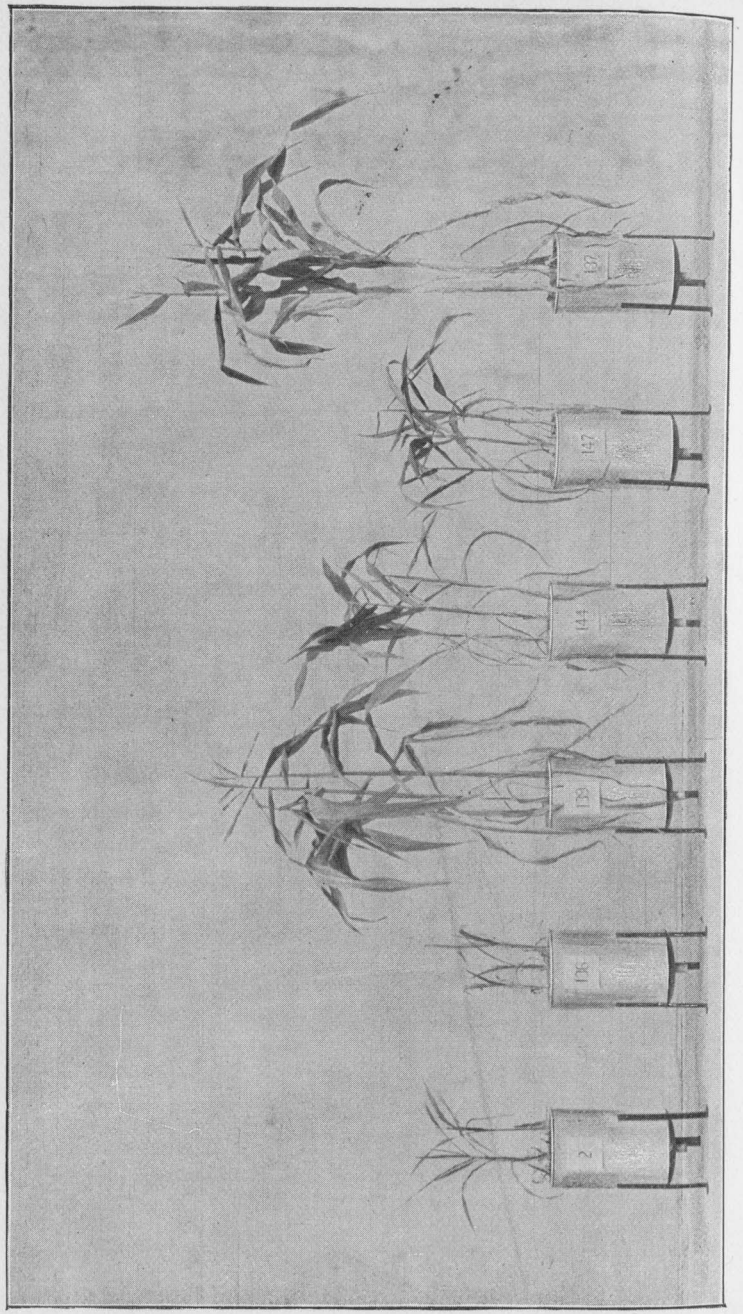


PLATE VII.

inferior to those in pot 9, and two of them developed diminutive ears.

The plants in 2 and 4 stood without any real growth through the whole season.

Plate VII shows the relative value of the different preparations of leather described on page 101. Beginning at the left of the picture, pot No. 2, received no nitrogen, pot 136, received 1.6 grams of nitrogen in form of pulverized raw leather, pot 139 received the same quantity of nitrogen in "leather and garbage," pot 144 received steamed leather, pot 147, roasted leather and pot 137 received only half as much nitrogen as the others, but in form of "dissolved leather."

The picture as well as the analytical results indicate that raw leather was rather worse than useless as a source of nitrogen, that the nitrogen of roasted and steamed leather was of very little value as as a fertilizer, "leather and garbage" did better than these last, thanks to the garbage ingredients, but dissolved leather did much better than any thing else in the series.

II. RELATIVE SOLUBILITY OF ORGANIC NITROGENOUS MATTERS IN PEPSIN-HYDROCHLORIC ACID.

Raw Materials used in Fertilizers.

For the results of work done in past years on this subject reference may be had to the Seventeenth Report of this Station, 1893, pp. 218–223.

This year the thirteen materials tested by vegetation experiments as described on pages 94 to 96 of the present Report have also been examined as to their solubility in pepsin-hydrochloric acid, in order to ascertain if there was any relation between the relative availability and the relative solubility (in pepsin-solution) of their nitrogen.

The method followed is precisely that described on page 219 of the Seventeenth Report.

The results are given below in Table XI.

TABLE XI.—SOLUBILITY IN PEPSIN-HYDROCHLORIC ACID OF ORGANIC NITROGEN IN VARIOUS RAW MATERIALS.

	Total Nitrogen in per cent. of the substance.	Pepsin-soluble Nitrogen in per cent. of the substance.	Pepsin-soluble Nitrogen in per cent. of total Nitrogen.
Dried Blood	13.20	12.31	93.3
Castor Pomace A	5 40	4.64	86.0
Castor Pomace B	5.56	4.94	88.9
Cotton Seed Meal	7.38	6.59	89.3
Dry Fish	9.34	7.46	81.0
Horn and Hoof	15.59	5.46	35.0
Tankage	4.17	2.84	68.1
Linseed Meal	5.75	5.27	91.6
Leather and Garbage	7.26	2.98	41.0
Raw Leather	6.61	.57	8.6
Steamed Leather	7.11	1.44	20.3
Roasted Leather	10.24	.87	8.5
Dissolved Leather	2.07	.11	5.3

What connection there is between the solubility of these materials in pepsin-solution and the availability of their nitrogen as determined by vegetation experiments may be seen in Table XII.

The second column of this table contains the figures which express the average relative availability of the nitrogen as determined by the vegetation experiments which have been described on pages 94 to 96 and page 101 of this report.

The third column is calculated from the last column of Table XI by multiplying the figures expressing the relative solubility of the nitrogen in pepsin-solution by the factor .826. By this means the figure in the third column (77.1) representing the solubility of the nitrogen of dried blood in pepsin-solution is made the same as that in the second column representing the availability of the nitrogen of dried blood, as determined by vegetation experiments. Hence if there were absolute agreement between the relative availability of the nitrogen and its relative solubility in pepsin-solution, the figures in the third column should be the same as the corresponding ones in the second column.

TABLE XII.—COMPARISON OF NITROGEN AVAILABILITY BY MAIZE AND SOLUBILITY IN PEPSIN-SOLUTION.—RAW MATERIALS.

	Relative Availability.	Relative Solubility in Pepsin-Solution.
Dried Blood	77.1	77.1
Castor Pomace B.	85.2	76.5
Linseed Meal	79.6	75 6
Cotton Seed Meal	75.5	73.8
Castor Pomace A.	73.9	71.0
Horn and Hoof	72.1	28.9
Dry Fish	69 8	66.9
Tankage	67.9	56.2
Leather and Garbage	30.8	33.8
Raw Leather	0.0	7.1
Steamed Leather	6.2	16.8
Roasted Leather	6.3	7.0
Dissolved Leather	79.3	5.3

With three exceptions, the agreement between these two columns of figures is satisfactory.

In general, therefore, the solubility of the nitrogen of these samples in pepsin solution was a fairly good measure of the relative availability of the nitrogen to the corn plant under the conditions of our vegetation experiment.

The difference between the results obtained with castor pomace B. (8.7) is hardly significant. The difference in case of tankage (11.7) is more pronounced.

In the case of horn and hoof the relative availability of the nitrogen is not indicated in the least by its solubility in pepsin solution. The former is represented by the figure 72.1, the latter by 28.9.

The same is true of the dissolved leather, where the availability of the nitrogen is represented by 79.3, the solubility in pepsin by 4.3.

In the case of horn and hoof we believe the discrepancy is one which cannot possibly be attributed to errors of experiment. Our tests previously made are confirmed by the results of this year and prove that pepsin-solution will not under the conditions of the test dissolve more than about 30 per cent. of the nitrogen of horn and hoof.

The results of the four vegetation tests made this year were consistent and showed that the nitrogen of horn and hoof was as available as that of castor pomace, dry fish and tankage.

Wagner's vegetation experiments carried on for three years on small plots of soil and with other crops than maize also showed that the nitrogen of horn and hoof was as available as that of fish guano or bone meal.

But the nitrogen of castor pomace, dry fish, tankage and bone, which in these experiments proved to be no more available to crops than that of horn and hoof, dissolves in pepsin-solution far more readily. Solubility in pepsin-solution is no indication, therefore, of the availability of the nitrogen of horn and hoof.

The sample of dissolved leather contained a very large amount of sulphate of lime produced when the oil of vitriol was neutralized by carbonate of lime, as described on page 101.

Previously to digestion with pepsin-solution the gram portion of dissolved leather was digested for an hour with 250^{cc} of .2 per cent. hydrochloric acid and then washed copiously with cold water. While our experiments have shown (Report, 1885, p. 121), that a very large amount of gypsum interferes considerably with the solvent action of pepsin-hydrochloric acid, it was believed that this preliminary treatment would nearly, if not entirely, remove the excess of gypsum. The tests prove, however, that the nitrogen is almost entirely insoluble in pepsin-solution.

We have, on the other hand, but a single vegetation experiment with this sample, and the result obtained requires confirmation by further experiment.

The Organic Nitrogen of Mixed Fertilizers.

The method of removing ammonia salts and nitrates from mixed fertilizers has been described on page 102.

The vegetation tests, as described on page 103, were made with that portion of the organic nitrogen which was insoluble in cold water.

The following determinations of solubility in pepsin-solution were *also* made on the portion of organic nitrogen insoluble in water, using the same preparations which had been made for the vegetation experiments.

Six fertilizers were selected, Nos. II, V, XI, XII, XVI, and XVIII (pots 51, 52, 57, 58, 68, 69, 70, 71, 78, 81, 82), being those which had shown the lowest nitrogen availability. The method of digestion with pepsin-solution was the same described above. Table XIII presents the results.

The third column of the table is obtained by multiplying the figures of the second column by the factor .826, as described on page 106.

If there were absolute agreement between the tests of relative nitrogen availability and relative nitrogen solubility in pepsin solution, the figures in the third column should be identical with the corresponding figures in the first column. There appears to be no satisfactory agreement between the two.

TABLE XIII.—COMPARISON OF NITROGEN AVAILABILITY BY MAIZE AND SOLUBILITY IN PEPSIN-SOLUTION.—MIXED FERTILIZERS.

	Relative Availability.	Solubility in Pepsin-Solution.	Relative Solubility.
II	52.9	75.3	62.2
V	51.4	64.0	52.8
XI	49.7	73.2	60.5
XII	48.4	67.4	55.7
XVI	39.6	55.0	45.4
XVIII	42.9	83.2	68.7

III. ON THE SOLUBILITY BY PUTREFACTION OF THE NITROGEN OF RAW MATERIALS USED AS FERTILIZERS.

The rapidity with which a nitrogenous substance decomposes by the action of microbe life, under favorable conditions, gives some indication of the value of the material as a source of nitrogen supply to growing plants. Thus leather, an animal tissue rendered proof against rapid decay by tanning, is inert as a fertilizer; but the untanned tissue, which decays readily, is a source of nitrogen available to plants.

Yet the compounds formed from different nitrogenous materials during decay differ in character and are probably not all equally available as plant food.

So that the value of a given nitrogenous substance as a source of plant-nitrogen depends both on the rapidity with which it decomposes in the soil and the nature and relative amount of the substances which are first formed from it (whether ammonia, amido-bodies, ptomaines, nucleins, etc.).

In continuation of work described in our Report for 1893, pages 223 and 228, samples of the same raw materials which have been tested by vegetation experiments, as just described, pages 94

to 96, and page 101 and by pepsin-solution, pages 105 to 108, have also been compared as regards the solubility of their nitrogen under putrefaction.

The method followed was the same described in the Seventeenth Report of this Station, 1893, page 228.

It was in brief as follows:—In a flask of sufficient capacity the substance suspended in water, containing a small quantity of tobacco ashes and having a *very* slight alkaline reaction, and sterilized by boiling, was inoculated with an extract of mixed manure and putrefying meat.

The flask was kept at 30°–40° C. for four weeks. The extent of decomposition was determined after two weeks and again after four weeks, as shown in Table XIV, which presents the results of the experiments in detail.

Under this putrefactive process which was certainly most favorable to rapid decomposition those forms of nitrogenous matters which are most valued as fertilizers (excepting tankage) had yielded up a half of their nitrogen or more in form of ammonia, and a considerably larger proportion of it had become soluble in water.

During the experiment in some cases a considerable quantity of nitrogen escaped from the flasks, presumably as carbonate of ammonia.

TABLE XIV.—SOLUTION OF ORGANIC NITROGEN DURING PUTREFACTION.

		Dried Blood.	Castor Pomace B.	Linseed Meal.	Cotton Seed Meal.	Castor Pomace A.	Horn and Hoof.	Dry Fish.	Tankage.	Leather and Garbage.	Raw Leather.	Steamed Leather.	Roasted Leather.	Dissolved Leather.
Nitrogen in Sample		13.20	5.56	5.75	7.38	5.40	15.59	9.34	4.17	7.26	6.61	7.11	10.24	2.07
After 14 days.	Nitrogen in Solution as Ammonia	6.68	3.18	2.42	3.52	2.60	3.05	4.72	1.66	1.96	.36	.68	.18	.68
	" " organic	2.29	.93	.72	1.02	1.10	2.63	1.64	.63	1.42	.66	1.09	.10	.12
	Total	8.97	4.11	3.14	4.54	3.70	5.68	6.36	2.29	3.38	1.02	1.77	.28	.80
Per cent. of the total Nitrogen gone into Solution		68.0	73.9	54.6	61.5	68.5	36.4	68.1	55.0	46.5	15.4	24.9	2.7	38.6
After 30 days.	Additional Nitrogen in Solution as Ammonia	.61	.17	.15	.35	.16	.80	.03	.48	.35	.65	.07	.08	.00
	Additional Nitrogen in Solution, organic	.57	.29	.58	.12	.26	.24	.78	.15	.26	.27	.07	.06	.07
Per cent. of total Nitrogen gone into Solution since the previous filtration		8.9	8.3	12.7	6.3	7.7	6.6	8.6	15.1	8.4	13.9	1.9	1.3	3.3
Per cent. of total Nitrogen in Solution as Ammonia		55.2	60.2	44.7	52.4	51.1	24.7	50.8	51.3	31.8	15.3	10.5	2.5	32.8
Per cent. of Nitrogen in Solution, organic		21.6	21.9	22.6	15.4	25.2	18.4	25.6	18.7	23.1	14.1	16.3	1.5	9.1
" " escaped*		14.6	1.9	9.1	5.9	8.9	4.9	8.0	3.6	4.2	0.0	1.3	8.1	0.1
" " left undissolved		8.6	16.0	23.6	26.3	14.8	52.0	15.6	26.4	40.9	70.6	71.9	87.8	58.0
		100 0	100.0	100 0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Escaped into the air as ammonia or other gas.

To compare these results with those given in Table XII, page 107, the solubility of dried blood under putrefaction (91.4 per cent.) is called 77.1 per cent. as in Table XII, and the solubilities of all the other materials are *correspondingly* reduced. Hence if there were perfect agreement between the relative solubility in pepsin solution and under putrefaction there would be perfect agreement between the corresponding figures. The comparison appears in Table XV.

TABLE XV.—COMPARISON OF NITROGEN AVAILABILITY BY MAIZE, SOLUBILITY IN PEPSIN-SOLUTION, AND SOLUBILITY IN PUTREFACTION.

	Relative Availability.	Relative Solubility In pepsin-solution	Relative Solubility By putrefaction.
Dried Blood	77.1	77.1	77.1
Castor Pomace B	85.2	76.5	70.8
Linseed Meal	79.6	75.6	64.4
Cotton Seed Meal	75.5	73.8	62.1
Castor Pomace A	73.9	71.0	71.8
Horn and Hoof	72.1	28.9	40.4
Dry Fish	69.8	66.9	70.9
Tankage	67.9	56.2	62.1
Leather and Garbage	30.8	33.8	49.8
Raw Leather	0.0	7.1	24.8
Steamed Leather	6.2	16.8	23.7
Roasted Leather	6.3	7.0	10.3
Dissolved Leather	79.3	5.3	35.4

The results show no satisfactory agreement with the results obtained either by vegetation experiments or by solubility in pepsin.

The relative solubility in pepsin-solution has this year agreed much more nearly with the relative availability as determined by vegetation tests, than has the relative solubility by putrefaction.

A further study of these methods is planned in the coming year.

FIRE-BLIGHT.

(*Micrococcus amylovorus*, Burr.)

By WM. C. STURGIS.

For some years there has been prevalent in certain parts of the country, a bacterial disease affecting pear, apple, and quince trees, and known familiarly as "Fire-blight" or "Twig-blight." This serious disease early engaged the attention of specialists, and now its nature and course have been accurately determined, and a line of treatment recommended which promises good results.

For the past two years I have watched the gradual spread of this disease, and the time has come when it should receive the serious attention of Connecticut fruit-growers. It will be well therefore to consider briefly the nature of this disease, its contagious character, and the means which may be taken to check its ravages.

This disease has been known for the past hundred years, the first recorded paper upon the subject bearing the date 1794. At that time it was attributed to a borer, and for eighty years the theories advanced as to its cause were almost as numerous as were the observers. The two theories which received the most general acceptance were (1) that the disease was primarily due to the borer, *Scolytus Piri*, and (2) that it was due to winter freezing of the sap whereby a poison was engendered which destroyed the young shoots the following season. It was not until 1880 however, that any theory was advanced, based upon accurate scientific observation. In that year Prof. Burrill published the results of his investigations tending to prove that "fire-blight" was directly caused by a specific bacterial organism of minute size which he named *Micrococcus amylovorus* from its destructive effects upon the amylum or starch-contents of the cells attacked. The admirable work of Prof. Arthur in 1884 and subsequent years, has established this fact beyond doubt. Not only were the bacteria found in every case, filling the cells and exuding on the exterior of the parts affected, but the inoculation of sound trees with pure virus obtained from diseased trees resulted in the transfer of the disease in a virulent form. That the disease was due to the bacteria themselves and not to any soluble poisonous substances or ptomaines excreted by them, was abundantly proved by the fact that trees inoculated with the

liquid obtained by filtering a pure culture of the bacteria through a porous earthenware cell, and thus freeing it from the bacteria, failed to produce the disease; while trees inoculated with the unfiltered liquid still containing the bacteria, invariably showed abundant evidences of the disease in the course of a few days.

Trees liable to the disease.

In this neighborhood "fire-blight" is most commonly found upon pear trees, but it also attacks the apple and the quince, and may be mutually transferred by inoculation or by the natural means of infection. It has also been proved by Arthur that the common Service-berry (*Amelanchier Canadensis*), the English Hawthorn (*Crataegus Oxyacantha*) and the Evergreen Thorn (*C. Pyracantha*) are subject to the disease.

Appearance of the disease.

The first indication of "fire-blight" is seen in the blackening of the leaves of young shoots; when this symptom becomes manifest, the disease has already been in progress for two or three weeks. Later the twigs themselves become blackened and dead and in severe cases, especially in damp weather, there appears upon the surface of the affected parts a slimy film or exudation. Occasionally the disease makes its appearance on the larger branches of the trees, or even upon the trunk, when in outward appearance it suggests the physiological injury commonly known as "sun-burn" or "sun-scald." Finally it may in rare instances attack the fruit, producing upon the surface watery ulcers accompanied by a brown discoloration and decay. In all cases the disease is characterized by a more or less distinct putrefactive odor.

Mode of Infection.

The bacteria causing "fire-blight" are extremely minute, oval or rod-shaped organisms, occurring in vast numbers in the diseased tissues, and possessing to a slight degree the power of motion. When separated from the tissues, they may be grown in various liquids such as infusions of hay, starch, corn-meal, cooked pear, manure, or garden soil, or upon gelatine containing nutrient substances; in other words they may live and multiply indefinitely upon dead vegetable matter in the presence of moisture. This fact has an important bearing upon the spread of the disease.

The bacteria as they exude from the diseased tissues are washed down by the rain, or fall to the ground with the leaves and twigs containing them; upon the decomposing vegetable matter surrounding them they multiply with rapidity, and when dry are disseminated by the wind, or by currents of water. Borne by the air in spring time they find a lodgment upon the neighboring trees; on the moist surfaces of the delicate parts of the flowers and upon the growing, succulent tissues of the young twigs and leaves, they find favorable conditions for growth, soon enter the tissues, and in the course of a few weeks give external evidence of their presence in blackened leaves and shoots. According to Arthur and Waite the moist surface-tissues of the flowers and especially of the nectaries afford suitable conditions for the growth of the bacteria, which multiply in the nectar and are thence carried by insects from flower to flower and also to other trees. Waite is authority for the statement that an artificial epidemic of blight may be started by infecting a few trees on the edge of an orchard, and allowing free access of insects; and that protecting the flowers from visits of insects will protect from blight. This is only partially true as it leaves out of consideration agencies of infection other than insects. Very tender tissues and a moist atmosphere are the primary requisites for the inception of the disease, and when it makes its appearance on the branches or the trunk it may usually be traced to spurs at the base of the limbs, or to adventitious shoots arising upon the trunk in spring. The stings of insects, open wounds whether caused accidentally or by the pruning knife, and in fact any injury which exposes the tender, growing tissues, may admit the germs and thereby indirectly cause the disease.

From the foregoing facts we may arrive at some conclusions which will be of value in considering practical methods of treatment.

(1) Inasmuch as moisture and tissues in process of active growth are conditions peculiarly favorable to the development of the bacteria, we should look for the first symptoms of the disease in the spring, and especially in damp weather.

(2) We are justified in concluding that anything which tends to force excessive growth, or the development of tender shoots upon the limbs or trunk, tends equally to the inception of the disease.

(3) That open wounds of any description whereby the delicate tissues are exposed may give access to the germs of disease.

(4) That the disease will spread outward from the locality first infected, in the direction of the prevailing winds.

(5) That varieties making slow growth, and characterized by density of the tissues will be least susceptible to the disease.

(6) That the disease is mutually communicable between the pear, apple, quince, and hawthorn.

Means of Prevention.

It is evident that in the case of "fire-blight" fungicides will be of less value than with other fungous diseases. The organisms producing the disease are so minute, they occur in such enormous numbers, and gain access to the plant through tissues either so slightly exposed as to render it impracticable to reach them with a spray, or so delicate as to be susceptible to injury from any fungicide used, that we must look to other means of prevention or eradication.

Careful examination of the orchard from time to time during the spring, and in early summer two or three weeks after the opening of the flowers, will enable anyone to recognize the first visible symptoms of the disease in the blackened leaves of the young shoots. If such shoots are at once removed by cutting them off at least six inches below the lowest point where the disease is manifest, much will have been done to prevent its recurrence. It is hardly necessary to say that it is essential to do this work early and thoroughly, even if by so doing the greater part of the new growth is destroyed; and also that the diseased shoots should be burned to ashes at once. After the middle of July there is but little danger of the active spread of the disease from one tree to another since the bacteria are then within the tissues enclosed by the bark, or if they appear externally are held together by the gummy exudation; and furthermore at that season there are but few points where the surface-tissue is sufficiently tender to allow of penetration on the part of the bacteria.

Vigorous pruning then, and the burning of all diseased parts, is the surest means of eradicating the disease when once it has gained a foothold. To prevent a second attack through the tissues exposed by pruning, the wound should be at once sealed up either with grafting wax, or better still with oil shellac to which is added a little flowers of sulphur and a few drops of carbolic acid. This forms a more or less viscous liquid and can be readily applied with a paint brush.

Secondly, care should be taken, especially in the case of trees which tend to grow rapidly and to develop soft, watery shoots, not to force growth in the spring by the application of fertilizers in

unusual quantities. The continuous and regular application of fertilizing materials to land already enriched will tend to produce a slow but continuous growth, and the young shoots will ripen as they develop. Such fertilizers as wood ashes and ground bone are to be recommended for inducing the maturing of the wood.

Those who desire more detailed information regarding the nature of "fire-blight" are referred to the original publications of Burrill and Arthur.*

Prevalence of "Fire-blight" in Connecticut.

From my own observations and from information received from others it would seem that "fire-blight" is not as yet very widely spread throughout the State. It has been reported as causing slight damage to pears and quinces at Bristol, Hartford Co.; it has done considerable damage to pears, and is on the increase, in the neighborhood of Meriden; during the past season it was very prevalent upon pears, apples, and quinces near Berlin, though not previously reported from that locality; and it attacked quinces here and there in the vicinity of New Haven. It is doubtless far more widely spread than would appear from the reports received, since it has not yet been generally recognized by the farmers of the State as a distinct and specific disease.

A "FIRE-BLIGHT" OF PLUM TREES.

By Wm. C. Sturgis.

About the middle of July last it was reported that a blight had attacked a large orchard of plum trees at East Hartford, and upon visiting the orchard I was at once struck by the resemblance of the blighted trees to pear trees affected with "fire-blight." The orchard occupied comparatively high, well-drained land, the soil was sandy, very light, and at that time extremely dry. The trees were three-year old stock of the Spaulding and Abundance varieties. The disease had attacked only the former variety, but had done great injury to the young wood. The young shoots

* Burrill, T. J., Proc. Amer. Assoc. Adv. Sci., Vol. xxix, 1880, p. 583.
Trans. Ill. Hort. Soc., 1883, p. 46.
Arthur, J. C. Rep. N. Y. Agr. Exp. Sta. for 1884, p. 357; Ibid, 1885, p. 241; Ibid, 1886 ,p. 275 (to which is appended a complete bibliography of the subject to date) Proc. Phila. Acad. Nat. Sci., 1886, p. 322.

and leaves were black, and bent over as though wilted. The leaves were dry and crisp, the twigs themselves flexible and somewhat of the consistency of soft sealing-wax. The blight had evidently started at the extreme tips of the twigs and had extended downwards a distance of from six to ten inches. In this case infection must have taken place through the young leaves, as no flowers had been produced. A number of the diseased twigs were collected for microscopic examination, and directions were given that all the affected tips should be removed and burned. On Aug. 2d I wrote asking for more samples of the disease from the same orchard, but was informed that the disease had not reappeared upon either variety and that all of the trees appeared to be healthy. Meantime specimens examined in the laboratory showed unmistakably the presence of bacteria in the diseased tissues, and there was also upon the leaves a species of Cladosporium, though this latter was apparently a common saprophytic fungus in no way connected with the disease. Specimens were sent to Prof. Arthur who kindly examined them and wrote as follows: "The appearance of the twigs is certainly that of pear blight, but I have never seen genuine pear blight attacking any of the stone fruits. I do not have any difficulty in finding the bacteria in quantity in the diseased tissues. I should say that the disease is likely to be bacterial in its nature, but not to be identical with pear blight."

Attempts to secure pure cultures of the bacteria proved unavailing, and a like result attended all efforts to inoculate pear, apple, and quince trees with virus from the plum twigs. Lack of material prevented further study of the disease. Meanwhile it is well to note the presence of this disease which, if permitted to run its course unchecked, is capable of doing very serious injury to plum stock.

EXPERIMENTS ON THE PREVENTION OF POTATO SCAB.

By Wm. C. Sturgis.

The use of corrosive sublimate in the treatment of potato scab was first suggested as the result of definite experiments, by Prof. Bolley in 1891.* The success attending those experiments led to

* N. Dak. Agr. Exp. Sta., Bull. 4, Dec. 1891.

others in various localities East and West, of which the most conclusive were those conducted by the Rhode Island* and Michigan† Stations in 1893.

Since these and other publications upon the subject are not readily accessible to the majority of farmers, it was thought advisable to repeat the experiment in a locality and upon a scale which would enable Connecticut farmers to judge for themselves regarding the value of the treatment. For this purpose a piece of land was secured through the coöperation of Mr. W. H. Olcott of South Manchester. The land adjoined Mr. Olcott's farm and measured about three-quarters of an acre; it was old meadow which had not been cultivated for many years and had probably never borne potatoes. A slight slope toward the west insured good drainage, and the soil was a sandy or gravelly loam. The rows were laid out east and west across the lot, and were, on an average, 126 feet in length. The land was prepared by ploughing and turning the sods under, harrowing, and lining out with the plough.

The course of treatment was as given by Prof. Bolley, as follows:

"Dissolve corrosive sublimate (bichloride of mercury) in water at the rate of two and one-fourth ounces of the chemical to fifteen gallons of water. Immerse all potatoes to be used for seed purposes in this solution one and one-half hours, after which they may be cut and planted as usual.

Notes: Corrosive sublimate is a strong poison; great care should be taken that none of it is taken into the stomach.

To insure rapid solution, all the chemical may conveniently be dissolved in a few gallons of hot water.

This chemical corrodes metallic substances and should therefore be mixed in wooden vessels.

A large barrel or hogshead will be found a convenient vessel in which to dip the potatoes.

A loosely woven sack (coffee-sack), will be found suitable for the dipping purposes.

If the potatoes are very dirty it will be found expedient to wash them before treatment.

After dipping spread the potatoes about so that they will dry quickly."

The seed used for planting was of three grades, (1) very scabby, the tubers being completely covered with the scab spots and quite unmarketable; (2) fairly scabby, showing a decided amount of scab but still marketable at low prices; (3) clean,

* R. I. Agr. Exp. Sta., Bull. 26, 1893.

† Mich. Agr. Exp. Sta., Bull. 108, 1894.

either completely free from any trace of scab, or exhibiting only small, isolated points of infection.

The seed was planted May 19th, 20th, and 21st; a month later the plants were making a good growth. The points upon which information was particularly desired were, (1) the effect upon the crop of the use of clean seed as compared with scabby seed, all other conditions being the same; (2) the effect of the use of barnyard manure as compared with commercial fertilizer; (3) the effect of treating the seed before planting, with corrosive sublimate, as compared with the product from seed not treated, the plants in both cases being raised on barnyard manure; and (4) the same, with the exception that the plants were raised on commercial fertilizer. No account was taken in the experiment of the varieties of seed used. It was selected solely with regard to its scabbiness or its freedom from scab, but the greater part consisted of New Queen, with some Early and Late Rose.

The land was divided into eight plots, separated by blank rows or by rows planted with clean seed and not considered in formulating the results.

The accompanying table shows for each plot the character of the seed, whether clean or scabby; the variety; the number of rows in the plot; the fertilizer used; the treatment or non-treatment of the seed with corrosive sublimate; the yield of two average rows from each plot; and the character of the crop. It will be seen that the experiment illustrates several minor points as well as those which were primarily important. The utmost care was exercised in grading the product. Every tuber was freed from dirt as thoroughly as was possible without washing, and carefully examined. If it showed the scab in quantity sufficient to render it practically unmarketable, it was classed as Grade 3; if slightly scabby, but marketable, or such as might generally be used as seed, it was classed as Grade 2; Grade 1 included only such tubers as showed, after careful examination, not the slightest trace of scab. Each grade in each plot was kept separate, measured, weighed, and photographed.

About the middle of July the tops were attacked by "early blight" (*Macrosporium Solani*, E. & M. ?), and they also suffered somewhat from sunburn, the weather being excessively hot and dry, and from the depredations of flea-beetles, but the damage was not sufficient to vitiate the results.

The potatoes were dug Sept. 25th and 26th, and, as has been said, two sample rows were taken from each plot for comparison.

Referring now to the table, a comparison between plots B^2 and D illustrates the result of planting clean seed as compared with scabby seed, there being no treatment in either case with corrosive sublimate. The character of the crop as regards the amount of scab shows surprisingly little difference, the difference, however, being in favor of the clean seed. Very similar results obtain in a comparison between the effects produced by planting clean seed and scabby seed, both being treated before planting with corrosive sublimate. Thus a comparison between plots B^1 and C shows that the clean seed treated produced only 7% more clean tubers than the scabby seed treated. The scabby seed produced 6% more tubers which were fairly scabby, and the percentage of very scabby tubers was in both cases the same. Undoubtedly, as will be seen later, the large amount of scab present on all four plots B^1, B^2, C, and D, was due to the presence of the barnyard manure, and we may conclude, so far as a single experiment may be taken as an indication, that the treatment with corrosive sublimate avails but little in the presence of barnyard manure. It should be stated that in all cases where barnyard manure was used, the seed was planted in direct contact with the manure both above and below, thus giving to the germs of the scab fungus presumably resident in the manure, the most favorable opportunity for attacking the tubers. We must also bear in mind in forming our conclusions that whereas all barnyard manures form a medium favorable to the growth of the scab fungus, there may be a very marked difference in the amount of the fungus present, a difference depending upon the season at which the manure is made and stored, the substances which have entered into its composition, and its liability to infection from diseased potatoes fed to stock or from the refuse of a diseased crop.

We may obtain more trustworthy data regarding the effect of barnyard manure on the amount of scab, as compared with commercial fertilizer, by contrasting plots A and B^2, the seed in neither case having been treated with corrosive sublimate. On both plots the crop shows the presence of scab, notwithstanding the fact that perfectly clean seed was used and that the land was presumably free from the scab fungus, but whereas the crop raised upon commercial fertilizer shows but 4% of very scabby tubers, one-third of the crop raised on barnyard manure is very scabby. A like difference is seen between the yield of fairly scabby and of clean tubers on the two plots. In this case cer-

tainly the use of barnyard manure has very materially increased the amount of scab, even upon clean land and with clean seed. We may fairly conclude then, that the use of barnyard manure is decidedly conducive to scab.

We may go one step further and compare the effect of barnyard manure and of commercial fertilizer used in connection with scabby seed treated with corrosive sublimate. Plots C, H, and B^2 present figures for comparison upon this point. Plot C offers every opportunity for a large percentage of scab except that the seed has received a presumably preventive treatment. Leaving the treatment out of account, we should expect a far larger percentage of scab than in the case of plot B^2, for example, where clean seed was used. As a matter of fact however, the results show only half as large a percentage of very scabby tubers and 5% more of clean tubers. In the case of plot C then, the treatment has been of undoubted value in lessening the amount of scab even under conditions otherwise most favorable to its spread.

But that the treatment has not been able entirely to overcome the conditions induced by the presence of the barnyard manure, becomes evident upon a comparison of plots C and H. Upon plot H, the treatment of the seed with corrosive sublimate has produced from scabby seed upon commercial fertilizer, a crop practically free from very scabby tubers, and showing only 15% of tubers at all affected with scab. With this favorable showing, the 15% of tubers rendered unmarketable by scab on plot C, evidently the result of the manure, is in marked contrast. There is good reason to believe that had the seed upon plot H been clean, there would have been no trace of scab upon the crop.

We may conclude then, that while the effect of barnyard manure upon the spread of scab may be partially counteracted by treating the seed with corrosive sublimate before planting, the use of either manure or scabby seed tends to induce scab upon the tubers.

Finally, we may reach more definite conclusions upon the question of the value of corrosive sublimate as a preventive of scab, by a comparison between plots G or H, and F. On these three plots scabby seed was planted in connection with commercial fertilizer. The seed used upon plots G and H was treated with corrosive sublimate before planting; that upon plot F was not so treated, but was merely washed clean with water. Here the beneficial effect of the treatment is very evident. Plot F shows 13%

Plot.	Quality of Seed.	Variety of Seed.	Fertilizer.	Treatment of Seed.	Total yield in pounds from two sample rows.	Quality of Crop.*	Percentages of Grades 1, 2, and 3 represented graphically.
A.	Clean.	Early Rose and Late Rose.	Commercial.	0	148¼	1. 114 lbs. = 77 per cent. 2. 28¾ " = 19 " 3. 6 " = 4 "	
B¹.	Clean.	Late Rose.	Barnyard Manure.	Corrosive sublimate.	176¼	1. 55 lbs. = 31 per cent. 2. 94 " = 54 " 3. 27¼ " = 15 "	
B².	Clean.	Early Rose.	Barnyard Manure.	0	132	1. 25 lbs. = 19 per cent. 2. 62½ " = 47 " 3. 44½ " = 33 "	
C.	Scabby.	New Queen.	Barnyard Manure.	Corrosive sublimate.	144	1. 34 lbs. = 24 per cent. 2. 87½ " = 60 " 3. 22½ " = 15 "	
D.	Scabby.	New Queen.	Barnyard Manure.	0	110½	1. 17 lbs. = 16 per cent. 2. 56½ " = 50 " 3. 37 " = 34 "	
F.	Scabby.	New Queen.	Commercial.	0 Washed.	97	1. 35 lbs. = 36 per cent. 2. 49 " = 50 " 3. 13 " = 13 "	
G.	Very Scabby.	New Queen.	Commercial.	Corrosive sublimate.	148¾	1. 105 lbs. = 71 per cent. 2. 41½ " = 28 " 3. 2¼ " = 1 "	
H.	Scabby.	New Queen.	Commercial.	Corrosive sublimate.	163⅜	1. 139 lbs. = 85 per cent. 2. 24 " = 15 " 3. 6 oz. = −1 "	

* Graded according to amount of scab on tubers: 1 = 1st quality, with no trace of scab. 2 = 2nd quality, fairly scabby but marketable. 3 = 3rd quality, very scabby, unmarketable.

For effect of scabby seed, compare plots B^2 and D (not treated), Or plots B^1 and C (treated.)
For effect of manure, compare plots A and B^2 (clean seed), Or plots C and H (scabby seed.)
For effect of treatment, compare plots B^1 and B^2 (manure), Or plots G or H and F (commercial fertilizer.)

of very scabby tubers as compared with 1% from plot G, and only one tuber from plot H, while the percentage of clean tubers from plot F is only half as large as that from plot G. Plot F shows 63% of scabby tubers, plot G 29%, and plot H only 15%. The difference between plots G and H is to be attributed to the seed; on plot H fairly scabby seed was used, while for plot G pains were taken to secure seed so thoroughly infested that there was not a spot half an inch square which was free from scab. That under such circumstances only 1% of the tubers proved to be as scabby as the seed planted, is a fact which strikingly attests the value of the treatment. Plots B^1 and B^2 illustrate the same point though in a less marked degree, owing to the fact that the crop was contaminated by barnyard manure. Even in this case however, there are but half as many very scabby tubers from the treated seed as from the untreated, and 12% more of clean tubers.

We are now in a position to sum up our conclusions from this experiment.

(1) The character of the seed as regards scab, has much to do with the character of the crop. As a rule scabby seed will produce a scabby crop, other things being equal; and the amount of scab on the crop will be directly proportional to the amount of scab on the seed.

(2) In the presence of barnyard manure the tubers tend to become scabby to a degree not markedly affected by the character of the seed, whether clean or scabby.

(3) Treating the seed with corrosive sublimate before planting, avails to some extent in preventing scab when barnyard manure is used, though the amount of scab present under such circumstances may vary with the character and composition of the manure. Further experiments may compel a modification of this conclusion.

(4) The use of commercial fertilizer is not a preventive of scab, but when clean seed is planted on clean land the amount of scab is far less with commercial fertilizer than with barnyard manure. The same is true in a lesser degree when scabby seed is used.

(5) Treating scabby seed with corrosive sublimate before planting tends to decrease the amount of scab upon the tubers even in the presence of barnyard manure.

(6) The treatment of scabby seed with corrosive sublimate before planting, may produce a practically clean crop if commercial fertilizer be used, and the land be clean. Clean seed under like conditions will certainly do so.

Results obtained on the Farm of Mr. Bidwell.

It will be of interest to note certain results attending the use of corrosive sublimate in the treatment of seed potatoes on the

farm of Mr. Dwight Bidwell of South Manchester. In this case the experiment was conducted without our assistance and for the purpose of securing as clean a crop as possible, rather than of affording a distinct proof of the value of the treatment. The results therefore are merely indicative and present no means of comparison between the product from seed treated and that from seed not treated.

Field No. 1 consisted partly of reclaimed swamp land and partly of a sandy loam; it had not previously borne potatoes and hence was presumably free from scab. It was heavily fertilized with stable manure and tobacco stems, thoroughly worked in. The seed was treated with corrosive sublimate, and produced a practically clean crop. In this instance the treatment seems to have prevented infection from the manure.

Field No. 2 comprised an underdrained swamp occupying about one-half of its area, the remainder being a dry sandy or gravelly knoll. During the summer of 1893 it had borne a crop of scabby potatoes. It was fertilized with stable manure and tobacco stems. The seed was treated with corrosive sublimate, but a portion of it failing to come up, that part was replanted with seed which received no treatment. The crop showed 75% of scabby tubers. In this case the land was undoubtedly thoroughly infested with scab, and a comparison of the results with those obtained on field No. 1, would lead to the impression, though definite proof is wanting, that the scabby quality of the crop was due primarily to the infested soil accentuated by the fact that the seed used in replanting received no preventive treatment. At least we may fairly conclude that the use of land known to be infested with the scab fungus from a former crop, is to be avoided.

Field No. 3 consisted of turf land, ploughed under and harrowed. It received commercial fertilizer sown between the drills at the rate of 1200 pounds per acre. The seed was treated, but it became necessary to replant a portion of the field, and for this purpose seed was used which was slightly scabby and received no treatment. The crop from this field showed from 15% to 20% of scabby tubers. In this case it seems probable that the loss was occasioned by the use of the scabby seed.

From these facts it is evident that in order to avoid scab we must observe certain precautions.

Select if possible, clean land, that is land which has not previously borne a scabby crop of potatoes, beets, or turnips.

Select only the cleanest seed for planting.

Avoid the use of barnyard manure on potatoes if practicable. In any case, and especially if scabby seed or barnyard manure must be used, treat the seed with corrosive sublimate before planting, according to the directions given on p. 119.

Corrosive sublimate may be bought at any apothecary's for 10 to 12 cents per ounce, three ounces will be sufficient to treat enough seed to plant five acres or more. The labor of preparing the solution and treating the seed is very slight, the potatoes require no further treatment for scab during their period of growth, and the treatment involves no expense in the way of apparatus.

In view of these facts there is no reason why this treatment against potato scab should not be universally adopted by growers of potatoes, and the percentage of scabby tubers in our markets and cellars be reduced to a minimum.

The experiment conducted this year will be continued another season with the view of confirming the facts already ascertained, and of securing more information upon other cognate questions of importance.

SCAB UPON TURNIPS.

By Wm. C. Sturgis.

A form of scab proved to be identical with that occurring upon potatoes has been recorded by Bolley, upon beets.* "With the beet it does not as a rule result in cavities, but the corky formations are very extensive. It has its inception at the points where the pith rays touch the surface. It is at these points that the rootlets arise from the beet, hence the scabs injure many points on the surface that might else be occupied by the fine roots that supply nourishment. In the past few days Swedish turnips, carrots, and cabbage roots have been procured in the market, all apparently affected with the same disease. It is quite a common appearance on the turnips and I have little doubt of its identity."

During the month of November specimens of turnips were sent to the Station from South Manchester, bearing numerous scabs as seen in the accompanying illustration, Plate IX. These turnips were grown upon land which for the two years preceding the planting of the turnips, had borne potatoes, and I am informed that the potatoes were more or less scabby.

* N. Dak. Agr. Exp. Sta. Bull. 4, p. 15, with plate, Dec. 1891.

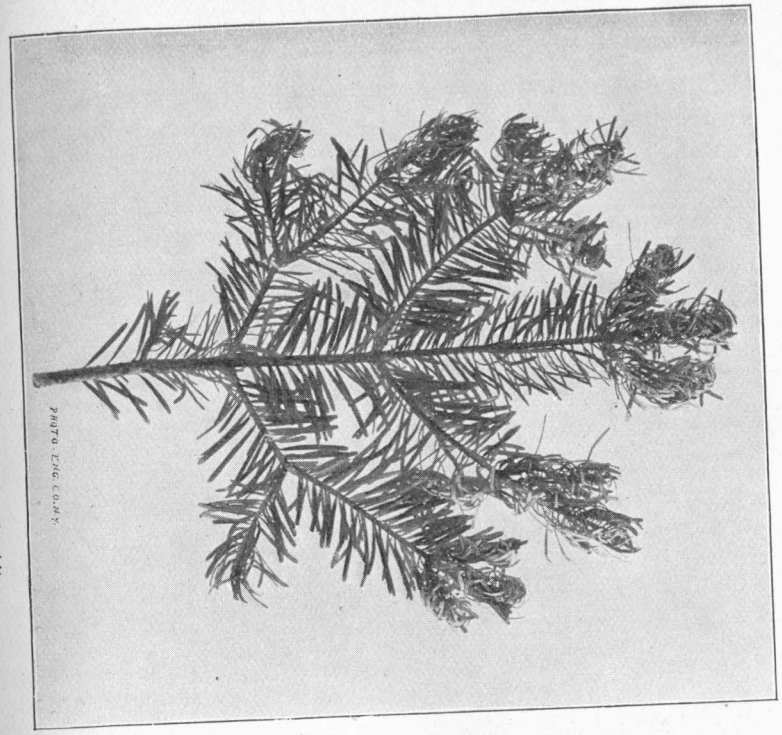


PLATE VIII. Fir Twigs injured by Fir Mite.

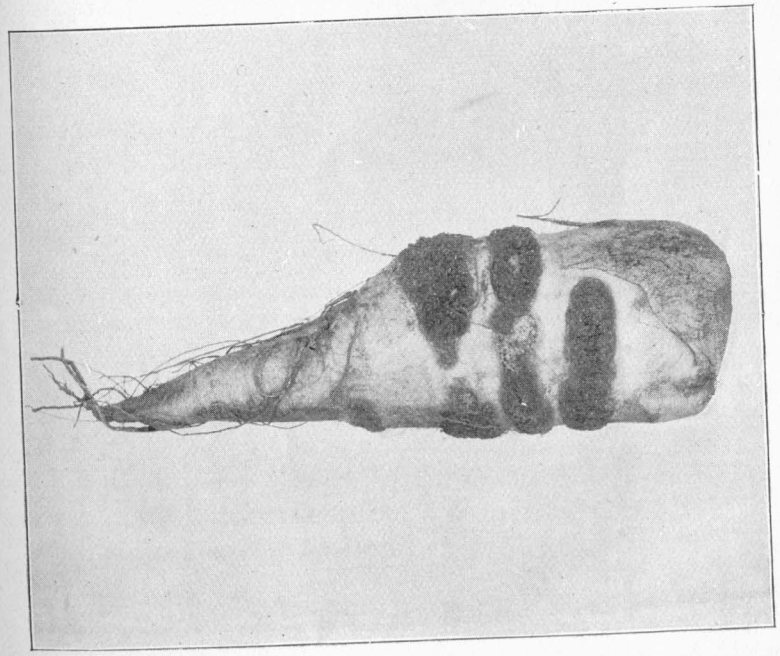


PLATE IX. Scab on Turnips.

