STATE OF CONNECTICUT

TWENTIETH ANNUAL REPORT

OF

The Connecticut Agricultural Experiment Station

For 1896

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.

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1897

CORRECTIONS.

In the Sixteenth Report of this Station, for 1892, p. 155, is given a statement of the quantities of nitrogen and ash ingredients "in one ton of onions." This should read "in one-half ton of onions," or else the figures contained in the statement should be doubled.

In the Nineteenth Report of this Station, for 1895, p. 228, is given an analysis of Atlas Gluten Meal. This article is made by the Atlas Distilling Co., of Peoria, and not by the Chicago Sugar Refinery.

The guaranteed per cent. of available phosphoric acid in Chittenden's Potato Phosphate, No. 6477, is 6.0 per cent.; not 8.0 per cent. as stated on page 145 of the present Report.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF FOR 1896.

STATE BOARD OF CONTROL.

	Term expires,
Ex-officio.	
HIS EXCELLENCY O. VINCENT COFFIN, *President.*	
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.	1898
JAMES H. WEBB, Hamden.	1899
Appointed by Board of Agriculture:	
T. S. GOLD, West Cornwall. (*Executive Committee.*)	1898
Appointed by Governing Board of Sheffield Scientific School:	
W. H. BREWER, New Haven, *Secretary and Treasurer.* (*Executive Committee.*)	1899
Ex-officio.	
S. W. JOHNSON, New Haven, *Director.* (*Executive Committee.*)	

STATION STAFF.

Chemists.

S. W. JOHNSON, *Director.* — T. B. OSBORNE, PH.D.
E. H. JENKINS, PH.D., *Vice-Dir.* — A. W. OGDEN, PH.B.
A. L. WINTON, PH.B. — G. F. CAMPBELL, PH.B.
W. L. MITCHELL, 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 Agent.
C. L. BACKUS, Andover.

*Deceased. Succeeded by S. M. Wells, Wethersfield.

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 Station Staff.

All Bulletins earlier than No. 71 and Nos. 83, 93, 101, 102 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 and 1891.

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.

☞ By a recent Act of Legislature it is made the business of this Station to examine articles of food and drink on sale in Connecticut, with reference to their adulterations.

Here it may be stated that, *until further notice,* the Station will examine only such samples of food and drink as are collected by its agents or such as shall be taken under its advice, and by the methods it shall prescribe or approve.

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 the 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.

and all remittances should be made payable to the undersigned.

☞ Station Grounds, Laboratories and Office are on Huntington Street, five minutes walk west from Whitney Avenue and 1⅝ miles north of City Hall.

☞ Huntington Street may be reached by Whitney Avenue Electric Cars, which leave the corner of Chapel and Church Streets five times hourly, viz: on the striking of the clock and at intervals of twelve minutes thereafter.

☞ The Station may also be reached by taking Winchester Avenue Electric Cars, going north, which pass the Union R. R. Depot, and also start from corner Chapel and Church Streets, at intervals of sixteen minutes. Get off at Harriet street, whence five minutes walk eastward, crossing Prospect Street, and entering Huntington Street, brings to the Station.

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

☞ The Grass Garden, in charge of Mr. James B. Olcott, is near South Manchester, two minutes walk from the line of the Manchester Electric Cars, leaving City Hall Square, State Street, Hartford, every half hour. Conductors on this line can direct visitors to the Garden.

S. W. JOHNSON, *Director.*

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REPORT OF THE TREASURER.

WM. H. BREWER, IN ACCOUNT WITH THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING SEPTEMBER 30TH, 1896.

RECEIPTS.

	For 9 months.	For 3 months.	Total.
State Comptroller, Agr. Appr.	$7,500.00	$2,500.00	$10,000.00
" " Food Appr.	1,875.00	625.00	2,500.00
United States Appr.	5,625.00	1,875.00	7,500.00
Analysis Fees due last year	170.00	----------	170.00
" " this year	4,995.00	150.00	5,145.00
Damages from new layout of streets	400.00	----------	400.00
Miscellaneous	70.72	----------	70.72
	$20,635.72	$5,150.00	$25,785.72

EXPENDITURES.