The attention of farmers is therefore called to the fact that the scab of potatoes is communicable to turnips, beets, and possibly to other root-crops, and that it is unsafe to plant such a crop upon land known to contain the germs of the scab-fungus.

The treatment of turnips for scab presents difficulties of which there is at present no solution. Care in the selection of the land, the use of commercial fertilizers, and rotation with other than root-crops are precautionary measures which may be recommended.

NOTES ON THE "EARLY BLIGHT" OF POTATOES.

By Wm. C. Sturgis.

Public attention was first called to this disease by Humphrey, who in the Annual Report of the Mass. Agr. Exp. Station for 1891, reported its occurrence on potatoes in the neighborhood of Hadley, Mass. He also records "the constant presence in the diseased spots of mycelium, from which were developed, on the lower surface of the leaves, spore-threads and spores of the form-genus *Macrosporium*."

Almost simultaneously with the publication of this report, Jones reported a similar disease from Vermont,† and Chester noted it in Delaware.‡ The former recorded no fungus as associated with the disease, and suggested that it might be identical with a bacterial blight of potatoes first described by Burrill.§ He furthermore stated with regard to spraying, that but little if any benefit was derived from the use of Bordeaux mixture and other fungicides. Chester, on the other hand, found a species of *Macrosporium* associated with the disease, and identified it with *M. Solani*, E. & M., which occurs also upon the tomato and "Jimson weed" (*Datura Stramonium*), and he has further recorded the results of inoculations proving that the fungus is a true parasite and can be artificially transferred from the potato to the tomato. He quotes Galloway as recommending from experience the use of Bordeaux mixture in checking the trouble.

But that the diagnosis of this peculiar disease is not yet complete, is shown by the later observations of Jones. As the result of the examination of a number of diseased potato leaves, he

* Vt. Agr. Exp. Sta., Rep. for 1892, p. 67.

† Vt. Agr. Exp. Sta., Rep. for 1891, p. 131. Also Bull. 28, p. 25, Apr. '92.

‡ Del. Agr. Exp. Sta., Rep. for 1891, p. 58. Also Bull. xv, p. 13, Jan. '92.

§ Proc. 11th An. Meet., Soc. Prom. Agr. Sci. 1890, p. 21.

states,* "We are still in some doubt as to the cause of part of this trouble, and do not think that any one thing is wholly responsible. In many leaves examined we were unable to find any trace of fungous attack. In the large majority however, we found a *Macrosporium*, apparently *M. Solani*, E. & M. The general association of this fungus with the disease, leaves little doubt in our minds that it was a cause of a large part of the trouble last summer." Regarding treatment for the disease, he states that "in so far as this early blight is caused by the attacks of the *Macrosporium*, we may hope to hold it in check by spraying," and he recommends Bordeaux mixture for this purpose.

Finally Galloway states,* "For blight (*Phytophthora*) and the *Macrosporium* disease nothing so effective as the Bordeaux mixture has been found."

This evidence as well as our own experience leads us to ask whether the so-called "early blight" of potatoes is always directly traceable to fungous attack; and if not, whether Bordeaux mixture is of much practical value in treating vines which, while evidently blighted, show no trace of the *Macrosporium*. Observations made last year, and commented upon briefly in our Report for 1893, failed to show any trace of fungi in the majority of diseased leaves examined, yet the gross appearance of the leaves was exactly that described by Jones and Chester in the case of "early blight,"—small dead spots, dry and brittle in texture, usually appearing first at the tips and edges of the leaflets, and marked with dark, concentric rings; spreading slowly, especially in very hot weather; usually originating at the edges of the eroded pits caused by the flea-beetle, (*Crepidodera* sp.).

During the season just past, the weather from the early part of June to the middle of July was extremely dry, a burning sun was frequently accompanied by high winds, and potatoes suffered severely. A large number of specimens of blighted leaves were obtained by correspondence and otherwise, and were carefully examined for the *Macrosporium*. The majority of specimens showed no trace of any fungus in the tissues; in a few instances the *Macrosporium* was found in small quantities, and in one case there was an abundance of a species of *Cladosporium* occupying the blighted areas, but evidently existing saprophytically on tissues destroyed by some other agency. Traces of the flea-beetle were abundant in all of the specimens examined.

* U. S. Dept. Agr., Farmer's Bull. No. 15, 1894, p. 6.

In view of such conflicting evidence, a few additional facts may be of interest.

We have seen that the blight has accompanied in every case reported, injuries induced by the flea-beetle, and so far as I am aware, there have been no instances of early blight as a specific disease attacking sound leaves to any marked degree. It is well known that the attacks of the flea-beetle are most severe in dry, hot weather, under which conditions the early blight seems also to prevail. Opinions differ regarding the value of Bordeaux mixture, some observers claiming that it is but slightly, if at all, effective against the trouble, others that in so far as it is caused by a fungus there is a possibility of holding it in check by spraying with Bordeaux mixture, while others again state that for blight (*Phytophthora*) and the *Macrosporium* disease nothing so effective as the Bordeaux mixture has been found. It is significant however, that there are no published reports giving distinct and accurate comparative results of experiments in the treatment of the "early blight" as a specific disease. The results in this direction have been as a rule obtained incidentally in the course of experiments designed to test the value of fungicides in the treatment of the mildew or rot (*Phytophthora infestans*).

Under date of July 11, 1894, an extensive grower of potatoes and manufacturer of fertilizers in Pittsburg, Pa., wrote me to the following effect. "For about six weeks there has been almost no rain; the weather has been very close, and sun hot. Under these conditions many potato fields have been wholly destroyed, those on sandy soil suffering most." My correspondent sprayed his potato vines during the drought with Bordeaux mixture, and "cultivated" frequently, a process frequently practiced and of great assistance in increasing the capacity of the soil for retaining moisture in dry weather; his vines made vigorous growth and held up throughout the drought, while those belonging to a neighbor, which were sprayed, but received no unusual cultivation, were a complete loss.

Specimens of blighted leaves received from this gentleman showed that the flea-beetle had been abundant, and on some of the specimens there were traces of *Macrosporium*. These facts seem to add probability to the theory that extreme heat and dryness, accentuated by lack of moisture in the soil, may induce the death of tissues at a distance from the roots (the tips and edges of leaflets); that this damage may be increased and even

initiated by the attacks of predatory insects (flea-beetles) which partially destroy the tissues at certain points; and that finally in some cases a facultative parasite (a fungus which exists normally as a saprophyte upon dead tissues, but may under certain conditions attack living tissues and thus become a parasite) such as species of the genera *Macrosporium*, *Cladosporium*, etc., may attack the dead or dying tissue, and aggravate the trouble, while in other cases no such fungus attack is observable.

Such a theory seems to be in accordance with the facts observed —the appearance of "early blight" at a season usually marked by dry, hot weather; its prevalence during the extremely dry summers of the past two years; its slow progress, in marked contrast to most fungous diseases of the nature of blight, rot, etc.; the advantage gained by frequent shallow tillage, preventing the rapid evaporation of moisture from the soil; and finally the fact that in the majority of cases the injury from "early blight" is directly proportional to the damage done by the flea-beetle. There are two facts however, which, if established, would go far to prove the fungous character of "early blight." These facts are, (1) the value of a well-known fungicide in checking the trouble, and (2) the fact reported by Chester that sound potato leaves inoculated with *Macrosporium* spores exhibit in the course of a few days symptoms of the "early blight."

As regards the value of Bordeaux mixture in this case, it has already been noted that testimony upon this point is not unanimous, and various reasons may be assigned to account for its apparent efficacy. It is well known that the use of Bordeaux mixture, or in fact of any compound of copper, tends to increase the vigor of potato plants to a very marked degree, apart from any fungicidal action which it exercises. It is not improbable that the beneficial effect arising from its use in certain cases of "early blight," may have been in a measure due to this tonic action. Again, if the *Macrosporium* may become a parasite under certain conditions, just so far as those conditions prevail Bordeaux mixture would doubtless act as a preventive of the initial attack upon tissues injured by insects. Finally, upon the theory outlined above, any agency which would tend to check the ravages of the insects would equally limit the spread of the blight. Bordeaux mixture is not usually regarded as of much value as an insecticide, but the careful investigations recently conducted by Jones* prove that Bordeaux mixture acts as a

* Vt. Agr. Exp. Station, Rep. for 1893, p. 50.

deterrent against flea-beetles, and in this fact a reason may be found for the benefit arising from the use of the mixture in the case of "early blight."

A few sentences from a recent address by Prof. Jones* have a direct bearing upon this subject. "Leaves thus mutilated (by the flea-beetle) are most disastrously exposed to the effects of drought during dry weather, and to the inroads of fungi during wet weather. Indeed these secondary injuries follow so closely after the attacks of the flea-beetle, that the majority of potato growers attribute the entire trouble to these secondary agencies."

We may now consider the second fact in favor of the parasitic nature of "early blight," viz: the susceptibility of potato leaves to inoculation with *Macrosporium* spores, as reported by Chester.

If these experiments are verified, there can be no doubt but that *Macrosporium Solani* is a true parasite capable of attacking sound leaves of the potato and tomato, and inducing in them symptoms of serious disease. Upon this point I will quote a letter received from Prof. Chester, under date of July 27th, 1894: "At the outset I was myself sceptical of *Macrosporium Solani* as the immediate and active cause of the trouble, and I am still inclined to regard the fungus as perhaps a facultative parasite, capable of assuming the role of a (true) parasite only under certain conditions unfavorable to the plant. In my examinations of diseased leaves I have so far always been able to find the *Macrosporium*, although I have quite invariably found the sporophores sparsely distributed and the spores correspondingly few. This has defeated my efforts to get the fungus in artificial cultures. My efforts at inoculation had therefore to be made by placing upon healthy potato leaves, upon plants growing in the glass house, small bits of the diseased leaves, which microscopic examination showed contained the spores of *Macrosporium*. In this way I brought the spores into direct contact with healthy, growing leaves, in the presence of sufficient moisture to favor their germination. Thus I succeeded in the majority of cases in infecting both potato and tomato leaves, causing the black spots which afterwards developed a fruiting of the fungus more abundantly than was the case in nature. Whether the moisture and shading of an area on the growing leaf effected by the bit of dead leaf placed thereon, may not at the outset have etiolated the leaf at this point sufficiently to have given the fungus just

† Agricultural Science, Vol. viii, p. 364.

the needed advantage, is a question which I did not attempt to answer. However, I felt convinced at the time that the fungus spoken of was either directly or indirectly an agent in the production of the trouble. It is quite possible that the trouble is partly physiological, partly parasitic, and it is furthermore quite possible that the *Macrosporium* in question is a facultative parasite, and not a true parasite as I at first assumed. Until we can get this fungus in pure cultures on artificial media so as to have an abundance of pure material for inoculation, we cannot expect to solve the questions under discussion."

It will be readily seen that these experiments do not furnish absolute proof. Pure cultures were not obtained, and there was therefore no positive proof that the *Macrosporium* was the immediate cause of the trouble induced in the leaves; the leaves themselves were subjected to conditions seldom obtaining out of doors; and the conditions of moisture were far more favorable to fungus growth than those observed in the field when the "early blight" is most severe. In fact the atmospheric conditions coincident with the appearance of "early blight" as thus far observed, are not generally conducive to fungus growth.*

Finally, through the kindness of Prof. Jones, I was enabled to examine a number of specimens of "early blight," and to compare them with specimens obtained by myself. In these specimens a somewhat similar appearance had apparently been caused by two distinct agencies, one of which might possibly be of a physiological nature. The other might as possibly be fungous, since upon many of the leaves examined, the *Macrosporium* was evident under the microscope. Both classes of injury appeared in connection with the marks of the flea-beetle, both were exhibited as brown spots and blotches marked with concentric rings; but in the specimens characterized by the presence of the fungus the spots were more sharply defined and darker in color. This difference was sufficiently marked to enable a close observer to distinguish either one in the field after a little practice, but a comparison between the two produced the impression that both classes of injury might have been originally caused by the same agency, and that the slight difference in appearance might be due to the fact that in the one case a fungus had occupied the injured tissue, and in the other had not done so. To sum up then, the essential points of this theory: It seems possible that the "early blight" of potatoes may be due to the physiological effects of extreme heat and dryness acting upon leaf tissues at a distance from the roots, and already injured by predatory insects, especially those abundant under such atmospheric conditions; that anything which will check the ravages of the insects will in a measure check the blight; and that tissues so injured are liable to the attacks of certain fungi which may enhance the injury.

* See additional note on the "early blight" of potatoes, p. 133.

Whatever the value of this theory, the facts in the case warrant certain recommendations regarding the treatment of potatoes.

(1) Cultivate the surface soil to a little depth frequently and thoroughly especially in seasons of extreme heat and drought.

(2) Treat the vines, beginning earlier than usual, with strong Bordeaux mixture (6 lbs. copper sulphate, 4 lbs. lime, 22 galls. water), or with Bordeaux mixture to every 10 galls. of which is added 1 lb. of soap dissolved in hot water; either mixture acts as a deterrent against the flea-beetle.* When the potato-bug appears, add Paris green to the mixture at the rate of ½ lb. to 50 gallons.

(3) Prof. Jones recommends late planting in order to escape the injuries of "early blight." "Early potatoes form their tubers largely during the dryer weather of July, then, weakened by this effort, they succumb readily to the combined effects of dry weather, insect attacks, and the early-blight fungus." This practice is to be emphasized in case growers are prepared to treat their vines for the late blight or rot, which is especially liable to attack late potatoes.

ADDITIONAL NOTE ON THE "EARLY BLIGHT" OF POTATOES.

Since the above was written there has been published by Prof. Sorauer,† one of the most able vegetable pathologists of Europe, an article which bears so directly upon the subject in hand that I may be pardoned for quoting from it somewhat at length. The article deals with a tendency which the author finds among investigators to attribute true parasitism to many fungi which are found associated with disease, and to conclude from insufficient data that in such cases the fungus is the primary cause of the diseased condition. Such conclusions are usually based upon inoculation experiments, and in this connection Prof. Sorauer writes as follows: "No doubt the greater number of such observations are correct, since as a rule inoculation experiments show that such fungi as those to which our common moulds

* Vt. Agr. Exp. Sta., Rep. for 1893, p. 50.

† Zeitschrift für Pflanzenkrankheiten. Bd. IV, Heft 6, p. 325.

belong, are able to destroy an organ completely. But this evidence remains incomplete and the designation of such fungi simply as parasites is uncertain and confusing, until experimental proof is obtained that *the fungus is able to induce disease in a sound organ still retaining its normal function upon the organism;* and this proof is rarely forthcoming. I am convinced that we should make greater advances in our knowledge of diseases if we would regard parasites less as exclusive causes of disease, and more as diagnostic means for the recognition of an unhealthy condition. The determination and the study of the parasite is of value as a hint as to the direction in which the organism is functionally weak, and our attempts at remedial treatment will no longer be directed merely locally at the diseased organ, but toward a change in the economy of the organism as a whole. In many instances the observer fails to consider the question whether the infected organ may not already have been brought by separation from the organism or by being kept for some time in a damp atmosphere deficient in light, into an enfeebled condition which is the sole cause of its susceptibility. It is often possible in the inoculation of delicate tissues to induce disease in damp weather merely by closely covering the infected area on a sound leaf not detached from the plant, with a portion of another leaf, while the portion not so covered remains sound. In other cases it may be proved by experiments that two seedlings of the same species, and even two shoots on the same plant behave quite differently toward parasites, if one of them be enfeebled by excess of heat in a greenhouse, while the other is allowed to grow normally in the open air. Recent experiments show that in the case of plants which require water, excessive dryness increases their susceptibility to fungus attack."

Upon these grounds Prof. Sorauer concludes that a distinction should be made between strictly obligate parasitism and cases in which the fungus can gain a foothold only upon an injured surface, and he suggests a separation of parasitic fungi into three classes: (1) absolute parasites, attacking uninjured, healthy organs; (2) partial parasites, attacking uninjured but unhealthy organs; and (3) wound-parasites, attacking injured organs at the point of injury.

The facts elucidated in connection with the fungus associated with "early blight" would seem to justify us in including it in the second or possibly the third class, instead of in the first class as heretofore.

EXPERIMENTS ON THE TREATMENT OF PEAR-SCAB.

(*Fusicladium pirinum*, (Lib.) Fckl.)

By Wm. C. Sturgis.

The experiments of the past two years in the orchard of Mr. A. E. Plant, of Branford, were continued during the summer of 1894. As in previous years, the experiment was designed mainly to test the value of the winter treatment alone, consisting of a simple solution of copper sulphate at the rate of 1 lb. to 25 galls. of water, as compared with the same treatment enforced by treatment during the summer with Bordeaux mixture. The winter treatment was applied thoroughly on March 31st, before the buds had begun to swell appreciably, and of the trees so treated a portion received no further treatment while the remainder were sprayed with Bordeaux mixture three times, on May 4th and 17th, and June 6th. A third block of trees was reserved as a check and received no treatment of any kind. For convenience of reference we here designate the separate plots and the treatment received by each.

Plot A, received winter treatment only.

Plot B, received winter and summer treatment.

Plot C, received no treatment. (Reserved as a check.)

Plot D, received winter and summer treatment.

Plot E, received summer treatment only.

At the time of harvesting, Mr. Plant made careful notes upon the general appearance of the trees, and the extent to which "scab" prevailed upon both leaves and fruit; the following points are based upon these notes:

In plot A, the fruit was considerably spotted by "scab," especially the Lawrence variety, most of which was unfit for use. The foliage however, was retained well.

In plot B, the fruit was very little affected by the "scab," and the leaves held on well. Regarding this plot Mr. Plant writes: "The plot comprises several Lawrence trees the fruit of which has been in previous years a total loss. If we can overcome the "scab" next year in the same proportion as we did this year, then, if the trees bear, we can sell some fruit." There is no doubt but that a fourth treatment should have been given late in June or early in July. The prolonged drought of June was broken July 22d, and frequent showers ensued accompanied by much warm,

damp weather. At this time there were but slight traces of the Bordeaux mixture remaining upon the trees from the spraying of June 6th, and the small amount of "scab" upon the trees of plot B developed after the rains began. This might have been prevented altogether by an application during July.

Plot C, which was reserved as a check and received no treatment, showed considerable "scab" on both foliage and fruit, although the trees were all Bartletts, a variety which in this orchard has not been subject to severe attacks of "scab." The leaves began to shed badly in August. In picking the fruit it was very easy to distinguish the dividing line between plots C and D.

Plots D and E showed little difference in the quality of the fruit. The trees were all of the Bartlett variety and yielded a crop of perfect fruit. The leaves also were free from "scab" and were held until frost.

On the whole the conclusion seems a fair one, that the winter treatment of pears for scab hardly warrants the necessary outlay of time and money. As good results are obtained by thorough treatment during the summer only, as when such treatment has been preceded by a single application of copper sulphate in early spring. That the winter treatment is of some value however, is seen from the fact that trees so treated matured a better quality of fruit and retained their foliage better than trees which received no treatment at all.

Mr. Plant's report calls attention incidentally to one or two other points of interest, especially the effect of Bordeaux mixture upon lichens which are liable to infest the bark of pear trees. The experiments of Waite* have indeed already demonstrated the value of Bordeaux mixture in ridding pear trees of lichens; nevertheless it is interesting to note how thoroughly and permanently this result is attained. Not only were the trees which received Bordeaux mixture this season, completely freed from all lichen-growths, but the trees in plot C which were sprayed during the summer of 1893 and thus denuded of lichens, remained completely free from them this year although the trees in this plot were not sprayed. Not only are such growths a disfigurement to the tree, but they would seem to offer peculiar conveniences for the harboring during the winter, of spores which will serve to infest the trees the next spring.

* Journal of Mycology, Vol. vii, No. 3, pp. 264–268, with plates.

Finally Mr. Plant calls attention to the fact that in the case of currant bushes occupying the spaces between the rows of pear trees in his orchard, those in the neighborhood of the unsprayed trees and which therefore received no Bordeaux mixture, shed their leaves several weeks ahead of time; while those which incidentally received a portion of the spray intended primarily for the pear trees, held their leaves, and, if the mixture contained Paris green, were not affected by currant worms. These facts are worthy of note.

MISCELLANEOUS NOTES ON FUNGI.

By Wm. C. Sturgis.

The following notes upon parasitic fungi and insects are compiled from the results of personal observation in the field and from correspondence received during the past year.

Quince Rust, (*Roestelia aurantiaca*, Pk.). This rust has been abundant upon quinces during the past season. It manifests itself in swollen distortions of the young branches and fruit, the portions affected showing minute pimples which eventually produce a brilliant orange dust, the spores of the fungus. Letters received from various parts of the State indicate a prevailing impression that this disease has some connection with the "fire blight" described in the present report. The impression is a mistaken one; the two diseases are quite distinct as to both cause and effect. It may be well to repeat the fact that this rust as it appears upon quinces is but another form of the fungus common upon red cedars in spring and known as "cedar apples." The form occurring upon quinces is unable immediately to infect other quince trees, but attacks the red cedar, and it is upon the latter that the spores are produced which give rise to the quince rust. As regards treatment, my own experience indicates that the common fungicides are of little avail in preventing the disease, trees which have been sprayed continuously for four years as a protection against leaf spot (*Entomosporium maculatum*), showing rust almost equally with trees not sprayed.

In the case of the orange rust of apples, a disease very nearly related to quince rust, the successful use of Bordeaux mixture has been reported,* but as a rule it would seem more advisable to cut out and burn the diseased portions (especially in view of the

* U. S. Dept. Agr., Sec. of Veg. Path., Bull. 11, p. 46, 1890.

opinion held by many that the fungus is perennial in the tissues attacked), and to eradicate neighboring red cedars.

Scab and Mould of Peaches. (*Cladosporium carpophilum*, Thm.,) and (*Oidium fructigenum*, Kze. & Schm.) These two fungi attack plums and cherries as well as peaches. The mould, producing a grayish, powdery coating upon the fruit, and inducing rapid decay, is too well known to require any extended description.

The scab seems to have received but little recognition, yet it undoubtedly has been the cause of widespread injury to the peach crop. It may make its appearance upon the fruit at any time during the growing season, appearing first as small, circular, greenish spots, which increase in size, become darker and of a brownish color, and in severe cases may spread over the greater part of the surface of the fruit, preventing the normal expansion of the skin, retarding the ripening and mellowing of the flesh, and eventually producing deep cracks in the fruit. The fungus does not induce decay, but it renders the fruit unsightly and prevents an even ripening, thus considerably reducing its market value.

So far as I know, no definite experiments have been as yet undertaken with a view of testing the value of fungicides in preventing this disease of peaches. Bordeaux mixture has been recommended for the treatment of the disease as it affects plums and cherries;* but the peach, as shown by Arthur,† is less susceptible to successful treatment. The foliage is of great delicacy, and liable to injury from fungicides; and the downy character of the surface of the fruit prevents the fungicide from reaching the fungus thoroughly, since the latter grows upon the skin itself and is in a measure protected by the fruit hairs. Possibly early applications of weak Bordeaux mixture, containing no more than six pounds of copper sulphate and four pounds of lime to fifty gallons of water would serve to prevent the initial attack of the fungus without injury to the foliage. Experiments in this direction will be attempted during the coming season.

As regards the peach mould, the experiments of Chester‡ prove conclusively that the trouble can be largely prevented by the use of copper carbonate in suspension (1 lb. copper carbonate in 25 galls. water), the ammonia solution of copper carbonate (5 oz.

* Iowa Agr. Coll. Exp. Sta., Bull. 23, p. 920, 1894.

† Ind. Agr. Exp. Sta , Bull. 19, pp. 5–8, 1889.

‡ Del. Agr. Exp. Sta., Bull. xix, 1892.

copper carbonate, 3 pts. strong ammonia, 45 galls. water), or Bordeaux mixture. He recommends that copper sulphate in the proportion of one pound to twenty-five gallons of water be applied before the fruit buds begin to swell in early spring; that as soon as the fruit buds begin to swell either one of the fungicides above mentioned be applied, and again just before the buds open. A third application should be made as soon as the fruit shows signs of color, and two or three more at intervals of a week during the period of ripening. Whatever method of treatment be adopted, it must be borne in mind that the source of infection in this case, and probably in that of the scab, lies in the diseased fruit of the previous year. Too much stress therefore cannot be laid upon the necessity of gathering and burning all such fruit.

SOME INJURIOUS INSECTS.

By Wm. C. Sturgis.

The Onion Maggot (*Anthomyia ceparum*). Frequent complaints have been received regarding this pest, and a few notes upon the subject may prove of value. The adult insect, a small two-winged fly, deposits its eggs on the lower portion of the young onion plants during the months of April and May. In about a week the eggs give rise to small, whitish grubs or maggots which eat their way into the bulb upon which they feed for about two weeks. They then leave the bulb, enter the ground, and change to the pupa-condition, from which, in course of time, the adult flies emerge. Occasionally the maggots remain in the bulb and the brown pupæ are found in the stored onions. Several broods are produced during the summer.

Various methods of destroying this pest have been recommended. Ormerod* suggests rotation with some other crop in order that the flies emerging from the pupæ which remain in the soil, may not find onion plants at hand upon which to deposit their eggs; earthing the young plants well up above the collar so that the flies are prevented from reaching the bulb; pulling and destroying the plants first affected, by which means the migration of the maggots to sound bulbs is checked; the avoidance as far as possible of natural manures, in which the larvæ of these insects

* A Text book of Agricultural Entomology, pp. 49–56, 1892.

live; or finally the application of lime to the land. E. O. Orpet* recommends the following method which is well worth a trial. "Half a pint of kerosene is well mixed with a pailful of some dry material, preferably wood ashes, but sand, sawdust, or even dry soil will do fairly well; after the plants are well up and the trouble is at hand, a sprinkling of this mixture along the rows about twice a week during the time the fly does its work, will be found a sure prevention of the trouble. After the end of May there is little danger, as the onions are of a good size and not so liable to injury."

The Fir Mite. Early in June specimens of fir-branches (*Abies balsamia*) were received from West Cornwall, showing a peculiar curling of the young leaves at the extremities of the branches. Careful examination revealed the presence of numbers of small mites, insects belonging to the Spider Family, and related to the "red spider" commonly found upon greenhouse plants. These mites were of a dark brownish color, rather lighter beneath, and were undoubtedly the cause of the trouble. The leaves attacked were curled and twisted, showing the silvery lower surface, and in many cases were of a pale yellowish color, Plate VIII. In the axils of the leaves were to be seen the delicate webs spun by the mites. The appearance of the twigs indicated that these insects might very seriously interfere with the development of the new growth. The only reference which I have found to this subject is contained in a short note on p. 869 of the Fifth Report of the Entomological Commission of the U. S. Dept. of Agriculture, (1890). The insect is described and its effect upon the leaves is figured, but no suggestions are given as to remedial treatment.

If we may judge from analogy with what we know of the "red spider," and from the atmospheric conditions prevailing during its period of attack the past summer, we may conclude that this mite flourishes during extremely dry weather, and that in a comparatively damp season or locality there is but little fear of serious injury. In nurseries or plantations of small trees, where the tips are readily accessible, keeping the tips wet with water during very dry weather, or spraying them with a decoction of tobacco, would probably rid them of this pest.

Lice of apple and cherry trees. Much injury is caused every year to the young foliage of the apple and cherry by two species of lice, *Aphis Mali*, and *Myzus Cerasi*. The former, infesting

* Garden and Forest, Vol. vii, p. 187, 1894.

apple trees, is green; the latter, upon cherry, is black and shining. They often occur in enormous numbers, covering the lower surface of the leaves and causing them to become curled and dwarfed. The life-history of these insects is not yet fully known. In the spring the eggs which have been laid upon the twigs the previous autumn, hatch into young lice which quickly infest the leaves and suck out the juices. In ten days or less they are mature and begin producing young, thus increasing with great rapidity. Early in July they migrate from the apple and cherry to some other plant. (Webster states* in regard to the apple lice, that they migrate to wheat and other grasses). In the late summer or early autumn they return to the apple and cherry trees as winged females which at once produce a brood of wingless, egg-laying females. With the laying of these eggs the life-history is completed. If it were known definitely to what plants these lice migrated in the summer, we could the more readily suggest a remedy. As it is, kerosene emulsion or strong soapsuds seem to be the most practical substances for destroying the insects. Wherever it is possible the entire twig infested should be bent over and dipped thoroughly in the mixture; when this method is impracticable, spraying the trees frequently must be resorted to, although many of the lice will escape owing to the fact that they are protected within the curled leaves. The following modification of the kerosene emulsion has been suggested, and would seem to be more fatal to insects than the usual formula.

(1) To 3 quarts of kerosene add $1\frac{1}{4}$ pounds of pyrethrum powder, and let it stand four days in a close vessel. (2) Dissolve 10 ounces of common hard soap in $2\frac{1}{2}$ quarts of boiling water. Strain off $2\frac{1}{2}$ quarts of (1) and add it to (2) while the latter is still hot. Churn for five minutes through a force pump until the mixture is creamy. For use, dilute with 150 parts of cold water. The undiluted mixture may be kept indefinitely in glass fruit jars or other vessels, if thoroughly closed.

The Peach curculio (*Conotrachelus nenuphar*). This is the same insect which commonly attacks plums, cherries, and apples. It has not been reported as common in this State upon peaches, but from my own observations in a number of orchards I am convinced that it is far more common than is supposed and that it is to blame for much injury at present attributed to other causes. The curculio attacks the young fruit almost as soon as the petals

* Ohio Agr. Exp. Sta., 12th Ann. Rept., p. xxxv, 1894.

have fallen, cutting the well known crescent-like flap beneath which the egg is deposited. The fruit so injured is liable to fall prematurely, and if it remain upon the tree the injury soon becomes apparent from the gummy exudation oozing from the wound. Many growers are accustomed to shake the insects from the trees on to a white cloth, by means of a sudden jar, and this is perhaps the best method of destroying them; but it would seem that a very weak mixture of Paris green in water would kill the insects without injuring even the delicate foliage of the peach. A safe formula would be 4 ounces of Paris green in 45 gallons of water, to which are added 2 pounds of fresh lime slacked in 5 gallons of water. As in the case of Bordeaux mixture and Paris green, the lime tends to neutralize the caustic action of the arsenite.

The Peach bark beetle (*Scolytus rugulosus*, Ratz.). Late in September last, portions of the bark of a peach tree were sent to the Station from Cheshire, completely riddled with minute holes the size of a pin head. With the bark were specimens of a small, black beetle to which the injury was attributed. There was little difficulty in referring the insect to the species above named, a species originally imported from Europe, but now, on Bailey's authority, "widely distributed in eastern America."* The same writer states that it attacks the plum, apricot, cherry, pear, apple, quince, and some ornamental trees.

At present it is not sufficiently common in Connecticut to cause any serious apprehension, nor does it seem to attack trees which are otherwise thrifty and well cared for. Should it become a pest it could probably be held in check by applying to the bark some poisonous substance containing either Paris green, kerosene, or carbolic acid. Bailey suggests that all seriously affected branches and trees should be burned.

For fuller information upon this subject reference may be had to the investigations of Forbes published in Bull. 15 of the Ill. Agr. Exp. Station (1891).

* Cornell Univ. Agr. Exp. Sta., Bull. 74, p. 378, 1894.

NOTES ON SOME LEAF MINERS.

By W. E. Britton.

During the season of 1894, plants of several different species on and about the Station grounds were attacked by "leaf miners." Though of no great economic importance at present these insects essentially injure the plants which they attack.

The term "leaf miner" is applied to those insects which feed upon the soft interior part of the leaf just below the epidermis, and between the upper and under layers of epidermal cells which form the two surfaces of the leaf. This injury is done while the insect is in the larval or grub stage, that being the period of growth.

The egg is usually deposited just beneath the epidermis, and the larva as soon as hatched feeds upon the soft parenchymatous tissue surrounding it.

The leaf miners observed by the writer belong to two different zoölogical orders, (1) Diptera, or two-winged flies, and (2) Lepidoptera, the order including moths and butterflies.

Those here noticed belong to the Diptera. We have found a different species of insect upon each species of plant attacked, and in some cases two distinctly different insects upon the same plant. The leaves of the apple, pear, quince, grape, columbine and corn, growing upon the Station grounds, have been attacked by leaf miners during the past season, though it was only on the columbine and corn that the insects were made notably conspicuous by their attacks.

Corn Leaf Miner (*Odontocera dorsalis*, Loew).

This insect attacked the corn which was grown under glass in the vegetation experiment referred to in a previous article, page 73 of this Report. It was first noticed about July 1st when it began its operations as a miner. The adult pierces the tip of the leaf, and deposits an egg beneath the epidermis, and the larva as soon as hatched, begins tunneling between the two epidermal surfaces. The larva usually travels toward the base of the leaf, sometimes along the midrib, sometimes near the edge, and often in a crooked or zigzag path. The tunnel is very narrow, a mere line at first, but it gradually increases in width as the larva grows, and so is broadest at the end farthest from the starting point.

The tunnels vary in size and length. One was nearly straight, and measured 19½ inches in length, and ⅛ of an inch wide at the broadest part. This, however, was an extremely large one, and the dimensions of the majority were less.

The tunnel usually begins near the tip of the leaf, though not always. Sometimes several larvæ are at work in the same leaf, with tracks parallel or crossing each other. The track usually shows more distinctly from the upper side of the leaf, but can generally be seen from either side. See Plate X. It is rendered nearly white and semi-transparent by the removal of the green coloring matter of the leaf.

In the enlarged end of this tunnel the larva may be found during its feeding stage. When it becomes full-grown, it retreats an inch or two in the tunnel and enters the pupa stage which is passed inside the leaf. Like all dipterous larvæ the skin hardens, and becomes the covering of the puparium.

After a short time it emerges from its prison, punctures the skin of the corn leaf, and escapes, a small two-winged fly.

The larva is a footless grub, about ⅛ of an inch in length when full-grown. It is pale yellow in color, and almost transparent. On entering the pupa state it becomes considerably darker in color, and shrinks slightly.

The adult is a small fly. Its head, thorax, and abdomen are nearly black, slightly marked with light brown or yellow. The wings are colorless, legs yellow, and the insect is covered with hairs.

Specimens sent to L. O. Howard, Entomologist of the Department of Agriculture at Washington, and submitted by him for determination to his assistant, Mr. D. W. Coquillett, a specialist in the order Diptera, were pronounced to be *Odontocera dorsalis*, Loew, of the family Agromyzidæ, an insect with habits hitherto unknown. The insect in its different stages of development is shown in Plate XI, prepared from original drawings.

a. Adult fly. *b.* Young larva. *c.* Pupa, all greatly enlarged.

Only a few leaves of the corn growing in the Station garden were attacked by this leaf miner, but the lower leaves of nearly every corn plant in the greenhouse were more or less tunneled by the larvæ. It is not probable that it will ever become a serious enemy to the field crop. If it should, however, it would be a difficult pest to fight, for the larva being inside the leaf cannot be reached by spraying. The only way to destroy them is to

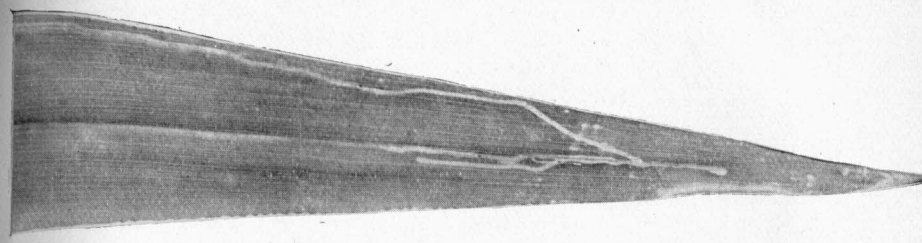


PLATE X. Corn Leaf injured by Leaf Miner, *Odontocera Dorsalis.*

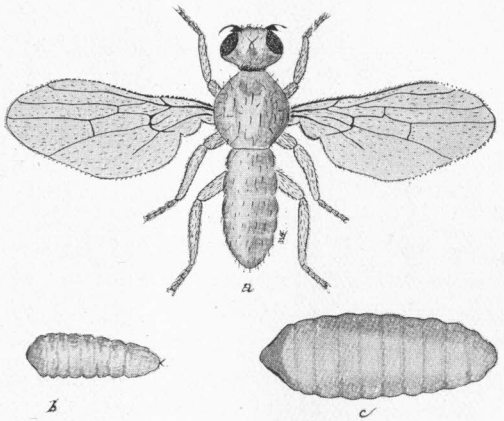


PLATE XI. Leaf Miner. *Odontocera Dorsalis.*

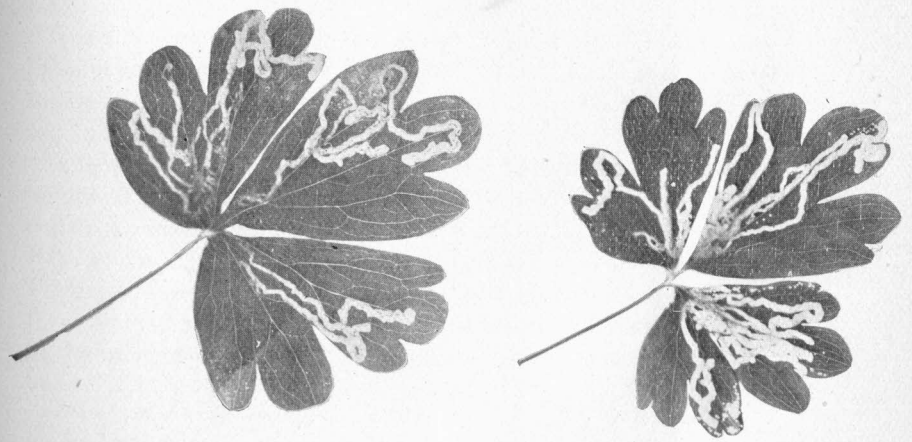


PLATE XII. Columbine Leaves injured by Leaf Miner, *Phytomyza Aquilegiæ.*

examine the affected leaves for each individual, which will be found near the enlarged extremity of the tunnel, where it may be destroyed by a knife or needle. Of course this method would be utterly impracticable in farm practice. Natural enemies will doubtless keep this leaf miner in check.

Hymenopterous insects came from two of the pupæ which were gathered. These both belonged to the same species which is evidently parasitic upon *Odontocera dorsalis*. This parasitic insect is stated by Mr. Howard to be a new species of *Sphegigaster*.

Columbine Leaf Miner (*Phytomyza aquilegiæ.*)

Several species of Aquilegia (Columbine) growing about the Station grounds were severely attacked by a small fly, which deposits its egg either on or inside the leaf. The larva as soon as hatched, begins to tunnel in the soft parenchymatous tissue of the leaf just beneath the epidermis.

My attention was first called to the injury June 26th, and from that time continuously until frost came, the leaves showed indications of the presence of the leaf miner. This signifies that there are several broods each year.

Some young seedlings of *A. Canadensis* were severely injured, and old plants of other species lost nearly all their leaves from the effects of its attack. The soft part was entirely eaten out in some cases, and nothing left but the skeleton or framework of the leaf.

The full-grown larva is a footless grub one-sixteenth of an inch in length. It emerges from its mine to pupate, and fastens itself to the underside of the leaf, eight or ten being often found hanging from the under surface of a single leaf.

The covering, during this stage of the insect's transformations, is formed by the hardening of the skin which the larva casts but does not vacate. It turns to a dark brown color, and shrinks slightly in length, the thickness remaining about the same. Finally the end of the covering is ruptured, and the adult comes forth a small two-winged fly. One specimen was found pupating in the mine of the leaf, but this does not appear to be the usual habit.

Adults were reared from the mines of the leaf, and sent to the U. S. Department of Agriculture for identification. Dr. C. L. Marlatt, Acting Entomologist, replied as follows: "Mr. D. W.

Coquillett reports that there are two distinct species of *Phytomyza*, the larvæ of which mine the leaves of Columbine in Europe, viz: *P. ancholiæ*, Desvoidy, an account of which is given in the Annales de la Soc. Entom. de France, 2d series, Vol. x, p. 153; and *P. aquilegiæ*, Hardy, described in the Annals and Magazine of Natural History, 2d series, Vol. iv, p. 392. Your species agrees so well with the last named that there is scarcely any doubt in so referring it, although it has not hitherto been reported as occurring in this country."

Plate XII shows leaves of *Aquilegia Canadensis* injured by larvæ of *Phytomyza aquilegiæ*.

No remedy has yet been suggested except to pick and destroy the infested leaves. If this leaf miner has no parasite to keep it in check, it will soon become so troublesome as to greatly diminish the use of the Columbine as a hardy flowering perennial.

THE PROTEIDS OF THE RYE KERNEL.

By Thomas B. Osborne.

The proteids of this seed have been but little studied and the statements published leave the subject in much confusion.

Einhof, who in 1805* undertook an analysis of rye, was the first to make observations on the proteids obtained therefrom. He found that an aqueous extract of rye meal contained two distinct proteid substances, one coagulating on boiling, and insoluble in alcohol, which he called albumin, and the other not coagulating, but soluble in alcohol, which he called gluten [kleber]. The latter he considered to be identical with the similar substance extracted from wheat gluten by alcohol. Treatment with alcohol yielded much more "kleber" than was extracted by water alone. It is interesting to note that Einhof in this investigation first discovered that characteristic differences exist between different kinds of vegetable proteid matter, it being thought at that time that gluten and albumin were simply modifications of the same body which under like conditions would show the same properties.

Heldt† in 1843 published a description of the proteid taken up by alcohol from rye meal. He prepared it by extracting the meal with hot alcohol, distilling off the alcohol and treating the residue with ether to remove fat, and with water to remove ether and sugar.

This preparation was analyzed with the following result:

Carbon	56.38
Hydrogen	7.87
Nitrogen	15.83
Sulphur, Oxygen	19.92
	100.00

Heldt remarked, "the same composition was found by Scherer and Jones for other nitrogenous constituents of plants, plant-casein, plant-albumin and plant-gelatin, to which last this body appears to stand nearest."

* Jour. d. Chem. v. Gehlen, V, 131.

† Ann. d. Chem. u. Phar., XLV, 195.

Jones* obtained albumin from rye by boiling the aqueous extract and treating the resulting coagulum with ether. He states that this albumin contained:

Carbon	54.74
Hydrogen	7.77
Nitrogen	15.85
Oxygen	21.64
	100.00

Verdeil,† contrary to the experience of Einhof, von Bibra, Ritthausen and the writer obtained gluten from rye meal by kneading and washing in a cloth until starch was removed. He states that there remained a tough, glutinous substance which could be easily drawn into threads. This gluten he says was not pure but was contaminated with a substance soluble in alcohol. When thoroughly extracted with alcohol he considered it to be pure. He determined sulphur in the gluten and found 0.989 and 0.972 per cent. Von Bibra‡ considered the proteid extracted from rye by alcohol to be the same as that similarly obtained from wheat. He gave the nitrogen content of this body as 15.73, 15.52 and 15.50 and the sulphur as 0.973 and 0.950 per cent. He also recognized the presence of "casein" which he did not analyze, and found from 1.565 to 2.799 per cent. of albumin which contained 15.53 and 15.42 per cent. of nitrogen. He considered the proteids of rye to be same as those of wheat.

Ritthausen§ described three proteid substances which he found in rye, albumin, soluble in water, mucedin, soluble in alcohol, and gluten-casein, soluble in dilute potash water but insoluble in water and cold alcohol.

Albumin, he says, is present in the aqueous extracts but he made no further examination of this body. The mucedin he considers to be the only proteid, soluble in alcohol, present in the rye kernel and this he regarded as similar to the mucedin which was believed to exist in the wheat kernel. He was unable to detect the presence of gliadin. Mucedin was prepared by extracting the meal with hot alcohol of 85 per cent. and concentrating and cooling the solution. The deposited substance was further

* Ann. d. Chem. u. Phar., XL, 66.

† Ann. d. Chem. u. Pharm., LVIII, 319.

‡ Die Getreidearten u. das Brod, Nuernberg, 1860, 291.

§ Jour. f. prakt. Chem., XCIX, 439, and Die Eiweisskoerper, etc., Bonn, 1872, p. 83.

extracted with alcohol and ether. It was then dissolved in acetic acid and fractionally precipitated with potash. He states the composition of the substance as:

Carbon	53.61
Hydrogen	6.79
Nitrogen	16.84
Sulphur	0.50
Oxygen	22.26
	100.00

The gluten-casein was obtained by extracting the rye meal directly with very dilute potash-water, precipitating with acetic acid and washing with water, alcohol and ether. Two preparations were made and gave as an average the following figures on analysis:

Carbon	52.14
Hydrogen	6.93
Nitrogen	16.38
Sulphur	1.06
Oxygen	23.49
	100.00

Sidney Martin* states that wheat, rye and barley contain a globulin substance similar in properties to animal myosin, being soluble in 10–15 per cent. sodium chloride solutions, precipitated therefrom by saturation with sodium chloride and with magnesium sulphate and coagulating at 55° to 60°. This globulin is precipitated by dialysis and thereby is converted into the albuminate form. It is very evident from the foregoing summary of previous work that we have no satisfactory knowledge of the rye-proteids.

In presenting the results of my investigation the subject may be most conveniently discussed under the following heads:

A, proteids soluble in water, B, proteids insoluble in water but soluble in saline solutions, C, proteids insoluble in water and in saline solutions and soluble in alcohol, and, D, proteid insoluble in water, saline solutions, or alcohol but soluble in dilute alkalies.

A, Proteids soluble in Water. Leucosin. Proteose.

The proteids soluble in water are best examined in extracts made in the first instance with 10 per cent. sodium chloride solution from which subsequently the soluble salts have been removed

* Jour. Physiol., VIII, viii.

by prolonged dialysis. When water is applied to the grain it becomes a weak saline solution which not only takes up globulins but also extracts gliadin whose presence greatly complicates the examination of the water soluble proteids. Rye meal* was accordingly exhausted with a solution containing 10-per cent. sodium chloride and the extract, after syphoning from the subsided insoluble matters, was freed from salts and globulin by dialysis in river water and filtration. The resulting solution yielded no more globulin by dialysis in distilled water and contained only those proteids extracted from the seed which were soluble in pure water. As the extract was bulky the proteids were precipitated by saturation with ammonium sulphate and thereupon dissolved in water. A comparatively concentrated solution was thus obtained which was very nearly freed from ammonium sulphate by dialysis. It then had the following properties. When heated slowly it became turbid at 52° and particulate at 63°. After filtering from this coagulum nothing more separated even on boiling. Saturation of the dialyzed solution with sodium chloride gave a precipitate that dissolved readily in water to a solution, which, heated to 63°, yielded a coagulum of albumin. The filtrate from this coagulum was again saturated with salt and a considerable precipitate obtained showing that with the albumin some proteose-like body was thrown down. Nitric acid added to the solution of this precipitate in water gave a precipitate which dissolved on warming and reappeared on cooling. The solution after filtering out the first precipitate of proteose and albumin, produced by saturation with sodium chloride, gave more precipitate on adding acetic acid, showing the presence of a further quantity of proteose. The coagulum above described, which separated on heating its solution to 65°, was washed thoroughly with water, alcohol, absolute alcohol and ether and dried over sulphuric acid. When dried at 110° it had the following composition:

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **1.**

	I.	II.	Average.	Ash-free.
Carbon	52.31	----	52.31	52.57
Hydrogen	6.78	----	6.78	6.81
Nitrogen	16.14	16.11	16.13	16.22
Sulphur } Oxygen }	----	----	----	24.40
				100.00
Ash	0.51			

* The rye meal used throughout this work was obtained by grinding, in the laboratory, portions of clean and fresh winter rye, as needed for each extraction.

Another extract was examined in a slightly different way. 1000 grams of rye meal were extracted with 11 liters of 10 per cent. sodium chloride solution and, in order to get rid of the large amount of gum taken up, the solution, after filtering, was dialyzed and then saturated with ammonium sulphate. The precipitate thus produced was dissolved, as far as possible in 10-per cent. sodium chloride brine, filtered clear and dialyzed until chlorides were removed. The solution after filtering clear was then heated to 65° and the albumin that separated was filtered out, washed thoroughly with hot water, with alcohol and with ether and dried over sulphuric acid. This preparation, **2**, weighed 1.21 grams and had the following composition:

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **2.**

		Ash-free.
Carbon	53.04	53.29
Hydrogen	6.70	6.74
Nitrogen	16.57	16.65
Sulphur } Oxygen }	----	23.32
		100.00
Ash	0.50	

The solution containing the proteoses, filtered from preparation **2**, was then treated with 20 per cent. of its weight of dry sodium chloride and a little two-tenths per cent. hydrochloric acid was added which gave a considerable precipitate. This was filtered out, dissolved in distilled water and the solution dialyzed till free from chlorides. This solution then gave a precipitate with nitric acid, which dissolved on warming and precipitated again on cooling. The solution concentrated to a syrup on a water bath was precipitated by pouring into absolute alcohol. The precipitate when dried over sulphuric acid weighed 0.41 gram or one-third as much as the albumin. The filtrate, from the precipitation of this substance [with 20 per cent. of sodium chloride and acid], was saturated with ammonium sulphate and the precipitate thus produced filtered out and dissolved in distilled water. With copper sulphate and potash this substance gave a clear pink color. Its solution gave no precipitate on adding nitric acid until it had been saturated with sodium chloride, when a slight precipitate fell. It yielded no precipitate with copper sulphate. These reactions indicate that besides albumin the aqueous extract contains small quantities of proto- and deutero-proteose.

Again, 2000 grams of rye meal were treated with 10-per cent. sodium chloride solution and the extract filtered and saturated with ammonium sulphate. The precipitate produced was dissolved in 10-per cent. sodium chloride solution, filtered and dialyzed until all chlorides were removed. After filtering clear the solution was heated to 65° for some time and the coagulum filtered out, washed with hot water, alcohol and ether and dried for analysis, preparation **3.** The filtrate from **3,** was then concentrated by boiling, during which a coagulum developed. This was filtered out, washed as usual and dried for analysis, preparation **4.**

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **3.**

	I.	II.	Average.	Ash-free.
Carbon	53.41	53.32	53.37	53.52
Hydrogen	6.90	6.82	6.86	6.88
Nitrogen	16.73	----	16.73	16.78
Sulphur } Oxygen }	----	----	----	22.82
				100.00
Ash	0.30			

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **4.**

	I.	II.	Average.	Ash-free.
Carbon	52.64	52.53	52.58	52.86
Hydrogen	6.76	6.73	6.75	6.79
Nitrogen	16.86	----	16.86	16.95
Sulphur } Oxygen }	----	----	----	23.40
				100.00
Ash	0.56			

Another extract was made by treating 1700 grams of rye meal with 16 liters of water. After standing over night the solution was filtered off and saturated with ammonium sulphate. The meal residue was treated again in the same way and the filtered extract, after saturating with ammonium sulphate, was added to that first obtained. The precipitated proteids were then dissolved in water yielding a very gummy solution. As this solution was bulky the proteids were again precipitated with ammonium sulphate and the precipitate after filtering out was treated with 3 liters of 10-per cent. sodium chloride solution. The whole was then dialyzed, it having been found that these viscid solutions lost their gummy character on dialysis. After 8 days all the gum had disappeared. The solution was then readily filtered clear. In order to reduce the volume of the solution it was again

saturated with ammonium sulphate and the large precipitate treated with about a liter of 10-per cent. sodium chloride solution. A turbid liquid resulted which was not cleared by passing through filter paper but on standing became clear and the sediment was found to consist of gliadin, which is to be noticed later. Gliadin is soluble to a considerable extent in pure water and in water containing but a very small amount of dissolved salts, but the addition of a little sodium chloride to its solution precipitates it completely. After the solution had entirely cleared by subsidence it was dialyzed free from chlorides and heated to 65°. The resulting coagulum was then filtered out, washed and dried in the usual manner and found to weigh 1.55 gram. The composition of this preparation was as follows:

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **5.**

		Ash-free.
Carbon	52.67	52.91
Hydrogen	6.78	6.81
Nitrogen	16.57	16.65
Sulphur	1.40	1.40
Oxygen	----	22.23
		100.00
Ash	0.47	

The meal residue, from the water extract that yielded **5,** was then treated with 10-per cent. sodium chloride solution and the filtered extract saturated with ammonium sulphate, the precipitate so obtained was filtered out, dissolved in water and sodium chloride solution and dialyzed till free from chlorides. The liquid was then filtered clear and heated to 65°. The coagulum washed and dried weighed 1.92 grams, being therefore considerably greater than the preparation obtained from the aqueous extract. It would appear therefore probable that the albumin forms a constituent of the aleurone grains which may not be broken up until treated with saline solutions. The following figures show the composition of this preparation:

COAGULATED RYE ALBUMIN, LEUCOSIN, *Preparation* **6.**

		Ash-free.
Carbon	52.55	52.77
Hydrogen	6.67	6.70
Nitrogen	16.61	16.68
Sulphur	1.29	1.29
Oxygen	----	22.56
		100.00
Ash	0.42	

SUMMARY OF ANALYSES OF COAGULATED RYE ALBUMIN, LEUCOSIN.

	1.	2.	3.	4.	5.	6.	Average.
Carbon	52.57	53.29	53.52	52.86	52.91	52.77	52.97
Hydrogen	6.81	6.74	6.88	6.79	6.81	6.70	6.79
Nitrogen	16.22	16.65	16.78	16.95	16.65	16.68	16.66
Sulphur	24.40	23.32	22.82	23.40	1.40	1.29	1.35
Oxygen					22.23	22.56	22.23
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Five hundred grams of rye flour* were extracted with 2000 c. c. of 5-per cent. sodium chloride solution and 1000 c. c. of the clear filtered extract were dialyzed till free from chlorides. The solution was then filtered and heated for 24 hours in a water bath of 70°. The coagulated albumin was filtered out, washed with water, alcohol and ether, and dried over sulphuric acid, and found to weigh 1.08 grams, equivalent to 0.43 per cent. of the flour.

So far as tested this albumin agrees in all respects with that obtained from wheat.† The variations in composition of these preparations are considerable but perhaps not greater than might be expected.

The aqueous and saline extracts of the rye meal contain much gum and coloring matters which render the isolation of pure proteids very difficult. It will be seen, however, that the preparations of wheat albumin and rye albumin have very nearly the same average composition and that both proteids show the same reactions and coagulate at the same temperature. They are unquestionably the same substance, for which I have adopted the name *leucosin*.

COAGULATED LEUCOSIN.

	Wheat. Av. of 5 analyses.	Rye. Av. of 6 analyses.
Carbon	53.02	52.97
Hydrogen	6.84	6.79
Nitrogen	16.80	16.66
Sulphur	1.28	1.35
Oxygen	22.06	22.23
	100.00	100.00

The proteoses of the rye also show the same reactions as those of the wheat kernel, and so far as it is possible to determine they are identical.

* Made by the Health Food Company of New York.

† Am. Chem. Jour., XV, p. 408; also Ann. Report of this Station for 1893, p. 179.

B. PROTEID SOLUBLE IN SALINE SOLUTIONS. EDESTIN.

Owing to the large amount of gum extracted from the rye meal, the preparation of the globulin in a pure state was found to be extremely difficult. Such preparations as were made disagreed in composition and in only one case was a substance obtained which appeared to be pure enough to warrant the publication of its analysis. So far as could be detected the globulin which separated on dialysis had the same properties as that similarly derived from wheat. One preparation of this globulin, which had nearly the same composition as the wheat globulin and appeared to be free from gum and other impurities, was obtained as follows:—5000 grams of rye flour, made by the Health Food Co. of New York, were extracted with 15 liters of 5-per cent. sodium chloride solution and the extract filtered clear. 9 liters of extract were thus obtained, being approximately equal to a complete extraction of 3 kilos of rye flour.

The entire solution was dialyzed for four days in order to remove the greater part of the gum. The extract was saturated with ammonium sulphate, the precipitate filtered out, suspended in water and dialyzed for three days. Most of the substance was now dissolved and the insoluble matter was filtered out, washed with sodium chloride solution and the filtrate and washings returned to the dialyzer. When free from chlorides the solution was filtered from a small precipitate and this latter washed with water, alcohol and ether and dried over sulphuric acid. Only 1.21 grams of globulin were obtained, which when dried at 110° had the following composition:

RYE GLOBULIN, EDESTIN, *Preparation* 7.		WHEAT GLOBULIN, EDESTIN.	
		Ash-free.	Av. of 5 analyses.
Carbon	51.03	51.19	51.03
Hydrogen	6.72	6.74	6.85
Nitrogen	18.14	18.19	18.39
Sulphur			0.69
Oxygen	----	23.88	23.04
Ash	0.33		
		100.00	100.00

The writer has no doubt that this globulin is identical with the *edestin* found in the wheat kernel and other seeds,* but owing to the difficulties encountered in preparing it from rye, further evidence on this point was not obtained.

* Annual Report of this Station for 1893, pp. 179 and 216.

With reference to Martin's statement concerning the presence of myosin—what is written on that point in the paper by Osborne and Voorhees on the Proteids of the Wheat Kernel applies equally to rye.*

C. Proteid soluble in Alcohol. Gliadin.

After extraction with sodium chloride solution, alcohol of 75 to 80 per cent. takes up a considerable quantity of proteid. 100 grams of rye meal were extracted thoroughly with 10-per cent. sodium chloride solution and then with 75-per cent. alcohol. The alcoholic extract was evaporated to very small volume and the separated proteid washed with water and ether and then dried. It weighed 3.93 grams, being therefore nearly 4. per cent. of the meal. 2000 grams of rye meal were then extracted with alcohol of 0.9 specific gravity, four successive times. Each extract, after filtering clear, was concentrated by distillation on a water bath. The first three extracts yielded on cooling a deposit of proteid but the fourth contained almost none. Each residue was then washed with water and dissolved in 75-per cent. alcohol. The substance from the first extract yielded an insoluble residue which when washed with dilute alcohol, absolute alcohol and ether, gave preparation **8.** This dried at 110° contained 17.00 per cent. of nitrogen. The solutions of the substances from the three extracts in dilute alcohol, were concentrated to about one-fourth their original volume and cooled, when the dissolved proteid separated. The substance from the first extract was digested with absolute alcohol which dissolved a part of it, then with ether and dried, giving preparation **9.** The residue from the second extract was washed superficially with water and then treated in a divided state with distilled water until dissolved. A little saturated sodium chloride solution was then added and the proteid wholly precipitated. The precipitate was then thoroughly dehydrated with absolute alcohol, digested with ether, and dried. This formed preparation **10.** The proteid separated from the third extract was digested with absolute alcohol and with ether, and yielded a small quantity of proteid, preparation **11,** which when dried contained, ash-free, 16.89 per cent. of nitrogen. The absolute alcohol used in dehydrating preparation **9,** with help of the water which it extracted, dissolved a considerable quantity of proteid. This was precipitated by adding a few drops

* Am. Chem. Jour., XV, p. 415.

of sodium chloride solution. The precipitate produced was then digested with absolute alcohol and ether and when dried was found to contain, ash-free, 16.02 per cent. of nitrogen. The preparation was therefore redissolved in dilute alcohol, filtered perfectly clear, concentrated to small volume and cooled. The proteid separating was then treated as before with absolute alcohol and ether and yielded preparation **12.** The proteid thus extracted showed in all respects the properties of wheat gliadin, and it will be seen that it has nearly the same composition.

Rye Gliadin, *Preparation* **9.**

	I.	II.	Average.	Ash-free.
Carbon	52.76	----	52.76	52.84
Hydrogen	6.81	----	6.81	6.82
Nitrogen	17.14	17.23	17.19	17.22
Sulphur } Oxygen }	----	----	----	23.12
Ash	0.16			100.00

Rye Gliadin, *Preparation* **10.**

	I.	II.	Average.	Ash-free.
Carbon	53.06	52.90	52.98	53.23
Hydrogen	6.83	7.11	6.97	7.00
Nitrogen	17.13	17.17	17.15	17.23
Sulphur } Oxygen }	----	----	----	22.54
Ash	0.48			100.00

Rye Gliadin, *Preparation* **12.**

	I.	II.	Average.	Ash-free.
Carbon	52.99	53.11	53.05	53.11
Hydrogen	6.73	6.83	6.78	6.79
Nitrogen	17.57	----	17.57	17.59
Sulphur	1.44	----	1.44	1.44
Oxygen	----	----	----	21.07
Ash	0.12			100.00

1000 grams of rye meal were thoroughly extracted with 10-per cent. sodium chloride solution and drained as dry as possible on filters. The extracted residue was then treated with alcohol of 0.860 specific gravity four consecutive times. The four red-brown extracts were filtered clear, concentrated till most of the alcohol was removed and then cooled. The precipitates thus obtained were united and treated at first with stronger and afterwards with

75-per cent. alcohol until all soluble was dissolved. A considerable residue remained which appeared to be coagulated gliadin. This was washed thoroughly with absolute alcohol and ether, and when dried weighed 5.62 grams, preparation **13.** The dissolved proteid, after filtering its solution perfectly clear, was separated by concentrating to small volume and cooling. The deposit was then treated with absolute alcohol, dissolved again in a little dilute alcohol and precipitated by pouring into absolute alcohol. The proteid, preparation **14,** separated perfectly colorless, in a finely divided state. When dried it weighed 11.66 grams.

RYE GLIADIN, *Preparation* **13.**

	I.	II.	Average.	Ash-free.
Carbon	52.36	----	52.36	52.62
Hydrogen	6.73	----	6.73	6.76
Nitrogen	17.75	17.59	17.67	17.75
Sulphur	1.18	----	1.19	1.19
Oxygen	----	----	----	21.68
				100.00
Ash	0.51			

RYE GLIADIN, *Preparation* **14.**

	I.	II.	Average.	Ash-free.
Carbon	52.74	----	52.74	52.93
Hydrogen	6.73	----	6.73	6.75
Nitrogen	17.32	17.52	17.42	17.48
Sulphur	1.23	----	1.23	1.23
Oxygen	----	----	----	21.61
				100.00
Ash	0.37			

These two preparations formed together 1.73 per cent. of the rye meal and have the composition of wheat gliadin. In order to prevent contamination of this proteid with the gum contained in rye meal, which Ritthausen* states to be freely soluble in 50-per cent. alcohol, the following method was tried.

After extracting rye meal with 10-per cent. sodium chloride brine the residue was treated with alcohol so strong that with the water retained by the meal, a mixture resulted containing about 75 per cent. of alcohol. After standing over night the extract was syphoned from the residue and greatly diluted with water. The proteid separated on standing and was filtered out and dis-

* Die Eiweisskoerper, etc., Bonn, 1872, p. 96, and Jour. f. prakt. Chem., XCIX, p. 454, and CII, p. 321.

solved in 75-per cent. alcohol. This solution was filtered perfectly clear, concentrated, cooled and the separated proteid treated with absolute alcohol and ether and dried. The resulting preparation **15,** was perfectly white. The residual meal was again extracted with 75-per cent. alcohol and the extract filtered clear, concentrated to one-fourth its volume, cooled, the precipitated proteid again dissolved in 75-per cent. alcohol, filtered clear, concentrated, cooled, and the separated proteid washed repeatedly with water. The substance was again dissolved in dilute alcohol and the clear solution precipitated by pouring into absolute alcohol. The precipitate produced was still again dissolved in dilute alcohol and a second time precipitated by pouring into absolute alcohol. The precipitate thus resulting was dissolved in dilute alcohol and precipitated by pouring into water and adding a little salt. The final pure white precipitate was digested with absolute alcohol and ether and dried, giving preparation **16.**

RYE GLIADIN, *Preparation* **15.**

	I.	II.	Average.	Ash-free.
Carbon	52.03	52.09	52.06	52.40
Hydrogen	6.78	6.91	6.85	6.89
Nitrogen	17.80	----	17.80	17.91
Sulphur	1.23	----	1.23	1.24
Oxygen	----	----	----	21.56
				100.00
Ash	0.68			

RYE GLIADIN, *Preparation* **16.**

	I.	II.	Average.	Ash-free.
Carbon	52.74	52.65	52.70	53.03
Hydrogen	6.90	6.96	6.93	6.97
Nitrogen	17.39	----	17.39	17.50
Sulphur	1.29	----	1.29	1.30
Oxygen	----	----	----	21.20
				100.00
Ash	0.65			

Another preparation of this substance was made by extracting 3000 grams of rye flour directly with 75 per cent. alcohol. The extract was concentrated to one-fourth its volume and the proteid which separated on cooling was washed many times with distilled water and dissolved in dilute alcohol, yielding a clear solution. This was then poured into three times its volume of absolute alcohol and an opalescent mixture obtained which depos-

ited a curdy precipitate after adding a little sodium chloride solution. The strong alcoholic solution from which this separated was clear and of a deep yellow color. The precipitate was treated with absolute alcohol as long as this was colored. During the process the substance was rubbed up to a fine powder. It was finally digested with ether for 24 hours and dried over sulphuric acid. This preparation, **17,** weighed 58 grams and was perfectly white. It formed very nearly 2 per cent. of the meal.

RYE GLIADIN, *Preparation* **17.**

Carbon	52.68
Hydrogen	6.71
Nitrogen	17.89
Sulphur	1.22
Oxygen	21.50
Ash	0.00
	100.00

In order to establish conclusively whether more than one alcohol-soluble proteid is contained in the rye-kernel, five preparations were made from the same portion of meal, by fractional precipitation. 4000 grams of rye meal were thoroughly extracted with 10-per cent. sodium chloride solution and the greater part of the bran removed by washing the meal through coarse cloth with the salt solution. The residue after decanting the salt solution was extracted with 75-per cent. alcohol, the extract was filtered clear and divided into two parts. The first part was concentrated to one-fourth and cooled, the second to one-half. The precipitated proteid from each was washed repeatedly with distilled water, dissolved in a small amount of 75-per cent. alcohol, filtered clear and precipitated by pouring into absolute alcohol. The proteid thus separated was digested with absolute alcohol and with ether. From the first portion of the alcoholic extract, preparation **18** was obtained, from the second, preparation **19.** These had the following composition:

RYE GLIADIN, *Preparation* **18.**

		Ash-free.
Carbon	51.90	52.67
Hydrogen	6.87	6.97
Nitrogen	17.50	17.76
Sulphur	1.26	1.27
Oxygen	----	21.33
		100.00
Ash	1.48	

RYE GLIADIN, *Preparation* **19.**

		Ash-free.
Carbon	52.04	52.40
Hydrogen	6.66	6.71
Nitrogen	17.77	17.89
Sulphur	1.15	1.16
Oxygen	----	21.84
		100.00
Ash	0.71	

The water washings from these two preparations were severally mixed with a little saturated sodium chloride solution which gave a considerable precipitate in each. These precipitates were then washed superficially with distilled water, dehydrated with absolute alcohol and treated with ether. The washings from **18** yielded preparation **20,** those from **19,** preparation **21.**

RYE GLIADIN, *Preparation* **20.**

	I.	II.	Average.	Ash-free.
Carbon	51.36	51.55	51.46	53.05
Hydrogen	7.07*	6.61	6.61	6.92
Nitrogen	17.64	17.61	17.63	18.17
Sulphur	1.14	----	1.14	1.17
Oxygen	----	----	----	20.69
				100.00
Ash	3.01			

RYE GLIADIN, *Preparation* **21.**

	I.	II.	Average.	Ash-free.
Carbon	52.01	----	52.01	52.37
Hydrogen	6.88	----	6.88	6.93
Nitrogen	17.99	17.97	17.98	18.10
Sulphur	1.04	----	1.04	1.05
Oxygen	----	----	----	21.55
				100.00
Ash	0.71			

The mother liquors from which **18** and **19** separated, after concentration, were united, further concentrated and cooled. The portion so separated was washed with water, dissolved in alcohol, the solution filtered clear and precipitated by pouring into absolute alcohol and after digesting with absolute alcohol and ether yielded preparation **22.**

* Omitted in average.

RYE GLIADIN, *Preparation* **22.**

		Ash-free.
Carbon	48.44	52.46
Hydrogen	6.22	6.73
Nitrogen	16.68	17.94
Sulphur	0.91	0.99
Oxygen	----	21.88
		100.00
Ash	7.67	

SUMMARY OF ANALYSES OF RYE GLIADIN.

	9.	10.	12.	13.	14.	15.	16.
Carbon	52.84	53.23	53.11	52.62	52.93	52.40	53.03
Hydrogen	6.82	7.00	6.79	6.76	6.75	6.89	6.97
Nitrogen	17.22	17.23	17.59	17.75	17.48	17.91	17.50
Sulphur	23.12	22.54	1.44	1.19	1.23	1.24	1.30
Oxygen			21.07	21.68	21.61	21·56	21.20
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	17.	18.	19.	20.	21.	22.	Average.
Carbon	52.68	52.67	52.40	53.05	52.37	52.46	52.75
Hydrogen	6.71	6.97	6.71	6.92	6.93	6.73	6.84
Nitrogen	17.89	17.76	17.89	18.17	18.10	17.94	17.72
Sulphur	1.22	1.27	1.16	1.17	1.05	0.99	1.21
Oxygen	21.50	21.33	21.84	20.69	21.55	21.88	21.48
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Comparing these results with those obtained by Osborne and Voorhees in analyzing gliadin from wheat* it is seen that they agree very closely, similar variations between the analyses existing in both cases. The averages of the two series of analyses agree well, as shown by the following figures:

GLIADIN.

	Wheat.	Rye.
Carbon	52.72	52.75
Hydrogen	6.86	6.84
Nitrogen	17.66	17.72
Sulphur	1.14	1.21
Oxygen	21.62	21.48
	100.00	100.00

In all their properties wheat gliadin and rye gliadin resemble each other so exactly as to leave no doubt of their chemical identity. Ritthausen, as already stated, failed to find gliadin in rye

* Amer. Chem. Jour., XV, p. 436.

meal and described the proteid soluble in alcohol as mucedin, having a lower nitrogen and higher carbon content. This disagreement is doubtless due to impurities in Ritthausen's preparations, which, as he mentions, contained coloring matter that could not be removed. This color was probably a result of extracting with hot alcohol, which Ritthausen appears to have used in all cases, cold alcohol having given him a small yield of proteid. I had, however, no trouble in obtaining an abundant yield of gliadin with cold alcohol of 70 per cent., and thereby have extracted far less coloring matter than with hot alcohol.

D. PROTEID SOLUBLE ONLY IN DILUTE ALKALIES.

The sample of rye flour previously used is this work contained 1.52 per cent. of nitrogen. The amount of nitrogen soluble in salt solution and in dilute alcohol was determined in this flour by extracting 100 grams with a large quantity of 5-per cent. sodium chloride solution and then with 75-per cent. alcohol. The residue was then thoroughly air-dried and found to weigh 78 grams. This residue contained 0.55 per cent. of nitrogen. The 100 grams of flour therefore contained 1.52 grams of nitrogen of which 0.43 grams remained after extraction and 1.09 grams was soluble in dilute salt solution and alcohol, or in other words, 71.7 per cent. of the nitrogen was soluble in the reagents named and 28.3 per cent. was insoluble. In the wheat kernel a considerable part of the nitrogen was likewise found to be insoluble in salt solution and in dilute alcohol, but as this substance could be separated as a constituent of the gluten it was possible to prepare it in quantity and in a state of comparative purity. Since rye flour yielded no gluten on washing with water, the proteid remaining in the meal after extracting with salt solution and dilute alcohol, could be obtained only by extracting the residual meal directly with dilute potash water. All attempts, however, to thus prepare this substance resulted only in the production of small preparations of very variable composition. The gum present in the seed dissolved freely in the alkaline solution and made it impossible by any means yet discovered to thoroughly purify the preparations. For this reason nothing positive can now be said in relation to the nature or composition of this residual proteid. Since the other proteids are the same as those found in the wheat kernel it might be conjectured that this proteid is identical with glutenin. The fact that rye flour yields no gluten is, however, opposed to such

a conclusion. It is therefore more probable that the substance in question is, partly or wholly, other than glutenin.

Quantities of the different Proteids in the Rye-Kernel.

Owing to the gum already mentioned the filtration and treatment of the rye extracts was difficult and prolonged and the amounts of globulin, albumin and proteose could not be determined separately, as in the case of wheat. The rye flour contained 1.52 per cent. of nitrogen. If we assume that the proteids of rye contain on the average 17.6 per cent. of nitrogen, as was very nearly the case with those of wheat, and that all the nitrogen exists in proteid form, this sample of flour would contain 8.63 per cent. of proteid. We have, therefore, 2.44 per cent. of insoluble proteid and 6.19 per cent. soluble in salt solution and alcohol. We have already shown that the alcohol-soluble gliadin amounted to 4.0 per cent. of the flour and the leucosin to 0.43 per cent., there thus remains 1.76 per cent. to be divided between edestin and proteoses.

Insoluble in salt solution	2.44	per cent.
Gliadin, soluble in alcohol	4.00	"
Leucosin, " " water	0.43	"
Edestin and Proteose, soluble in salt solution	1.76	"
	8.63	"

THE PROTEIDS OF BARLEY.

By Thomas B. Osborne.

The proteids of barley have received little attention on the part of chemists. Mulder* states that this grain contains six per cent. of albumin and plant gelatin; the latter was obtained by extracting barley meal with hot alcohol, cooling the resulting solution and treating the deposited substance with ether. The composition of this body he gave as follows:

	1.	2.
Carbon	54.93	54.75
Hydrogen	7.11	6.99
Nitrogen	15.71	15.71
Sulphur	0.57	0.62
Oxygen	21.68	21.93
	100.00	100.00

v. Bibra† names albumin, plant-gelatin and casein as constituents of barley but gives no particulars concerning these bodies further than that they all contain on the average 15.5 to 15.6 per cent. of nitrogen.

Kreusler made an investigation of the proteids of barley, the results of which are given by Ritthausen.‡ Kreusler employed coarsely ground meal and finely ground flour, the latter yielding purer preparations, the results being otherwise the same.

He states that the aqueous extract of the ground seed contains an albumin coagulated by boiling and of the following composition:

Carbon	52.86
Hydrogen	7.23
Nitrogen	15.75
Sulphur	1.18
Oxygen	22.98
	100.00

* Physiolog. Chemie, I, 306–308.

† Die Getreidearten u. das Brod. Nürnberg, 1860, p. 304.

‡ Die Eiweisskoerper &c., Bonn, 1872, page 103.

The extract made with hot 75-per cent. alcohol contains, according to Kreusler, three proteids ; gluten-casein, gluten-fibrin and mucedin.

The gluten-casein separates on cooling the hot alcoholic extract and when purified by boiling with dilute alcohol and fractionally precipitated from solution in acetic acid has the composition stated below.

1, is not corrected for ash and represents the first precipitation from a turbid solution.

2, is the second precipitation from a clear solution and is corrected for ash.

The cold alcoholic extract contains gluten-fibrin and mucedin.

The composition of these Kreusler gives as follows :

	Gluten-casein.		Gluten-fibrin.		Mucedin.	
	1.	2.	From meal.	From flour.	From meal.	From flour.
Carbon	53.84	53.25	55.23	54.55	53.19	53.97
Hydrogen	7.16	7.13	7.24	7.27	6.65	7.03
Nitrogen	16.63		15.49	15.70	16.14	16.98
Sulphur }			22.04	22.48	24.02	0.68
Oxygen }						21.34
						100.00

These proteids were supposed to be the same as those similarly named and described by Ritthausen as occurring in the wheat kernel.

So far as the writer has been able to learn the preceding summary includes all that has been published hitherto in regard to the proteids of the barley kernel that is now worthy of notice.

My preliminary examination of barley meal showed that the seeds contain proteid matters soluble in water, in sodium chloride solutions and in alcohol, and that after complete extraction with all these reagents there remains a considerable quantity of proteid which can be partly extracted by dilute potash solutions, but the greater part of which is insoluble in any reagent hitherto applied.

The material employed consisted of meal made from two-rowed barley and of a very white barley flour kindly furnished by the Health Food Co., of New York, both of which yielded proteids of the same composition and properties, the preparations derived from the flour, however, being less contaminated with coloring matter than those derived from the meal made from the entire grain, including the ground husk, which was so closely adherent, as to render its removal in the laboratory impossible.

Proteids Soluble in Water. Leucosin. Proteose.

As an aqueous extract of any seed, is in reality a dilute saline solution, owing to the salts extracted from the seed, and as the proteid matter soluble in alcohol dissolves to a slight extent in very dilute saline solutions the proteids properly soluble in water were obtained by extracting the meal with sodium chloride solutions, dialyzing away the salts and filtering off the proteid that thereby precipitated. In this way the proteid matter, soluble in pure water, which had been extracted from the meal was obtained in solution by itself. Three kilos of barley, ground to a fine meal, were treated with nine liters of 10-per cent. salt solution, applied in successive portions, the bran being removed by washing on a coarse cloth. The starch and other suspended matter was allowed to settle out and the extract was filtered clear. This solution was then saturated with ammonium sulphate and the precipitate produced, after filtering out, was treated with 10-per cent. salt solution. The resulting liquid was filtered clear and dialyzed for five days. The globulin that separated in this process was collected on a filter, the solution was returned to the dialyzer for three days longer, and the very small additional amount of substance that separated was filtered out. The clear solution was then heated in a water bath to 65°, the water of the bath not exceeding 70°. After an hour the coagulum was filtered out, washed with warm water, alcohol and ether, and dried over sulphuric acid. This preparation, **1**, weighed 4.15 grams and when dried at 110° had the following composition :

Coagulated Barley Albumin, Leucosin. *Preparation* **1.**

Carbon	53.04
Hydrogen	6.78
Nitrogen	16.84
Sulphur	1.42
Oxygen	21.92
	100.00
Ash	0.29

Another preparation was made by treating two kilos of barley meal with 10-per cent. sodium chloride solution, squeezing out in a press and repeating the process on the residue. The filtered extract was saturated with ammonium sulphate, the precipitate dissolved in dilute salt solution, subjected to dialysis and when freed from chlorides filtered and heated to 65° in a water bath of

70°. The coagulum produced was washed thoroughly with hot water, alcohol and ether and dried over sulphuric acid. This preparation, **2**, weighed 2.3 grams and when dried at 110° had the following composition:

Coagulated Barley Albumin, Leucosin. *Preparation* **2.**	
Carbon	52.67
Hydrogen	6.77
Nitrogen	16.41
Sulphur } Oxygen }	24.15
	100.00
Ash	0.31

As this body separated slowly when its solutions were heated to 65° it was thought possible that more than one albumin was present, which if a fact might be shown by analysis of preparations precipitated in successive fractions.

Accordingly six kilos of barley meal were extracted with 10-per cent. salt solution and the clear filtered extract saturated with ammonium sulphate. The precipitate produced was dissolved in brine and the solution, after filtering clear, was dialyzed until all the globulin had precipitated. It was then again filtered clear and in order to obtain a concentrated solution the filtrate was saturated with ammonium sulphate, the precipitate formed was dissolved in water and this solution was filtered clear and dialyzed. After six days only a very little more globulin had separated, which was filtered out and a portion of the clear solution was tested carefully for its coagulation point. When slowly heated in a double water bath it became faintly turbid at 39° and but very little more so at 49°. The turbidity then rapidly increased, flocks appearing at 56°. After heating at 56° for twenty minutes the solution was filtered and again heated. Turbidity occurred at 50° and flocks formed at 60°. After heating to 65° and holding at this temperature for some time the solution was filtered and again heated. Thereupon the turbidity took place at 70° and a very few flocks formed at 74°. The solution still had a just detectable acid reaction. The entire solution was then heated with great care to precisely 56° in a large water bath, the temperature of which did not exceed 57°. After keeping at this temperature for an hour the coagulum was filtered out, washed with hot water, alcohol and ether and dried over sulphuric acid

This preparation, **3**, weighed 0.36 gram and contained, when dried, without correction for ash, 16.48 per cent. of nitrogen.

The filtrate from preparation, **3**, was then heated to just 60° for three hours and the second coagulum filtered off and treated as the first had been. This preparation, **4**, weighed 0.4 gram and contained, without correcting for ash, 16.74 per cent. of nitrogen. Another part of this same extract after freeing from globulin as above described was dialyzed into alcohol for three days whereby the solution was concentrated and the proteid partly precipitated. In order to separate the albumin from any proteose thrown down with it, the precipitate produced by alcohol-dialysis was digested with absolute alcohol for three days longer and then washed thoroughly with water. A considerable part of the albumin was thus rendered insoluble in water, and after being further washed with absolute alcohol and ether was dried over sulphuric acid and found to weigh 0.51 gram. This preparation, **5**, contained 16.30 per cent. of nitrogen without correcting for ash.

Another preparation of albumin was made in the same way, in order to obtain a larger quantity for complete analysis. Six kilos of barley flour were mixed with 28 liters of 10-per cent. salt solution and 17 liters of clear filtrate obtained, which was saturated with ammonium sulphate. The precipitate produced was dissolved as far as possible in 10-per cent. salt solution, filtered clear, and in order to reduce the volume of the solution it was saturated with ammonium sulphate, the precipitate dissolved in 1000 c. c. of water and dialyzed until entirely free from globulin. The solution was then filtered and dialyzed into alcohol. After being concentrated, absolute alcohol was added and the precipitate filtered off, washed with absolute alcohol and ether and dried over sulphuric acid. This preparation, **6**, weighed 4.1 grams. It was then digested with water and the insoluble matter washed thoroughly with water, alcohol and ether, dried over sulphuric acid, and had the following composition when dried at 110°:

Coagulated Barley Albumin, Leucosin. *Preparation* **6.**	
Carbon	52.71
Hydrogen	6.78
Nitrogen	16.93
Sulphur	1.51
Oxygen	22.07
	100.00
Ash	0.50

SUMMARY OF ANALYSES OF COAGULATED BARLEY ALBUMIN—LEUCOSIN.

	1.	2.	3.*	4.*	5.*†	6.†	Average.
Carbon	53.04	52.67	----	----	----	52.71	52.81
Hydrogen	6.78	6.77	----	----	----	6.78	6.78
Nitrogen	16.84	16.41	16.48	16.74	16.30	16.93	16.62
Sulphur	1.42	24.15	----	----	----	1.51	1.47
Oxygen	21.92					22.07	22.32
	100.00	100.00				100.00	100.00

If this proteid is compared with the leucosin‡ obtained from the wheat and rye kernels it will be seen that the three are almost identical in composition.

LEUCOSIN.

	Wheat.	Rye.	Barley.
Carbon	53.02	52.97	52.81
Hydrogen	6.84	6.79	6.78
Nitrogen	16.80	16.66	16.62
Sulphur	1.28	1.35	1.47
Oxygen	22.06	22.23	22.32
	100.00	100.00	100.00

The aqueous extract of the barley kernel contains also a small quantity of one or more proteoses, but owing to the great difficulties encountered in attempting to separate these no pure preparations have been obtained.

PROTEID SOLUBLE IN SODIUM CHLORIDE SOLUTION. EDESTIN.

The large amount of gum extracted from barley meal by salt solution renders it very difficult to prepare the globulin in anything like a pure state. This difficulty is further increased by the readiness with which the globulin passes into the insoluble or albuminate condition and is thus lost for further purification. In only three cases was it possible to redissolve and reprecipitate this proteid in sufficient quantity for analysis. In all the extracts made, a considerable amount of globulin was precipitated by dialysis in the form of minute spheroids. So far as noticed, this globulin resembled in all respects that found in wheat and rye. It was readily and completely precipitated from salt solution by dialysis and also by adding acid. When dissolved in 10-per cent. sodium chloride solution and heated, turbidity occurred at 90° but no

* Not corrected for ash. † Coagulated by alcohol.

‡ Report of the Conn. Agricultural Experiment Station, 1893, p. 179.

coagulum formed until the solution was boiled and then only a small part of the dissolved substance separated.

Three kilos of barley meal were extracted with 10-per cent. salt solution, the filtered extract saturated with ammonium sulphate and the resulting precipitate filtered out, dissolved in 10-per cent. brine and the insoluble matter removed by filtration after adding a *very* small quantity of two-tenths-per cent. potash water in order to neutralize the slight acid reaction of the extract. The solution was then filtered clear and dialyzed for four days. The proteid separated in the form of small spheroids which were filtered out, washed with water, alcohol and ether, and after drying over sulphuric acid found to weigh 4.02 grams. This preparation was dissolved in 10-per cent. salt solution and again submitted to dialysis. After the proteid had precipitated it was filtered out, washed with water, alcohol and ether, and the final preparation, **7**, when dried at 110°, had the following composition:

BARLEY GLOBULIN, EDESTIN, *Preparation* **7**.

Carbon	51.43
Hydrogen	6.71
Nitrogen	18.14
Sulphur, Oxygen	23.72
	100.00
Ash	0.48

Again six kilos of barley flour were extracted with 10-per cent. salt solution, the filtered extract saturated with ammonium sulphate, the resulting precipitate dissolved in salt solution and dialyzed. The precipitated globulin was again dissolved in 10-per cent. salt solution and precipitated a second time by dialysis. 1.9 grams of preparation **8** were obtained, having the following composition:

BARLEY GLOBULIN, EDESTIN, *Preparation* **8**.

Carbon	50.82
Hydrogen	6.76
Nitrogen	18.16
Sulphur, Oxygen	24.26
	100.00
Ash	0.37

Another preparation was made in the same way, save that after dissolving the ammonium sulphate precipitate in salt solution, the proteids were again precipitated by saturation with ammonium sulphate and redissolved in brine, thus yielding a solution of smaller volume which was then dialyzed. After five days' dialysis, the chlorides having been removed, the precipitated globulin was treated in the usual manner and found to weigh 1.85 grams. This preparation, **9**, had the following composition:

BARLEY GLOBULIN, EDESTIN, *Preparation* **9.**

Carbon	50.40
Hydrogen	6.48
Nitrogen	18.00
Sulphur, Oxygen	25.12
	100.00
Ash	0.44

The foregoing analyses, although not showing the agreement to be desired, are on the whole sufficiently alike to warrant their publication, and for the sake of comparison they are here tabulated.

BARLEY GLOBULIN, EDESTIN.

	7.	8.	9.	Average.
Carbon	51.43	50.82	50.40	50.88
Hydrogen	6.71	6.76	6.48	6.65
Nitrogen	18.14	18.16	18.00	18.10
Sulphur, Oxygen	23.72	24.26	25.12	24.37
	100.00	100.00	100.00	100.00

In view of the close resemblance in properties and similarity in composition it is the writer's opinion that this globulin is the same as that found in a large number of other seeds and previously described under the name edestin.* The following table affords a comparison of the composition of this proteid from its different sources.

EDESTIN.

	Wheat.	Maize.	Hemp-seed.	Castor-bean.	Squash-seed.	Flax-seed.	Cotton Seed.	Rye.	Barley.
C.	51.03	51.71	51.28	51.31	51.66	51.48	51.71	51.19	50.88
H.	6.85	6.85	6.84	6.97	6.89	6.94	6.86	6.74	6.65
N.	18.39	18.12	18.84	18.75	18.51	18.60	18.64	18.19	18.10
S.	0.69	0.86	0.87	0.76	0.88	0.81	0.62	23.88	24.37
O.	23.04	22.46	22.17	22.21	22.06	22.17	22.17		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Report Conn. Agricultural Experiment Station, 1893, pp. 179 and 216.

On comparing the above analyses it will be seen that the preparations obtained from the cereals show the greatest deviation from the average of these figures. This is unquestionably due to the fact that in these seeds this substance is present in small quantity and is associated with other bodies so that it has been impossible to prepare it from them in a state of perfect purity.

PROTEID SOLUBLE IN DILUTE ALCOHOL. HORDEIN.

After extracting 500 grams of barley meal with brine the residue was treated with alcohol added in sufficient quantity to form with the water retained by the meal, an alcohol of approximately 75-per cent. After digesting a short time the meal was squeezed out and again treated with 75-per cent. alcohol, and pressed out. The united alcoholic extracts were then filtered clear, concentrated to small volume on a water bath, cooled and the proteid thus separated washed thoroughly by kneading with distilled water. The separated substance now presented every appearance of gliadin, the proteid similarly obtained from wheat and rye. It was dissolved in a little dilute alcohol in which it was very readily soluble with the exception of a slight residue of coagulated proteid which rendered filtration extremely difficult. The solution was then precipitated by pouring into absolute alcohol and the precipitate digested with absolute alcohol, rubbed to a powder while still moist with alcohol and treated with ether. When dried over sulphuric acid this preparation, **10**, weighed 4.54 grams and when dried at 110° gave on analysis the following results:

BARLEY PROTEID, *Preparation* **10.**

	I.	II.	Average.
Carbon	53.83	53.93	53.88
Hydrogen	6.72	6.92	6.82
Nitrogen	17.32	----	17.32
Sulphur, Oxygen	----	----	21.98
			100.00
Ash			0.22

Another extract was made by treating 500 grams of barley meal with three liters of alcohol of 0.9 specific gravity applied directly to the freshly ground meal. The extract which had a red-brown color was squeezed out in a press and concentrated to about one-eighth of its volume. After standing over night the mother

liquor was poured off from the proteid which had separated in a firm mass on the bottom of the dish.

This was then dissolved in dilute alcohol and precipitated by pouring into absolute alcohol. The resulting precipitate was washed with absolute alcohol, digested with ether, dried over sulphuric acid and found to weigh 12.3 grams. This preparation, **11,** when dried at 110°, had the following composition:

BARLEY PROTEID, *Preparation* **11.**

Carbon	53.78
Hydrogen	6.51
Nitrogen	17.27
Sulphur	0.95
Oxygen	21.49
	100.00
Ash	0.19

The remainder of preparation **11** was then dissolved in dilute alcohol and, after filtering clear, poured into distilled water and precipitated by adding a few drops of sodium chloride solution. This substance was again dissolved in dilute alcohol and precipitated by pouring into absolute alcohol. After treating with ether and drying at 110°, this preparation, **12,** was analyzed with the following results:

BARLEY PROTEID, *Preparation* **12.**

Carbon	53.78
Hydrogen	6.82
Nitrogen	17.16
Sulphur	0.93
Oxygen	21.31
	100.00
Ash	0.86

Three kilos of barley meal were treated with 10-per cent. salt solution and washed on a coarse cloth until only the bran and larger particles of meal remained. This residue was then extracted with alcohol of 0.9 sp. gr. yielding a deep red solution, which was filtered through animal charcoal, but only a part of the coloring matter was removed. The clear solution was next concentrated on a water bath, poured into absolute alcohol and the resulting precipitate digested with absolute alcohol and treated with ether, giving preparation **13,** weighing 30 grams and when dry having the following composition:

BARLEY PROTEID, *Preparation* **13.**

	I.	II.	Average.
Carbon	53.80	53.70	53.75
Hydrogen	----	6.78	6.78
Nitrogen	17.48	17.33	17.41
Sulphur	0.93	----	0.93
Oxygen	----	----	21.13
			100.00
Ash			0.25

A portion of the solution from which preparation **13** had been obtained was precipitated separately by pouring into strong alcohol and adding a few drops of salt solution. The precipitate was treated in the usual manner and gave a preparation, **14,** containing much less coloring matter than the preceding and having the following composition:

BARLEY PROTEID, *Preparation* **14.**

Carbon	54.32
Hydrogen	6.74
Nitrogen	17.13
Sulphur, Oxygen	21.81
	100.00
Ash	1.43

The starchy portion of the barley meal which had been washed through the cloth, as described, was thoroughly extracted with salt solution and then with dilute alcohol, the extraction being repeated until the proteid was completely removed. The united extracts were filtered and concentrated to two-thirds of their volume by distillation when the solution was poured into a dish and the evaporation continued. The proteid separated as a skin on the surface of the liquid and as a solid mass on the bottom of the dish. When reduced to about one-half the volume of the original liquid the hot mother liquor was decanted from the separated proteid which formed a tough mass of a pink color. This was washed with water and redissolved in dilute alcohol, giving a deep red solution which was poured into absolute alcohol and the mass of substance that separated was cut up with scissors into small pieces and digested with absolute alcohol and with ether. When dried over sulphuric acid this preparation, **15,** was pinkish in color and weighed 30 grams. Dried at 110° and analyzed the following results were obtained:

BARLEY PROTEID, *Preparation* **15.**

Carbon	54.00
Hydrogen	6.72
Nitrogen	17.49
Sulphur } Oxygen {	21.79
	100.00
Ash	0.95

The mother liquor, decanted from preparation **15,** was still further concentrated and allowed to cool over night. Only a little substance separated which however was washed with water, redissolved in dilute alcohol and precipitated by pouring into much distilled water to which a little salt had been added. On standing about 36 hours the milky solution cleared and the proteid was found in a transparent layer at the bottom of the vessel. After treating with absolute alcohol and ether and drying over sulphuric acid, preparation **16** was obtained weighing 7 grams and having when dried, the following composition:

BARLEY PROTEID. *Preparation* **16.**

Carbon	53.90
Hydrogen	6.63
Nitrogen	17.08
Oxygen } Sulphur {	22.39
	100.00
Ash	0.23

As this proteid resembled gliadin so closely in its physical and chemical properties it seemed important to subject it to very thorough fractional precipitation in order to determine whether it was a mixture of gliadin with another body or a new, distinct proteid. Another extract was made by treating three kilos of freshly ground barley meal with 10-per cent. salt solution, squeezing out in a press and treating the residue again in the same way. The meal residue was then mixed with alcohol in quantity sufficient to make with the water retained by the meal an alcohol of about 40-per cent. After squeezing out the liquid, alcohol was again added to the residual meal sufficient to increase the strength of the solvent to 75-per cent. After digesting for some time the extract was squeezed out and found less colored than the first dilute alcohol extract. This second extract was concentrated by

distillation to small volume and cooled giving a deposit of proteid much whiter than any previously made. The mother liquor from this precipitate was poured into absolute alcohol and a second precipitate obtained. The two precipitates, when united, dehydrated in the usual way, treated with ether, and dried over sulphuric acid weighed 22 grams. Dried at 110° this substance had the following composition:

BARLEY PROTEID. *Preparation* **17.**

Carbon	54.30
Hydrogen	6.67
Nitrogen	17.47
Sulphur	0.84
Oxygen	20.72
	100.00

About 18 grams of this preparation were dissolved in alcohol of 0.9 specific gravity and absolute alcohol was added until a considerable precipitate resulted, when the mixture was heated on a water bath until the precipitate dissolved. The solution was then cooled and after standing sometime the mother liquor was decanted from the separated substance. This precipitate was marked I. The solution decanted from I, was further treated with absolute alcohol and a second precipitate II, obtained in the same way. The mother liquor from II was mixed with a large quantity of absolute alcohol and, as the proteid did not separate, a few drops of salt solution were added and the resulting precipitate III filtered off and treated with absolute alcohol and ether in the usual manner.

In the first place, precipitate I was dissolved in a small quantity of 75-per cent. alcohol and absolute alcohol was added until the precipitate began to reappear. The whole was heated until this precipitate again dissolved whereupon the solution was cooled. The substance which separated settled out leaving the solution milky. The mother liquor was decanted from the small amount of deeply colored proteid which adhered to the bottom of the beaker, and this deposit was dissolved in a little 75-per cent. alcohol, treated with absolute alcoho and the opalescent solution so produced mixed with a little ether. This gave a very small precipitate, almost black in color and very sticky. The solution decanted from this small deposit was treated with a drop of potassium acetate solution

and the resulting precipitate after washing with absolute alcohol and ether was dried over sulphuric acid. It formed a light pink powder, preparation **18**, weighing 0.65 gram and when dry contained, ash free, 16.60 per cent. of nitrogen. Its ash content was 1.04 per cent. The mother liquor, decanted from the first precipitation of **18**, was treated with a drop of potassium acetate solution and the precipitate produced allowed to settle. After standing, the substance settled out and adhered to the bottom of the beaker in a solid mass, from which the clear supernatant solution was decanted. This solution after treatment with absolute alcohol yielded a precipitate which, washed with absolute alcohol and ether and dried, formed preparation **19** weighing 1.79 grams and having the following composition:

BARLEY PROTEID. *Preparation* **19.**

Carbon	53.85
Hydrogen	6.69
Nitrogen	17.22
Sulphur } Oxygen }	22.24
	100.00
Ash	0.40

The substance deposited after the addition of potassium acetate to the solution from which **19** was derived, was dissolved in 75-per cent. alcohol, absolute alcohol added to the solution and the resulting precipitate dissolved by heating. On cooling, a part of the proteid separated and after this had settled, the liquid was decanted and mixed with absolute alcohol, and on treating the precipitate in the usual manner preparation **20** was obtained, which when dried weighed 1.18 gram and gave the following results on analysis:

BARLEY PROTEID. *Preparation* **20.**

Carbon	54.33
Hydrogen	6.81
Nitrogen	16.93
Sulphur } Oxygen }	21.93
	100.00
Ash	0.58

The substance deposited by cooling the solution from which **20** was obtained was only partly soluble in dilute alcohol. It was

accordingly treated with 75-per cent. alcohol and allowed to stand until the insoluble matter had settled out. The clear liquid was then decanted and completely precipitated with absolute alcohol. The separated substance was washed with absolute alcohol and ether and when dry weighed 0.81 gram. This preparation, **21**, contained ash-free, 16.65 per cent. of nitrogen and 0.32 per cent. of ash. The insoluble matter just described, after washing by decantation with 75-per cent. alcohol, was treated in the usual manner and yielded preparation **22**, weighing 1.56 gram and having the following composition:

BARLEY PROTEID. *Preparation* **22.**

Carbon	53.91
Hydrogen	6.77
Nitrogen	17.00
Sulphur } Oxygen }	22.32
	100.00
Ash	0.71

Precipitate II was dissolved in a little 75-per cent. alcohol and the solution mixed with absolute alcohol. The resulting precipitate (*a*) was dissolved by heating and the solution cooled, whereupon a part (*b*) of the proteid was precipitated. The supernatant solution was poured off, mixed with absolute alcohol and this precipitate (*c*) which contained all the proteid remaining was dehydrated with absolute alcohol and washed with ether, giving preparation **23**, weighing 2.2 grams and having when dry the following composition:

BARLEY PROTEID. *Preparation* **23.**

	I.	II.	Average.
Carbon	54.63	54.68	54.65
Hydrogen	6.62	6.50	6.56
Nitrogen	17.16	----	17.16
Sulphur } Oxygen }	----	----	21.63
			100.00
Ash			0.32

The substance (*b*) deposited on cooling the solution as above described, was dissolved in 75-per cent. alcohol and partly precipitated by adding absolute alcohol. After redissolving the precipitate by the application of heat, the solution was cooled and

allowed to stand some time to deposit the precipitate which formed. The liquid was then decanted and the separated substance treated with absolute alcohol and ether, yielding preparation **24**, weighing 3.11 grams and having the following composition after drying at 110°.

BARLEY PROTEID. *Preparation* **24.**

Carbon	54.27
Hydrogen	6.67
Nitrogen	17.39
Sulphur } Oxygen }	21.67
	100.00
Ash	0.32

To the solution from which **24** separated absolute alcohol was added in considerable quantity and the proteid thus thrown down was dehydrated with absolute alcohol and washed with ether. When dried this preparation, **25**, weighed 0.87 gram and, without correction for ash contained 17.28 per cent. of nitrogen.

Precipitate III was treated with absolute alcohol and with ether, and dried over sulphuric acid. It weighed 1.63 grams and its composition after complete drying was :

BARLEY PROTEID. *Preparation* **26.**

Carbon	53.39
Hydrogen	7.02
Nitrogen	17.49
Sulphur } Oxygen }	22.10
	100.00
Ash	0.59

If these figures are compared it will be seen that no fractional separation has been effected, the variation in the results being no greater than in the preparations previously described. Preparation **18** is low in nitrogen, but this is doubtless due to its containing nearly all the impurities precipitable from the solution. Preparation **21** is also low in nitrogen but this was the most colored of all the preparations and as it was also small in quantity the accuracy of the analysis could not be confirmed. Excluding these two preparations the results agree fairly as shown by the following table.

SUMMARY OF THE PRECEDING FRACTIONAL PRECIPITATES.

	19.	20.	22.	23.	24.	25.	26.	Original substance 17
Carbon	53.85	54.33	53.91	54.65	54.27	----	53.39	54.30
Hydrogen	6.69	6.81	6.77	6.56	6.67	----	7.02	6.67
Nitrogen	17.22	16.93	17.00	17.16	17.39	17.28	17.49	17.47
Sulphur } Oxygen }	22.24	21.93	22.32	21.63	21.67	----	22.10	21.56
	100.00	100.00	100.00	100.00	100.00		100.00	100.00
Weight	1.79	1.18	1.56	2.2	3.11	0.87	1.63	18.00

As all the preceding preparations were made by extracting barley meal which contained a large quantity of bran, they were much contaminated with coloring matter.

In order to obtain products free from color 880 grams of fine ground "pearled barley" (a commercial preparation of barley made by rubbing off the outer coat of the grain), were treated with salt solution and after squeezing out the excess of liquid the residue was digested with 75-per cent. alcohol. The extract was then filtered, concentrated to small volume, cooled and the mother liquor decanted from the separated proteid. This was then dissolved in dilute alcohol, the solution poured into distilled water and the proteid thrown down by adding a little salt. The precipitate was again dissolved in a small amount of dilute alcohol and reprecipitated by pouring into absolute alcohol, digested with absolute alcohol for some time, then with ether, dried over sulphuric acid and found to weigh 8 grams. This preparation, **27**, was pure white and had the following composition when thoroughly dried :

BARLEY PROTEID, *Preparation* **27.**

Carbon	54.37
Hydrogen	6.81
Nitrogen	17.33
Sulphur	0.88
Oxygen	20.61
	100.00
Ash	0.48

Another preparation was made by extracting six kilos of barley flour with salt solution and then treating the residue with alcohol added in sufficient quantity to make with the water of the brine which still adhered to the meal as nearly as possible 75-per cent. alcohol. After standing over night the extract was filtered off,

concentrated to about one-third its original volume and cooled slightly. The proteid that now separated out from the hot solution was removed from the liquid, rinsed with water, dissolved in a very little dilute alcohol to a thick syrup, and reprecipitated by pouring into absolute alcohol. The substance was then cut up into small pieces and digested with absolute alcohol and also with ether. When dried over sulphuric acid 78 grams of a pure white preparation were obtained. Twenty-five grams of this were then dissolved in 75-per cent. alcohol and the clear solution poured into a large volume of distilled water. A part of the substance separated, leaving the liquid milky. The milky solution was decanted from the separated substance and the latter was washed with water in which some of it dissolved. The turbid liquid and washings were united and precipitated with a little salt solution. After standing over night the proteid separated as a transparent viscid liquid on the bottom of the vessel in the same way as gliadin does under similar conditions. After decanting the supernatant liquid the deposit was dissolved in dilute alcohol and precipitated by pouring its solution into absolute alcohol. The separated proteid was then digested with absolute alcohol and with ether and dried over sulphuric acid. A pure white preparation, **28**, resulted, which when dried at 110° had the following composition:

BARLEY PROTEID, *Preparation* **28.**

Carbon	54.02
Hydrogen	6.79
Nitrogen	17.38
Sulphur	0.84
Oxygen	20.97
	100.00
Ash	1.00

The mass which separated on pouring the alcoholic solution into water, as above described, was dissolved in 75-per cent. alcohol and, as it contained a little insoluble proteid which rendered filtration impossible, the solution was allowed to stand over night. The clear supernatant solution was then poured off and concentrated to about one-third of its volume and cooled. The proteid which separated was again dissolved in dilute alcohol and precipitated by pouring into absolute alcohol. After thorough dehydration with absolute alcohol and digestion with ether the substance was dried over sulphuric acid and yielded preparation **29**, which was white in color and weighed 5.46 grams. This substance when dried had the following composition:

BARLEY PROTEID, *Preparation* **29.**

	I.	II.	Average.
Carbon	54.48	54.54	54.51
Hydrogen	6.70	6.79	6.75
Nitrogen	17.22	17.18	17.20
Sulphur } Oxygen }	21.60	21.49	21.54
	100.00	100.00	100.00
Ash			0.32

Another preparation was made without heating, by pouring a part of the original extract from which preparations **28** and **29** were derived into a large amount of distilled water and allowing the separated substance to deposit. After some time this settled and the supernatant liquid was poured off, the precipitate washed with water, dissolved in cold dilute alcohol and the solution poured into absolute alcohol. The precipitate produced was digested with absolute alcohol and then with ether and dried over sulphuric acid yielding a pure white preparation having when dry the following composition:

BARLEY PROTEID, *Preparation* **30.**

Carbon	54.23
Hydrogen	6.83
Nitrogen	17.27
Sulphur	0.75
Oxygen	20.92
	100.00
Ash	0.17

In order to obtain a larger quantity of a colorless preparation, five kilos of barley flour were treated with 10.5 liters of 75-per cent. alcohol and after standing some time the extract was filtered off and 6 liters of clear solution obtained. This was then concentrated to one-third its volume and rapidly cooled. The proteid separated as a bulky plastic mass, which, after decanting the mother liquor, was macerated with about 500 c. c. of distilled water, the washings were poured off and the mass of proteid dissolved in 500 c. c. of 75-per cent. alcohol, yielding a solution of a pale yellowish brown tint. This solution was poured in a thin stream

into a quantity of distilled water and the separated proteid, after removal from the liquid, was again dissolved in 75-per cent. alcohol and the perfectly clear solution poured in a small stream into a large quantity of absolute alcohol. As the soluble salts had been almost completely removed the proteid did not separate even after admixture of 800 c. c. of absolute ether. Three or four c. c. of salt solution were therefore added to the milky liquid and an immediate precipitate resulted which rapidly settled leaving the solution clear and free from proteid. This mixture of absolute alcohol and ether retained all the fat present in the proteid before precipitation and also some coloring matter, the liquid being yellow. The solution was decanted and the voluminous precipitate treated with successive portions of absolute alcohol and obtained as a snow white granular substance, weighing when dried over sulphuric acid 93 grams. This preparation, **31**, had the following composition when dried at 110°:

BARLEY PROTEID. *Preparation* **31**.

	I.	II.	Average.
Carbon	54.18	54.31	54.25
Hydrogen	6.98	6.65	6.82
Nitrogen	17.20	17.30	17.25
Sulphur	0.84	----	0.84
Oxygen	----	----	20.84
			100.00
Ash	----	----	0.09

In order to make certain that this proteid, which so closely resembled gliadin in every respect but composition, was not that substance contaminated with fat, a portion of this preparation was ground to a very fine powder and washed for a long time with hot ether in an extraction apparatus. Only a trace of substance was removed by this treatment and the proteid after drying had the same composition as before as the following figures show:

BARLEY PROTEID. *Preparation* **32**.

Carbon	54.20
Hydrogen	6.58
Nitrogen	17.07
Sulphur	0.91
Oxygen	21.24
	100.00
Ash	0.25

Another portion of **31** was dissolved in two-tenths per cent. potash water yielding a clear solution which was precipitated by neutralization with two-tenths per cent. hydrochloric acid. The precipitate was washed with water, dehydrated with absolute alcohol, washed with ether and analyzed with the following results:

BARLEY PROTEID. *Preparation* **33**.

Carbon	54.21
Hydrogen	6.87
Nitrogen	17.12
Sulphur	0.76
Oxygen	21.04
	100.00
Ash	0.25

Preparation **31** was then subjected to fractional precipitation in order to make sure that it was not a mixture of two or more proteids. Twenty-five grams were dissolved in 300 c. c. of alcohol of 0.865 specific gravity by heating on a water bath and the solution was quickly cooled. After adding a few drops of 10-per cent. salt solution the most of the proteid separated in a coherent mass leaving the liquid clear. After decantation the residue was treated in the same way again, the decanted solutions being united. The residue was again dissolved and absolute alcohol added to the hot solution until a considerable precipitate resulted, when it was heated until clear and then cooled. A few drops of salt solution were then added and the proteid precipitated leaving the solution slightly milky. This liquid was joined to the two solutions from which the proteid had been previously separated and a little more salt solution added to the mixture thereby precipitating the remainder of the dissolved proteid. After decanting the liquid from the separated substance the latter was treated with absolute alcohol and gave preparation **34**, representing the fraction soluble in the strongest alcohol and having when dry the following composition:

BARLEY PROTEID. *Preparation* **34**.

Carbon	54.32
Hydrogen	6.78
Nitrogen	17.02
Sulphur	0.94
Oxygen	20.94
	100.00
Ash	0.21

The proteid which had been precipitated during the preparation of this substance as just described was dissolved in alcohol of 0.865 specific gravity and the solution cooled rapidly by immersing in cold water. When a part of the substance had separated the solution was decanted and the separated substance treated with absolute alcohol. Preparation **35** was thus obtained which gave the following figures on analysis:

BARLEY PROTEID. *Preparation* **35.**

Carbon	54.47
Hydrogen	7.01
Nitrogen	17.15
Sulphur	0.74
Oxygen	20.63
	100.00
Ash	0.43

The above preparation represented the portion least soluble in strong alcohol. The solution decanted from this preparation was precipitated with absolute alcohol and a few drops of salt solution and the resulting precipitate after the usual treatment yielded preparation **36** having the following composition:

BARLEY PROTEID. *Preparation* **36.**

Carbon	54.37
Hydrogen	6.81
Nitrogen	17.30
Sulphur	0.84
Oxygen	20.68
	100.00
Ash	0.38

The following table includes all analyses of the preparations which were free from coloring matter. (See also the next page.)

HORDEIN. BARLEY PROTEID SOLUBLE IN DILUTE ALCOHOL.

	27.	**28.**	**29.**	**30.**	**31.**	**32.**
Carbon	54.37	54.02	54.51	54.23	54.25	54.20
Hydrogen	6.81	6.79	6.75	6.83	6.82	6.58
Nitrogen	17.33	17.38	17.20	17.27	17.25	17.07
Sulphur	0.88	0.84	21.54	0.75	0.84	0.91
Oxygen	20.61	20.97		20.92	20.84	21.24
	100.00	100.00	100.00	100.00	100.00	100.00

	33.	**34.**	**35.**	**36.**	Average.
Carbon	54.21	54.32	54.47	54.37	54.29
Hydrogen	6.87	6.78	7.01	6.81	6.80
Nitrogen	17.12	17.02	17.15	17.30	17.21
Sulphur	0.76	0.94	0.74	0.84	0.83
Oxygen	21.04	20.94	20.63	20.68	20.87
	100.00	100.00	100.00	100.00	100.00

This body differs essentially from all the well defined plant-proteids now known. As it appears to be characteristic of barley, I propose to adopt for it the latterly disused name *hordein*, which was first applied about 1820 by Proust* and ten years later by Hermbstädt† to certain products of their attempts to isolate the proximate principles of this cereal.

Hordein appears to have been obtained nearly pure from barley flour by Kreusler, as shown by the following comparison of his analysis with the average above given.

BARLEY PROTEID SOLUBLE IN DILUTE ALCOHOL.

	Kreusler.	Osborne.
Carbon	53.97	54.29
Hydrogen	7.03	6.80
Nitrogen	16.98	17.21
Sulphur	0.68	0.83
Oxygen	21.34	20.87
	100.00	100.00

Ritthausen regarded this proteid as identical with the mucedin believed by him to occur in wheat and rye, but which, as my investigations prove, does not exist in those grains.

Toward water my different preparations of hordein behave somewhat differently. Preparations dried over sulphuric acid and still retaining a little alcohol dissolve in cold water to a greater or less extent according to the amount of alcohol present. When dried completely at 110°, so that all the alcohol is removed, very little hordein dissolves in cold water and slightly more on raising the temperature. Solutions thus made with hot water do not precipitate on cooling or coagulate on boiling although they give no inconsiderable precipitates on adding salt. A large number of preparations of this proteid and of wheat gliadin were thus tested and compared under similar conditions. The gliadin

* Ann. Chim. phys., V, 337.

† Jour. of Techn. Chem., XII, 46.

showed variations in solubility in the same way as the barley proteids, but throughout was much more soluble than the latter, yielding solutions with warm water which were precipitated by cooling. As drying at 110° tends to render more or less of these proteids insoluble in 75-per cent. alcohol it is not possible to say definitely whether the difference was due to original difference in properties of the two proteids tested or to the drying. It is the opinion of the writer that the hordein of barley is decidedly less soluble in water than the gliadin of wheat.

Toward alcohol the hordein behaves, so far as could be detected, exactly like gliadin. In very dilute acids and alkalies it is readily soluble and is precipitated by neutralization. Dissolved in concentrated hydrochloric acid a beautiful crimson color is produced similar to that given by gliadin under like conditions. With a warm mixture of equal volumes of water and concentrated sulphuric acid a red color is given by hordein, not a purple red as by gliadin.

The most marked difference between hordein and gliadin is in composition, since hordein contains one and a half per cent. more carbon, one-half per cent. less nitrogen, and three-tenths per cent. less sulphur than gliadin.

In the extraction last described, 5000 grams of barley flour were treated with 10.5 liters of alcohol, and the extract obtained measured 6 liters, which was equivalent to 57.1 per cent. of the whole solution employed. If we assume, as is very nearly true, that this was equal to a complete extraction of 57.1 per cent. of the flour, the proteid obtained was equivalent to all the alcohol soluble proteid contained in 2855 grams of flour. In addition to the 93 grams of proteid above described, there was obtained a further quantity weighing when thoroughly dried over sulphuric acid 17.5 grams, thus making in all 110.5 grams. This quantity is 3.87 per cent. of the 2855 grams extracted. In order to confirm these figures 500 grams of barley flour were extracted with 2 liters of hot 75-per cent. alcohol, squeezed out in a press and the residual meal treated again in the same way with another liter of alcohol and the united extracts filtered clear and concentrated by evaporation. All the proteid contained in the solution separated on cooling and was washed with ether, then dehydrated with absolute alcohol, again digested with ether and dried completely over sulphuric acid. 20.2 grams of proteid were thus obtained equal to 4.04 per cent. of the flour. We may therefore assume that this barley flour contained about 4 per cent. of the alcohol-soluble proteid, hordein.

Proteid insoluble in Water, Saline Solutions and Alcohol.

The proteids thus far described form only a part of the total proteids of the seed. One hundred grams of barley flour were extracted, first, with a large excess of 5-per cent. salt solution and then, repeatedly, with hot 75-per cent. alcohol. The residue, washed with absolute alcohol and thoroughly air dried, weighed 71 grams and contained 1.07 per cent. of nitrogen. The air dry flour before extraction contained 1.83 per cent. of nitrogen. The 100 grams of flour therefore contained 1.83 grams of nitrogen and the residue after extraction contained 0.76 grams. The nitrogen removed by the solvents therefore amounted to 58.3 per cent. of the whole.

If we assume that the nitrogen all belonged to proteid matter containing 17 per cent. of nitrogen, the flour included 10.76 per cent. of proteids, of which 58.3 per cent. was soluble in the reagents used in extracting the proteids already described. We have therefore $10.76-6.28=4.48$ per cent. of proteid unextracted. It was only possible to obtain this proteid by treating the residue with potash water. All attempts, however, to thus prepare it in quantity sufficient to yield preparations of even approximate purity resulted in complete failure.

The previous extraction of the flour to remove the proteids already described seemed to render to a great extent the remaining proteid insoluble in potash water and only insignificant precipitates resulted on neutralizing the extracts. The barley flour also contained a large quantity of gum which rendered the filtration of the alkaline extract very difficult, as this gum dissolved freely in potash water. As the proteids prepared from the barley flour are all so similar to those obtained from wheat flour it is most probable that this seed also contains a considerable quantity of proteid soluble only in dilute alkaline solutions, but, as in the case of rye, the writer was unable to obtain results of any value whatever in regard to it.

Conclusion.

The barley kernel contains:

I. Leucosin coagulating at 52°, which is the same as the albumin found in the wheat and rye kernels. Its composition, as shown by the average of six analyses, is:

Carbon	52.81
Hydrogen	6.78
Nitrogen	16.62
Sulphur	1.47
Oxygen	22.32
	100.00

This substance forms about 0.3 per cent. of the seed.

II. A small quantity of proteose, the reactions and composition of which could not be definitely ascertained.

III. Edestin, a globulin which is the same as that found in the wheat and rye kernels and in a large number of other seeds. Its composition is approximately shown by the figures given below. Owing to the small amount of this body and the difficulty in preparing it, no perfectly pure preparations were obtained.

Carbon	50.88
Hydrogen	6.65
Nitrogen	18.10
Sulphur, Oxygen	24.37
	100.00

This is the proteid commonly known as vegetable vitellin. It is precipitated from saline solutions by dilution and by dialysis, is not coagulated by heating below 90°, and above that temperature only partially. It is not precipitated by saturating its solutions with sodium chloride, but is thrown down from saline solutions by adding acid.

IV. Hordein, a proteid insoluble in saline solutions, very slightly soluble in pure water and extremely soluble in alcohol of about 75-per cent. This is the barley-proteid described by Ritthausen as mucedin. It has almost exactly the same physical and chemical properties as gliadin obtained from wheat and rye kernels but a different composition.

Carbon	54.29
Hydrogen	6.80
Nitrogen	17.21
Sulphur	0.83
Oxygen	20.87
	100.00

About 4.0 per cent. of the seed consists of this substance.

V. After extracting the barley flour with salt solution and with alcohol the residue still contained 42 per cent. of the total nitrogen, corresponding to proteid matter equal to about 4.5 per cent. of the flour. It was not possible to extract more than a very small amount of this residual proteid with dilute potash water, as the treatment for removal of the other proteids rendered it insoluble, if it were not so already.

VI. The barley flour contained 1.83 per cent. of nitrogen and, if it is assumed that this all belonged to proteid matter with 17 per cent. of nitrogen, the flour would contain 10.75 per cent. of proteids. The barley accordingly contained about 4.5 per cent. of insoluble proteid, 4.0 per cent. of hordein soluble in dilute alcohol, 0.30 per cent. albumin and 1.95 per cent. of globulin and proteose.

THE CHEMICAL NATURE OF DIASTASE.

By THOMAS B. OSBORNE.

Few substances are of more importance or of more interest than the enzymes or unorganized ferments, yet our knowledge relating to these bodies is almost wholly confined to the products of their activity and the conditions under which this is manifested. Although the existence of these ferments was recognized early in the present century, our information in respect to their true nature is exceedingly limited and unsatisfactory. It was for a long time supposed that the active substance causing a fermentative change is a soluble proteid, and the power of inducing such change seems by many to have been ascribed to soluble proteid matter in general. Later, this power was thought to be restricted to special forms of proteid, but no sufficient evidence was brought forward. Of late years investigators have undertaken to isolate ferments and prepare them in a state of purity. The results of these attempts have led to very conflicting conclusions respecting the character of these bodies. Some of the so-called pure preparations of ferments have had the properties of the proteids, and have more or less agreed with them in composition, while others have differed widely from the proteids in both respects.

It still seems to be the opinion of many that the enzymes are in fact true proteids and that the ferments thus far supposed to be obtained in a state of purity were simply somewhat contaminated with other substances. This opinion is based on the fact that all those changes which are ascribed to the action of enzymes occur only in solutions which contain proteid matter, and that the activity of the ferment is greatly influenced by conditions known to have a pronounced action on proteids, such as heat, the presence of acids and alkalies, salts of the heavy metals, etc.

The first discovered and one of the most carefully studied of these ferments is diastase. The practical application of the action of diastase in the manufacture of alcohol and of malt liquors has given rise to careful and extended studies of the conditions affecting the activity of this ferment, and the result of these studies has led some to the opinion that the active substance is the albumin present in the malt extracts. The conversion of

starch into maltose and dextrin by diastase increases in rate and extent as the temperature of the solution is raised, until the heat reaches the point at which the albumin begins to coagulate. The ferment then begins to lose power, and, when the heat is sufficient to completely coagulate the albumin, its amylolytic action ceases entirely. In 1883, C. Lintner, Jr., showed that the diastatic power of fifteen different samples of malt was very nearly proportional to the amount of coagulable albumin which they contained. In 1886, however, C. J. Lintner prepared diastase in, as he supposed, a state of purity, and came to the conclusion that the results of his analysis of diastase indicate that, in the ferments, we have a special class of proteid substances. The composition of Lintner's purest diastase differed much from that of the proteids, since it contained only two-thirds as much nitrogen and also less carbon. His diastase furthermore, failed to give the reaction with cupric sulphate and potassic hydrate which is characteristic of proteid matter. These results of Lintner's threw much doubt on the hypothesis that the vegetable albumin is identical with diastase.

In my investigations of the proteids of wheat, rye and barley, I found in all these grains the same albumin and was impressed with the close relation between the temperature at which this albumin coagulates and the temperature at which diastase begins to lose its activity. The aqueous extracts of these seeds, as is well known, possess considerable diastatic power, and it seemed to be more than probable that this was due to the albumin. I accordingly undertook an investigation of this subject, and I now offer the results thus far obtained, which are preliminary to a more extended study.

The usual method of preparing vegetable enzymes is to treat the aqueous or glycerin extract containing them with alcohol as long as a precipitate, having fermentative power appears, to purify this by repeated precipitation from its solution in water, by means of alcohol, and finally to subject the aqueous solution to dialysis to remove salts. This method is wholly unsuited to yield pure preparations, because the precipitate produced by alcohol contains not only a large amount of carbohydrates and salts, but also nearly all of the various forms of proteid matter present in the extract. Lintner employed this method, and there can be no doubt that he obtained a mixture of proteids with other substances which defied all attempts at further separation.

The most rational method (hitherto very little used) is first to separate the proteids from the carbohydrates and other soluble substances by saturating the extract with ammonium sulphate, thereby precipitating the ferment and proteids together, next to remove the proteid existing as globulin, by dialysis, and then, if possible, to separate the albumin and proteoses by fractional precipitation with alcohol. In following this method, a measured quantity of malt extract was saturated with ammonium sulphate, the precipitated proteid matter was filtered out, dissolved in water, and the clear filtered solution made up to the volume of the original extract. This solution was found to have the same diastatic power as before precipitation, thus showing that ammonium sulphate had not injured the diastase. Throughout my work diastatic power has been measured by Lintner's method, which gives a very ready means of accurately comparing different preparations. This method consists in adding to each of a series of carefully measured volumes of the solution containing definite amounts of the diastatic preparation, ten c. c. of a two per cent. solution of soluble potato starch, and allowing the ferment to act upon the starch for one hour at the ordinary temperature of the room. At the end of this time five c. c. of Fehling's solution are added to each portion and the mixtures are heated for ten minutes in a boiling water bath. After the precipitated cuprous oxide has settled, where too little sugar has been formed to precipitate all the copper, the liquids will be blue; if sugar is in excess they will be yellow. The one colorless liquid that should result gives the measure of diastatic power. Lintner represented the value of his most active preparation by 100, and that of the other preparations by figures stating the amount of each necessary to give a complete reaction with Fehling's solution under the above conditions, in comparison with his most active preparation, of which, under the conditions of the test just described, twelve one-hundredths of a milligram completely reduced the five c. c. of Fehling's solution.

For the sake of comparison I have measured the activity of my preparations by the same standard, so that a preparation whose activity is given as 200 means that six one-hundredths of a milligram sufficed to give a complete reduction.

As Lintner recommended extracting the malt with water containing twenty per cent. of alcohol instead of pure water, since thereby less foreign matter was removed with the proteid, this

procedure was first tried. Fifteen hundred grams of ground air-dried malt, prepared in the laboratory, were treated with three liters of twenty per cent. alcohol, the extract squeezed out in a press and the residue again treated with another liter of the same dilute alcohol. Three liters of extract were obtained which after being filtered clear were saturated with ammonium sulphate. Owing to the presence of the alcohol much less ammonium sulphate was dissolved than by a water extract, and the proteids were consequently incompletely precipitated. The precipitate obtained was treated with water and a considerable quantity of insoluble matter, consisting mostly of globulin rendered insoluble by contact with the reagents, was filtered out. The solution was saturated with ammonium sulphate, and the precipitate dissolved in water. This clear solution was then dialyzed in water for some days, and after filtering from a slight deposit was dialyzed in alcohol of 0.845 sp. gr. for 48 hours.

As the water passed out of the dialyzer faster than the alcohol entered, the solution became concentrated and a considerable precipitate formed. This was filtered out and washed, first with dilute alcohol and afterwards with absolute alcohol, and dried over sulphuric acid. This preparation, **1**, when thus dried, dissolved in water with the exception of a not inconsiderable residue. When filtered clear, the solution, on heating, gave an abundant coagulum, and after boiling and filtering out the coagulum, the filtrate gave a strong pink color with cupric sulphate and potassic hydrate, showing the presence of proteose. The diastatic power of this preparation, in comparison with Lintner's best was 86, but, as it was afterward found to contain a comparatively small amount of ash, the test was repeated with the addition of a few milligrams of sodium chloride and then found to equal 150.

The composition of preparation **1** was as follows:

PREPARATION **1**.

	Ash-free.
Carbon	52.55
Hydrogen	6.48
Nitrogen	16.41
Sulphur } Oxygen }	24.56
	100.00
Ash	2.29

These figures indicate that this preparation consisted almost wholly of proteid matter, and the reactions proved the presence

of at least three forms, namely, coagulated proteid, albumin and proteose. This mixture was one and a half times more active than Lintner's most energetic preparation, and contained about six per cent. more nitrogen and one-half as much ash. The composition of the preparation is very similar to that of the coagulated albumin-like body obtained from wheat, rye and barley, and for which I have adopted the name leucosin. As this albumin has been found to have the same composition, whether coagulated by heat or by alcohol, and as most, if not all of the proteids have identical composition (so far as analysis can show), in the soluble and the coagulated states, it seems probable that preparation **1** consisted mostly of coagulated and soluble leucosin together with a little proteose.

The filtrate from this preparation on addition of absolute alcohol, yielded a small precipitate **2** which dissolved wholly in water and gave only a very slight coagulum on heating, but a strong pink biuret reaction, showing it to be mostly proteose. Its diastatic power was only 19.

As above stated, owing to the presence of alcohol, saturation of the original extract of malt with ammonium sulphate, precipitated only a part of the proteids. Accordingly the filtrate from this first precipitation was dialyzed for 24 hours, so as to remove most of the alcohol, and was again saturated with ammonium sulphate. The resulting precipitate was dissolved in water, filtered from a slight residue, and the clear solution dialyzed until nearly all the ammonium sulphate was removed. The dialyzer was then transferred to alcohol and left for 48 hours. The resulting precipitate was then filtered out and treated in the manner before described. After drying, this substance, preparation **3**, like preparation **1**, consisted of insoluble proteid, soluble leucosin and proteose. Its diastatic power was 133, and it had the following composition :

PREPARATION 3.

	Ash-free.		
	I.	II.	Average.
Carbon	52.34	----	52.34
Hydrogen	6.73	----	6.73
Nitrogen	15.90	15.92	15.91
Sulphur } Oxgen	----	----	25.02
			100.00
Ash			0.82

The filtrate from this preparation was next treated with a large quantity of absolute alcohol, and the contained proteid completely thrown down. This substance, preparation **4**, dissolved entirely in water; its solution yielded but a trace of coagulum on heating, and when boiled and filtered gave a strong proteose reaction. It contained, ash-free, only 12.02 per cent. of nitrogen, and had a diastatic activity of 11.

These results prove: that extraction of the malt with twenty per cent. alcohol is not suited for a subsequent precipitation of the proteids with ammonium sulphate: that otherwise, the method is capable of yielding preparations of diastase of high fermentative power, which to a certain extent, can be separated into fractions containing the different forms of proteid matter : that the fractions including the greatest amount of soluble albumin have the greatest diastatic power: and that a part at least of the proteose is almost if not entirely free from this power.

Another extraction was made on a much larger scale, so that the fractional precipitations might be more numerous, and the fractions examined more closely.

Ten kilograms of malt were exhausted with water and the extract was saturated with pure and neutral ammonium sulphate. The very bulky precipitate was suspended in four liters of water and dialyzed until much of the sulphate had been removed and the precipitated proteid largely dissolved. The solution was then filtered from an insoluble residue consisting mostly of globulin, and the clear filtrate was saturated with ammonium sulphate. The precipitate thus obtained was suspended in 1500 c. c. of water and was dialyzed until nearly all the sulphate had been removed and the precipitate mostly dissolved. The globulin contained in the extract was thus largely separated and, after it had been filtered out, the clear solution was dialyzed into an equal volume of alcohol of .84 sp. gr. After 48 hours the precipitate, number I, which had separated was filtered out and set aside for further examination. The filtrate was again dialyzed into an equal volume of alcohol of 0.84 sp. gr., and after 48 hours another precipitate II obtained. The filtrate was further dialyzed into a rather larger quantity of somewhat stronger alcohol, and precipitate III separated, and by similarly treating the filtrate from this, precipitate IV was obtained, the filtrate from which, on adding a large quantity of absolute alcohol yielded precipitate V. All the proteid in the extract was thus separated. Precipitate I was much

contaminated with coloring matter, II less so, and III was nearly colorless, as were also IV and V.

The approximate weights of each of these precipitates was as follows: I, 13.0 grams; II, 8.0; III, 6.0; IV, 5.0; and V, 3.0, a total of 35.0 grams.

Precipitate I was treated with water and found to be very largely insoluble. The insoluble matter was filtered out and washed with water, and the clear solution was dialyzed for several days to remove all the salts. No proteid was thus precipitated, and the dialysis was continued in strong alcohol, thereby throwing down all but a trace of proteid. The precipitate, preparation **5**, weighed 2.11 grams. After drying, it dissolved in water with the exception of a small residue, and its solution when slowly heated became turbid at 65° and deposited flocks at 70°. After boiling and filtering out the slight coagulum, the solution gave a strong pink reaction with the biuret test. These tests show the preparation to consist largely of proteose. Its composition was as follows:

PREPARATION **5**.

	Ash-free.
Carbon	53.16
Hydrogen	7.03
Nitrogen	16.50
Sulphur	1.50
Oxygen	21.81
	100.00
Ash	0.49

With Lintner's test this preparation showed a diastatic power of 30.

The insoluble residue, remaining after treating precipitate I with water, was thoroughly extracted with ten per cent. sodium chloride solution, what remained insoluble in this menstruum was filtered out and the clear solution dialyzed until free from chlorides. The precipitate thus formed, preparation **6**, weighed 1.20 grams, and after drying was not soluble in water, but dissolved readily and nearly completely in salt solution, having, as was to be expected, the properties of a globulin. This substance had a very slight diastatic power, and its sodium chloride solution when heated slowly became turbid at 60°, a few flocks appearing at 65°, due to a trace of albumin. Its composition was as follows:

PREPARATION **6**.

	Ash-free.
Carbon	53.11
Hydrogen	6.45
Nitrogen	15.78
Sulphur } Oxygen }	24.66
	100.00
Ash	0.75

The filtrate from preparation **6** still contained proteid matter which was separated by dialysis in alcohol. Preparation **7** was so obtained, weighing 1.54 grams, having the same properties as **6**, and the following similar composition:

PREPARATION **7**.

	Ash-free.
Carbon	53.58
Hydrogen	6.70
Nitrogen	15.87
Sulphur } Oxygen }	23.85
	100.00
Ash	1.43

After extracting precipitate I with water and salt solution a very considerable part still remained undissolved. This was treated with water to remove all the salt, and then with alcohol, and was dried over sulphuric acid. This preparation, **8**, weighed 8 grams and was quite dark in color. It had the properties of an insoluble form of globulin, being dissolved in one-half per cent. sodium carbonate solution and precipitated therefrom by neutralization. Its composition was nearly the same as that of the two last globulin-like preparations and is probably a so-called "albuminate" derived from that substance. The composition of preparation **8** was:

PREPARATION **8**.

	Ash-free.
Carbon	53.55
Hydrogen	7.01
Nitrogen	15.72
Sulphur	1.23
Oxygen	22.49
	100.00
Ash	1.09

Precipitate II was treated with water and the solution thus formed was dialyzed in water for several days and then in alcohol

for 24 hours. A quantity of absolute alcohol was finally added to the contents of the dialyzer, thus completely precipitating the proteid. This preparation after drying was almost wholly soluble in water, and when heated slowly its solution became turbid at 60° and deposited flocks at 66°. The amount of proteid thus coagulated was somewhat greater than was given by preparation **5,** and its diastatic power was likewise greater, being 75. Analysis showed its composition to be as follows:

PREPARATION **9.**

	Ash-free.
Carbon	53.19
Hydrogen	6.71
Nitrogen	16.74
Sulphur	1.38
Oxygen	21.98
	100.00
Ash	0.78

This preparation contained a slight amount of insoluble matter, some albumin and much proteose.

The residue of precipitate II, which was not dissolved by water, was treated with sodium chloride solution and the clear extract dialyzed till free from chlorides, but as no precipitate was produced, the dialyzer was transferred to alcohol when preparation **10** separated, weighing 0.49 gram, and containing, ash-free, 15.18 per cent. of nitrogen. It is probable that this is the same globulin obtained in larger quantity from precipitate I, but less pure. That part of precipitate II which remained undissolved after extracting with water and salt solution, was then washed thoroughly with water and with alcohol, yielding preparation **11,** which weighed 5.0 grams and had the following composition:

PREPARATION **11.**

	Ash-free.
Carbon	53.51
Hydrogen	6.75
Nitrogen	15.76
Sulphur	1.12
Oxygen	22.86
	100.00
Ash	0.66

These figures show that precipitate II contained less globulin and proportionately more leucosin and proteose than precipitate I and it was accordingly found to be more powerfully diastatic.

Precipitate III was in turn treated with water, the resulting extract filtered clear, dialyzed for several days in water and then in alcohol, absolute alcohol being finally added in quantity to the contents of the dialyzer. The resulting precipitate, preparation **12,** weighed 3.0 grams. It was almost completely soluble in water, and its solution when slowly heated became turbid at 55° and flocculent at 60°. The amount of this coagulum was much greater than that yielded by preparation **9.** The filtrate from the coagulum gave a strong proteose reaction. The diastatic power was 222, indicating the presence of much more diastase than any of the preceding preparations. Its composition was as follows:

PREPARATION **12.**

	Ash-free.
Carbon	52.80
Hydrogen	6.96
Nitrogen	16.09
Sulphur	1.45
Oxygen	22.70
	100.00
Ash	0.59

The residue of precipitate III was digested with salt solution, the filtered extract was dialyzed in water till free from chlorides, and then, as no proteids separated, the dialysis was continued in alcohol. Only 0.28 grams of proteid resulted, which, without correction for ash, contained 12.53 per cent. of nitrogen. This was marked preparation **13,** and considered to be impure globulin.

The part of precipitate III still undissolved was washed with water and with alcohol, yielding preparation **14,** which weighed 2.87 grams. This had the following composition:

PREPARATION **14.**

	Ash-free.
Carbon	53.25
Hydrogen	7.65
Nitrogen	16.12
Sulphur	1.38
Oxygen	21.60
	100.00
Ash	0.55

This preparation has a somewhat higher nitrogen and lower carbon content than preparations **8** and **11,** which is probably due to its being a mixture of the insoluble form of the globulin with

some insoluble albumin coagulated by the long contact with alcohol to which it had been subjected. This is to be expected, as precipitate III contained relatively more albumin than precipitates I and II.

Precipitate IV was next treated with water, the solution filtered clear, dialyzed for some days in water, and afterwards transferred to alcohol and the dialysis continued. Absolute alcohol was then added to the contents of the dialyzer, giving preparation **15,** weighing 4 grams. This substance dissolved in water to a nearly clear solution, which when filtered perfectly clear and heated carefully became turbid at 50° and gave a large coagulum at 56°. After heating the solution and filtering off the coagulum, a good reaction for proteose was obtained with the biuret test. This preparation had a diastatic power of 600. As this was a much more powerful ferment than any yet produced, its properties were carefully studied and will be described at length later. When analyzed this substance was found to have the following composition:

PREPARATION **15.**

	Ash-free.
Carbon	52.50
Hydrogen	6.72
Nitrogen	16.10
Sulphur	1.90
Oxygen	22.78
	100.00
Ash	0.66

It will be noticed that the sulphur in this preparation is a little higher than in the preceding preparations, which is probably due to its containing some sulphate.

The part of precipitate IV which did not dissolve in water was treated with salt solution, but no globulin was extracted. The residue was then washed with water, giving preparation **16,** which weighed 0.9 gram and had the following composition:

PREPARATION **16.**

	Ash-free.
Carbon	53.42
Hydrogen	7.15
Nitrogen	16.65
Sulphur, Oxygen	22.78
	100.00
Ash	0.24

The composition of this insoluble product shows it to be probably coagulated leucosin.

A portion of precipitate V, when treated with water, was found to dissolve completely. It was therefore washed with absolute alcohol, yielding preparation **17,** which weighed 2.87 grams. The clear solution of this substance when heated became turbid at 50°, and yielded a small coagulum at 58°. Boiled and filtered a strong pink coloration was given with the biuret test, thus showing it to consist mostly of proteose. The diastatic power of this substance was 60, only one-tenth that of preparation **15.** Its composition was:

PREPARATION **17.**

	Ash-free.
Carbon	51.21
Hydrogen	6.52
Nitrogen	15.40
Sulphur, Oxygen	26.87
	100.00
Ash	2.37

The lower nitrogen content of this preparation indicates that the strong alcohol had thrown down, together with the proteids, some non-nitrogenous substances.

Much is to be learned by studying these results which will be of service in future attempts to isolate pure diastase.

In the first place, it is plain that we have in our malt extract a globulin, an albumin and at least one, more probably, two, forms of proteose. I believe the substance soluble in salt solution to be a true globulin, since it so readily assumes an insoluble form, and also because a much larger quantity of the same body was obtained by extracting with ten per cent. salt solution, the malt-residue remaining after the extraction with water. I also think that at least two forms of proteose are present, for the water-soluble portion of precipitate I consisted chiefly of proteose, as did also precipitate V. The amount of proteose diminished from precipitate I to precipitate IV, which contained the least, while precipitate V, which, it will be remembered, was thrown down by adding to the solution a very large amount of absolute alcohol was mainly proteose. A part of the proteose was precipitated by alcohol more readily than the albumin, while another part was less readily precipitated. Beside the albumin, globulin and

proteoses, we have also to take account of the "albuminate" or insoluble forms of the albumin and globulin. The results of this extraction show that the globulin is rendered insoluble more rapidly than the albumin, so that precipitation with alcohol and solution in water, repeated a few times, may be depended upon to remove the former. Whether repeated fractional precipitation can be employed to completely separate the albumin from the proteoses is not so certain. The albumin is thrown down from the malt-extract by saturation with magnesium sulphate, and it is not unlikely that a complete separation can be accomplished by this reagent. It is, however, not to be forgotten that the diastase may be a substance which when heated to from 50°–60° splits apart into an albumin and a proteose, and that the proteose found in the solutions which have been heated is a decomposition product of the diastase. Kühne's attempts to produce pure trypsin led him to suspect that this ferment is a body which when heated yields a coagulable fraction and a proteose-like substance.

Now that we have some precise knowledge of the associated substances, it seems probable that we may succeed in obtaining diastase nearly if not quite pure, and arrive at a clearer and more positive knowledge of this ferment, and also have a guide in further study of other enzymes, which will lead to a more satisfactory understanding of this whole subject. It is probable that the ferments contained in seeds are much easier to prepare than those of animal origin, since the substances with which they are associated are largely non-proteid and comparatively easy to separate. It is also certain that the amylolytic ferments present an easier problem than the proteolytic, for the products of the activity of the latter are so similar, in their nature, to that which the ferment is supposed to possess, as to make it always a matter of great uncertainty whether the separated enzyme is free from those bodies or not.

As already stated, preparation **15** was a very energetic ferment, and on this account its properties were more fully studied, with the following results:

Dissolved in water this substance gave all the usual proteid reactions, and when heated slowly became turbid at 50° and gave a flocculent coagulum at 56°. This is exactly the temperature of coagulation of the albumin (leucosin) which I have prepared from wheat, rye, barley and malt, with identical composition and properties. The aqueous extracts of these grains have,

moreover, a strong diastatic action on starch. The amount of coagulable albumin in preparation **15** was determined and found to be 53.2 per cent. of the dry substance.

These facts point strongly to the albumin as being the diastatic substance, yet there are several facts, hard to explain if this is true, which cannot be overlooked. Although in general the diastatic power of my preparations was greater the larger the amount of coagulable albumin they contained, I have never yet been able to establish any numerical relations between the two. In no case have I found any diastatic action with solutions free from albumin. Furthermore, the activity of my preparation **15,** is such as to require a much greater diastatic power for malt than this shows if its coagulable albumin is the enzyme.

A malt extract corresponding to a solution of the diastase in five milligrams of malt had the same diastatic power as 0.02 milligram of preparation **15.** As the preparation contained but a little over 50 per cent. of coagulable albumin, this would correspond to only 0.01 milligram of albumin in the five milligrams of malt, or two-tenths per cent. The amount of albumin in malt is much greater than this, as it is also in wheat, rye and barley, whose diastatic power is greatly inferior to that of malt. It is not probable that the *separated* diastase is more active than that *in the seed*, especially in view of the experiments which follow, comparing the action of malt extract and preparation **15.** The only explanation of this that occurs to me, is that the active diastase is a combination of albumin with some other body, presumably the proteose, which breaks up on heating, yielding coagulated albumin, and that, besides this combined albumin, free albumin is also present, which has no diastatic power, but which is coagulated at the same time. There is no direct evidence, however, that this hypothesis is correct.

Compared with other so-called pure ferments, preparation **15** is very active. At 20° it was in a condition to produce, from soluble starch, over 2000 times its weight of maltose and a further undetermined quantity of dextrin, within one hour. After having been dried over sulphuric acid and kept for six months, its activity was reduced to one-half, but in this condition it produced in 17 hours, at 20°, 10,000 times its weight of maltose besides an unknown quantity of dextrin. At 45° the same quantity of maltose was produced in one hour as at 20°. At 50° much less and at 55° very little maltose was formed. These tests were made by using

an amount of diastase solution just sufficient to produce enough maltose at 20° to exactly reduce 5 c. c. of Fehling's solution.

Compared with malt extract of the same diastatic strength, as measured by the amount of maltose produced in one hour at 20°, the distilled water solutions of preparation **15** have a less powerful action in liquifying starch paste. Five c. c. of malt extract added to ten c. c. of a starch paste containing 2 per cent. of starch, dissolved the starch completely in eight minutes, while the solution of preparation **15** required thirty-seven minutes.

The malt extract is also more energetic in converting starch completely into bodies giving no color with iodine. Five c. c. of the same malt extract added to ten c. c. of soluble starch solution caused the blue reaction with iodine to disappear in thirteen minutes, while it required thirty-eight minutes to reach the same result with the solution of the separated diastase. When, however, the diastase was dissolved in malt extract, whose enzymes had been previously killed by heating, the difference between the separated diastase and that in the malt extract nearly disappeared.

Two test tubes were each charged with 10 c. c. of starch paste. To one tube was added 5 c. c. of fresh malt extract, and to the other the same amount of boiled and cooled malt extract in which had been dissolved a quantity of preparation **15**, sufficient to make a solution of the same sugar-producing power as the fresh malt extract itself.

The fresh malt extract liquefied the starch in seven minutes, the mixture of preparation **15** and boiled malt extract in fourteen minutes, while thirty-seven minutes were required to produce the same result with a distilled water solution of preparation **15**. In completely converting starch into bodies giving no color with iodine, the solution of preparation **15** in boiled malt extract gave exactly the same result as the fresh malt extract, showing that the difference first noticed was due to the conditions and not to the ferment.

In view of these results, it seems highly probable that diastase is a true proteid, for if we consider the extremely minute quantity of preparation **15** required to produce large amounts of maltose, it is hard to believe that this action is due to some substance adhering to the proteid to the extent of only three or four per cent. at the most. If such were the case it is also remarkable that the enzyme should adhere in so much greater quantity to

the particular precipitate represented by preparation **15** than to any of the other numerous fractions. If diastase, then, is to be considered as a true proteid, it is evidently either an albumin, a combination of an albumin with a proteose, or a proteose. We have seen that those fractional precipitates which consist largely or wholly of proteose have little or no diastatic action, amylolytic power being manifested most strongly in the fractions containing the most albumin, and least in those containing but little, though not in strict proportion to the amount of the albumin. It is to be concluded that the diastatic enzyme is most closely related to the albumin, named leucosin, and it is not improbable that further careful study will show more clearly what this relation is.

WORK DONE FOR THE DAIRY COMMISSIONER.

By E. H. Jenkins.

The General Statutes of Connecticut provide that the Dairy Commissioner of this State "may have samples suspected to be imitation butter analyzed at the Connecticut Agricultural Experiment Station, or by any State chemist, and a sworn or affirmed certificate of the analyst shall be *prima facie* evidence of the ingredients," etc.

The statute does not require the Station to make these analyses, neither does it provide for any payment to the Station for the work.

The Station has, however, thus far done all the work required by the Dairy Commissioners gratuitously, as there appeared to be no other way in which the Commissioners could have it satisfactorily performed.

The provision that a chemist's affidavit shall be *prima facie* evidence has been ruled by the courts to be unconstitutional.

The affidavit being really the foundation of the accusation the one who draws it must appear in court. Hence the work done for the Commissioner involves the necessity of appearing at every police court where the cases are first brought and when appealed, at the Superior Court till they are finally disposed of.

This feature of the work is the most expensive, taking much time which cannot well be spared from Station duties. No expert fee can be allowed for it by the courts. The Station therefore receives the usual witness fees; mileage and fifty cents for eaeh appearance!

During the year ending Nov. 1st, 1894, twenty-three samples of butter and five of molasses have been examined and sworn statements returned to the Commissioner. In twelve cases expert evidence has been offered in court.

In no case since the office of Dairy Commissioner was created, has the evidence given by the Station been disputed.

THE BABCOCK METHOD OF FINDING THE AMOUNT OF BUTTER-FAT IN MILK AND CREAM.

By A. L. Winton and A. W. Ogden.

This method is based on the fact that when milk, cream, skim-milk, and butter-milk are mixed in proper proportions with sulphuric acid of a certain strength the acid dissolves or mixes with all the milk-ingredients except the butter-fat, and the latter is completely separated with suitable apparatus and accurately measured.

The quantity of butter-fat determined by the Babcock method, is the most satisfactory basis of payment for milk or cream. It is used by numerous successful creameries east and west and promises to become almost universally applied.

In Bulletin 106 of this Station. issued in 1891, the attention of Connecticut dairymen was called to this method. To answer inquiries more frequently made of late regarding the way to work the Babcock test, Bulletin 117 was issued in January, 1894. In its preparation full use was made of Bulletin 36, of the Wisconsin Experiment Station, written by Dr. Babcock. The substance of Bulletin 117 is here reproduced with suitable additions.

Directions are first given for weighing and sampling milk and its products. Then follow instructions for preserving samples which cannot be immediately tested, and lastly the method of executing the tests is fully described.

Directions for Weighing.

Milk.—To determine the quantity of butter-fat which a cow produces it is absolutely necessary in the first place to know the quantity of milk which she gives.

Weigh the milk accurately at milking time, which may be conveniently done on a spring balance in a pail which weighs an even number of pounds.* If the milk cannot be weighed, the number of quarts multiplied by 2.15 will give its approximate weight. Thus: $8\frac{1}{2}$ quarts is about ($8\frac{1}{2} \times 2.15 =$) 18.3 pounds. *The measuring must be accurate.* Froth is not milk. A quart measure filled to a quarter of an inch of the top is not a quart.

* See page 217.

An "eight quart" pail may hold considerably less or more than eight quarts.

Skim-milk and Butter-milk.—To learn how complete the skimming has been, or how much butter-fat is lost in butter-milk, it is absolutely necessary to know the weight as well as the per cent. of butter-fat in each. The whole quantity must therefore be thoroughly mixed and weighed.

Cream.—A description of the method used for weighing cream will be found on pages 217 and 220.

Directions for Sampling.

Milk of Single Cows.—Milk that has soured or on which cream has risen and dried, so as to form a clot or skin, cannot be accurately sampled on the farm.

Thoroughly mix the milk, as soon after milking as possible, either by pouring three or four times from one pail to another, or by stirring vigorously with a dipper. To secure an accurate sample, thorough mixing is absolutely essential. Failure to secure a fair sample makes the test worthless or worse than worthless. Immediately after mixing, dip out a sample of about one-half gill or two ounces. From this a sample may be at once measured in the way to be described later for testing, or the whole quantity may be put into a *clean and dry* bottle,* with a preservative when necessary, and kept till used in a cold place where it will not freeze.

Mixed Milk of a Herd..—Into some vessel like a cream carrier, pour all the milk from the pails or cans *one immediately after the other*, and from such a height that the whole quantity is stirred up from the bottom. Then with a cup, dipper or pitcher, *at once* take out about a pint. Stir this thoroughly with a spoon immediately before pouring into the sample bottle, or before measuring the quantity for the Babcock test. If there is no can at hand large enough to hold the whole lot of milk, very accurate sampling is more difficult. Still if the milk is in a number of cans or pails of the same size or shape, and all have the same quantity of milk in them, a fair sample may be got by taking the same quantity of milk, a gill, pint or quart, from each can or pail, after thorough stirring as already described, mixing these samples thoroughly, and then taking a single sample from the mixture.

* Rather than try to use large bottles or those not perfectly clean it is better to buy from a druggist new two-ounce bottles with new corks.

Skim-Milk and Butter-Milk.—The same course should be followed as with the mixed milk of a herd. The *whole quantity* of the skim-milk or butter-milk should be mixed. The sample must not be taken from a part of it.

Cream.—Cream that is very thick, clotted or soured cannot readily be sampled on the farm. The same is true of centrifugal cream when it is badly frothed; but sweet cream thin enough to pour freely, may be sampled in the same way as whole milk, after pouring it two or three times from one vessel to another. See page 211.

Directions for Preserving Samples.

Composite Samples.—If the samples daily taken from the milk of a cow or herd or from the cream supplied by a creamery patron are poured as soon as drawn into a bottle kept for the purpose and mixed together, this mixture is a "composite sample" and represents the average quality of the milk or cream for the entire period during which daily samples were added to it.

By a test of this composite therefore it is possible to determine the average per cent. of butter-fat in the milk or cream for the whole of this period, which may be one, two or even three weeks.

The daily samples of milk added to the composite must be fairly proportional to the total quantity of milk. Full directions regarding the preparation and preservation of such samples will be found on page 222.

Apparatus for Making the Test.

Test Bottles.—The test bottles used for whole milk (figure 1) have graduations from 0 to 10, each division of the scale representing 0.2 per cent. These bottles can be used also for skim-milk and butter-milk, but a bottle which holds twice as much and has a scale graduated to 0.1 per cent. (shown in figure 2) is preferable for that purpose.

The bottle used for cream testing is described on page 223.

Pipettes.—For whole milk, skim-milk and butter-milk a pipette delivering 17.6 cubic centimeters is used (figure 3). When skim-milk and butter-milk are tested in bottles shown in fig. 2, the pipette is filled twice, that is to say 35.2 c. c. are used for the test. The pipette to be used in testing cream is described on page 223.

Acid Measure.—This is a glass graduate which holds, when filled to the mark, 17.5 c. c. See fig. 4.

Centrifugal Machine.—Most makers of dairy machinery supply machines suitable for the purpose. The sizes vary from four bottle testers to those carrying fifty or more bottles, those last

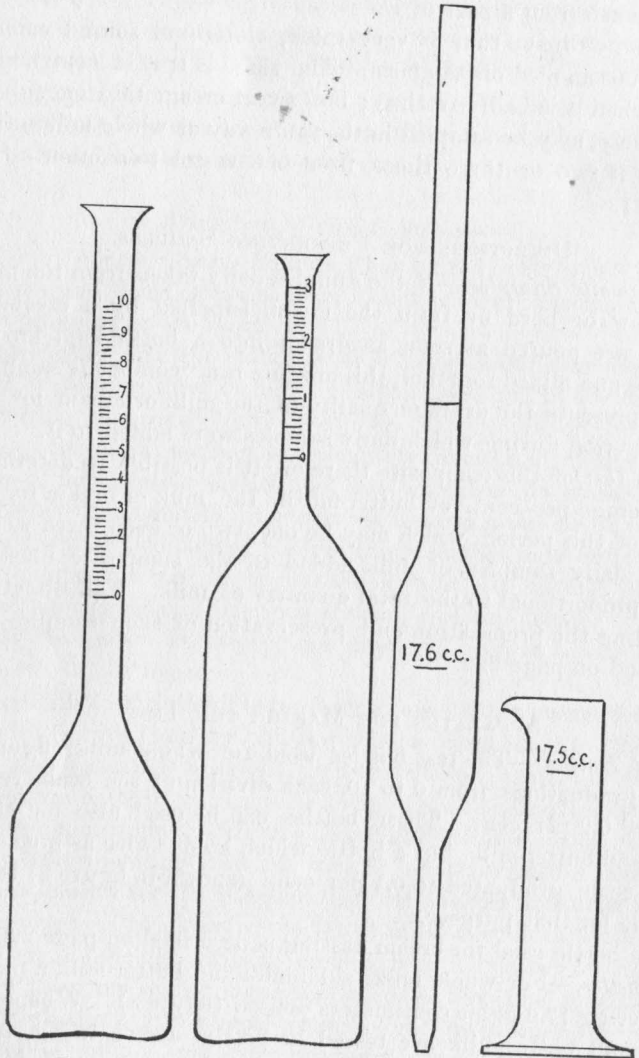


FIG. 1. FIG. 2. FIG. 3. FIG. 4.

being designed for factory use. The wheel to whose circumference the bottles are attached should make from 700 to 1200 revolutions per minute according to its diameter, about 700 revolutions being sufficient for the larger wheels with a diameter of

about 20 inches, while small 12-inch wheels should run at the rate of about 1200 revolutions per minute.

Commercial Sulphuric Acid (*Oil of Vitriol*).—This should have a specific gravity of 1.82. For further description see page 225.

DIRECTIONS FOR MAKING THE TEST.

The details of the process of testing are the same for whole milk, skim-milk, butter-milk and cream (except as far as the quantities for testing, and the form of the bottles is concerned, and are fully described on pages 226 to 229.

The method of measuring the fat of milk, skim-milk and butter-milk is as follows :

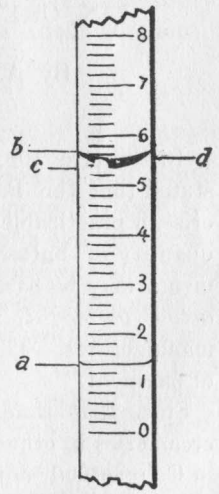
Measuring the fat.—The fat when measured should be warm enough to flow readily, so that the line between the acid liquid and the column of fat will quickly assume a horizontal position when the bottle is removed from the machine.

Any temperature between 110° F. and 150° F. will answer, but the higher mperature is to be preferred. The slight difference in the volume of fat due to this difference in temperature is not sufficient to materially affect results.

To measure the fat, take a bottle from its socket, and holding it in a perpendicular position with the scale on a level with the eye, observe the divisions which mark the highest and the lowest limits of the fat. The difference between these gives the per cent. of fat directly. The reading can easily be taken to half divisions or to one-tenth per cent.

The line of division between the fat and the liquid beneath is nearly a straight line and no doubt need arise concerning the reading at this point, but the upper surface of the fat being concave, errors often occur by reading from the wrong place. The reading should be taken at the line where the upper surface of the fat meets the side of the tube and not from surface of fat in the center of the tube nor from the bottom of the dark line caused by the refraction of the curved surface. For instance in Fig. 6 the reading should be taken from *a* to *b* and not to *c* or *d*.

FIG. 6.



The reading may be made with less liability of error by measuring the length of the column of fat with a pair of dividers, one point of which is placed at the bottom and the other at the upper limit of the fat. The dividers are then removed and one point being placed at the 0 mark of the scale on the bottle used, the other will be at the per cent. of fat in the milk examined.

Sometimes bubbles of air collect at the upper surface of the column of fat and prevent a close reading; in such cases a few drops of strong alcohol (over 90 per cent.) put into the tube on top of the column of fat, will cause the bubbles to disappear and give a sharp

line between the fat and alcohol for the reading. Whenever alcohol is used for this purpose, the reading should be taken directly after the alcohol is added, as after it has stood for a time, the alcohol partially unites with the fat and increases its volume.

Whenever the fat is not quite clear, more satisfactory results may be obtained by allowing the bottles to stand until the fat has crystallized and then warm them by placing the bottles in hot water, before taking the reading.

If the column of fat is less than about one division as will often happen with skim-milk, butter-milk or whey, it may assume a globular form instead of a uniform layer across the tube; when this occurs the fat can usually be estimated with sufficient accuracy by simple inspection, but in such cases it is better to take a double portion of milk in a large bottle.

The way of reading is illustrated in the figure. The bottom of the clear yellow liquid fat layer is at *a*. The upper surface is represented by *b*, *c*, *d*. The readings are 1.4 and 5.7. The difference, 4.3, is the per cent. of fat in this sample of milk.

To the breeder of dairy stock, to the dairyman who wishes to knows what his cows return for their keep, and to creameries, whether milk gathering or cream gathering, the Babcock tester can be of the greatest service.

THE BABCOCK TEST AS A BASIS FOR PAYMENT IN CREAM-GATHERING CREAMERIES.

By A. L. Winton and A. W. Ogden.

In Bulletin 108, issued by this Station in May, 1891, it was stated that the Babcock test "offers to cream-gathering creameries, a practicable and accurate method of ascertaining the actual quantity of butter-fat which each patron furnishes, so that payments may be based, not on volume of cream supplied, but on *actual butter-fat*, which is the raw material that the creamery manufactures. This is obviously the most satisfactory method of payment."

Since that time, this method has been adopted by several creameries in other States, but nothing of the kind was attempted in Connecticut, until the winter of 1893–4.

Several creamery managers having expressed a desire to introduce a system of payment based on the Babcock test, a practical study of such a system was made early in the year with the

coöperation of the managers of the Golden Ridge Creamery at Berlin, Conn. The first trials were partly to study the inequalities of the space system and partly to determine by practical experience the forms of apparatus best suited for the Babcock system.

A few weeks experience demonstrated the unfairness of the space system and the practicability of the system based on the Babcock test. At a meeting of the directors of the creamery it was voted to abandon the space system and pay for cream according to the fat which it contained as shown by the Babcock test. On March 1st this change went into effect.

In response to special request, eight other cream-gathering creameries were subsequently visited and the working of the new system illustrated. The plan followed at most of these creameries was to run the two systems side by side for a day thus securing a comparison of results and at the same time giving those interested opportunity to become acquainted with the details of the Babcock system.

The results of these comparative tests are given on pages 236 to 244.

Of these eight creameries, five decided later to adopt the Babcock system and were further assisted by us in carrying out this decision. All of the six creameries which have, with our coöperation, introduced the new system are to-day running successfully on that plan, and others have adopted or are about to adopt the method.

Defects of the Space System of Payment for Cream.

Most of the cream gathered by creameries in this State, is raised by the submerged, deep-setting system, and is paid for by the "space." The "space" is the volume of a cylinder $8\frac{1}{2}$ inches in diameter and $\frac{19}{64}$ of an inch high, and the number of "spaces" in each can of milk is read off before skimming, by means of a strip of glass set in the sides of the can on which the space graduations are marked. The unit for payment is therefore a given volume of cream which, to make the system perfectly equitable, should always contain the same quantity of pure butter-fat.*

* Butter is a mixture of butter-fat—its essential, most abundant and most distinctive ingredient—with more or less water, salt and curd. As the quantities of these several ingredients in butter are quite variable, accuracy and simplicity are best secured by basing all calculations on the quantities of *butter-fat*.

That the "space" does not always contain the same quantity of butter-fat and that the differences in the quantity of butter-fat in it are often large enough to make this system of payment unfair, are facts of every day observation in creamery practice, which have also been abundantly confirmed by chemical tests. See pages 236 to 244.

Even when the directions of the makers of the apparatus and of the creamery manager are closely followed, the cream raised from milk of one and the same herd, which is fed, handled, and milked as uniformly as possible, will yet show moderate differences in the quantity of butter-fat present, per "space," from day to day.

The time which elapses from the setting to the skimming of the milk, has considerable effect on the number of spaces gathered. For a certain time after setting, the depth of the cream layer and the number of spaces, increase; then follows a period during which the number of spaces slowly decreases, on account of the coalescence of the fat particles, but the per cent. of butter-fat and with it the value of the cream for butter making, is, nevertheless, all the while increasing.

But when the prescribed method of setting is not closely followed by a part of the patrons, differences in the quality of the "space" become so large as to work great injustice to other patrons and generally to those who are producing the most and the best cream. Abundant proof of this will be noticed in the following pages.

Much dissatisfaction comes from the fact that during the winter it is absolutely necessary in some creameries for each patron to measure and record the "spaces" of cream which he raises, so that he may have his cans for use again. The cream-gatherer only makes from two to four trips a week, to get the cream and a copy of the patron's score.

In addition to the defects already noted, it need hardly be said that the dishonest patron may so manipulate his cream as to increase the number of spaces in ways which the cream-gatherer is unlikely to detect.

While the system of setting milk and raising cream now generally in use, if strictly followed, is an excellent one, well suited to our conditions, the system for payment is unsatisfactory because it does not bear a close relation to the actual butter-fat furnished by the several patrons to the creamery.

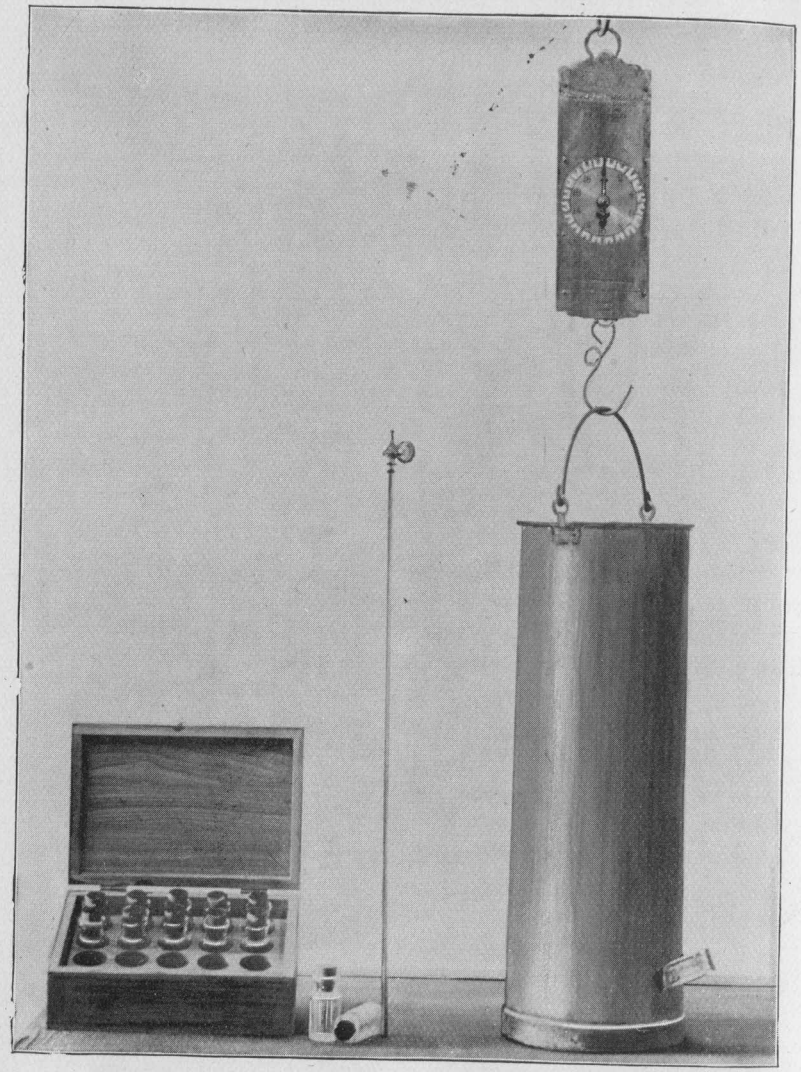


PLATE XIV. Outfit of the Cream Gatherer.

The Method of Payment According to Amount of Butter-Fat Furnished.

On the following pages is a full description of the system which, with the advice of this Station, has been adopted by a number of Connecticut creameries and which, it is believed, secures to all the patrons fair payment for the cream furnished.

The plan followed is briefly this: The cream, skimmed by each patron, is weighed by the cream-gatherer who also takes a sample accurately representing the entire cream, both as to its quantity and its quality. The samples of each patron's cream gathered from day to day, are mixed and make a "composite sample" which is kept from curdling by a preservative and is finally tested by the Babcock method.

From the total weight of cream gathered and the per cent. of fat in it, the actual weight of butter-fat furnished by each patron is determined and is placed to his credit. Spaces are not taken into account.

APPARATUS FOR SAMPLING AND WEIGHING THE CREAM.

See Plate XIV.

Spring Balance.—A No. 270 Chatillon spring balance, weighing 60 pounds by 2 ounces, is commonly used for weighing the cream. In order to avoid calculation, the index may be set back one-quarter of the circle (equivalent to 5 pounds), so that when the empty pail, which is made to weigh 5 pounds, hangs on the balance, the index stands at 0. See plate XIV.

Prof. Woods of the Storrs Station has devised an improved form of this balance with a loose index, which by means of a set screw, can be adjusted to tare a pail of any weight. A jam screw prevents loosening of the index. Such balances are now made by the Chatillon Spring Balance Co., 85 to 93 Cliff Street, N. Y., and are designated by them as No. 270 M. They can be obtained from all dealers in dairy supplies.

These scales properly used will last for a number of years and may then generally be repaired at a cost of $1.00 to $1.25. They should not be exposed to rain unnecessarily, as the rusting of the mechanism destroys their accuracy.

The pail should not be thrown on the scale hook with a sudden jerk. To draw out the slide and let it snap back suddenly is the worst possible treatment the scale can receive.

The balance may hang on a proper support from the back of

the gatherer's wagon, at such height that the pail full of cream can be hung on it handily, but will not touch the ground, or the gatherer may take it with him to the room where the patron keeps his cream, and hang it on a hook provided for the purpose. The advantages of the latter plan are, that the weighing, recording and sampling, are done under cover, and a trip from the cart to the patron's score card, which it is necessary to make when the cream is weighed at the cart, is avoided.

Pail for Sampling and Weighing.—This pail should be of cylindrical (not conical) form with a stout bail, and, to aid in pouring, it must either be provided with a handle on the side near the bottom, or have the sides extend an inch or two below the bottom. It may have any diameter from 8 to 12 inches, but the height should be so proportioned to the diameter that it will hold about 40 pounds of cream. When carried in the hand it should clear the ground by several inches. See plate XIV.

Sampling Tube.—This tube, devised by Mr. Ogden, is of stout brass about $\frac{1}{32}$ of an inch thick, and a few inches longer than the weighing pail which is used with it. On the upper end, a small brass stop-cock of the same bore is fastened. It should be nickel plated inside and out to keep the metal smooth and free from corrosion. These tubes may be obtained from less than $\frac{3}{16}$ to over $\frac{1}{4}$ inch bore. The greater the diameter of the weighing pail, the wider should be the bore of the tube. For use with pails 8 inches in diameter, a $\frac{3}{16}$ inch bore sampling tube will serve the purpose but when the pail has a diameter of 9 or more inches a tube with a bore of $\frac{1}{4}$ inch or more should be used. It must be borne in mind that doubling the diameter of the pail, or of the sampling tube, increases the capacity fourfold.

The tube when not in use should be kept in an upright position to permit draining.

Sample Bottles.—Two sets of sample bottles are used:

(1.) *Collecting bottles.*—Small wide-mouthed bottles, holding from one to one and one-half fluid ounces, closed by good corks are suited for carrying the collected samples. Numbers, corresponding to the different patrons, may be burned into the tops of the corks by means of a red hot iron. The bottles themselves are not otherwise marked. These are taken by the cream-gatherer on each trip, to receive the samples that represent every lot of cream collected. See Plate XIV.

The gatherer should be provided with a convenient case, having a compartment for each bottle, and a cover which when closed and fastened, will hold the corks securely in their places.

(2.) *Composite Sample Bottles.*—Half pint "Lightning" fruit jars, or wide-mouthed bottles of convenient size fitted with corks, are used for this purpose. The bottles should not be much larger than is necessary to hold the largest of the composite samples.

INSTRUCTIONS FOR SAMPLING AND WEIGHING THE CREAM.

Numbering of patrons.—The patrons are distinguished by numbers, and the corks of the sample bottles bear corresponding numbers. To avoid error each patron's number should be posted in a conspicuous place near his creamer.

Skimming.—Patrons are required to draw off their own cream and to keep it protected from dirt and odors, *and at a low temperature.* This saves the time of the cream-gatherer, and puts most of the cans more promptly at the disposal of the patron. If separators are used they are so gauged as to run cream of about the same thickness as Cooley cream, i. e. with not more than 25 per cent., preferably from 18 to 20 per cent., of fat. Pan-set cream, or cream that is frozen or sour cannot be accurately sampled, and is rejected for this, if for no other reason.

Mixing the Cream.—Pour each patron's cream at least twice from one vessel to another. The last pouring must bring it into the weighing pail. *It is absolutely essential that the cream should be thoroughly mixed before sampling. This is the most critical part of the whole operation.* If there is enough cream to fill the weighing pail more than once, each pailful must be carefully mixed and sampled.

The following experiment illustrates the importance of thorough mixing.

A Cooley can full of cream was allowed to stand quiet for 24 hours. Three portions were then taken: the first by dipping from the surface, the second by drawing from the bottom and the third by taking a section through the cream from surface to bottom with the sampling tube.

The remaining cream was poured once into a second can and three portions were taken as before.

After pouring the cream once more, a third sample was drawn with the sampling tube.

Determinations of fat in the several portions gave the following results:—

First: The surface portion of the cream before it was disturbed by pouring contained 28 per cent. of fat, the bottom portion only 5 per cent., or less than $\frac{1}{5}$ as much as the surface.

Second: After the first pouring, there was a difference of only one and one-quarter per cent. of fat between the surface and bottom portions of cream.

Third: The sample taken with the tube before pouring the cream did not contain within three per cent. as much fat as the whole quantity of cream was known to contain.

Fourth: After pouring once, the per cent. of fat in the sample drawn with the sampling tube was practically the same as that in the sample drawn after the second pouring.

The reason why the sampling tube did not draw a correct sample from the cream which had stood quiet for 24 hours was that the very thick cream on the surface was pushed aside by the tube instead of filling into it, thus making the sample deficient in fat. It follows that it is necessary to mix the cream even when a sampling tube is used.

The per cents. of fat found in the test just described were as follows:—

Fat in Cream which stood for 24 hours.

	Surface.	Bottom.	Sample drawn with sampling tube.
Not mixed	28.0	5.0	19.25
Poured once	23.75	22.0	22.50
Poured twice	----	----	22.25

Sampling and Weighing.—Lower the sampling tube *with the cock open*, to the bottom of the weighing pail which holds the mixed cream. When it is filled raise it out of the liquid and allow it to drain for a few seconds. By this means the tube is rinsed with the cream to be sampled and any traces of cream adhering to the tube from previous use are removed. With the cock still open, slowly lower the sampling tube to the bottom of the cream pail. After allowing a moment for the cream to rise in the tube to the same height as in the pail, close the cock and raise the sampler carefully out of the cream. As long as the cock is closed the cream in the tube will not flow out, unless the tube is strongly jarred. Allow the cream adhering to the outside of the tube to drain off for a few seconds, then put the lower end into the collecting bottle which bears the patron's number on its cork and open the cock. The cream will then flow out of the sampler into the bottle, which is afterwards securely corked and put into the cream-gatherer's case. Immediately weigh the cream in the cream pail to the quarter or half pound as may be judged expedient and record the weight.

If the patron has more than one pailful, repeat with each pailful the operation of sampling and weighing, putting all the samples in one and the same bottle. *Weigh all cream collected, in one and the same sampling pail and draw a sample from each separate portion weighed.*

In case a patron has so little cream that a single portion drawn by the tube from day to day will not be sufficient to make a composite sample large enough for testing, two or more cores may be taken, *but at every gathering the same number.* If two cores are taken to-day, then two must be taken to-morrow and every day until the test is made; if three cores, then three every day.

Operating according to these directions the sample not only represents the quality of the whole amount of cream, but is also proportional to its quantity. If a patron furnishes twice as much cream to-day as he did yesterday, the sample drawn from to-day's cream will also be twice as large as yesterday's and if there is a decided difference in the quality of cream on the two days this method of sampling will make due account of it in the composite sample.

When the whole quantity of cream is very small, less than half a pailful, it is best not to take a sample in the way above described, but putting the sampler in the cream, apply the mouth to the stop cock and suck the sampler full, close the cock and transfer this sample to the collecting bottle.

The size of the sample taken in this way does not correspond to the quantity of cream, but the possible error thus introduced is inconsiderable when the quantity of cream is small and nearly alike from day to day.

If, however, it is desired to be more exact, small lots of cream can be sampled in the way first described, in a pail having a diameter of four inches.

A given quantity of cream in this pail will have four times the depth which it has in the larger one and the sampler will therefore draw a sample four times as large.

Where the gatherer's route is long there has been some trouble during the hottest days of summer with the samples souring or churning during transit. The churning may take place without the sample souring. Such samples should be rejected as it is better to lose a single day's sample occasionally than to render the composite sample unfit for testing. If during hot days the gatherer carries his case of samples in a box with a piece of ice, sour-

ing and churning can generally be prevented provided the cream has been properly cared for previously by the patron and the gatherer is not on the road more than half a day. Churning can be avoided by filling the collecting bottles full to the cork thus avoiding the agitation which takes place in partially filled bottles. The samples thus obtained are all of the same size and do not represent the quantity of cream. If experience has proved that the cream of the several patrons does not vary greatly in quantity from day to day it is sufficiently accurate to add samples of the same size from day to day to the composite sample. If, however, there is considerable variation a quantity proportional to the weight of cream furnished may be measured out each day in a graduate from each man's sample and added to the corresponding composite sample.

As samples of each patron's cream come in to the creamery the superintendent has opportunity to gain an idea of the quality of the product furnished by each. If a sample is sour or foul smelling when it reaches the creamery it is usually evidence that the patron has been remiss in caring for his cream. We have been told by a creamery manager that the feeding of turnips may also be detected by the odor of the daily samples.

THE COMPOSITE SAMPLE.

Preservative.—Bichromate of potash when added in the proportion of one grain of the salt to two ounces of cream (or milk) will preserve the sample, when kept in a cool place, in a suitable condition for testing for at least two weeks.

Although poisonous, this substance is by no means so violent a poison as corrosive sublimate, which some have recommended, and may be used with comparatively little danger. It gives to the liquid an orange yellow color easily distinguishable from pure cream (or milk) which lessens the danger from its use. Packages containing this material should, however, always be labelled "Poison." The quantity used need not be weighed as the amount may vary considerably without affecting the results, although greatly excessive quantities are to be avoided.

A pistol cartridge shell, of .22-inch calibre, cut to a length of $\frac{1}{4}$ inch, will hold, when loosely filled, enough of finely powdered bichromate to preserve one-quarter of a pint of cream.* Con-

* A .22-inch calibre shell cut to $\frac{1}{2}$ inch long holds enough to preserve $\frac{1}{2}$ pint. A .32-inch calibre shell cut to $\frac{1}{4}$ inch long holds enough to preserve $\frac{1}{2}$ pint. A .32-inch calibre shell cut to $\frac{1}{2}$ inch long holds enough to preserve one pint.

venient measures can be made by cutting off shells to the proper length with a file and soldering on a piece of wire for a handle.

When beginning a series of tests, place in each composite sample bottle the quantity of powdered bichromate of potash required for keeping one-quarter of a pint of cream. If the quantity at any time amounts to more than this, more bichromate may be added.

Transferring the Samples.—As soon as the collected samples arrive at the creamery, shake each moderately, pour it into the composite sample bottle bearing the corresponding number and allow the collecting bottle to drain for a moment. Cork the composite sample bottle and give it a rotary motion to mix the new cream with that previously collected, as well as with the bichromate. If this is not done, the thick layer which has risen since the last addition of cream, may adhere to the side of the bottle and finally interfere with taking the portion for testing. Keep the samples in a cool place, but do not allow them to freeze. The small collecting bottles and corks should be put into hot water at once, or before the adhering cream dries to them, should be washed, dried and placed in the cases ready for the next collecting trip. Since only the corks are marked, no confusion of bottles can arise.

APPARATUS FOR TESTING CREAM BY THE BABCOCK METHOD.

Test Bottles.—The form of cream bottle devised by Mr. Winton, and described in Bulletin 117 of this Station, is suited for creamery use. (See figure 1, page 224.) It has a wider neck than the bottles used for testing milk. The neck is graduated from 0 to 30 per cent., but the readings can be readily made to a quarter of a per cent.

One of the most convenient ways of numbering the test bottles is to have a ground or etched spot on the neck of the bottle above the graduation, on which the number of the test can be marked with a lead pencil.

The necessary grinding may be done with a sharp wet file.

Pipettes.—The cream is measured in a pipette delivering 18 cubic centimeters. The opening at the lower end should be rather larger than for milk pipettes, so that the cream, which is thicker than milk, will deliver readily. See fig. 2.

Acid Measure.—This is a glass graduate, which holds when filled to the mark, 17.5 cubic centimeters. The labor of measuring

the acid may be considerably diminished by using the special forms of apparatus devised by Farrington, Patrick and Greiner. See fig 3.

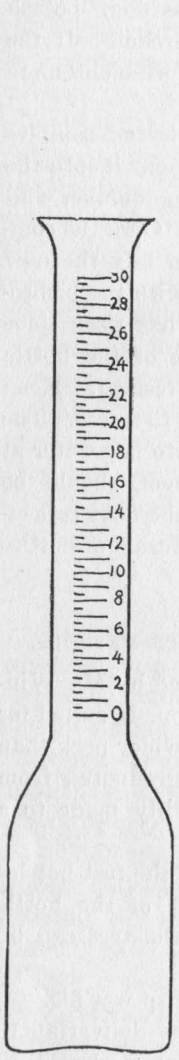


FIG. 1.



FIG. 2.

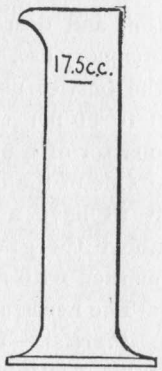


FIG. 3.

Centrifugal Machine.—The so-called steam turbine testers are especially adapted for creamery use. The power is communicated by a jet of steam, playing into pockets attached to the rim

of the wheel which carries the bottles. By this device the time and labor consumed in operating the hand machines are spared and the more complicated machinery of the power testers is avoided. The escaping steam keeps the contents of the bottles from cooling, and after the last whirling, the fat is at a proper temperature for measuring. The wheel to which the bottles are attached should make, during the test, from 700 to 1200 revolutions per minute, according to its diameter; 700 revolutions being sufficient for the larger wheels with a diameter of about 20 inches, while 12-inch wheels should run at the rate of 1200 revolutions per minute. The machine should have a spindle to which a speed indicator can be applied, and should be tested from time to time to make sure that it is working properly. We have found, in creameries, machines which were running too slowly to do thorough work. In ordering machines it should be specified that they shall be fitted with a spindle for testing speed and that when the machine is loaded with the test bottles the shaft shall make the proper number of revolutions per minute with 30 pounds of steam. Be sure that the steam pipe is large enough to deliver *dry* steam and that while the tester is running, the steam is not used elsewhere in such quantity as to interfere.

Commercial Sulphuric Acid (*Oil of Vitriol*).—This should have a specific gravity of 1.82 to 1.83. If much stronger, the fat will be of a dark color; if weaker, the fat is liable to be contaminated with undissolved curd. It should be purchased of guaranteed strength. The acid should be kept in tightly stoppered bottles, as otherwise it rapidly absorbs moisture from the air and becomes too weak. The stopper should be of either glass or rubber and not of cork, which is rapidly destroyed by the acid. This oil of vitriol is extremely corrosive. It will ruin very quickly, clothing or leather on which it falls and soon makes painful burns if in contact with the skin. If the hands come in contact with it they should be immediately and thoroughly rinsed. Sal-soda or wood ashes will neutralize it and check its corrosive action. The greatest care must be used in handling this acid.

Apparatus for Filling the Test Bottles With Hot Water.—A convenient arrangement for this purpose consists of a four quart pail, the contents of which may be delivered through a piece of small flexible rubber tubing attached to a piece of metal tubing that is soldered on the side of the pail at the bottom. The rubber tubing is about three feet long and provided with a pinch-cock.

For use the pail is filled with boiling hot water and placed on a support a foot or two above the machine, thus giving the necessary head. By opening and closing the pinch-cock, the hot water may be delivered in the bottles, in proper quantity.

Making the Test.

Tests may be made twice, three times, or four times a month, as is most convenient, since experience has proved that bichromate will keep cream at least two weeks.

The details of the process of testing are best described, substantially, in Dr. Babcock's own words. Certain minor changes are advisable, as the directions here are wholly designed for testing cream.

Temperature of the Cream.—The composite sample bottles should be brought from the cold room into the room where the tests are to be made and allowed to warm to at least 60° F. before testing. The effect of too cold cream is similar to that of too weak acid.

Mixing the Sample.—Shake the bottle until the cream is thoroughly mixed, and of uniform consistency.

Measuring the Cream.—Immediately after mixing, the pipette is filled by placing its lower end in the cream and sucking at the upper end until the cream rises above the mark on the stem; then remove the pipette from the mouth and quickly close the tube at the upper end by firmly pressing the end of the fore-finger to prevent access of air. So long as this is done the cream cannot flow from the pipette. Holding the pipette in a perpendicular position, with the mark on a level with the eye, carefully relieve the pressure of the finger so as to admit air slowly to the space above the cream. In order to more easily control the access of air both the finger and end of the pipette should be dry. When the upper surface of the cream coincides with the mark upon the stem, the pressure should be again applied to stop the flow of cream. Next, place the point of the pipette in the mouth of one of the test bottles, and removing the finger allow the cream to flow into the bottle. After waiting a short time for the pipette to drain, blow into the upper end to expel the cream held in the point. If the pipette is not dry when used it should be filled with the cream to be tested, and this thrown away before taking the test sample.

Persons who have had no experience in the use of the pipette will do well to practice a short time by measuring water into a test bottle before attempting to make a test.

Adding the Acid.—After the cream has been measured into the test bottle the test may be proceeded with immediately, or the bottles may be left for a day or two without materially changing the results; samples that have remained in the test bottles two or three months and which had commenced to mould before the acid was added, have given the same amount of fat as samples tested immediately after being measured. If the cream has become coagulated, the curd should be broken up by shaking the test bottle before the acid is added. It is advisable, however, that the test be proceeded with immediately after the samples are measured, if possible.

The volume of commercial sulphuric acid required for a test is approximately the same as that of the cream, or 17.5 c. c. for the ordinary test. If too little acid is added, the casein is not all held in solution throughout the test, and an imperfect separation of the fat results. If too much acid is used, the fat itself is attacked. The acid need not be measured with great accuracy, as small variations will not affect the result.

Great care must be taken in handling the acid to avoid getting any of it upon the skin or clothing, as it is very corrosive. If by accident any is spilled upon the hands or clothes, it should be washed off immediately, using plenty of water. A prompt application of ammonia water to clothing upon which acid is spilled may prevent the destruction of the fabric and restore the color.

When all the samples of cream to be tested are measured ready for the test, the acid measure is filled to the 17.5 c. c. mark with sulphuric acid, and from this it is carefully poured into a test bottle containing the cream. The acid being much the heavier sinks directly to the bottom of the test bottle without mixing with the cream that floats upon it. The acid and cream should be *thoroughly mixed* together by gently shaking with a rotary motion. At first there is a precipitation of curd, but this rapidly dissolves. Much heat is evolved by the chemical action and the solution, at first nearly colorless, soon changes to a very dark brown, owing to the charring of the milk sugar.

Whirling the Bottles.—The test bottles containing the mixture of cream and acid should be placed in the machine and whirled directly after the acid is added. An even number of bottles should be whirled at the same time and they should be placed in the wheel in pairs opposite to each other, so that the equilibrium of the apparatus will not be disturbed. When all the test bottles are in the apparatus, the cover is placed upon the jacket and the

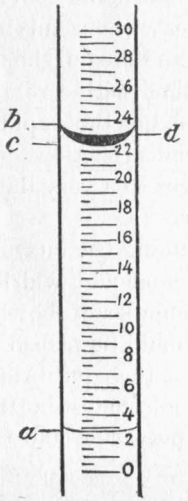
machine turned at the proper speed for about five minutes. The test should never be made without the cover being placed upon the jacket as this not only prevents the cooling of the bottles when they are whirled, but in case of the breakage of bottles, may protect the face and eyes of the operator from injury by pieces of glass or hot acid.

The machine should be frequently tested with the speed indicator to make certain that the bottles are whirled at the required speed. Too slow motion results in imperfect separation of butter-fat.

If a steam turbine is not used, the test bottles should be whirled immediately after adding the oil of vitriol. In case of delay they must be heated to a temperature of about 200° Fahr. before putting them in the machine.

Filling the bottles with hot water.—As soon as the bottles have been sufficiently whirled, they should be filled to the neck with hot water. If practicable, distilled or rain water should be used for the purpose. The bottles are most conveniently filled by help of the apparatus already described; the flow of water can be perfectly controlled by the pinch-cock upon the rubber tube. If only a few tests are to be made, the bottles may be filled with a pipette, or by pouring from a graduate. The cover should then be replaced and the machine turned for about two minutes. Hot water is now added to fill the test bottles nearly to the 28 per cent. mark, and after whirling for about one minute longer the fat is ready for measuring.

Fig. 4.



Measuring the fat.—The fat when measured should still be hot to the touch.

To measure the fat, hold the bottle in a perpendicular position with the scale on a level with the eye, observe the divisions which mark the highest and the lowest limits of the fat. The difference between these gives the per cent. of fat directly.

The line of division between the fat and the liquid beneath is nearly a straight line and no doubt need arise concerning the reading at this point, but the upper surface of the fat being concave, errors often occur by reading from the wrong place. The reading should be taken at the line where the upper surface of the fat meets the side of the tube and not from surface of fat in the center of the tube nor from the bottom of the dark line

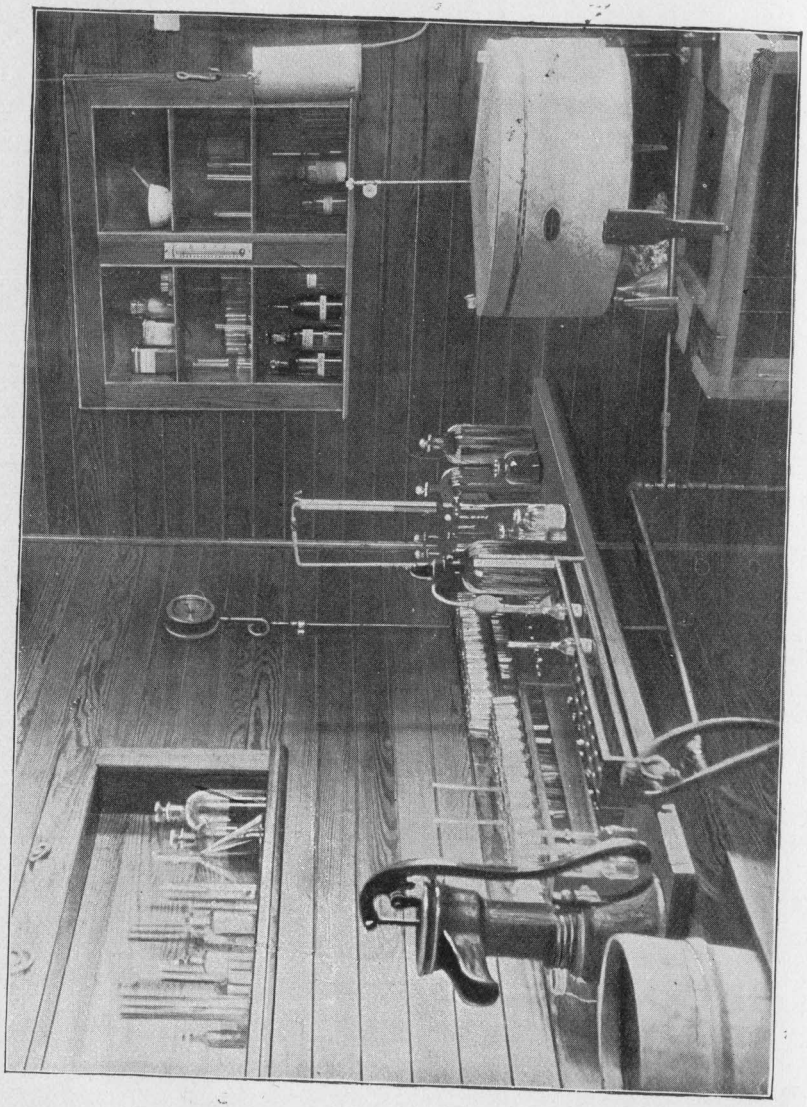


PLATE XV. Creamery Laboratory for Babcock Tests.

caused by the refraction of the curved surface. For instance in fig 4 the reading should be taken from *a* to *b* and not to *c* or *d*.

The reading may be made with less liability of error by measuring the length of the column of fat with a pair of dividers, one point of which is placed at the bottom and the other at the upper limit of the fat. The dividers are then removed and one point being placed at the 0 mark of the scale on the bottle used, the other will be at the per cent. of fat in the cream examined.

Sometimes bubbles of air collect at the upper surface of the column of fat and prevent a close reading; in such cases a few drops of strong alcohol (over 90 per cent.) put into the tube on top of the column of fat, will cause the bubbles to disappear and give a sharp line between the fat and alcohol for reading. Whenever alcohol is used for this purpose, the reading should be taken directly after the alcohol is added, as after it has stood for a time, the alcohol partially unites with the fat and increases its volume.

Whenever the fat is not quite clear, more satisfactory results may be obtained by allowing the bottles to stand until the fat has solidified and then warm them by placing the bottles in hot water, before taking the reading.

The way of reading is illustrated in the figure. The bottom of the clear yellow liquid fat layer is at *a*. The upper surface is represented by *b*, *c*, *d*. The readings are 2.75 and 23.75. The difference, 21.00, is the per cent. of fat in this sample of cream.

After satisfactory tests have been made on all the samples, the cream that remains in the sample bottles is thrown away.

Cleaning the Test Bottles.—If the fat has solidified by cooling, warm until it is melted. This may be done by replacing the bottles in the machine and turning on the steam, or by running hot water over the bottles from the apparatus already described. Give each bottle a quick motion so as to throw out the fat, then empty out the remainder of the liquid, shaking all the time to loosen the white sediment on the bottom. Fill to the brim with boiling water, and place in the rack to empty and drain. After wiping off the outside with a cloth, the tubes, although not perfectly clean, are free from fat and ready for use again.

The accompanying plate, Plate XV, shows a very convenient arrangement of the testing apparatus made by Mr. B. F. Case, manager of the Canton Creamery, at Canton Center, in this State.

To the right of the picture is a steam turbine apparatus carrying 50 test bottles, provided with a speed indicator. Above it

hangs a pail from which the hot water is drawn for filling the test bottles after whirling.

On the bench are racks for drying and storing the test bottles and pipettes and in front is a stand to hold the bottles while they are being filled.

At the right of this stand is a convenient apparatus for measuring the oil of vitriol into the test bottles.

At the extreme left is a sink for washing apparatus. The water can be quickly heated from the hose attached to the steam pipe. The cupboards above carry bichromate of potash and any other chemicals and apparatus which are desired.

PLATE XIII.



Plate XIII shows the method of storing the composite samples at the Canton Creamery. The closets, closing in front by doors hinged at the top, which can be securely locked, and communicating at the back with the cold storage room, are fitted with drawers, each devoted to a particular cream-gathering route. Each jar bears the number of one of the patrons and all samples of his cream are poured into it as soon as brought in.

BOOK KEEPING OF THE BABCOCK TEST SYSTEM.

The pounds of cream collected from each patron are recorded from day to day and footed up at the end of the month, exactly as was done with spaces by the space system. The record of the Babcock tests are conveniently kept by themselves in a book or on blanks prepared for the purpose. Once a month the total pounds of cream furnished by each patron, and the average per cent. of fat in it, are posted in the ledger. Fractions of a pound are carried over to the next month and the percentages of fat are given to one place of decimals. The ledger is generally ruled with columns properly headed for names of patrons, numbers of patrons, pounds of cream, pounds of fat, average per cent. of fat, and finally the amount due, as shown below :

JANUARY, 1895.

No. of patron.	Name of patron.	Pounds of cream.	Average per cent. of fat.	Pounds of fat.	Payment at 30c per lb. of fat.
1	John Smith	1500	18.9	283.5	$85.05
2	James Jones	147	20.2	29.7	8.91
3	Henry Brown	963	14.0	134.8	40.44

This arrangement is compact and gives opportunity to foot up the total pounds of cream and fat received during the month by the creamery, and the total amount paid the patrons.

In the monthly report for distribution among the patrons details such as are on page 232 may be given.

RECORDS OF FIVE CONNECTICUT CREAMERIES RUNNING ON THE BABCOCK TEST SYSTEM.

In the following table is given an abstract from the records of five creameries which have used the Babcock system of payment for from five to ten months, to the entire satisfaction of the creamery managers and nearly all of the patrons.

It will be noticed that while the average composition of the cream of all the patrons does not show very great fluctuations, from 16.9 to 19.8 per cent. of fat, the cream of certain patrons on certain days has contained as little as 9.5 per cent. of butter-fat and of other patrons has contained 30 per cent.

Under this system of payment however both those whose cream is exceptionally poor and those whose cream is exceptionally rich receive their fair share and only their fair share of the payments.

The pounds of cream required to make a pound of butter has varied between 4.18 and 5.02 and has averaged 4.54 lbs.

The lowest average per cent. of fat, 16.9 was during December at creamery A and it took more pounds of this cream, 5.02, than of any other to make a pound of butter. On the other hand the highest average per cent. of fat, 20.3, obtained during October at creamery D, corresponds with the lowest number of pounds of cream required to make a pound of butter, 4.18.

In general the poorer the cream in fat the more pounds it takes to make a pound of butter and *vice versa*.

The number of pounds of butter-fat in the cream required to make a pound of finished butter varied between .807 and .877 pound and averaged .841 pound.

		Pounds of Cream received.	Pounds of Fat received.	Per cent. of Fat in the Cream.			Pounds of Butter made.	Pounds of Cream to make a Pound of Butter.	Pounds of Fat to make a Pound of Butter.
				Average.	Highest.	Lowest.			
Creamery A.	March	20676	3787.1	18.3	24.7	12.0	4365	4.74	.868
	April	20832	3849.7	18.5	23 0	14.9	4384	*4.59	*.848
	May	27601	4919.8	17.8	25.1	16 9	5323	*4.92	*.877
	June	25757	4927.4	19.2	27.0	16.6	5426	*4.34	*.830
	July	20771	3920.4	18.9	28.0	15.9	4088	*4.30	*.808
	Aug.	19904	3793.6	19.1	30.0	16.6	4084	*4.54	*.865
	Sept.	18148	3421.0	18.8	28.3	14.8	3935	*4.49	*.847
	Oct.	17144	3209.0	18.7	26.4	15.3	3886	4.41	.826
	Nov.	17694	3082.7	17.4	20.4	12.0	3626	4.88	.850
	Dec.	17971	3037.3	16.9	23.3	9.5	3582	5.02	.848
Creamery B.	June	57440	11113.	19.3	24.3	15.0	12841	4.47	.865
	July	45412	8769.	19.3	23.7	15.0	10642	4.27	.824
	Aug.	33077	6416.	19.4	23.8	14.3	7573	4.37	.847
	Sept.	28959	5684.	19.6	24.7	14.0	6571	4.41	.865
	Oct.	31155	6169.	19.8	24.0	15.8	7085	4.40	.871
Creamery C.	July	60190	11222.5	18.6	23.5	9.5	13346	4.51	.841
	Aug.	55568	10142.5	18.3	25.5	12.5	12367	4.49	.820
	Sept.	44453	8355.7	18.8	26.0	12.5	9623	4.62	.868
	Oct.	47005	8861.8	18.8	24.5	11.8	10665	4.41	.831
	Nov.	40399	6946.5	17.2	22.3	12.8	8609	4.69	.807
	Dec.	42665	7280.6	17.1	21.5	10.0	8804	4.85	.827
Creamery D.	Aug.	53938	10380.9	19.2	26.5	15.3	12100	4.46	.858
	Sept.	50161	9684.2	19.3	25.6	15.4	11398	4.40	.850
	Oct.	53022	10770.9	20.3	25.3	14.6	12692	4.18	.849
	Nov.	48890	9396.4	19.2	24.1	12.8	11244	4.35	.836
	Dec.	50365	9740.3	19.3	24.5	10.2	11569	4.35	.842
Creamery E.	Aug.	55029	9430.8	17.1	21.8	12.2	11191	4.92	.843
	Sept.	45633	8018.7	17.6	24.1	14.0	9884	4.62	.811
	Oct.	54730	9926.9	18.1	23.2	13.2	12204	4.48	.813
	Nov.	46668	8201.0	17.6	23.0	14.1	9953	4.69	.824
	Dec.	51646	8991.0	17.4	21.2	13.5	10923	4.73	.823

* After allowing for cream sold.

Comparison of the Space System and the Babcock System of Payment at Six Creameries.

The comparisons of the two systems here given, were made at the request of the Superintendent or the President of each of the respective creameries. The six creameries used the Cooley system exclusively. Creameries Nos. 1 and 2, allow the patrons during the winter time to do the skimming themselves every other day, or in some cases oftener. At creameries Nos. 3 and 5, the skimming and the counting of spaces is all done by the cream-gatherers, except on Sundays when it is done by the patrons. The patrons of creameries Nos. 4 and 6, do all of the skimming and count their own spaces.

At the creameries where tests were made of a single gathering, a representative of the Station went with the cream-gatherer over his route, witnessed the skimming (when done by the cream-gatherer), and weighed and sampled the cream. The samples were tested by the Station agent at the creamery. In the week's trial at creamery No. 4, the composite system as here described was followed, all the work except the testing being done by the creamery. Details of the tests are given in tables on pages 236 to 244. To facilitate their study, the following explanations are given :

The first column gives the numbers which represent the individual patrons.

Spaces of Cream.—The second column gives the spaces credited to each, which is the basis of payment by the space system.

Pounds of Cream and per cent. of Fat in the Cream.—The third and fourth columns,—pounds of cream and per cent. of butter-fat in the cream,—furnished the data for calculating the quantity of butter-fat to be credited to each patron.

It should be noticed that, from the number of spaces and the total weight of "cream" given in the tables, it is not possible to calculate the average weight of a space accurately, because some cream-gatherers or patrons "draw closer" than others, that is, draw off more of the skim-milk from the cream, after measuring the spaces.

In any case some skim-milk is gathered with the cream, and in some cases much more than in others. Again, if the gatherer draws equally "close" from each can, still a larger proportion of skim-milk will go with the cream from a can which is half full than from one which is full.

The number of spaces of cream of course is not changed, however much skim-milk is poured with it into the cream carrier. Nor on the other hand, is the quantity of butter-fat, credited to the patron by the Babcock System, made either larger or smaller by the amount of skim-milk that is weighed with the cream, for the more skim-milk that is added, the lower will be the per cent. of butter-fat shown by the test.

For instance, suppose a patron has 50 pounds of cream which would test 25 per cent. butter-fat, and hence would credit him with 12½ pounds of butter-fat, and suppose he mixes with it 25 pounds of skim-milk so that the cream-gatherer credits him with 75 pounds of cream instead of fifty. He gains nothing, for the Babcock test will only show 16.7 per cent. of fat in this mixture, which is equivalent to 12½ pounds of fat, the same that would be credited from 50 pounds of rich cream.

Per cent. of Fat in the Cream.—It follows from the explanation just given that the per cent. of fat in the total quantity of cream weighed is *of itself* no accurate index of the relative value to the creamery of each patron's cream.

The gatherer may have skimmed one patron's cream much closer than another's, that is, he may have taken with the cream in one case more skim-milk than in another.

Pounds of Fat in the Cream.—The fifth column (calculated from the two preceding columns), is the basis of payment by the Babcock System. It is not butter but butter-fat, the essential ingredient of butter.*

The other columns of the table are those which deserve the careful study of every manager and patron of a cream-gathering creamery, for they furnish a comparison of the two systems, and show moreover just what is the state of things in the present creamery practice of Connecticut.

Pounds of Fat in 100 "Spaces" of Cream.—This column shows the relative value of the "spaces" taken from the different patrons. Notice in Table I, for example, that while 100 "spaces" of cream from Patrons Nos. 5, 8, 18 and 19 furnish to the creamery 15 pounds or more of pure butter-fat, 100 spaces of cream from Patrons Nos. 12, 15 and 21 supply not more than 11½ pounds.

* Butter is a mixture of some 80 to 90 per cent. of pure butter-fat with variable quantities of water, salt and curd.

Spaces of Cream required to make a Pound of Average Butter.—This column expresses in a more popular, but less accurate way, the facts given in the preceding column. Butter in each case is assumed to contain 85 per cent. of butter-fat.

Referring again to Table I, there is seen abundant illustration of the trouble which is spoken of at every dairymen's meeting. Patrons 5, 8, 18 and 19 furnished cream which required less than 6 spaces to make a pound of butter, while 7¼ to 8 spaces of the cream from Patrons 12, 15 and 21 were required to make a pound of butter.

The next two columns show *the Payment for the Cream by the Space System* at 4 cents per space, and *Payment for the Cream by the Babcock Test System* at 28+cents per pound of butter-fat.

The price per pound of fat given, was obtained by dividing the sum of the amounts paid each patron by the total number of pounds of fat from his cream. The number of pounds of fat in each patron's cream was multiplied by this price per pound, thus giving the price paid for his cream. The columns which give the cost of the cream by the two systems, both foot up to the same amount in dollars and cents.

These columns give the amounts each man would receive if the same total amount of money was distributed by the two systems.

Percentage difference.—In the last column, the difference in the payment by the two systems, is given in per cents. Those with + sign would receive more by the test system; those with the — sign less. Supposing, for example, the percentage difference for a patron is + 10, then that patron would receive by the Babcock test system $110.00, where he gets by the space system $100.00, but if — 10, then he would receive only $90.00 by the Babcock test system when by the space system he would receive $100.

In this connection should be mentioned the fact that the purchase of a Babcock tester and the drawing of samples of cream in the presence of patrons has in some cases made a very noticeable change in the quality and quantity of cream furnished.

The superintendent of one of our creameries reports that, during the week immediately following the taking of samples for testing at the creamery, the number of spaces of cream charged to the creamery notably diminished, but at the same time the output of butter increased. The Babcock test, before its adoption as a basis for payment, had paid for itself in this way.

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 1, Feb. 15 and 16, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter. (85 per cent. Butter-fat.)	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System @ $29\frac{93}{100}$ cts. per Pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
1†	46	31.00	20.50	6.36	13.8	6.15	$1.84	$1.90	+ 3.3
2†	46	32.00	20.25	6.48	14.1	6.03	1.84	1.94	+ 5.4
3†	93	61.00	22.50	13.72	14.8	5.76	3.72	4.10	+10.2
4†	32	21.50	21.75	4.68	14.6	5.81	1.28	1.40	+ 9.4
5†	46	31.25	22.50	7.03	15.3	5.55	1.84	2.11	+14.7
6†	34	22.25	20.50	4.56	13.4	6.34	1.36	1.37	+ .8
7†	53	35.50	19.25	6.83	12.9	6.60	2.12	2.05	— 3.3
8†	40	27.75	22.00	6.11	15.3	5.56	1.60	1.83	+14.4
9 *	42	29.00	19.75	5.73	13.7	6.23	1.68	1.72	+ 2.4
9 †	42	31.75	17.50	5.57	13.3	6.41	1.68	1.67	— .6
10 *	30	23.75	17.25	4.10	13.7	6.22	1.20	1.23	+ 2.5
10 †	29	21.00	17.50	3.68	12.7	6.69	1.16	1.10	— 5.2
11 *	48	36.00	18.00	6.48	13.5	6.28	1.92	1.94	+ 1.0
11 †	46	35.75	17.50	6.26	13.6	6.24	1.84	1.87	+ 1.6
12 *	----	----	----	----	----	----	----	----	----
12 †	15	12.75	12.50	1.59	10.6	8.02	.60	.48	—20.0
13 *	37	26.00	17.50	4.55	12.3	6.91	1.48	1 36	— 8.1
13 †	36	27.50	18.00	4.95	13.7	6.18	1.44	1.48	+ 2.8
14 *	27	21.50	16.50	3.56	13.2	6.45	1.08	1.07	— .9
14 †	26	21.75	17.00	3.70	14.2	5.97	1.04	1.11	+ 6.7
15 *	40	28.50	16.00	4.56	11.4	7.46	1.60	1.37	—14.4
15 †	39	27.75	17.00	4.72	12.1	7.03	1.56	1.41	— 9.6
16 *	19	14.50	16.75	2.43	12.8	6.65	.76	.73	— 3.8
16 †	18	14.75	17.00	2.51	13.9	6.10	.72	.75	+ 4.1
17 *	22	16.00	17.00	2.72	12.3	6.88	.88	.81	— 8.0
17 †	24	17.75	16.25	2.88	12.0	7.08	.96	.86	—10.4
18 *	25	16.00	18.75	3.00	12.0	7.07	1.00	.90	—10.0
18 †	21	17.00	18.50	3.15	15.0	5.67	.84	.94	+11.9
19 *	14	11.00	18.00	1.98	14.1	6.01	.56	.59	+ 5.4
19 †	15	14.00	17.80	2.49	16.6	5.12	.60	.74	+23.3
20 *	37	28.00	18.30	5.12	13.8	6.14	1.48	1.53	+ 3.4
20 †	36	26.50	18.80	4.98	13.8	6.14	1.44	1.49	+ 3.5
21 *	69	52.00	15.50	8.06	11.7	7.27	2.76	2.41	—12.7
21 †	70	54.00	15.00	8.10	11.5	7.35	2.80	2.42	—13.6
Total	1217			162.64			$48.68	$48.68	

* Skimmed and spaces counted by patron.

† Skimmed and spaces counted by cream-gatherer.

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 2, Feb. 21, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter.	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System at $29\frac{65}{100}$ cts. per Pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
1	18	13.25	15.75	2.09	11.6	7.32	$ .72	$ .62	—13.9
2	30	23.50	19.00	4.47	14.9	5.70	1.20	1.33	+10.8
3	90	64.75	19.00	12.30	13.7	6.21	3.60	3.65	+ 1.4
4	18	15.00	12.50	1.88	10.4	8.14	.72	.56	—22.2
5	22	16.50	15.50	2.56	11.6	7.30	.88	.76	—13.6
6	36	21.75	23.00	5.00	13.9	6.12	1.44	1.48	+ 2.8
7	17	12.75	19.25	2.45	14.4	5.87	.68	.73	+ 7.4
8	77	57.00	21.00	11.97	15.5	5.47	3.08	3.55	+15.2
9	18	15.25	12.75	1.94	10.8	7.88	.72	.58	—19.4
10	59	45.00	17.25	7.76	13.1	6.46	2.36	2.30	— 2.5
11	21	19.75	18.00	3.56	17.0	5.01	.84	1.06	+26.2
12	52	41.50	16.00	6.64	12.8	6.66	2.08	1.97	— 5.3
13	68	58.25	18.75	10.92	16.1	5.29	2.72	3.24	+19.1
14	15	17.50	12.50	2.18	14.5	5.85	.60	.65	+ 8.0
15	109	84.75	18.75	15.89	14.6	5.83	4.36	4.72	+ 8.2
16	53	46.50	18.00	8.37	15.8	5.37	2.12	2.48	+17.0
17	47	39.75	16.00	6.36	13.5	6.28	1.88	1.89	+ .5
18	34	25.00	17.00	4.25	12.5	6.80	1.36	1.26	— 7.3
19	161	135.50	14.00	18.97	11.8	7.22	6.44	5.62	—12.7
20	9	10.00	13.50	1.35	15.0	5.67	.36	.40	+11.1
21	16	17.00	11.50	1.96	12.2	6.97	.64	.58	— 9.4
22	38	28.50	16.75	4.77	12.5	6.77	1.52	1.41	— 7.2
23	49	37.50	17.00	6.38	13.0	6.53	1.96	1.89	— 3.5
24	35	27.00	16.75	4.52	12.9	6.58	1.40	1.34	— 4.3
25	8	8.00	7.25	.58	7.2	11.72	.32	.17	—46.9
26	47	33.00	15.25	5.03	10.7	7.94	1.88	1.49	—20.8
27	49	37.75	16.75	6.32	12.9	6.60	1.96	1.87	— 3.5
28	25	20.00	13.50	2.70	10.8	7.87	1.00	.80	—20.0
29	21	16.75	13.00	2.18	10.4	8.20	.84	.64	—23.8
30	27	21.75	18.75	4.08	15.1	5.62	1.08	1.21	+12.0
31	95	48.00	17.00	8.16	12.5	6.77	2.60	2.42	— 6.9
32	109	80.75	19.25	15.55	14.2	5.96	4.36	4.61	+ 5.7
34	160	124.75	18.50	23.08	14.4	5.90	6.40	6.84	+ 6.9
Total	1603			216.22			$64.12	$64.12	

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 3, Route A, Feb. 22, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter.	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System @ $28\frac{94}{100}$ cts. per Pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
20	73	59.00	12.75	7.52	10.3	8.25	$2.92	$2.18	—25.3
21	13	11.50	17.50	2.01	15 5	5.50	.52	.58	+11.5
22	48	39.75	18.00	7.16	14.9	5.70	1.92	2.07	+ 7.8
23	34	29.00	15.00	4.35	12.8	6.64	1.36	1.26	— 7.4
24	16	13.75	15.25	2.10	13.1	6.48	.64	.61	— 4.7
25	50	40.00	18.75	7.50	15.0	5.67	2.00	2.17	+ 8.5
26	29	23.25	18.25	4.24	14.6	5.80	1.16	1.23	+ 6.0
27	24	18.25	18.50	3.38	14.1	6.03	.96	.98	+ 2.1
28	7	6.00	18.50	1.11	15.9	5.36	.28	.32	+14.3
29	36	28.50	17.00	4.85	13.5	6.31	1.44	1.40	— 2.8
30	32	24.25	19.00	4.61	14.4	5.90	1.28	1.34	+ 4.7
31	18	13.50	19.50	2.63	14.6	5.81	.72	.76	+ 5.5
32	37	26.25	20.00	5.25	14.2	5.99	1.48	1.52	+ 2.7
33	30	24.50	18.50	4.53	15.1	5.63	1.20	1.31	+ 9.1
34	28	22.25	17.50	3.89	13.9	6.12	1.12	1.13	+ 0.9
35	34	26.00	16.00	4.16	12.2	6.94	1.36	1.20	—11.8
36	33	25.00	17.25	4.31	13.1	6.50	1.32	1.25	— 5.3
37	16	15.25	17.25	2.63	16.4	5.17	.64	.76	+18.8
38	32	23.50	19.75	4.64	14.5	5.86	1.28	1.34	+ 4.7
39	23	18.00	18.25	3.29	14.3	5.94	.92	.95	+ 3.3
40	22	18.00	18.25	3.29	15.0	5.68	.88	.95	+ 7.9
41	19	15.75	17.50	2.76	14.5	5.85	.76	.80	+ 5.3
42	21	15.25	18.75	2.86	13.6	6.26	.84	.83	— 1.2
43	98	78.25	18.50	14.48	14.8	5.75	3.92	4.19	+ 6.9
44	8	6.75	16.50	1-11	13.9	6.13	.32	.32	0.0
45	64	48.00	18.50	8.88	13.9	6.13	2.56	2.57	+ 0.4
46	74	54.50	17.00	9.27	12.5	6.79	2.96	2.68	— 9.5
47	26	19.75	19.25	3.80	14.6	5.82	1.04	1.10	+ 5.8
Total	945			130.61			$37.80	$37.80	

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 3, Route B, Feb. 22, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a Pound of average Butter.	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System @ $28\frac{16}{100}$ cts. per pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
1	21	15.50	17.75	2.75	13.1	6.49	$ .84	$ .77	— 8.3
2	98	75.00	17.25	12.94	13.2	6.44	3.92	3.64	— 7.1
3	87	71.25	16.50	11.76	13.5	6.29	3.48	3.31	— 4.9
4	29	23.50	16.00	3.76	13.0	6.55	1.16	1.06	— 8.6
5	19	15.25	15.75	2.40	12.6	6.71	.76	.68	—10.5
6	19	11.50	24.00	2.76	14.5	5.85	.76	.78	+ 2.6
7	22	15.75	19.75	3.11	14.1	6.01	.88	.88	0.0
8	6	6.00	18.00	1.08	18.0	4.72	.24	.30	+25.0
9	7	6.50	14.00	.91	13.0	6.53	.28	.26	— 7.1
10	24	21.00	18.75	3.94	16.3	5.18	.96	1.11	+15.6
11	29	21.00	16.75	3.52	12.1	7.00	1.16	.99	—14.7
12	42	28.25	24.25	6.85	16.3	5.22	1.68	1.93	+14.9
13	10	9.00	18.50	1.67	16.7	5.10	.40	.47	+17.5
14	18	14.25	18.25	2.60	14.4	5.88	.72	.73	+ 1.4
15	38	30.00	20.00	6.00	15.8	5.38	1.52	1.69	+11.2
16	12	10.50	18.25	1.92	16.0	5.31	.48	.54	+12.5
17	25	19.00	19.25	3.66	14.6	5.80	1.00	1.03	+ 3.0
18	36	26.25	19.50	5.12	14.2	5.98	1.44	1.44	0.0
19	22	16.00	21.00	3.36	15.3	5.57	.88	.95	+ 8.0
Total	564			80.11			$22.56	$22.56	

Comparison of the Space and Babcock Test Systems for One Gathering.*

Creamery No. 4, Feb. 2, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a Pound of average Butter.	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System @ $30\frac{98}{100}$ cts. per Pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
1	28	20.7	15.75	3.27	11.7	7.28	$1.12	$1.01	— 9.9
2	55	39.8	17.50	6.96	12.6	6.72	2.20	2.16	— 1.8
3	108	80.5	17.50	14.09	13.0	6.51	4.32	4.36	+ .9
4	115	93.6	17.50	16.38	14.2	5.97	4.60	5.08	+10.4
5	53	41.0	17.50	7.18	13.5	6.27	2.12	2.22	+ 4.7
6	69	55.8	15.50	8.64	12.5	6.79	2.76	2.68	— 2.9
7	128	88.5	18.00	15.93	12.4	6.83	5.12	4.94	— 3.5
8	29	26.0	14.00	3.64	12.6	6.77	1.16	1.13	— 2.6
9	107	74.8	18.50	13.83	12.9	6.58	4.28	4.28	0.0
10	37	29.1	17.25	5.02	13.6	6.26	1.48	1.55	+ 4.7
11	15	10.5	14.00	1.47	9.8	8.74	.60	.46	—23.3
12	135	100.0	14.25	14.25	10.5	8.05	5.40	4.42	—10.0
14	91	68.8	19.25	13.23	14.6	5.85	3.64	4.10	+12.6
16	51	41.7	17.00	7.09	13.9	6.11	2.04	2.20	+ 7.8
17	25	21.5	18.50	3.98	15.9	5.34	1.00	1.23	+23.0
18	29	21.5	15.50	3.33	11.5	7.40	1.16	1.03	—11.2
19	56	39.5	15.50	6.12	10.9	7.78	2.24	1.89	—15.1
20	96	60.3	18.25	11.00	11.5	7.42	3.84	3.41	—11.2
21	90	61.2	22.50	13.78	15.3	5.55	3.60	4.26	+18.4
22	29	23.0	16.50	3.80	13.1	6.49	1.16	1.18	+ 1.7
23	40	28.1	14.00	3.94	9.8	8.63	1.60	1.22	—23.8
24	27	20.0	17.00	3.40	12.6	6.75	1.08	1.05	— 2.8
25	68	48.3	20.00	9.66	14.2	5.98	2.72	2.99	+10.0
27	48	36.0	13.75	4.95	10.3	8.24	1.92	1.53	—20.3
28	9	6.0	12.75	.77	8.5	9.94	.36	.24	—33.3
33	100	68.0	23.25	15.81	15.8	5.38	4.00	4.90	+22.5
Total	1638			211.52			$65.52	$65.52	

* The numbers of patrons in this table represent the same persons as the corresponding numbers in the table on page 241.

Comparison of the Space and Babcock Test Systems for One Week.*

Creamery No. 4, Feb. 12 to 19, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a Pound of average Butter.	Value of the Cream by the Space System @ 4 cts. per Space.	Value of the Cream by the Babcock Test System @ $31\frac{23}{100}$ cts. per Pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System in per cent.
1	82	62.75	17.00	10.67	13.0	6.53	$3.28	$3.33	+ 1.5
2	188	141.00	15.50	21.86	11.6	7.31	7.52	6.83	— 9.2
3	396	299.75	16.00	47.96	12.1	7.02	15.84	14.98	— 5.4
4	400	330.75	16.00	52.92	13.2	6.42	16.00	16.53	+ 3.3
5	282	240.25	16.50	39.64	14.1	6.04	11.28	12.38	+ 9.7
6	282	233.75	16.50	38.57	13.7	6.21	11.28	12.05	+ 6.8
7	423	294.00	16.50	48.51	11.4	7.41	16.92	15.16	—10.4
8	98	82.50	14.00	11.55	11.8	7.21	3.92	3.61	— 7.9
9	414	277.25	18.00	49.90	12.1	7.05	16.56	15.59	— 5.9
10	125	93.25	17.50	16.32	13.0	6.51	5.00	5.10	+ 2.0
11	47	31.25	14.00	4.38	9.3	9.12	1.88	1.37	—27.1
12	444	334.50	17.00	56.86	12 8	6.63	17.76	17.76	00.0
13	70	56.00	17.00	9.52	13.6	6.25	2.80	2.97	+ 6.1
14	341	247.75	20.25	50.17	14.7	5.77	13.64	15.67	+14.9
15	78	60.75	11.00	6.68	8.5	9.92	3.14	2.09	—33.4
16	144	115.25	17.25	19.88	13.8	6.16	5.76	6.21	+ 7.8
17	95	78.00	15.25	11.89	12.5	6.79	3.80	3.71	— 1.9
18	100	82.50	15.50	12.79	12.8	6.65	4.00	3.99	— 0.2
19	194	138.25	17.00	23.50	12.1	7.01	7.76	7.34	— 5.4
20	302	201.25	17.00	34.21	11.3	7.50	12.08	10.69	—11.5
21	400	271.00	22.00	59.62	14.9	5.70	16.00	18.63	+16.5
22	120	87.00	17.00	14.79	12.3	6.90	4.80	4.62	— 3.7
23	99	68.50	15.25	10.45	10.5	8.05	3.96	3.26	—17.7
24	86	66.00	17.75	11.71	13.6	6.24	3.44	3 66	+ 6.4
25	333	230.50	19.25	44.37	13.3	6.38	13.32	13.86	+ 4.1
26	113	81.75	19.50	15.94	14.1	6.03	4.52	4.98	+10.2
27	134	103.25	15.50	16.00	11.9	7.12	5.36	5.00	— 6.7
28	56	38.75	14.25	5.52	9.9	8.62	2.24	1.72	—23.2
33	100	66.00	24.50	16.17	16.2	5.25	4.00	5.05	+26.2
35	51	38.50	14.50	5.58	10.9	7.77	2.00	1.74	—14.7
	5997			767.93			$239.88	$239.88	

* See foot note, page 240.

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 5, April 23, 1891.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter.	Value of the Cream by the Space System @ 4 cents per Space.	Value of the Cream by the Babcock Test System @ $27\frac{32}{100}$ cents per pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System.
1	38	27.25	20.6	5.61	14.8	5.76	$1.52	$1.56	+ 2.6
2	28	22.00	20.3	4.47	15.9	5.32	1.12	1.25	+11.6
3	$27\frac{1}{2}$	19.50	20.7	4.04	14.7	5.78	1.10	1.13	+ 2.7
4	14	10.25	22.2	2.27	16.2	5.24	.56	.63	+12.5
5	$24\frac{1}{2}$	15.00	23.4	3.51	14.3	5.93	.98	.98	0.0
6	55	34.00	21.5	7.31	13.3	6.39	2.20	2.04	— 7.3
7	$31\frac{1}{2}$	21.75	19.8	4.31	13.7	6.21	1.26	1.20	— 4.8
8	20	11.75	20.4	2.40	12.0	7.08	.80	.67	—16.3
9	52	36.50	21.0	7.67	14.8	5.76	2.08	2.14	+ 2.9
10	11	7.50	23.7	1.78	16.2	5.25	.44	.50	+13.6
11	59	42.25	19.2	8.11	13.7	6.18	2.36	2.27	— 3.8
12	$16\frac{1}{2}$	11.50	20.7	2.38	14.4	5.89	.66	.66	0.0
13	29	20.75	18.9	3.92	13.5	6.29	1.16	1.09	— 6.0
14	16	11.25	20.1	2.26	14.1	6.02	.64	.63	— 1.6
15	50	34.75	19.8	6.88	13.8	6.18	2.00	1.93	— 3.5
16	26	18.75	21.0	3.94	15.2	5.61	1.04	1.10	+ 5.8
17	37	24.50	19.1	4.68	12.6	6.72	1.48	1,31	—11.5
18	26	18.25	21.3	3.89	14.9	5.68	1.04	1.09	+ 4.8
19	29	20.00	20.7	4.14	14.3	5.95	1.16	1.15	— .9
20	32	21.75	23.3	5.07	15.9	5.36	1.28	1.41	+10.1
21	68	48.50	20.7	10.04	14.8	5.75	2.72	2.81	+ 3.3
22	42	29.75	20.4	6.07	14.4	5.88	1.68	1.70	+ 1.2
23	$22\frac{1}{2}$	16.00	21.0	3.36	14.9	5.69	.90	.94	+ 4.4
24	$15\frac{1}{2}$	10.25	21.5	2.20	14.2	5.99	.62	.61	— 1.6
	770			110.31			$30.80	$30.80	

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 5, April 17, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter.	Value of the Cream by the Space System @ 4 cents per Space.	Value of the Cream by the Babcock Test System @ $28\frac{65}{100}$ cents per pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System.
1	22	15.50	19.50	3.02	13.6	6.19	$ .88	$ .87	— 1.1
2	38	25.75	18.75	4.83	12.7	6.69	1.52	1.38	— 9.2
3	23	16.25	19.50	3.17	13.7	6.17	.92	.91	— 1.1
4	20	14.25	20.00	2.85	14.1	5.97	.80	.82	+ 2.5
5	19	14.50	18.00	2.61	13.7	6.18	.76	.75	— 1.3
6	42	30.75	19.50	6.00	14.3	5.95	1.68	1.72	+ 2.4
7	18	14.00	18.50	2.59	14.3	5.90	.72	.74	+ 2.8
8	22	17.75	18.75	3.33	15.1	5.61	.88	.96	+ 9.1
9	49	35.00	19.75	6.91	14.0	6.03	1.96	1.98	+ 1.0
10	47	32.00	20.25	6.48	13.8	6.17	1.88	1.86	— 1.1
11	60	46.75	16.50	7.71	12.9	6.61	2.40	2.21	— 7.9
12	15	11.75	18.75	2.20	14.7	5.80	.60	.63	+ 5.0
13	146	101.50	20.50	20.81	14.1	5.96	5.84	5.96	+ 2.1
14	26	18.00	20.25	3.65	14.0	6.06	1.04	1.05	+ .9
15	24	16.50	19.75	3.26	13.6	6.25	.96	.93	— 3.1
16	33	22.25	21.75	4.84	14.7	5.80	1.32	1.39	— 5.3
17	32	22.00	17.50	3.85	12.0	7.07	1.28	1.10	—14.1
18	19	13.50	19.25	2.60	13.7	6.21	.76	.74	— 2.6
19	20	15.00	20.00	3.00	15.0	5.67	.80	.86	+ 7.5
20	30	21.25	21.25	4.52	15.1	5.64	1.20	1.29	+ 7.5
21	33	24.00	20.25	4.86	14.8	5.77	1.32	1.39	+ 5.3
22	39	28.50	19.75	5.63	14.4	5.88	1.56	1.61	+ 3.2
23	25	17.75	18.25	3.24	12.9	6.56	1.00	.93	— 7.0
24	57	42.75	19.50	8.34	14.6	5.81	2.28	2.39	+ 4.8
25	72	52.25	17.00	8.88	12.3	6.89	2.88	2.55	—11.5
26	23	21.25	16.00	3.40	14.8	5.75	.92	.97	+ 5.4
27	35	25.50	20.50	5.23	14.9	5.69	1.40	1.50	+ 7.1
28	23	17.00	17.00	2.89	12.6	6.76	.92	.83	— 9.8
29	17	12.50	16.50	2.06	12.1	7.01	.68	.59	—13.2
30	85	65.00	19.50	12.68	14.9	5.70	3.40	3.63	+ 6.8
31	27	19.25	20.00	3.85	14.3	5.96	1.08	1.10	+ 1.9
	1141			159.30			$45.64	$45.64	

Comparison of the Space and Babcock Test Systems for One Gathering.

Creamery No. 6, April 18, 1894.

Number of Patron.	Spaces of Cream.	Pounds of Cream.	Per cent. of Fat in the Cream.	Pounds of Fat in the Cream.	Pounds of Fat in 100 Spaces of Cream.	Number of Spaces to make a pound of average Butter.	Value of the Cream by the Space System @ 4 cents per Space.	Value of the Cream by the Babcock Test System (@ 31 43/100 cents per pound of Fat.	Payment by the Babcock Test System would give more (+) or less (—) than by the Space System.
1	26	17.5	15.75	2.76	10.6	8.01	$1.04	$ .87	—16.3
2	30	21.0	19.00	3.99	13.3	6.39	1.20	1.25	+ 4.2
3	40	27.5	17.00	4.68	11.7	7.26	1.60	1.47	— 8.1
4	43	27.0	19.00	5.13	11.9	7.14	1.72	1.61	— 6.4
5	24	18.0	19.25	3.47	14.5	5.88	.96	1.09	+13.5
6	34	23.0	18.50	4.26	12.5	6.80	1.36	1.34	— 1.5
7	31	21.5	15.75	3.39	10.9	7.79	1.24	1.07	—13.7
8	15	12.5	17.00	2.13	14.2	6.00	.60	.67	+11.6
9	19	17.0	16.00	2.72	14.3	5.94	.76	.85	+11.8
10	33	26.0	16.25	4.21	12.8	6.67	1.32	1.32	0.0
11	32	25.0	19.00	4.75	14.8	5.72	1.28	1.49	+16.4
12	58	36.0	20.25	7.29	12.6	6.76	2.32	2.29	— 1.3
13	67	42.0	21.00	8.82	13.2	6.46	2.68	2.77	+ 3.4
14	55	38.5	19.50	7.51	13.7	6.22	2.20	2.36	+ 7.3
15	20	15.0	16.50	7.48	12.4	6.86	.80	.78	— 2.5
16	42	30.0	19.50	5.85	13.9	6.10	1.68	1.84	+ 9.5
17	30	21.5	18.25	3.92	13.1	6.51	1.20	1.23	+ 2.5
18	22	14.0	19.00	2.66	12.1	7.03	.88	.84	— 4.5
19	23	17.0	17.00	2.89	12.6	6.76	.92	.91	— 1.1
20	57	40.5	17.25	6.99	12.3	6.93	2.28	2.20	— 3.5
21	17	12.0	16.00	1.92	11.3	7.52	.68	.60	—11.7
22	24	17.0	13.50	2.30	9.6	8.87	.96	.72	—25.0
24	40	29.0	18.50	5.37	13.5	6.33	1.60	1.70	+ 6.2
25	62	42.0	17.00	7.14	11.5	7.38	2.48	2.25	— 9.3
26	44	38.0	16.75	6.37	14.5	5.87	1.76	2.00	+13.6
Total	888			113.00			$35.52	$35.52	

OBSERVATIONS ON THE GROWTH OF MAIZE CONTINUOUSLY ON THE SAME LAND.

By E. H. Jenkins.

In the years 1888 and 1889 a parcel of land containing 1⅕ acres which had been a meadow for some years previous, was dressed with commercial fertilizers and planted to corn. Fertilizers and crops were weighed and analyzed each year and the enrichment or exhaustion of the soil by the dressing and cropping were determined as accurately as possible.

In the spring of 1890 this land was divided into four strips, each containing three-tenths of an acre, and was dressed as shown in the following diagram.

South.

Plot A.—Cow Manure at the rate of 10 cords per acre.
Plot B.—Hog Manure at the rate of 13½ cords per acre.
Plot C.—Fertilizer Chemicals at the rate of 1700 pounds per acre.
Plot D.—No manure or fertilizer of any kind.

North.

Corn was planted in drills four feet apart and the stalks stood singly at distances of ten inches in the drill. The crop from each plot was separately weighed and analyzed.

The several plots have received the same dressing as in 1890 annually since that time, have been planted with the same variety of seed and have been under the same conditions of planting, cultivation and harvesting.

Full particulars regarding the details of the experiment and the results obtained from year to year will be found in the Reports of this Station for 1890, pages 183 to 194; 1891, pages 139 to 149; 1892, pages 122 to 129; 1893, pages 286 to 300.

The experiment was repeated in 1894 precisely as in the four years previous.

The time and method of plowing, planting, cultivating, and harvesting was essentially the same as in previous years.

Considering simply the gross amounts of nitrogen, phosphoric acid and potash which the dressing added to the soil of the several plots and those which the crops removed, it appears from Table VII, to be noticed later, that after the crop of 1894 was harvested there had been added to Plot A *per acre, in excess of what had been taken off in crops* over 930 pounds of nitrogen, 680 of phosphoric acid and 710 of potash, all from cow manure.

The corresponding enrichment of Plot B consisted *per acre,* of over 1570 pounds of nitrogen, 2890 of phosphoric acid and 100 of potash, all from hog manure. The very large excess of phosphoric acid in the hog manure is due to the fact that the hogs were fed chiefly on hotel garbage, which contained a large quantity of bones of fowls.

The enrichment of plot C, *per acre,* amounted to over 418 pounds of nitrogen, 831 of phosphoric acid and 158 of potash all from fertilizer-chemicals.

Plot D received fertilizer-chemicals in 1888 and 1889, but in the following four years no dressing of any sort; so that after the harvest of 1894 it had acquired, *per acre,* 65 pounds more of phosphoric acid (from the applications of 1888 and 1889), than the crops had removed, but had lost 287 pounds of nitrogen and 54 pounds of potash.

Plot B also received more "organic matter" from the dressing than plot A, while plot C acquired only an insignificant amount in the dressing of fertilizer-chemicals, and plot D none at all.

Plot A receives annually about 3,207 pounds, plot B about 5,440 pounds and plot C not more than 200 pounds of organic matter.

Gross Yield of the Plots in 1894.

Table I presents the gross weight of the kernels, cobs and stover harvested on each plot. Inasmuch as the kernels were air-dried on the cob, the weight of the latter in the field-cured condition could not be taken. Hence the weight of the kernels given in the table is slightly higher and that of the cobs slightly lower than it should be. But the error is small.

Table I.—Gross Yield of the Plots in Pounds per Acre. 1894.

	Plot A. Cow manure.	Plot B. Hog manure.	Plot C. Chemicals.	Plot D. No fertilizer.
Kernels	2808.4	2904.0	2886.1	1871.0
Cobs	361.7	396.0	402.5	259.0
Stover	3609.9	3930.0	3026.4	1920.0
Total	6780.0	7230.0	6315.0	4050.0

Since these crops contain a large and variable quantity of water a strict comparison of the yields can only be made on the dry matter which the crops contain.

This appears in Table II.

Table II.—Dry Matter of the Crops, Pounds per Acre. 1894.

	In Kernels.	In Cobs.	In Stover.	Total.
Plot A, cow manure	1770.4	323.0	1927.3	4020.7
Plot B, hog manure	1686.4	353.6	1805.4	3845.4
Plot C, fertilizer-chemicals	1761.1	359.4	1777.1	3897.6
Plot D, no fertilizer	1142.1	231.3	1317.9	2691.3

During the last five years there has been no striking difference in the crops of these four plots as far as the proportion of kernels, cobs and stover is concerned unless perhaps the crop on D which received neither fertilizers nor manure for five years, had a rather larger proportion of stover than the others. The figures are as follows:

Table IIa. Percentage of Water-free Kernels, Cobs and Stover, in the Crops. Average of Five Years.

	Plot A.	Plot B.	Plot C.	Plot D.
Kernels	45.9	46.4	45.3	43.3
Cobs	7.5	8.4	8.8	7.0
Stover	46.6	45.2	45.9	49.7
	100.00	100.00	100.0	100.0

Excess of nitrogen has not made the crop "run to leaves" nor has deficiency of plant food strikingly affected the relative proportion of ears and stalks.

The relative yields of dry matter from these plots for the last five years are given in Table III, the yield of plot A being marked in each case as 100.

Table III.—Relative Yield of Dry Matter from Plots A, B, C, D for Five Years.

	Plot A.	B.	C.	D.
1890	100	104.7	89.5	73.5
1891	100	92.9	82.0	65.9
1892	100	114.6	98.3	48.9
1893	100	95.1	73.2	43.1
1894	100	95.6	96.9	66.9
Average	100	100.6	88.0	59.7

It appears that during the five years the two plots A and B which were dressed with heavy applications of manure have yielded on the average the same amount of water-free crop.

Plot C, dressed with fertilizer chemicals, supplying considerably more nitrogen, phosphoric acid and potash yearly than the crop removed, yielded on the average a little less than nine tenths as much, and plot D without fertilizers six tenths as much.

The relative yield on plot D fell steadily till 1894 when it rose very considerably.

This would indicate that this plot suffered less from the prolonged drought of the last summer than those which had been dressed with manure for a term of years and which contained much more humus.

During the last five years there has been a pretty regular falling off from year to year in the yield of all four plots as is shown in Table III[a], in which the yield of dry matter for each plot in 1890 is marked as 100.

TABLE III[a].—RELATIVE YIELD OF DRY MATTER IN THE FIVE YEARS FROM 1890 TO 1894.

	Plot A.	Plot B.	Plot C.	Plot D.
1890	100	100	100	100
1891	96	81	83	81
1892	79	87	88	53
1893	58	53	48	34
1894	44	41	48	41

The falling off in yield of Plot D is no doubt in part due to lack of plant food. In the other cases this cannot be the cause. Possibly the character of the seasons or deterioration of the seed corn may explain the lessened crops on the other plots.

YIELD OF EACH FOOD INGREDIENT.

In Table IV are given the quantities, in pounds per acre, of each food ingredient harvested from the four plots in 1894.

The cobs were not analyzed, but as their amount is relatively very small, the average composition of cobs as determined in other analyses, is used for the calculation.

The yield of each food ingredient from the four plots shows, in general, differences like those already noted in respect to the yield of total dry matter.

Table V shows the composition of the crops on the four plots, A, B, C, and D, for the year 1894.

TABLE IV.—YIELD OF FOOD INGREDIENTS IN POUNDS PER ACRE. 1894.

	Plot A.				Plot B.				Plot C.				Plot D.			
	Kernels.	Cob.	Stover.	Total.	Kernels.	Cob.	Stover.	Total.	Kernels.	Cob.	Stover.	Total.	Kernels.	Cob.	Stover.	Total.
Water	1038.0	38.7	1682.6	2759.3	1217.6	42.4	2124 6	3384.6	1125.0	43.1	1249.3	2417.4	728.9	27.7	602.1	1358.7
Ash	23.9	5.1	143.3	172.3	24.1	5.5	131.7	161.3	20.2	5.6	140.4	166.2	13.1	3.6	80.6	97.3
Albuminoids	212.6	8.7	140.8	362.1	204.5	9.5	140.3	354.3	196.0	9.7	133.5	339.2	109.3	6.2	75.7	191.2
Fiber	35.6	108.8	612.6	757.0	32.8	119.2	543.5	695.5	34.6	121.1	555.6	711.3	23.4	78.0	437.6	539.0
Nitrogen-free extract	1395.5	198.6	998.8	2592.9	1331.8	217.4	956.5	2505.7	1414.5	221.0	919.1	2554.6	936.8	142.2	702.7	1781.7
Fat	102.8	1.8	31.8	136.4	93.2	2.0	33.4	128.6	95.8	2.0	28.5	126.3	59.5	1.3	21.3	82.1
	2808.4	361.7	3609.9	6780.0	2904.0	396.0	3930.0	7230.0	2886.1	402.5	3026.4	6315.0	1871.6	259.0	1920.0	4050.0

TABLE V.—Analyses of Field-cured Maize, Kernels and Stover, from Plots A, B, C, D. 1894.

	Analyses of Field-cured Maize.						Analyses, Calculated Water-free.				
	Water.	Ash.	Albuminoids.	Fiber.	Nitrogen-Free Extract.	Fat.	Ash.	Albuminoids.	Fiber.	Nitrogen-Free Extract.	Fat.
KERNELS.											
Plot A	36.96	.85	7.57	1.27	49.69	3.66	1.36	12.01	2.02	78.81	5.80
Plot B	41.93	.83	7.04	1.13	45.86	3.21	1.44	12.12	1.95	78.97	5.52
Plot C	38.98	.70	6.79	1.20	49.01	3.32	1.15	11.12	1.97	80.32	5.44
Plot D	38.96	.70	5.84	1.25	50.07	3 18	1.15	9.57	2.04	82.03	5.21
STOVER.											
Plot A	46.61	3.97	3.90	16.97	27.67	.88	7.44	7.31	31.78	51.82	1.65
Plot B	54.06	3.35	3.57	13.83	24.34	.85	7.29	7,77	30.10	52.98	1.86
Plot C	41.28	4.64	4.41	18.36	30.37	.94	7.91	7-51	31.26	51.71	1.61
Plot D	31.36	4.20	3.94	22.79	36.60	1.11	6.13	5.74	33.20	53.32	1.61

Table VI exhibits the striking differences in the percentage composition of the crop on the four plots calculated from the average of the five years.

The crops on A and B, which have been very heavily dressed each year, the one with cow manure the other with hog manure, have a like composition.

The crop on C, which receives each year a liberal dressing of fertilizer chemicals, 1500 pounds to the acre, contains in the kernels considerably less ash or mineral matter and albuminoids than the crops on A and B, and correspondingly more nitrogen-free extract (starch).

The kernels in the crop on D, to which no fertilizer or manure has been applied since 1889, have 1½ per cent. less albuminoids than that of plots A and B, somewhat less ash and fat, but more fiber and nitrogen-free extract.

TABLE VI.—Average Composition of the Dry Matter of Kernels and Stover of Crops of 1890, 1891, 1892, 1893 and 1894.

	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
KERNELS.					
Plot A	1.39	11.26	1.69	80.32	5.34
" B	1.41	11.02	1.69	80.66	5.22
" C	1.26	10.60	1.73	81.30	5.11
" D	1.24	9.53	1.85	82.46	4.92
STOVER.					
Plot A	6.80	6.40	32.80	52.51	1.49
" B	6.46	6.63	32.59	52.80	1.52
" C	6.50	6.65	32.70	52.72	1.43
" D	5.94	6.01	32.77	53.83	1.45

To complete the data regarding this experiment two other tables are given.

Table VII gives the quantities of nitrogen, phosphoric acid and potash which were added in the manure or fertilizers and remained in the crops of 1894.

It also gives the amounts of those fertilizing materials which have been added to the soil capital (+) or withdrawn (—) in the seven years during which accurate account has been kept.

Table VIII gives the record of the crops on the four plots for the whole period covered by the experiment and also the percentage composition of the several crops.

TABLE VII.—ENRICHMENT OR IMPOVERISHMENT OF SOIL BY SEVEN YEARS' MANURING AND CROPPING. POUNDS PER ACRE.

	Cow Manure. Plot A.			Hog Manure. Plot B.			Fertilizer Chemicals. Plot C.			No Fertilizer. Plot D.		
	Nitrogen.	Phos. acid.	Potash.	Nitrogen.	Phos. acid.	Potash.	Nitrogen.	Phos. acid.	Potash.	Nitrogen.	Phos. acid.	Potash.
After six years' cropping	+706.2	+561.8	+570.5	+1207.8	+2330.0	+ 68.5	+300.9	+683.3	+129.4	−256.9	+73.6	−40.0
Applied in 1894	286.3	136.4	204.5	419.9	586.5	72.4	172.0	162.0	69.0	00.0	00.0	00.0
Taken off in Crop of 1894	57.9	17.5	63.3	56.7	18.5	39.6	54.3	13.9	39.7	30.6	8.2	14.3
Excess (+) or Deficiency (−) after seven years' cropping	+934.6	+680.7	+711.7	+1571.0	+2898.0	+101.3	+418.6	+831.4	+158.7	−287.5	+65.4	−54.3

TABLE VIII.—YIELD OF DRY MATTER AND "SHELLED CORN" PER ACRE FOR SEVEN YEARS AND COMPOSITION OF DRY MATTER.

	Year.	Distance of Planting.	Pounds of Dry Matter per Acre.	Bushels of Shelled Corn.	Percentage Composition of Dry Matter				
					Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
Fertilized alike with chemicals	1888	Stalks 12 inches apart.	7350	75	3.3	7.8	19.4	66.1	3.4
	1888	" 6 " "	7980						
	1889	" 12 " "	6144	60	3.5	6.1	21.7	69.7	3.0
	1889	" 6 " "	6353						
Cow Manure	1890A	" 10 " "	9014	91	4.0	7.9	19.8	65.7	2.6
Hog Manure	1890B	" 10 " "	9436	97	4.2	8.0	19.6	65.5	2.7
Fertilizer Chemicals	1890C	" 10 " "	8070	87	3.9	8.0	21.2	64.4	2.5
No Manure or Fertilizer	1890D	" 10 " "	6626	51	3.8	6.2	20.7	66.7	2.6
Cow Manure	1891A	" 12 " "	8176	103	3.2	7.5	15.5	70.2	3.6
Hog Manure	1891B	" 12 " "	7599	88	3.3	7.6	16.2	69.3	3.6
Fertilizer Chemicals	1891C	" 12 " "	6708	70	3.2	6.4	18.5	68.8	3.1
No Manure or Fertilizer	1891D	" 12 " "	5391	60	3.1	6.0	17.4	70.2	3.3
Cow Manure	1892A	" 12 " "	7181	72	4.0	8.2	19.6	65.1	3.1
Hog Manure	1892B	" 12 " "	8233	84	4.0	8.8	19.3	64.8	3.1
Fertilizer Chemicals	1892C	" 12 " "	7062	86	3.2	8.3	17.5	67.8	3.2
No Manure or Fertilizer	1892D	" 12 " "	3509	38	3.3	7.7	18.8	67.2	3.0
Cow Manure	1893A	" 12 " "	5277	53	4.3	8.8	20.8	63.3	2.8
Hog Manure	1893B	" 12 " "	5020	52	3.8	8.4	21.1	63.9	2.8
Fertilizer Chemicals	1893C	" 12 " "	3858	37	3.8	9.0	21.6	63.0	2.6
No Manure or Fertilizer	1893D	" 12 " "	2277	18	4.6	8.2	22.5	62.4	2.3
Cow Manure	1894A	" 12 " "	4021	42	4.3	9.0	18.8	64.5	3.4
Hog Manure	1894B	" 12 " "	3845	40	4.2	9.2	18.1	65.2	3.3
Fertilizer Chemicals	1894C	" 12 " "	3898	42	4.3	8.7	18.2	65.5	3.3
No Manure or Fertilizer	1894D	" 12 " "	2691	27	3.6	7.2	20.0	66.2	3.0

EXPERIMENTS IN GROWING TOBACCO WITH DIFFERENT FERTILIZERS. SEASON OF 1893.

FINAL REPORT ON THE FERMENTED CROPS OF 1893.

By E. H. Jenkins.

The plan of these experiments and full particulars regarding the planting, cultivating, harvest, cure, and sorting of the crops of 1893 are to be found in the Seventeenth Report of this Station, 1893, pages 128 to 144.

As the crops were sorted, samples of the long and short wrappers from each plot were carefully drawn. Each sample contained twelve "hands" (15 to 20 leaves in each "hand"). Four "hands" were tied together by the butts with a tag attached bearing a number which designated the plot. No one except the Station representative knew to which plots the several numbers referred.

Early in January, 1894, these samples, each consisting of three bunches, four hands in each bunch, were cased for fermentation at the warehouse of Mr. L. B. Haas—the case being lined with top leaves and seconds from the same crop.

The case was opened and the fermented crops examined on Dec. 10th of the same year.

Shrinkage of the Tobacco during Fermentation.

The net weight of the tobacco when it was cased was 357 pounds, and after fermenting was 307 pounds. The loss was 14 per cent., nearly the same that the crop of 1892 lost (13.8 per cent.).

Quality of the Crops.

The fermented crops of 1893 were examined and graded by Mr. Benjamin L. Haas, of Hartford, one of the experts who judged of the quality of the crop of 1892.

He was not told which plots were represented by the different lots under examination, and was asked to make a strict judgment, noting all defects in the tobacco from the standpoint of a dealer in Connecticut leaf tobacco.

He devoted the greater part of two days to the work, with such assistance as could be rendered by two others not experts.

It is believed that there has thus been secured a perfectly unbiased and intelligent judgment by an expert in touch with the present requirements of the trade.

Before considering Mr. Haas' report, the conditions of the growing season of 1893 should be called to mind. It was the coldest season since 1888. It was also a very dry summer. The rainfall for the year was 4.18 inches below normal and all the summer months were much dryer than usual. On Aug. 19 and 20 there was a very light rain which wet the ground 3 inches down, and this was more rain than had fallen at any one time since the plants were set.

During the last week of August two severe gales swept over the State, which whipped and broke the tobacco somewhat.

The season was therefore a very unfavorable one for the tobacco crop, as regards both yield and quality.

The yield in 1893 was less than 85 per cent. of what it was the year before, and while the crop of 1892 had 66.7 per cent. of wrapper leaves, that of 1893 had but 48.5 per cent.

Report on the Quality of the Fermented Crop of 1893.

The crop is a very poor one. The leaves have not sweated well. The colors are extremely poor, if indeed, the crop can be said to have "color."

The one good feature of the crop is the burning quality, which is surprisingly good, better even than that of the 1892 crop.

These facts make it extremely difficult to judge the different lots of tobacco. There is no very great difference in quality observable. It is all poor.

Lot A.

Fertilizers: 1500 lbs. cotton seed meal and 1660 lbs. cotton hull ashes per acre, containing 105 lbs. nitrogen, 150 lbs. phosphoric acid and 342 lbs. potash. Cost, $60.35 per acre.

Yield:	525	lbs. long wrappers per acre.
	160	" short " " "
Total	685	"

Quality:—*Burn*, fairly free, holds fire well, does not coal. *Ash*, clear gray, does not flake. *Vein*, prominent, curly, white. *Texture*, mottled, unsweated, good grain. *Size*, desirable. *Ripeness*, fairly ripe. *Colors*, bad. *Yield*, not desirable. *Taste*, fair. *Stem*, medium size. *Relative rank*, 23d.

LOT B.

Fertilizers: 1760 lbs. linseed meal, 1660 lbs. cotton hull ashes per acre, containing 105 lbs. nitrogen, 138 lbs. phosphoric acid and 340 lbs. potash. Cost, $57.79 per ton.

Yield: 585 lbs. long wrappers per acre.
190 " short " " "
Total 775 "

Quality:—*Burn*, very free, holds fire well, does not coal. *Ash*, clear white, does not flake. *Vein*, small, fine, some white. *Texture*, clear, unsweated, good grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, fairly good. *Yield*, desirable. *Taste*, fair. *Stem*, medium to small. *Relative rank*, 1st.

LOT C.

Fertilizers: 2500 lbs. cotton seed meal, 1540 lbs. cotton hull ashes per acre, containing 175 lbs. nitrogen, 172 lbs. phosphoric acid and 342 lbs. potash. Cost, $73.88 per acre.

Yield: 475 lbs. long wrappers per acre.
165 " short " " "
Total 640 "

Quality:—*Burn*, free, holds fire well, does not coal. *Ash*, clear white, does not flake. *Vein*, small, fine. *Texture*, clear, unsweated, good grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, fairly good. *Yield*, desirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 5th.

LOT D.

Fertilizers: 3000 lbs. cotton seed meal, 1500 lbs. cotton hull ashes per acre, containing 210 lbs. nitrogen, 184 lbs. phosphoric acid and 342 lbs. potash. Cost, $81.00 per acre.

Yield: 535 lbs. long wrappers per acre.
185 " short " " "
Total 720 "

Quality:—*Burn*, free, holds fire well, coals slightly. *Ash*, clear gray and does not flake. *Vein*, medium, curly. *Texture*, mottled, unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium. *Yield*, desirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 8th.

LOT E.

Fertilizers: 2260 lbs. castor pomace, 1660 lbs. cotton hull ashes per acre, containing 105 lbs. nitrogen, 139 lbs. phosphoric acid, 340 lbs. potash. Cost, $64.60 per acre.

Yield: 605 lbs. long wrappers per acre.
185 " short " " "
Total 790 "

Quality:—*Burn*, free, holds fire well, inclined to coal. *Ash*, mixed gray, but does not flake. *Vein*, prominent, curly, white. *Texture*, mottled, unsweated, close grain. *Size*, desirable. *Ripeness*, not quite ripe. *Colors*, unsweated, bad. *Yield*, undesirable. *Taste*, bitter. *Stem*, medium, woody. *Relative rank*, 29th.

LOT F.

Fertilizers: 1760 lbs. linseed meal, 660 lbs. cotton hull ashes, 260 lbs. Cooper's bone per acre, containing 105 lbs. nitrogen, 150 lbs. phosphoric acid, 150 lbs. potash. Cost, $41.79 per acre.

Yield: 725 lbs. long wrappers per acre.
185 " short " " "
Total 910 "

Quality:—*Burn*, free, holds fire well, coals slightly. *Ash*, clear gray, does not flake. *Vein*, small, fine. *Texture*, mottled, unsweated, dry, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium. *Yield*, desirable. *Taste*, fair. *Stem*, small. *Relative rank*, 3d.

LOT G.

Fertilizers: 3760 lbs. castor pomace, 1560 lbs. cotton hull ashes per acre, containing 175 lbs. nitrogen, 154 lbs. phosphoric acid and 342 lbs. potash. Cost $81.32 per acre.

Yield: 425 lbs. long wrappers per acre.
220 " short " " "
Total 645 "

Quality:—*Burn*, fairly free, holds fire fairly well, does not coal. *Ash*, clear gray, does not flake. *Vein*, medium. *Texture*, mottled, gummy, unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, undesirable. *Yield*, desirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 22d.

LOT H.

Fertilizers: 4520 lbs. castor pomace, 1520 cotton hull ashes per acre, containing 210 lbs. nitrogen, 164 lbs. phosphoric acid, 342 lbs. potash. Cost $89.94 per acre.

Yield: 690 lbs. long wrappers per acre.
210 " short " " "
Total 900 "

Quality:—*Burn*, Very free, holds fire well, does not coal. *Ash*, clear gray, does not flake. *Vein*, white. *Texture*, gummy, mottled, unsweated, good grain. *Size*, little large. *Ripeness*, ripe. *Colors*, medium. *Yield*, good. *Taste*, fair. *Stem*, large and woody. *Relative rank*, 9th.

LOT I.

Fertilizers: 2260 lbs. castor pomace, 1660 lbs. cotton hull ashes, 656 lbs. nitrate of soda (the latter in two applications after planting), per acre, containing 210 lbs. nitrogen, 139 lbs phosphoric acid, 340 lbs. potash. Cost, $81.96 per acre.

Yield: 670 lbs. long wrappers per acre.
185 " short " " "
Total 855 "

Quality:—*Burn*, fairly free, holds fire well, coals slightly. *Ash*, clear gray, does not flake. *Vein*, curly, white. *Texture*, unsweated, gummy, mottled, good grain. *Size*, desirable. *Ripeness*, not quite ripe. *Colors*, bad. *Yield*, poor. *Taste*, fair. *Stem*, medium to small. *Relative rank*, 21st.

LOT J.

Fertilizers: 2260 lbs. castor pomace, 1660 lbs. cotton hull ashes, 656 lbs. nitrate of soda per acre (the latter applied after planting), containing 210 lbs. nitrogen, 139 lbs. phosphoric acid, 340 lbs. potash. Cost $81.96 per acre.

Yield 805 lbs. long wrappers per acre.
260 " short " " "
Total 1065 "

Quality:—*Burn*, very free, holds fire well, does not coal. *Ash*, clear gray, does not flake. *Vein*, small, inclined to be white. *Texture*, fairly good but unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium, mottled. *Yield*, good. *Stem*, medium. *Relative rank*, 6th.

LOT K.

Fertilizers: 1500 lbs. cotton seed meal, 1220 lbs. double manure salt, 360 lbs. Cooper's bone per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 342 lbs. potash. Cost, $47.12 per acre.

Yield: 750 lbs. long wrappers per acre.
190 " short " " "
Total 940 "

Quality:—*Burn*, holds fire fairly well, fairly free burn, coals slightly. *Ash*, clear gray, does not flake. *Vein*, curly, white. *Texture*, dry, unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium. *Yield*, good. *Stem*, medium. *Relative rank*, 15th.

LOT L.

Fertilizers: 1500 lbs. cotton seed meal, 1220 lbs. double manure salt, 360 lbs. Cooper's bone, 300 lbs. lime per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 342 lbs. potash. Cost, $47.94 per acre.

Yield: 515 lbs. long wrappers per acre.
185 " short " " "
Total 700 "

Quality:—*Burn*, holds fire fairly well, free burn, coals very slightly. *Ash*, medium flaky, gray. *Vein*, medium. *Texture*, unsweated, mottled and gummy, good grain. *Size*, medium. *Ripeness*, ripe. *Colors*, poor. *Yield*, fair. *Taste*, fair. *Stem*, medium. *Relative rank*, 25th.

LOT M.

Fertilizers: 1500 lbs. cotton seed meal, 620 lbs. high grade sulphate of potash, 360 lbs. Cooper's bone per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 340 lbs. potash. Cost $45.87 per acre.

Yield: 455 lbs. long wrappers per acre.
195 " short " " "
Total 650 "

Quality:—*Burn*, holds fire fairly well, free burn, coals somewhat. *Ash*, mixed gray and flakes somewhat. *Vein*, prominent and curly. *Texture*, gummy and mottled, unsweated, good grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, poor. *Yield*, good. *Taste*, fair. *Stem*, medium. *Relative rank*, 28th.

LOT N.

Fertilizers: 1500 lbs. cotton seed meal, 620 lbs. high grade sulphate of potash, 360 lbs. Cooper's bone, 300 lbs. lime per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 340 lbs. potash. Cost, $46.69 per acre.

Yield: 590 lbs. long wrappers per acre.
240 " short " " "
Total 830 "

Quality:—*Burn*, holds fire well, free burn. *Ash*, blue white, does not flake. *Vein*, prominent and curly. *Texture*, gummy, mottled, unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, fair. *Yield*, good. *Taste*, fair. *Stem*, medium. *Relative rank*, 19th.

LOT O.

Fertilizers: 1500 lbs. cotton seed meal, 580 lbs. carbonate of potash, 360 lbs. Cooper's bone per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 342 lbs. potash. Cost, 78.12* per acre.

Yield: 435 lbs. long wrappers per acre.
200 " short " " "
Total 635 "

Quality:—*Burn*, holds fire fairly well, free burn, but coals somewhat. *Ash*, gray, does not flake. *Vein*, woody, white, not prominent. *Texture*, gummy, mottled, unsweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, fair. *Yield*, good. *Taste*, fair. *Stem*, medium. *Relative rank*, 24th.

LOT. P.

Fertilizers: 1500 lbs. cotton seed meal, 1740 lbs. double carbonate of potash and magnesia, 360 lbs. Cooper's bone per acre, containing 110 lbs. nitrogen, 150 lbs. phosphoric acid, 342 lbs. potash. Cost, $62.75* per acre.

Yield: 480 lbs. long wrappers per acre.
235 " short " " "
Total 715 "

Quality:—*Burn*, free, holds fire very well. *Ash*, gray, does not flake. *Vein*, fine. *Texture*, fairly good, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium to good. *Yield*, good. *Taste*, fair. *Stem*, light. *Relative rank*, 14th.

* If bought in ton lots, not chemically pure, the cost would be considerably less.

LOT Q.

Fertilizers: 2000 lbs. Baker's AA superphosphate, 4000 lbs. Baker's tobacco manure per acre, containing 233 lbs. nitrogen, 456 lbs. phosphoric acid, 533 lbs. potash.

Yield: 850 lbs. long wrappers per acre.
200 " short " " "
Total 1050 "

Quality:—*Burn*, fairly free, does not hold fire very well. *Ash*, firm, black and white. *Vein*, prominent and curly. *Texture*, harsh, undesirable. *Size*, medium to large. *Ripeness*, ripe. *Colors*, medium to good. *Yield*, undesirable. *Stem*, large. *Relative rank*, 20th.

LOT R.

Fertilizers: 2000 lbs. Stockbridge tobacco manure, 500 lbs. Stockbridge tobacco manure* per acre, containing 153 lbs. nitrogen, 245 lbs. phosphoric acid, 302 lbs. potash.

Yield: 455 lbs. long wrappers per acre.
165 " short " " "
Total 620 "

Quality:—*Burn*, free, does not coal, holds fire. *Ash*, mixed gray. *Vein*, prominent, curly. *Texture*, mottled, unsweated, good grain. *Size*, medium. *Ripeness*, ripe. *Colors*, poor. *Yield*, undesirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 17th.

LOT S.

Fertilizers: 3000 lbs. Stockbridge tobacco manure, 500 lbs. Stockbridge tobacco manure* per acre, containing 214 lbs. nitrogen, 343 lbs. phosphoric acid, 403 lbs. potash.

Yield: 615 lbs. long wrappers per acre.
215 " short " " "
Total 830 "

Quality:—*Burn*, free, does not coal, holds fire fairly well. *Ash*, mixed gray, does not flake. *Vein*, not prominent, but some white. *Texture*, fairly good, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, fair. *Yield*, desirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 7th.

* Applied as a starter.

LOT T.

Fertilizers: 880 lbs. dry fish, 440 lbs. nitrate of soda, 720 lbs. Cooper's bone, 300 lbs. lime per acre, containing 153 lbs. nitrogen, 268 lbs. phosphoric acid, no potash. Cost, $42.05 per acre.

Yield: 735 lbs. long wrappers per acre.
180 " short " " "
Total 915 "

Quality:—*Burn*, free, does not coal, holds fire fairly well. *Ash*, light gray, does not flake. *Vein*, prominent, curly. *Texture*, gummy, harsh and undesirable, good grain. *Size*, not desirable. *Ripeness*, ripe. *Colors*, mottled and dry. *Yield*, undesirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 18th.

LOT U.

Fertilizers: 600 lbs. Mapes' starter, 2200 lbs. Mapes' tobacco manure, wrapper brand per acre, containing 147 lbs. nitrogen, 206 lbs. phosphoric acid, 259 lbs. potash.

Yield: 975 lbs. long wrappers per acre.
250 " short " " "
Total 1225 "

Quality:—*Burn*, fairly free, coals slightly, holds fire fairly well. *Ash*, light gray, does not flake. *Vein*, prominent, curly. *Texture*, desirable, fine with good grain. *Size*, a little large. *Ripeness*, ripe. *Colors*, medium to good. *Yield*, desirable. *Stem*, medium. *Relative rank*, 4th.

LOT V.

Fertilizers: 800 lbs. Mapes' tobacco starter, 2000 lbs. Mapes' tobacco manure, wrapper brand per acre, containing 141 lbs. nitrogen, 220 lbs. phosphoric acid and 244 lbs. potash.

Yield: 690 lbs. long wrappers per acre.
180 " short " " "
Total 870 "

Quality:—*Burn*, fairly free, does not coal, holds fire fairly well. *Ash*, light gray, does not flake. *Vein*, not prominent, but some white. *Texture*, fairly well sweated, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, fairly good. *Yield*, good. *Taste*, fair. *Stem*, medium to heavy. *Relative rank*, 11th.

LOT W.

Fertilizers: 1000 lbs. Mapes' starter, 1800 lbs. Mapes' tobacco manure, wrapper brand per acre, containing 135 lbs. nitrogen, 232 lbs. phosphoric acid, 229 lbs. potash.

Yield: 615 lbs. long wrappers per acre.
165 " short " " "
Total 780 "

Quality:—*Burn*, fairly free, coals slightly, holds fire well. *Ash*, light gray, does not flake. *Vein*, medium. *Texture*, good, good grain. *Size*, desirable. *Ripeness*, ripe. *Colors*, fairly good, fairly well sweated. *Yield*, desirable. *Taste*, fair. *Stem*, medium. *Relative rank*, 2d.

LOT X.

Fertilizers: 2000 lbs. Sanderson's formula per acre, containing 103 lbs. nitrogen, 281 lbs. phosphoric acid, 105 lbs. potash.

Yield: 525 lbs. long wrappers per acre.
200 " short " " "
Total 725 "

Quality:—*Burn*, not free, coals very slightly, does not hold fire. *Ash*, light gray, does not flake. *Vein*, medium. *Texture*, unsweated, gummy and mottled. *Size*, not desirable. *Ripeness*, ripe. *Colors*, very bad. *Yield*, not desirable. *Stem*, small. *Relative rank*, 27th.

LOT Y.

Fertilizers: 1500 lbs. cotton seed meal, 5620 lbs. unleached wood ashes, 160 lbs. Cooper's bone per acre, containing 105 lbs. nitrogen, 153 lbs. phosphoric acid, 342 lbs. potash. Cost, $59.74 per acre.

Yield: 360 lbs. long wrappers per acre.
125 " short " " "
Total 485 "

Quality:—*Burn*, holds fire fairly well, fairly free burn, coals slightly. *Ash*, light gray, does not flake. *Vein*, small, white. *Texture*, gummy, unsweated. *Size*, desirable. *Ripeness*, ripe. *Colors*, medium. *Yield*, desirable. *Taste*, fair. *Stem*, very small. *Relative rank*, 10th.

LOT Z.

Fertilizers: 1300 lbs. dry fish, 1220 lbs. double manure salt, 200 lbs. Cooper's bone per acre, containing 105 lbs. nitrogen, 147 lbs. phosphoric acid, 342 lbs. potash. Cost, $52.12 per acre.

Yield: 315 lbs. long wrappers per acre.
150 " short " " "
Total 465 "

Quality:—*Burn*, holds fire fairly, fairly free burn, does not coal. *Ash*, light gray, does not flake. *Vein*, small, fine. *Texture*, unsweated, gummy. *Size*, desirable. *Ripeness*, ripe. *Colors*, poor. *Yield*, desirable. *Taste*, fair. *Stem*, small. *Relative rank*, 12th.

LOT AA.

Fertilizers: 10–12 cords stable manure, and on half the plot 500 lbs. swift-sure superphosphate as a starter per acre, containing 126 lbs. nitrogen, 143 lbs. phosphoric acid, 172 lbs. potash.

Yield: 270 lbs. long wrappers per acre.
255 " short " " "
Total 525 "

Quality:—*Burn*, holds fire well, free burn, but coals. *Ash*, mixed gray, does not flake. *Vein*, small and fine. *Texture*, good, unsweated, rather close grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, mottled and bad. *Yield*, good. *Taste*, fair. *Stem*, very small. *Relative rank*, 13th.

LOT BB.

Fertilizers: 6000 lbs. tobacco stems, 2640 lbs. castor pomace. On one-half the plot 500 lbs. swift-sure superphosphate as a starter per acre, containing 252 lbs. nitrogen, 146 lbs. phosphoric acid, 538 lbs. potash. Cost, $84.80 per acre.

Yield: 300 lbs. long wrappers per acre.
180 " short " " "
Total 480 "

Quality:—*Burn*, holds fire well, free burn, coals very slightly. *Ash*, mixed gray, does not flake. *Vein*, small, fine. *Texture*, good, unsweated, rather close grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, mottled and bad. *Yield*, good. *Taste*, fair. *Stem*, very small. *Relative rank*, 16th.

LOT CC.

Fertilizers: Pinney's Formula, containing 139 lbs. nitrogen, 210 lbs. phosphoric acid, 224 lbs. potash per acre.

Yield: 175 lbs. long wrappers per acre.
155 " short " " "
Total 330 "

Quality:—*Burn*, fairly free, does not hold fire well, coals slightly. *Ash*, mixed gray, does not flake. *Vein*, small, fine. *Texture*, good, but unsweated, rather close grain. *Size*, very desirable. *Ripeness*, ripe. *Colors*, mottled and bad. *Yield*, good. *Stem*, small. *Relative rank*, 26th.

The lots in order of their value as wrappers, taking all points into consideration, were arranged by Mr. Haas as follows:—

B, (best), W, F, U, C, J, S, D, H, Y, V, Z,
1st, 2d, 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th,
AA, P, K, BB, R, T, N, Q, I, G, A, O,
13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22d, 23d, 24th,
L, CC, X, M, E.
25th, 26th, 27th, 28th, 29th.

DISCUSSION OF THE QUALITY OF THE FERMENTED TOBACCO, CROPS OF 1893.

It must be borne in mind in considering these statements of the judge that there was no really good tobacco in any of the lots. They were all badly damaged by drought, and between the lots scored as best and those scored as poorest there was no great difference in quality. All the plots, however, did not suffer equally from drought. Its effects were especially severe on those plots Y, Z, AA, BB, and CC which were planted for the first time in 1893. Those which had been tilled the previous year suffered less.

Comparing the 1893 crop with that of 1892, it appears that of the seven plots which bore the best tobacco in 1892 only two are among the seven best in 1893 (C and F). Of the seven plots which bore the poorest tobacco in 1892 only two are among the seven poorest in 1893 (M and X).

It is questionable whether any fair conclusions can be drawn as to the effects of different fertilizers on the quality of the

tobacco when it seems probable that the drought rather than the fertilizers controlled the quality of the crop.

It is a striking fact that the fermented tobacco of 1893 crop from almost all the plots had a fair to very good burning quality, considerably better in fact than the 1892 crop from the experiment field, which was regarded by the judges, and especially by the manufacturers who bought and worked it into cigars as exceptionally good.

The judge's report on the burn of the two crops was as follows :

	1892 Crops.	1893 Crops.*
Burn "very free to free"	14	23
Burn "not free"	19	1
	24	24
Hold fire "very well to well"	10	13
Hold fire fairly well	8	9
"Do not hold fire"	6	2
	24	24
"Do not coal"	9	13
"Coal slightly"	11	11
"Coal"	4	0
	24	24

The defects of the experimental crop of 1893, common to the tobacco of nearly all the plots, and therefore attributed to conditions of weather are wholly in the "texture" and "colors." These defects cannot be defined at present more accurately than is done in the judge's report. Most of the tobacco is called "unsweated." But that it did ferment to some extent is certain. It lost as much weight in the case as the 1892 crop.

That the tobacco was of quite inferior quality was evident when it was sorted and before it was "sweated" or fermented. The popular saying "burn in tobacco is everything," does not hold in the present state of the trade. Desirable burn, texture and color are everything, and either two of the three are of no account without the other.

Comparative Fire-Holding Capacity.

In addition to the tests made by the expert a more extensive test was made at the Station laboratory by Messrs. Winton and

* Includes only those plots on which tobacco was grown in 1892.

Ogden, following the method described in the Station Report for 1893, p. 124.

The lot which held fire the shortest time is marked 100 and the other lots are so marked as to express numerically their comparative capacity for holding fire : for example, lot Z held fire for a shorter time than any other (100); lot AA held fire about 2¼ times as long (227).

Comparative Fire-Holding Capacity. Fermented Crop of 1893.

	Long Wrappers.	Short Wrappers.	Calculated from mean of both.	Average number of seconds during which leaf holds fire. Unfermented.	Fermented.
A	246	319	252	11	22
B	233	308	246	14	21
C	224	282	229	10	20
D	243	298	245	9	22
E	252	231	217	8	21
F	393	354	380	11	32
G	198	143	197	10	15
H	209	212	198	11	19
I	313	383	301	10	27
J	228	536	354	11	24
K	160	223	174	8	14
L	217	147	213	7	15
M	210	182	203	7	17
N	229	155	170	8	18
O	252	260	230	8	21
P	281	382	303	12	25
Q	111	166	126	6	10
R	160	172	125	7	9
S	203	169	166	8	17
T	120	121	109	7	10
U	149	230	173	8	14
V	179	225	103	9	16
W	151	185	152	8	14
X	108	115	101	7	9
Y	186	309	226	8	18
Z	114	100	100	5	10
AA	235	269	227	9	20
BB	154	178	150	8	13
CC	118	180	136	7	11

The fire-holding capacity of all the lots was increased by fermentation though not by any means equally in all cases.

The *average* fire-holding capacity before fermentation was 9 seconds, after fermentation 18 seconds.

The average of the 1892 crop was, before fermentation 9.6 seconds, after fermentation 24.4 seconds.

The better "burn" of the '93 crop as compared with that of '92 is due rather to its greater freedom from "coal" and its "free" burn when wrapped on cigars, than to its fire-holding capacity.

A more accurate method of determining fire-holding capacity is desirable. Tobaccos can only be fairly compared by this method when they are equally damp. But it is well-nigh impossible to get the crop of different seasons into the same condition of moisture in every case.

Nevertheless there is substantial agreement between the judgment of the expert on the fire-holding capacity of the different lots and the results of the laboratory tests on this point.

Thus, a study of the data regarding the two fermented crops of 1892 and 1893 shows that of the nine lots which the expert claimed did not "hold fire," eight had less than the average fire-holding capacity as determined in the laboratory. The ninth lot had just the average.

Of the twenty which the expert marked as holding fire only "fairly well," eighteen lots had less than average fire-holding capacity, as determined in the laboratory.

Of the twenty-seven lots which held fire well in the expert's opinion, only seven had less than average fire-holding capacity in laboratory tests.

Tendency to "coal" when wrapped on a cigar is not apparently associated with deficiency in fire-holding capacity. Thus, of twenty-nine lots which "coaled" more or less, fifteen had more than average fire-holding capacity.

Effect of Large Quantities of Cotton Seed Meal and Comparison of Cotton Seed Meal and Castor Pomace.

(Plots A, C, D, compared with E, G, H).

In 1893 castor pomace produced a larger yield of wrappers than equivalent quantities of cotton seed meal; on the average 778 lbs. per acre, as against 682 lbs. produced by cotton seed meal. The quality of that grown with cotton seed meal was somewhat better than the other.

The heaviest applications, 3000 lbs. of cotton seed meal and 4520 lbs. of castor pomace per acre, gave the best quality of leaf as well as the largest yield. This latter observation was also made on the crops of 1892.

Linseed Meal as a Fertilizer.

(Plot B compared with A and E; also note plot F).

The best tobacco in 1893 was raised with linseed meal. The crop which ranked third in quality, F, was also raised with linseed meal with a smaller quantity of potash. The yield of wrappers was above the average of the plots which received equivalent quantities of cotton seed meal or castor pomace, and amounted to 842 lbs. per acre.

Fish as a Fertilizer for Tobacco.

We merely call attention to the plots T and Z. T received nitrogen in form of dry fish scrap and nitrate of soda with no potash. Z received nitrogen in dry fish alone. Z was one of the plots which suffered most from the drought, and evidently no conclusions are justified from this year's crop.

Effect of Nitrate of Soda at the First and Second Cultivation.

(Plots I and J compared with H).

The point of this experiment is to ascertain the effect on the crop of supplying one-third of the nitrogen of a heavy application (210 pounds), as a top dressing in the form of nitrate of soda in one application at the time of the first cultivation (Plot I) or in two applications at the time of the first and second cultivation (Plot J). In 1892 the effect in both cases was decidedly injurious on the quality of the wrappers, though Plot J yielded 180 lbs. more of wrappers than H. In 1893 J yielded 165 lbs. more wrappers than H, and the quality of the wrappers was even better. Plot I, which received all the nitrate in one application, produced less tobacco and of inferior quality.

Effect of the Different Forms of Potash.

(Plots A, K, L, M, N, O, P, Y).

Of the plots named, the best tobacco in 1893 came from the plot which had received wood ashes, Y, which ranked 10th. That raised with the double carbonate of potash and magnesia, P, and double sulphate of potash and magnesia without lime, K, ranked 14th and 15th. But that raised with an equivalent quantity of cotton hull ashes, A, carbonate of potash, O, double

sulphate of potash and magnesia, *with lime*, L, and high grade sulphate *without* lime, M, were among the poorest lots in the field as regards quality.

As has been already stated conclusions are hardly possible where all the crops were so seriously injured by the drought.

EXPERIMENTS IN GROWING TOBACCO WITH DIFFERENT FERTILIZERS. SEASON OF 1894.

By E. H. Jenkins.

These experiments are in continuation of those begun in 1892 in cöoperation with the Connecticut Tobacco Experiment Co. of Poquonock in the town of Windsor.

Full particulars regarding the land, the conduct of the experiments and their results are given in the Report of this Station for 1892, pages 1 to 24, and Report for 1893, pages 112 to 144.

Fertilizers.

The stalks of the crop of 1893 were spread evenly on the plots and plowed in very early in the spring of 1894.

The fertilizers employed in 1894 were sampled and analyzed by Messrs. Winton and Ogden, with the following results:

Composition and Cost of Fertilizers Used.

	Cost Per Ton.	Nitrogen.	Phosphoric Acid.	Potash.
Nitrate of Soda	$50.00	16.00	----	----
Cotton Seed Meal	26.50	7.72	2.94	1.85
Castor Pomace	24.00	5.55	1.69	.90
Linseed Meal	27.00	5.75	1.77	1.28
Tobacco Stems	14.00	1.90*	.60*	8.10*
Cooper's Bone	27.00	1.60	29.20	----
Cotton Hull Ashes	45.00	----	7.04	20.1
Wood Ashes	12.00	----	1.00	3.69
High Grade Sulphate of Potash	55.00	----	----	47.44
Carbonate of Potash	170.00†	----	----	54.10
Double Carbonate Potash and Magnesia	39.00‡	----	----	18.10
Double Sulphate Potash and Magnesia	30.00	----	----	27.16
Fish	40.00	8.02	6.79	----

* Estimated. † By single pound; ton rates would be much lower.
‡ Total cost of importing a one ton lot from Stassfurt.

The chemicals used for each plot were accurately weighed and labeled by the Station representative, mixed thoroughly and bagged by Mr. DuBon and himself.

The bags were carried to the several plots by Mr. DuBon, and their contents were sowed under his constant supervision.

The following table shows the plan of the experiment, the fertilizers applied, with the cost of each as far as known, and the quantities of nitrogen, phosphoric acid and potash contained in them. See pages 272 and 273.

The fertilizers were mixed and sown on May 11th and 12th. The plants were set, with a Bemis planter, on May 22d. The field superintendent, Mr. John A. DuBon, took entire care of the land and the crop, as he has done for the past three years. The crop was harvested on August 23d and 24th.

Notes on the Rainfall, Soil Moisture and Temperature. Season of 1894.

Through the coöperation of Prof. Milton Whitney, Chief of the Division of Agricultural Soils of the U. S. Department of Agriculture, who supplied the necessary instruments, daily observations were made by Mr. Adelbert DuBon during the growing season of maximum and minimum air temperature (radiation thermometers), maximum and minimum soil temperatures (average to depth of nine inches), and rainfall.

The instruments were placed near the crop on a plot which was kept free from all vegetation.

Samples of soil to the depth of nine inches were also daily drawn by Mr. DuBon from several plots and sent to the Station for determination of moisture.

The sampling apparatus and method of packing were designed by Prof. Whitney.

These observations taken together give a record of meteorological conditions which, however incomplete, is of great assistance in comparing the conditions under which the crops of successive years are raised.

Fertilizers Applied, Season of 1894.

Name of Plot.	Fertilizers Applied. Pounds per Acre.	Cost per Acre.	Fertilizer contains pounds. Nitrogen.	Phosphoric Acid.	Potash.
A	1360 Cotton Seed Meal 1560 Cotton Hull Ashes	$53.12	105	150	339
B	1826 Linseed Meal 1572 Cotton Hull Ashes	60.02	105	143	339
C	2260 Cotton Seed Meal 1480 Cotton Hull Ashes	63.24	175	170	339
D	2720 Cotton Seed Meal 1440 Cotton Hull Ashes	68.44	210	180	340
E	1900 Castor Pomace 1640 Cotton Hull Ashes	59.70	105	148	347
F	1820 Linseed Meal 640 Cotton Hull Ashes 260 Cooper's Bone	42.48	105	153	152
G	3160 Castor Pomace 1540 Cotton Hull Ashes	72.52	175	162	338
H	3780 Castor Pomace 1520 Cotton Hull Ashes	79.56	210	171	340
I	1900 Castor Pomace 1640 Cotton Hull Ashes 320 Nitrate of Soda* 320 Nitrate of Soda†	75.70	208	148	347
J	1900 Castor Pomace 1640 Cotton Hull Ashes 640 Nitrate of Soda*	75.70	208	148	347
K	1360 Cotton Seed Meal 1160 Double Sulphate of Potash and Magnesia 380 Cooper's Bone	40.55	105	149	341
L	1360 Cotton Seed Meal 1160 Double Sulphate of Potash and Magnesia 380 Cooper's Bone 300 Lime	43.55	105	149	341
M	1360 Cotton Seed Meal 660 High Grade Sulphate of Potash 380 Cooper's Bone	41.30	105	149	338
N	1360 Cotton Seed Meal 660 High Grade Sulphate of Potash 380 Cooper's Bone 300 Lime	44.30	105	149	338

* Applied between the rows at time of first cultivation.

† Applied between the rows at time of second cultivation.

Fertilizers Applied, Season of 1894.

Name of Plot.	Fertilizers Applied. Pounds per Acre.	Cost per Acre.	Fertilizer contains pounds. Nitrogen.	Phosphoric Acid.	Potash.
O	1360 Cotton Seed Meal 580 Carbonate of Potash 380 Cooper's Bone	$72.45	105	149	339
P	1360 Cotton Seed Meal 1740 Double Carbonate Potash and Magnesia 380 Cooper's Bone	57.08	105	149	340
Q	2000 Baker's A. A. Superphosphate 4000 Baker's Tobacco Manure	----	241	489	495
R	2000 Stockbridge Tobacco Manure 500 Stockbridge Tobacco Manure*	----	149	281	283
S	3000 Stockbridge Tobacco Manure 500 Stockbridge Tobacco Manure*	----	209	393	396
T	880 Dry Ground Fish 440 Nitrate of Soda 300 Lime	31.60	142	60	----
U	2200 Mapes' Tobacco Manure, Wrapper Brand 600 Mapes' Starter	----	158	211	278
V	2400 Mapes' Tobacco Manure, Wrapper Brand 400 Mapes' Starter	----	163	196	294
W	2400 Mapes' Tobacco Manure, Wrapper Brand	----	151	143	280
X	2000 Sanderson's Formula for Tobacco	----	103	281	105
Y	1360 Cotton Seed Meal 8540 Wood Ashes 80 Cooper's Bone	70.34	105	147	340
Z	1300 Dry Ground Fish 1260 Double Sulphate of Potash and Magnesia 200 Cooper's Bone	47.60	104	146	342
AA	Stable Manure 10–12 cords† On half the plot Swift Sure Superphosphate as a starter, at rate of 500 pounds per acre.	----	125	143	171
BB	6000 Tobacco Stems 2640 Castor Pomace On half the plot, Swift Sure Superphosphate as a starter, at rate of 500 pounds per acre	83.18	253	146	539
CC	3000 Pinney's Formula Fertilizer	----	131	196	305

* Applied as a starter.

† Estimated to contain 111 lbs. nitrogen, 71 lbs. phosphoric acid and 149 lbs. potash.

Rainfall in 1894.

The tobacco was set on May 22d and harvested on Aug. 13th and 14th, and was in the field, therefore, 83 days. The rainfall was as follows :—

May	23	.37 inch.	June 19	.04 inch.	July 16	.16 inch.
"	24	.47 "	" 20	.09 "	" 23	.12 "
"	25	.12 "	July 1	.54 "	" 29	.26 "
"	29	.62 "	" 4	.20 "	Aug. 3	2.45 "
"	31	.24 "	" 7	.10 "	" 9	.08 "
June	3	.57 "	" 14	.73 "		

Total, 7.16 inches.

June was a very dry month. The rainfall from June 3d to to July 1st was only .13 inch, and no rain at all fell from the 3d till the 19th of June.

Yet daily reports from the field marked the conditions "favorable" till June 28th, when the soil was called "too dry." The store of moisture in the soil was by that time so depleted by the hot, dry weather and the demands of the quickly growing crop that frequent showers were needed. The soil is reported "too dry" on the following days :—June 28th to 30th, July 7th, 10th to 13th, 27th to Aug. 2d; fifteen days in all.

Some crops in the same town suffered severely from drought. No marked signs of damage appeared in the experiment field, though the yield would have been larger if there had been more rain. The distribution of the rainfall is of great importance, as well as the total amount. Thus if the heavy rain of August 3d had fallen in two portions during June, it would have materially improved the crop.

The Percentage Amount of Water in the Soil.

Daily determinations of moisture in the soil, taken to the depth of 8 inches, were made on five different plots of the field, as follows :—

Plot 1 had lain unfertilized and untilled for ten years. In 1894 it was plowed and kept free from vegetation and the soil surface was occasionally stirred by raking.

Plot 2 differed from plot 1 only in having an application of linseed meal and cotton hull ashes at the rate of 1500 pounds per acre of each.

Plot 3 in like manner received dry ground fish and double sulphate of potash at the rate of 1500 pounds of each per acre.

Plots F and Y were planted with tobacco, the former dressed with 1760 lbs. to the acre of Linseed Meal, 660 of Cotton Hull Ashes and 260 lbs. of Cooper's Bone. Plot Y was dressed with

1500 lbs. Cotton Seed Meal, 5620 lbs. unleached wood ashes and 160 lbs. Cooper's bone per acre. The samples of soil on the two plots Y and F were always drawn in the row, never between the rows. For comparison are also given determinations of moisture daily made in samples of soil from the tobacco field of Mr. Addison Lamphear, of Poquonock. These samples Mr. Lamphear had the kindness to draw and mail to the Station through the season gratuitously. This field is some fifty feet lower than the experiment field, lies in a bend of the Farmington river, and is believed to be a river deposit, but its texture is not very different from that of the experiment field and the quality and color of leaf raised on it are not very different.

In the following table are given the average per cents. of water found in the soils for each week, calculated from daily determinations.

Average Moisture Content of Soil by Weeks.

	Plots bare of Vegetation.			Plots planted to Tobacco.		
Plots	1	2	3	F	Y*	A. Lamphear's.
June 10 to June 16	7.7	7.9	7.9	12.1	7.7	--
" 17 " 23	7.4	7.4	7.6	11.1	7.2	8.1
" 24 " 30	6.9	7.3	7.3	10.3	6.1	7.5
July 1 to July 7	7.3	8.0	7.6	8.9	8.3	7.5
" 8 " 14	7.5	7.7	7.5	8.4	6.2	7.0
" 15 " 21	7.7	8.0	8.1	6.6	6.0	7.5
" 22 " 28	7.7	8.0	7.9	6.6	5.4	6.5
" 29 to Aug. 4	7.5	7.7	7.9	7.5	4.3	7.3
Aug. 5 " 11	8.0	8.3	7.9	9.2	7.5	7.4
Average	7.52	7.81	7.74			

Examination of the first three columns shows that neither fertilizer had any pronounced effect in controlling the amount of water contained in the soil.

The average per cents. of moisture in the soil (to the depth named) for the growing season on plots 1, 2 and 3 were 7.5, 7.8 and 7.7 respectively.

It also appears that for some reason the soil of plot F contained considerably more moisture than either of the other plots all through the season.

Comparison of the per cent. of water in the soil of plots F and Y with the per cent. of water in the soil of the three unplanted plots shows the exhaustion of the soil water by the growing crop.

Thus until July 7, the per cents. of water in the soils of plots I and Y are not very unlike, but from there on, plot Y on which the crop was growing, held much less water than plot 1, which was bare of vegetation.

On June 19th samples of soil were carefully drawn from each plot in the field, to ascertain whether there was any striking difference in the water content of the several plots, and if so whether this could be connected with the fertilizers applied.

The diagram on the next page presents the results:—

The lowest water-content in any plot planted to tobacco was 6.5 per cent., the highest, 12.4.

The dampest soils were those of U, F, Q and T. The dryest soils were those of B, CC and X.

There is no apparent connection between the amount of moisture and the nature of the fertilizer.

There are two places in the field which are damper than the rest, one covering plots J, T, V, U, Q and F, the other covering E, A, M, N, K, H.

The first named spot was sometimes marked by a damper look of the soil after the ground was rowed out and before the crop had fairly started; the latter was never noticeable.

These spots cannot be accounted for by the "lay of the land" simply. There is no apparent reason for the difference in moisture.

Whether this difference is sufficient to affect in any way the quality of the tobacco grown on the several plots is a question which requires further study.

Temperature of Air and Soil.

Daily observations of temperature were made, as already described by Mr. Adelbert DuBon.

In a following table are given the average weekly maxima, minima and ranges of temperature.

Accidents to the minimum radiation thermometer make Mr. DuBon's record deficient.

Similar observations were made by Mr. Addison Lamphear on his own tobacco field, above described from June 17 to Aug. 18, and these are included in the table, being distinguished from those of Mr. DuBon by full-face type.

It appears that the maximum and minimum air temperatures in Mr. Lamphear's field were somewhat higher than on the experiment field. There is a very striking difference in the soil temper-

The Experiment Tobacco Field, Poquonock, Conn., Showing per cent. of moisture in the several plots on June 19, 1894.

H 9.8	D 8.2	C 7.7	DD —	CC 6.6	C 7.3	P 8.3	S 8.9	J 9.3	BB 8.9	Z 8.2	F 11.8	Q 10.9	U 12.4	T 10.5	V 9.0	W 7.4	AA 9.1	Y 7.7	B 6.5	X 6.9	C 7.2	B 7.3	A 7.6
K 10.1	L 8.8	O 8.7	R 8.6	I 8.6																			
N 9.3	M 9.2																						
A 9.3	E 9.6																						

ature of the two fields. The maximum soil temperatures are much lower, and the minimum soil temperatures are much higher on Mr. Lamphear's field than on the other. It follows that his soil had a much more equable temperature than the other, it transmitted heat much more slowly. To what this is due has not been determined. It seems quite possible, however, that such differences might have a very decided effect on the growth and quality of the crop.

AIR AND SOIL TEMPERATURE AT THE EXPERIMENT TOBACCO FIELD.
WEEKLY AVERAGES.

	Radiation Thermometer.			Soil Temperature.		
	Max.	Min.	Range.	Max.	Min.	Range.
June 3– 9	79.5	58.7	20.8	70.3	63.6	6.7
10–16	94.8	----	----	81.5	71.2	10.3
17–23	98.0	----	----	84.9	76.8	8.1
	98.7	**60.6**	**38.1**	**82.3**	**77.5**	**4.8**
24–30	90.7	----	----	83.9	72.3	11.6
	92.5	**63.2**	**29.3**	**77.2**	**75.2**	**2.0**
July 1– 7	92.5	58.2	34.3	89.9	68.4	21.5
	95.7	**58.4**	**37.3**	**83.3**	**75.3**	**8.0**
8–14	90.3	53.3	37.0	85.9	64.1	21.8
	95.8	**50.4**	**45.4**	**77.2**	**73.5**	**3.7**
15–21	97.0	54.4	32.6	92.1	68.8	23.3
	101.8	**59.8**	**42.0**	**83.7**	**74.9**	**8.8**
22–28	94.2	51.5	42.7	87.6	65.6	22.0
	96.0	**59.2**	**36.8**	**79.2**	**72.4**	**6.8**
29–Aug. 4	94.8	54.1	40.7	89.8	72.4	17.4
	96.4	**61.1**	**35.3**	**80.3**	**75.1**	**5.2**
Aug. 5–11	91.3	----	----	86.3	66.5	19.8
	93.4	**51.4**	**42.0**	**75.2**	**70.5**	**4.7**
12–18	86.6	----	----	83.0	62.7	20 3

The highest temperature recorded in the experiment field by the radiation thermometer was 111° Fahr., the lowest 39½°.

The highest record of the soil thermometer was 97.9, the lowest 53.1° F.

HARVESTING, CURING, STRIPPING AND SORTING.

On August 13th and 14th the crop was harvested. The method of harvest, stringing and hanging has already been described in the Report for 1893, p. 138.

The weather was favorable for curing and on Oct. 24th the crop was taken down from the poles, stripped and bundled, the crop of each plot by itself. The crops were sorted by Mr. DuBon from Nov. 17th to 22d.

As the crops were sorted, samples were carefully drawn from each lot of long and short wrappers as described in the Report for 1893, p. 138.

These samples were for laboratory examinations and for fermentation.

The following table gives the results of the sorting. The weights are in pounds. For those unfamiliar with the details of sorting leaf-tobacco, it may be said that the "seconds" are the lower leaves on the stalk, smaller than those of either of the other grades, over-ripe and unfit for wrappers. The "long wrappers" and "short wrappers" are the most valuable part of the crop, the latter being smaller and lighter, and often cutting to greater advantage than "long wrappers." The "top leaves" are often as large as the long wrappers, but heavier, darker in color and unripe.

WEIGHT OF POLE-CURED LEAVES FROM $\frac{1}{20}$ ACRE.
CROP OF 1894.

Plot.	Long Wrappers.	Short Wrappers.	Top Leaves.	Seconds.	Net Weight of Sorted Tobacco.
A	37	11½	12	21½	82
B	34½	10¼	10⅜	18	73½
C	44	13	10½	12½	80
D	52½	14	12	14	92½
E	35½	12	14½	22	84
F	41	13	12	16	82
G	43	14	11½	16	84½
H	52½	14	12	15	93½
I	46	12½	16	18	92½
J	49	13	14	18	94
K	46½	11¼	14⅜	17⅜	90¼
L	38	13½	12	17	80½
M	34	10½	16½	23	84
N	36	11	15½	22½	85
O	39	12	13½	11	75½
P	33	11	10	16½	70½
Q	46	9½	15½	21½	92½
R	36½	11½	16½	14½	79
S	45½	12½	15	15½	88½
T	37	8	23½	23½	92
U	55½	9	14	20¼	105⅜
V	43½	11¼	12⅜	15⅜	83¼
W	49½	13½	13½	10½	78
X	34	12	12	17	75
Y	42	10	10½	14	76½
Z	33½	12½	12½	14⅜	73¼
AA	19	9	12¼	23½	63½
BB	30	9	18	19⅜	76⅜
CC	31	11½	16	12½	71

PER CENT. OF THE FOUR DIFFERENT GRADES.

POLE-CURED CROP OF 1894.

Plot.	Long Wrappers.	Short Wrappers.	Total per cent. of Wrappers.	Tops.	Seconds.
A	45.1	14.0	59.1	14.7	26.2
B	46.9	13.9	60.8	14.6	24,6
C	55.0	16.2	71.2	13.1	15.7
D	56.7	15.2	71.9	12.9	15.2
E	42.3	14.3	56.6	17.3	26.1
F	50.0	15.8	65.8	14.6	19.6
G	50.9	16.5	67.4	13.6	19.0
H	56.1	14.9	71.0	12.8	16.2
I	49.7	13.5	63.2	17.3	19.5
J	52.1	13.9	66.0	14.9	19.1
K	51.5	12.5	64.0	16.3	19.7
L	47.2	16.7	63.9	14.9	21.2
M	40.4	12.5	52.9	19.6	27.5
N	42.3	12.9	55.2	18.2	26.6
O	51.7	15.9	67.6	17.9	14.5
P	46.8	15.6	62.4	14.1	23.5
Q	49.7	10.3	60.0	16.7	23.3
R	46.2	14.6	60.8	20.9	18.3
S	51.4	14.1	65.5	17.0	17.5
T	40.2	8.8	49.0	25.5	25.5
U	52.5	8.5	61.0	19.9	19.1
V	52.2	13.5	65.7	15.3	19.0
W	51.9	17.3	69.2	17.3	13.5
X	45.3	16.0	61.3	16.0	22.7
Y	54.8	13.0	67.8	13.7	18.5
Z	45.7	17.1	62.8	17.1	20.1
AA	29.9	14.1	44.0	19.3	36.7
BB	39.1	11.7	50.8	23.5	25.7
CC	43.7	16.2	59.9	22.5	17.6

COMPARATIVE FIRE-HOLDING CAPACITY.

POLE-CURED CROP OF 1894.

The method of determining the fire-holding capacity is described in the Station Report for 1892, page 17.

The lot which held fire for the shortest time is marked 100. The others are marked higher and according to their relative fire-holding capacity. Thus of the long wrappers, lot Q is marked 100 as it had a lower fire-holding capacity than any other. Lot A has about 2$\frac{1}{5}$ (218) times the fire-holding capacity of lot Q.

	Long Wrappers.	Short Wrappers.	Calculated from the Average of both.
A	218	247	218
B	207	223	201
C	224	245	220
D	201	258	217
E	223	146	167
F	134	166	142
G	204	181	177
H	245	226	218
I	130	265	192
J	283	267	255
K	215	100	139
L	132	133	123
M	154	158	146
N	196	183	175
O	241	214	210
P	314	236	251
Q	100	113	100
R	166	227	187
S	128	182	148
T	133	138	126
U	121	178	142
V	146	164	145
W	217	141	162
X	126	126	117
Y	235	349	279
Z	150	252	193
AA	151	156	143
BB	169	214	180
CC	186	202	181

NUMBER OF POLE-CURED LEAVES TO THE POUND.

CROP OF 1894.

	Long Wrappers.	Short Wrappers.
A	67	92
B	74	93
C	65	87
D	55	86
E	67	94
F	66	91
G	60	80
H	65	83
I	68	88
J	69	88
K	63	94
L	62	81
M	72	87
N	67	97
O	70	94
P	69	94
Q	67	90
R	53	103
S	65	91
T	60	87
U	59	81
V	62	84
W	73	93
X	64	89
Y	59	90
Z	67	88
AA	66	77
BB	59	81
CC	56	81

Discussion of the Results.

The following paragraphs notice the principal features in the results of this year's experiments. The present plan is not to attempt any general conclusions till five successive crops have been raised, cured and fermented.

Net Weight of the Sorted Crops, 1894.

In 1892 there was harvested from 23 plots of $\frac{1}{20}$ acre each, 2122 pounds of sorted tobacco, or at the rate of 1845 pounds per acre.

In 1893 there was harvested from 28 plots 2183 pounds, or at the rate of 1559 pounds per acre.

In 1894 there was harvested from 28 plots, 2399$\frac{1}{4}$ pounds of sorted tobacco, or at the rate of 1713 pounds per acre.

The crop of 1892 contained 66.7 per cent. of wrappers. The crop of 1893 contained 48.5 per cent. of wrappers, and the crop of 1894, 62.1 per cent. of wrappers.

The maximum yield in 1894 was on plot U, at the rate of 2115 lbs. of sorted tobacco per acre, of which 1290 pounds were wrappers. The maximum yield of wrappers was on plots D and H, (1860 pounds sorted tobacco, 1330 pounds wrappers.) Plots H, D, I and Q, all yielded from 1870 to 1850 pounds of sorted tobacco, with 1330, 1330, 1170 and 1110 pounds of wrappers respectively.

The smallest crops were on plots P, CC, Z and B and were respectively, 1410, 1420, 1465 and 1470 pounds of sorted tobacco. The weights of wrappers were respectively 880, 841, 920, 895 pounds.

Cotton Seed Meal and Castor Pomace. (Plots A, C, D, compared with E, G, H.)

The yield of sorted tobacco from the cotton seed meal plots averaged 1696 pounds per acre. The yield from the plots which received castor pomace in quantity equivalent to the cotton seed meal averaged 1746 pounds. The yield of wrappers grown on cotton seed meal averaged 1146 pounds, grown on castor pomace the average was 1140 pounds. The yield of the cotton seed plots and castor pomace plots are therefore practically identical.

Increasing the quantity of cotton seed meal in the fertilizer from 1360 to 2260 pounds per acre did not increase the yield, but a further increase of 500 pounds per acre made an increase of

250 pounds per acre in the sorted tobacco. The quantity of wrappers increased regularly with the increase in the quantity of cotton seed meal or castor pomace applied. These facts are shown in the following table, expressed in pounds per acre.

Cotton Seed Meal in fertilizers.	Sorted Tobacco.	Wrappers.	Castor Pomace in fertilizers.	Sorted Tobacco.	Wrappers.
1360	1640	970	1900	1680	950
2260	1600	1140	3160	1690	1140
2720	1850	1330	3780	1870	1330

Nitrate of Soda with Castor Pomace. Where for an application of 210 pounds of nitrogen, as on plot H, was substituted half that quantity of nitrogen in pomace and the other half in nitrate of soda, plots I and J, the yield was practically the same in all cases, the extreme difference of sorted tobacco being only 30 pounds per acre.

The yield of wrappers however was greatest where castor pomace alone was used, plot H, 1330 pounds, and least where half the nitrate was applied at planting and half later in the season, plot I, 1170 pounds.

Potash Salts. Of the various potash salts, the double sulphate of potash and magnesia, K, yielded the largest crop (1805 pounds) and the largest quantity of wrappers (1155 pounds). This was also true of the crops of 1892 and 1893.

When lime was used with the double sulphate L, both the total yield and the yield of wrappers was considerably smaller.

Plots L, Y, and O, to which double sulphate of potash and magnesia with lime, wood ashes, and carbonate of potash were respectively applied, yielded about 1030 pounds of wrappers each. Next rank A, cotton hull ashes, 970 pounds, N, high grade sulphate of potash with lime, 940 pounds, and M, high grade sulphate of potash and P, carbonate of potash and magnesia, which yielded each 880 pounds of wrappers.

Linseed Meal. Plot B, which received linseed meal in place of cotton seed meal, yielded 180 pounds less of crop and 75 pounds less of wrappers than A which was dressed with cotton seed meal.

But plot F which received the same quantity of linseed meal as B but less than half the quantity of cotton hull ashes yielded the same quantity of tobacco as A and 110 pounds more of wrappers.

Fish. Plot Z received its nitrogen in form of fish and is comparable with plot K on which an equivalent amount of cotton seed meal was used.

Plot Z produced 340 pounds less of tobacco than K and 235 pounds less of wrappers.

Stems and Stable Manure. Plot AA which was dressed with stable manure and BB which was dressed with tobacco stems and castor pomace produced less tobacco than most of the other plots and the least wrappers of any plots.

INDEX.

	Page.
Abies balsamia	140
Acts Concerning Commercial Fertilizers	3
Albumin from Barley	167, 168, 169, 170
" from Rye	148
Alderman, G. B. Special Potato Fertilizer	58
Amelanchier Canadensis	114
Ammonia. Explanations concerning	13
" " " Meaning of "Unit of"	68
" Sulphate of	19
Announcement	v
Anthomyia ceparum	139
Aphis mali	140
Aquilegia Canadensis	145, 146
Armour Packing Co. Fine Ground Beef Bone	6, 29
" " Fruit, Vegetable and Tobacco Special	6, 46, 47
Ashes, Cotton Hull	59
" Lime Kiln	64
" Unleached Wood	64
Babcock Method of Determining Fat	209
" System of Payment, Comparison with Space System	233, 244
Babcock Test. Acid Measure	211
" Apparatus for Filling Test Bottles with hot water	225
" As Basis for Payment in Cream-Gathering Creameries	214
" Book-keeping of	231
" Centrifugal Machine for	212
" Directions for making Test	213
" Method of making the Test	226
" Method of reading Per cent. of Fat by	214
" Oil of Vitriol for	213, 225
" Pipettes for Cream	223
" Pipettes for Milk	211
" Test Bottles for Cream	223
" Test Bottles for Milk	211
" Records of Creameries using	231
Baker, H. J. & Bro. A. A. Ammoniated Superphosphate	6, 38, 39
" Castor Pomace	6, 23
" Corn Manure	6
" Harvest Home Phosphate	6, 42, 43
" Onion Manure	6, 46, 47
" Potato Manure	6, 46, 47
" Pure Ground Raw Bone	6, 29, 30
" Tobacco Manure	6, 48, 49

Page.

Barley Albumin 167, 168, 169, 170
" Edestin 171, 172, 190
" Globulin 171, 172
" Proteids of 165
" " Soluble in Water, Saline Solutions and Alcohol 189
" " " Dilute Alcohol 173–189
" " " Sodium Chloride Solution 170–173
" " " Water 167–170
Bichromate Potash. A Preservative for Milk and Cream 222
Blight, Early, of Potatoes, Notes on 127
Blood. Relative Availability of Nitrogen of Dried 94–100
Board of Control, Report of xiii
Bone and Potash 33
Bone Manures 28
Bone, Valuation of, How Calculated 16
Bordeaux Mixture. Effect on Lichens 136
" for Early Blight of Potatoes, Value of 130
" for Flea Beetle 131
Bottles for Composite Samples 219
" Collecting Cream 218
Bowker Fertilizer Co. Bowker's Farm and Garden Phosphate or Ammoniated Bone Fertilizer 6, 40, 41
" Bowker's Hill and Drill Phosphate 6, 40, 41
" " Potato Manure 6, 52, 53
" " Sure Crop Bone Phosphate 6, 42, 43
" " Tobacco Grower 6, 52, 53
" Stockbridge Special Grain Manure 6
" " Grass Top Dressing and Forage Crop Manure 6, 48, 49
" " Potato and Vegetable Manure 6, 50, 51
" " Tobacco Manure, ... 6, 46, 47
Bradley Fertilizer Co. Bradley's B. D. Sea Fowl Guano 6, 44
" " Circle Brand Ground Bone and Potash 6, 33, 34, 35
" " Complete Manure for Corn and Grain 6, 46, 47
" " Complete Manure for Potatoes and Vegetables 6, 48, 49
" " Complete Manure for Top-Dressing Grass and Grain 6, 52, 53
" " Farmer's New Method Fertilizer 6, 40, 41
" " Fish and Potash, Anchor Brand 6, 44
" " Fish and Potash, Triangle A Brand 6, 42, 43
" " High Grade Tobacco Manure 6, 50, 51
" " Original Coe's Superphosphate 6, 44
" " Potato Manure 6, 52, 53
" " Pure Fine Ground Bone 6, 29
" " Superphosphate 6, 40, 41
Buckingham, C. A No. 1 Fertilizer 6, 33, 34
Bulletins, Notice as to iv

Page.

Burn of Tobacco 266
Burning Quality of Tobacco Crop of 1893 266
Butter, Examinations of 208
Butter-Fat, Definition of 215
Castor Pomace 23
" as a Fertilizer for Tobacco 268, 282
" Availability of Nitrogen of 94–100
Centrifugal Machines for Babcock Test 212, 224
"Chemical Compound Fertilizers" for Tobacco and for Corn 55
Chicopee Guano Co. Chicopee Farmer's Reliable 6, 42, 43
" " Potato Manure 6, 50, 51
Cladosporium carpophilum 138
Clark's Cove Fertilizer Co. Bay State Fertilizer 7, 42, 43
" " G. G. 7, 42, 43
" Great Planet "A" 7, 44
" King Philip Guano 7
" Potato and Tobacco Fertilizer 7, 52, 59
Cleveland Linseed Oil Co. Connecticut Wrapper Fertilizer, Pinney Formula 7, 58
Coe Co., The E. Frank. Alkaline Bone 7, 40, 41
" Fish and Potash 7, 40, 41
" Gold Brand Excelsior 7, 44
" Ground Bone and Potash 7, 34
" High Grade Ammoniated Superphosphate 7, 40, 41
" " Potato Fertilizer 7, 50, 51, 54
" Special Tobacco Fertilizer, N. E. Brand 7, 58
Composite Samples of Cream 222
" Preservative for 222
Composite Samples of Milk, Preserving 211
Conotrachelus nenuphar 14
Cooper's Glue Factory. Bone Dust 7
Corn Crop on Same Land continuously. *See Maize.*
Corn-Leaf Miner 143
Corrections ii
Corrosive Sublimate Solution for Potato Scab, Preparation of 119
Cotton Hull Ashes 59
Cotton Seed Meal 20
" Analyses of 22
" as a Fertilizer for Tobacco 268, 282
" Availability of Nitrogen of 94–100
Cratægus Oxyacantha 114
" *Pyracantha* 114
Cream. Acid Measure for Use with Babcock Test of 223
" Apparatus for Sampling and Weighing 217
" Apparatus for Testing by Babcock Method 223
" Babcock Test as Basis of Paying for 214
" Balance for Weighing 217
" Composite Sample Bottles 219
" Directions for Mixing 219

		Page.
Cream.	Directions for Sampling and Weighing	220
"	Directions for Skimming	219
"	Method of Measuring Fat by Babcock Test	228
"	Method of Testing by Babcock Test	226
"	Pail for Sampling and Weighing	218
"	Pipettes for	223
"	Sample Bottles for	218
"	Sampling Tube for	218
"	Test Bottles for	223
"	The Composite Sample of	222
Creameries Using Babcock Test, Records of		231
Crocker Fertilizer & Chemical Co.	Crocker's Ammoniated Bone Superphosphate	7, 44
"	Crocker's Ammoniated Practical Superphosphate	7, 44
"	" " Wheat and Corn Phosphate	7, 50, 51, 57, 58
"	" Ground Bone Meal	7, 29
"	" New Rival Ammoniated Bone Superphosphate	7, 42, 43
"	" Potato, Hop and Tobacco Phosphate	7, 50, 51
"	" Pure Ground Bone	7, 29
"	" Special Conn. Tobacco Manure	7, 58
"	" Special Potato Manure	7, 50, 51
"	" Vegetable Bone Superphosphate	7, 38, 39
Cumberland Bone Phosphate Co.	Cumberland Potato Fertilizer	7, 58
"	" Superphosphate	7, 44
Curculio of Peach		141
Dairy Commissioner, Work for		208
Danbury Fertilizer Co.	Bone Meal	7, 29
"	Nameless Fertilizer	7, 38, 39
"	Potato Manure	7, 46, 47
Darling Fertilizer Co.	Darling's Animal Fertilizer	7, 50, 51
"	" Extra Bone Phosphate	7, 44
"	" Fine Ground Bone	7, 29
"	" Potato and Root Crop Manure	7, 50, 51
"	" Tobacco Grower	7, 46, 47
"	" Wheat and Corn Fertilizer	7, 50, 51
Diastase, The Chemical Nature of		192
Dissolved Bone Black		25
" Phosphate		25
Downes & Griffin.	Ground Bone	7, 29
Dried Blood		20
Early Blight of Potatoes		127
Early Blight of Potatoes, Additional Note on		133
Edestin		155
" from Barley		170, 171, 172, 190
Ellsworth, F.	Collier Castor Pomace	7, 23
"	Shoemaker's Swift Sure Bone Meal	7, 29

		Page.
Ellsworth, F.	Shoemaker's Swift Sure Superphosphate	7, 38, 39, 45
Entomosporium maculatum		137
Enzymes, Nature of		192
Evergreen Thorn, affected by Fire Blight		114
Explanations concerning Analysis and Valuation		12
Fertilizer Law of Connecticut		1
"	Observance of	6
Fertilizer Market, Review of		66
Fertilizers, Acts Concerning Commercial		3
"	Agricultural Value of	17
"	Availability of Nitrogen in Mixed	102–104
"	Average Wholesale Prices of	71
"	Classification of	18
"	Collection and Sampling	11
"	Description and Analyses of	19
"	Explanations concerning Analysis of	12
"	Methods to Determine availability of Nitrogen in	73
"	Mixed, Availability of Organic Nitrogen of	102–104
"	Quantity annually sold in Connecticut	72
"	Trade Values of Fertilizing Elements in	15
Fir Mite		140
Fire-Blight		113
"	Appearance of	114
"	Means of Prevention	116
"	Mode of Infection	114
"	of Plum-Tree	117
"	Prevalence of in Connecticut	117
"	Trees liable to	114
Fire-holding Capacity of Tobacco Crop of 1893		266
"	of Tobacco Crop of 1894	280
Fish as a Fertilizer for Tobacco		269, 283
"	Availability of Nitrogen of	94–100
"	Dry Ground	33
Fish Guano, Law concerning Treatment of		4
Frisbie Co., L. F.	Bone Meal	8, 30
Fungi.	Miscellaneous Notes on	137
Fusicladium pirinum		135
Gliadin from Rye		157–162
Globulin from Barley		171, 172
Gluten Feed		23
Gluten from Rye		148
Gluten-Casein from Barley		166
"	from Rye	148, 149
Gluten-fibrin from Barley		166
Great Eastern Fertilizer Co.	Great Eastern General Fertilizer for Grass and Grain	8, 50, 51
"	Great Eastern General for Oats, Buckwheat and Seeding down	8, 52, 53

Page.

Great Eastern Fertilizer Co. Great Eastern General Soluble Bone and Potash Fertilizer ---- 8, 34
" " Great Eastern Vegetable, Vine and Tobacco 8, 50, 51
Ground Bone, Valuation of ---- 16
Guarantees of Nitrogenous Superphosphates ---- 35
" Special Manures ---- 54
Hawthorn, Affected by Fire-Blight ---- 114
Home Mixtures ---- 59
Hordein ---- 173, 186, 187, 188, 190
Horn and Hoof ---- 20
" Availability of Nitrogen in ---- 94–96
Insects, Injurious ---- 139
Kainit, Market Review of ---- 68
Kelsey, E. R. Bone, Fish and Potash ---- 8, 38, 39
Leaf Miners, Notes on some ---- 143
Leaf Miner of Columbine ---- 145
Leather, Availability of Nitrogen in various preparations of ---- 100
" in Mixed Fertilizers, Law concerning ---- 4
Leucosin from Barley ---- 167, 168, 169, 170, 189
" from Rye ---- 149–154
Lice of Apple and Cherry Trees ---- 140
Lichens, Effects of Bordeaux Mixture on ---- 136
Lime Kiln Ashes ---- 64
Linseed Meal as a Fertilizer for Tobacco ---- 269, 283
" Availability of Nitrogen of ---- 94–100
Lister's Agricultural Chemical Works. Ammoniated Dissolved Bone ---- 8, 38, 39
" " " Celebrated Ground Bone ---- 8, 29
" " " Potato Fertilizer ---- 8, 48, 49
" " " Standard Superphosphate ---- 8, 38, 39
" " " Success Fertilizer ---- 8, 38, 39
Macrosporium Solani ---- 120, 127, 131
Maize Crop. Analyses of Field-cured Kernels and Stover, Crop of 1894 ---- 250
" Average Composition of Dry Matter of Kernels and Stover for five years ---- 251
" Enrichment or Impoverishment of Land in seven years by growing ---- 252
" Gross Yield per acre in 1894 ---- 246
" Observations on Growth of, Continuously on same Land ---- 245
" Yield of Dry Matter and Shelled Corn per acre for seven years ---- 253
" Yield of Dry Matter per acre in 1894 ---- 248, 249
" Yield of Food Ingredients per acre in 1894 ---- 248, 249
Manure, Sheep ---- 65
Mapes' Formula & Peruvian Guano Co. Complete Manure "A" Brand ---- 8, 38, 39
" " " for general use ---- 8, 38, 39
" " " light soils 8, 46, 47
" " Corn Manure ---- 8, 48, 49

Page

Mapes' Formula & Peruvian Guano Co. Fine Dissolved Bone ---- 8, 38, 39
" " Fruit and Vine Manure ---- 8, 58
" " Grass and Grain Spring Top-Dressing ---- 8, 48, 49
" " Potato Manure ---- 8, 48, 49
" " Seeding Down Manure ---- 46, 47
" " Tobacco Manure, Wrapper Brand ---- 8, 46, 47
" " Tobacco Starter ---- 8, 46, 47
Micrococcus amylovorus ---- 113
Milk, Directions for Testing by Babcock Method, Weighing ---- 209
" of Single Cows or Herds. Directions for Sampling ---- 210
Miller, Geo. W. Flour of Bone Phosphate ---- 8, 38, 39
Ground Bone ---- 8
Molasses, Examination of ---- 208
Mould of Peaches ---- 138
Mucedin from Barley ---- 166
" from Rye ---- 148
Muriate of Potash ---- 27
Myzus cerasi ---- 140
National Fertilizer Co. Chittenden's Ammoniated Bone Phosphate ---- 8, 38, 39
" " Complete Fertilizer ---- 8, 58
" " Fish and Potash ---- 8, 38, 39
" " Ground Bone ---- 8, 30
Nitrate of Soda, Analyses of ---- 19
" as a Fertilizer for Tobacco ---- 269, 283
" Availability of Nitrogen of ---- 94, 100
Nitric Acid. Explanations concerning ---- 13
Nitrogen, Ammonic, Market Review of ---- 66
" free. Explanations concerning ---- 12
" Availability of in certain Raw Materials ---- 94–100
" in Various Proportions of Leather, Availability of ---- 100
" Market Review of Nitric ---- 66
" of Raw Materials Used as Fertilizers, Solubility by Putrefaction 109–112
" of Raw Materials Used as Fertilizers, Solubility of in Pepsin Solution ---- 105–108
" of Mixed Fertilizers, Solubility of in Pepsin Solution ---- 108
" organic. Explanations concerning ---- 12
" of Mixed Fertilizers, Availability of ---- 102–104
" Methods to Determine Availability of ---- 73
" Market Review of ---- 66
" Solubility of in Pepsin Solution ---- 105–109
Phosphoric Acid, Available. Explanations concerning ---- 13
" Citrate-soluble. Explanations concerning ---- 13
" Insoluble. Explanations concerning ---- 13
" Water-soluble. Explanations concerning ---- 13
Phosphorus. Explanations concerning ---- 13
Phytomyza ancholiae ---- 146

	Page.
Phytomyza aquilegiae	145, 146
Phytophthora infestans	129
Pipettes for Measuring Cream	223
" for Measuring Milk	211
Plumb & Winton. Ground Bone	8, 31, 32
Nuhn, Frederick. Self-Recommending Fertilizer	8, 33, 34
Odontocera dorsalis	143, 144, 145
Odorless Phosphate	24
Officers and Staff of Station	iii
Oidium fructigenum	138
Oil of Vitriol for Babcock Test	213, 225
Olds & Whipple. O. & W. Special Phosphate	8, 38, 39
" Red Seal Castor Pomace	8, 23
Onion Maggot	139
Peach Bark Beetle	142
" curculio	141
Peaches, Scab and Mould of	138
Pear Scab. Experiments on Treatment of	135
Peck Bros. Pure Ground Bone.	8, 29
Phosphates, Market Review of	67
Potash and Magnesia, Double Sulphate of	26
as a Fertilizer for Tobacco. Effects of Different Forms of	269, 283
Double Sulphate of, Market Review of	68
Explanations concerning	14
High Grade Sulphate of	26
High Grade Sulphate, Market Review of	68
Muriate of	27
Muriate, Market Review of	67
Potassium. Explanations concerning	14
Potatoes, Notes on Early Blight of	127
Potato Scab, Experiments on Prevention of	118
Pots for Vegetation Experiments	76
Preston Fertilizer Co. Ammoniated Bone Superphosphate	8, 38, 39
" Onion Fertilizer	8
" Potato Fertilizer	8, 52, 53
Proteids of Barley	165
Proteids of Rye Kernel	147
Proteose from Rye	149
Quince Rust	137
Quinnipiac Co. Dissolved Bone Black	9, 25, 26
" Muriate of Potash	9, 27
" Sulphate of Potash	9, 26, 27
" Tankage	9, 32
" Quinnipiac Ammoniated Dissolved Bone	9, 40, 41
" " Bone Meal	9, 29
" " Corn Manure	9, 58
" " Dry Ground Fish	9, 33
" " Fish and Potash, Crossed Fishes Brand	9, 40, 41

	Page.
Quinnipiac Co. Quinnipiac Fish and Potash, Plain Brand	9, 40, 41
" " Grass Fertilizer	9, 58
" " Havana Tobacco Fertilizer	9, 46, 47
" " Phosphate	9, 42, 43
" " Pine Island Phosphate	9, 44
" " Potato Manure	9, 52, 53
" " Market Garden Phosphate	9, 44
Quinnipiac Rendering Co. Pure Ground Bone	8, 29
Rainfall. Observations on, at Windsor	271, 274
Read Fertilizer Co. Fish and Potash	9, 40, 41
" High Grade Farmer's Friend	9
" Read's Standard	9, 42, 43
" Vegetable and Vine	9, 42, 43
Reese, J. S. & Co. Reese's New England Favorite,	9, 42, 43
" " Potato Special	9, 50, 51
Report of Board of Control	xiii
Report of Station Work	1
Report of Treasurer	xi
Reports, Notice as to	iv
Roestelia aurantica	137
Rogers & Hubbard Co. Fairchild's Formula for Corn and General Crops	9, 46, 47
" Fertilizer for Oats and Top-Dressing	9, 46, 47
" Grass and Grain Fertilizer	9, 46, 47
" Pure Ground Raw Knuckle Bone Flour	9, 29
" " " " Meal	9, 29
" Soluble Potato Manure	9, 46, 47
" Soluble Tobacco Manure	9, 46, 47
" Strictly Pure Fine Bone	9, 29, 31
Rogers Mfg. Co. Complete Fertilizer	9, 38, 39
" Grass and Grain Fertilizer	9
" High Grade Corn Fertilizer	9, 46, 47
" High Grade Fertilizer for Oats and Top Dressing	9, 58
" Pure Ground Bone	9, 31
" Soluble Potato and General Crops	9, 46, 47
Rust of Quince	137
Rye Albumin	150–154
Rye Gliadin	157-162
Rye Globulin	155
Rye Kernel, Alcohol-soluble Proteids	156, 163
" Proteids of	147
" Proteids of, Soluble in Saline Solutions	155
" Proteids of, Soluble only in alkalies	163
" Quantities of the different Proteids in	164
" Water-Soluble Proteids of	149, 154
Saltpeter Waste	64
Sample Bottles for Cream	218
Sampling and Collection of fertilizers	11
Sampling Tube for Cream	218

		Page.
Sanderson, L.	Blood, Bone and Meat	9, 31, 32
"	Dissolved Bone Black	9, 25, 26
"	Fine Ground Bone	9, 29
"	Formula A. (Complete)	9, 38, 39
"	High Grade Sulphate of Potash	9, 26, 27
"	Muriate of Potash	9, 27
"	Nitrate of Soda	9, 19
"	Old Reliable Superphosphate	9, 40, 41
"	Pulverized Bone and Meat	9, 31, 32
"	Regular Sulphate of Potash	9, 27
"	Sulphate of Ammonia	9, 20
Scab of Peaches		138
" upon Turnips		126
Scolytus Piri		113
" *rugulosus*		142
Service Berry, affected by Fire-Blight		114
Sheep Manure		65
Shoemaker L. & Co.	Swift sure Superphosphate	7, 38, 39, 45
" "	Swift-Sure Bone Meal	7, 29
Soil Artificial for Vegetation Experiments		77
Soil Moisture, Observations on, at Windsor		271, 274
Soluble Pacific Guano Co.	High Grade General Fertilizer	10, 38, 39
"	Pacific Guano	10, 42, 43
"	Potato Manure	10, 52, 53
Space of Cream, Definition of		215
Spaces of Cream Required for a pound of butter		235
Space System, Comparison with Babcock System at six Creameries		233, 244
Space System of Payment for Cream, Defects of		215
Special Manures, Analyses of		45
" Guarantees of		54
" Valuation of		16, 54
Sphegigaster Sp.		145
Stable Manure as a Fertilizer for Tobacco		284
Standard Fertilizer Co.	Standard Complete Manure	10, 44
" "	Standard Potato & Tobacco Fertilizer	10, 52, 53
" "	Standard Superphosphate	10, 42, 43
Sulphate of Ammonia		19
Sulphate of Potash and Magnesia		26
Sulphate of Potash, High Grade		26
Superphosphates, Analyses of Nitrogenous		35
" Cost and Valuation of		36
" Guarantees of Nitrogenous		35
" Nitrogenous		35
" Valuation of Nitrogenous		16, 36
Tankage		31
Tankage. Availability of Nitrogen of		94, 100
Temperature of Soil and Air. Observations on, at Windsor		271, 276
Test Bottles for Cream		223

	Page.
Test Bottles for Milk	211
Test Bottles, Method of Cleaning	229
Trade Value of Fertilizers for 1894	15
Treasurer, Report of	xi
Tobacco Crop of 1893. Burning quality of	266
" Discussion of Quality of	265
" Effects of Various Fertilizers	269
" Fire-holding Capacity of	266
Tobacco Experiment, Season of 1893	254, 270
Tobacco, Fermented Crop of 1893, Report on	254
Tobacco Crop of 1894. Effect of different Fertilizers	282
" Fire-holding Capacity of	280
" Net Weight of Sorted Crops	282
" Number of Pole-cured Leaves to the Pound	281
" Per cent. of the Different Grades	280
" Weights of Pole-cured Leaves	279
Tobacco Experiment of 1894. Fertilizers Applied to the Several Plots	272
" Harvest, Curing, Stripping, Sorting	278
" Observations on Rainfall, Soil Moisture and Temperature	271
Tobacco Experiment, Season of 1894	270
Tobacco, Shrinkage of, during Fermentation	254
Tobacco Stems as a Fertilizer for Tobacco	284
Turnips. Scab upon	126
"Unit of Ammonia," Meaning of	68
Valuation of Fertilizers, Explanations concerning	12, 14
Valuation of Fertilizers, How obtained	16
Valuation of Bone, How Calculated	15
Valuation of Nitrogenous Superphosphates	36
Valuation of Special Manures	54
Valuation of Superphosphates	16
Valuation, Uses of	17
Vegetation Experiments	74
" Artificial Soil for	77
" Care of, During Growth	79
" Data regarding crops harvested	83, 86
" Influence of Water Supply on Crop Production	87
" Method of Planting	78
Vegetation House	75
"Vitellin"	190
Walker, Stratman & Co. Banner Fertilizer	10, 44
" Four Fold Fertilizer	10, 42, 43
" Potato Special	10, 52, 53
" Tobacco Special	10, 58
Walton & Whann Co. Diamond Soluble Bone and Potash	10, 34
" Peerless Potato Manure	10, 48, 49
Wheeler, M. E. & Co. Corn Fertilizer	10, 50, 51
" Electrical Dissolved Bone	10
" Grass and Oats Fertilizer	10, 52, 53

		Page
Wheeler, M. E. & Co.	Potato Manure	10, 50, 51
Wilcox, Leander.	Ammoniated Bone Phosphate	10, 40, 41
"	Complete Bone Superphosphate	10, 45
"	High Grade Fish and Potash	10, 38, 39
"	Potato, Onion and Tobacco Manure	10, 48, 49
Wilkinson & Co.	Economical Bone Fertilizer	10, 42, 43
Williams & Clark Fertilizer Co.	Americus Ammoniated Bone Superphosphate	10, 42, 43
"	" Corn Phosphate	10, 52, 53
"	" Fine Wrapper Tobacco Grower	10
"	" Fish and Potash	10, 40, 41
"	" Grass Manure	10, 58
"	" High Grade Special	10, 48, 49
"	" Potato and Tobacco Fertilizer	10, 50, 51
"	" Potato Phosphate	10, 52, 53
"	" Pure Bone Meal	10, 29
"	Royal Bone Phosphate	10, 42, 43
Wood Ashes		64