	For 9 months.	For 3 months.	Total.
Salaries, State account	$6,345.83	$2,187.51	$8,533.34
" U. S. account	5,625.00	1,875.00	7,500.00
Labor	1,036.53	50.80	1,087.33
Publications	164.06	190.80	354.86
Postage	78.61	53.60	132.21
Stationery	163.59	26.80	190.39
Freight and Express	92.43	2.70	95.13
Coal	65.10	702.00	767.10
Gas	264.10	42.74	306.84
Water	147.00	----------	147.00
Chemicals and Laboratory Supplies	977.09	69.74	1,046.83
Supplies—Agr., Hort., Bot., etc.	321.64	19.10	340.74
Fertilizers	153.51	2.79	156.30
Feeding Stuffs	73.46	16.04	89.50
Library	452.44	33.68	486.12
Tools and Machinery	33.94	19.20	53.14
Furniture and Fixtures	11.35	----------	11.35
Scientific Apparatus	290.55	5.40	295.95
Travelling, by the Board	8.30	17.09	25.39
" " Staff	170.43	15.50	185.93
Telephone	162.35	----------	162.35
Tobacco Exper.	79.65	12.50	92.15
Grass Exper.	1,000.00	----------	1,000.00
Field Exper.	58.50	----------	58.50
Fertilizer Sampling	448.98	5.45	454.43
Food Sampling	308.06	47.07	355.13
Bank Discount	19.03	----------	19.03
Insurance	269.98	----------	269.98
New lay-out of streets	42.88	25.20	68.08
Unclassified Sundries	26.84	----------	26.84
New Buildings	390.82	----------	390.82
Betterments	327.00	48.95	375.95
Repairs	165.83	121.18	287.01
Total Expenditures	$19,774.88	$5,590.84	$25,365.72
Balance to New Acct.			420.00
			$25,785.72

The accounts are rendered for periods of nine and three months, as were those of the Report of last year, to facilitate the comparison and correlation of the two Reports rendered to the State and the United States for their respective fiscal years. The classification of expenditures is, as far as is practicable, in accordance with that required to be given for the expenditures of the funds received from the United States, and recommended by the U. S. Dept. of Agriculture for the general use of all the stations in the country.

The new lay-out of streets has necessitated very considerable changes, costing much more than the $400 awarded as damages. Some of these changes, however, are of the nature of betterments and permanent improvements. Of the $420 balance carried to the new account, 331\frac{92}{100}$ are from this award and will pay probably about half of the amount required for the remaining changes that are necessary.

WM. H. BREWER, *Treasurer.*

REPORT OF THE BOARD OF CONTROL.

To His Excellency, O. Vincent Coffin, Governor of Connecticut:

The Board of Control of the Connecticut Agricultural Experiment Station herewith submits its report for the year ending October 31st, 1896.

EXAMINATION OF FOOD PRODUCTS.

Eleven hundred and thirty-two samples of Food Products have been purchased by agents of this Station, who have visited all sections of the State for this purpose. The samples thus collected have been suitably examined with reference to the presence of adulterants.

The necessary microscopic work has been entirely done by Mr. Winton, and the chemical work by Messrs. Winton, Ogden and Mitchell.

The first publication of this Station on Foods was issued in July, as Bulletin No. 123, and covers seventy-nine pages, giving a detailed account of the examination of eight hundred and forty-eight articles of food, thirty per cent. of which were adulterated.

As provided by statute, this will form a part of the forthcoming twentieth report of this Station.

WORK FOR THE DAIRY COMMISSIONER.

All the chemical work required by the Dairy Commissioner has been done in the laboratory of this Station, including examinations of nine samples of butter, fifteen of molasses and fifty-four of vinegar.

THE FERTILIZER CONTROL.

During the months of April, May and June, members of the Station staff and Mr. C. L. Backus, of Andover, sampling agent of this Station, visited ninety-four towns and villages of this State and drew five hundred and eighty-nine samples of commercial fertilizers. These represented nearly all of the two hundred and fifty-five brands of these goods which have been entered for sale within the State.

Analyses of all these brands have been made in the chemical laboratory, by Messrs. Winton, Ogden and Mitchell, with the assistance of Mr. Lange. A manuscript copy of each analysis has been sent to the manufacturer and to each dealer from whom a sample of the goods was drawn.

The results of these fertilizer analyses have been tabulated and are ready for publication.

The Work of the Chemical Laboratory.

Besides the examination of Food Products, the work for the Dairy Commissioner and the analyses of the fertilizers just referred to, Messrs. Winton, Ogden and Mitchell have analyzed two hundred and eleven samples of fertilizers and manurial waste products, making the total number of fertilizer analyses four hundred and sixty-six.

In connection with vegetation experiments, the chemists have analyzed two hundred and seventeen crops of maize and forty-eight of oats, all grown in pots, and two crops of cucumbers, two of carnations, fifty-one of tomato vines and roots, four of tomato fruit, fourteen of lettuce and two of radishes, which were raised in the forcing-houses.

The chemists have also analyzed eight samples of maize and maize stover, and one hundred and sixteen of leaf tobacco, coming from the field experiments carried on by the Station.

Two hundred and eleven samples of vegetable seeds have been tested with regard to their vitality, in the interests of seedsmen and purchasers.

A very considerable number of determinations have also been made in testing analytical methods, chiefly concerning the determination of potash.

Study of Plant Proteids.

During the year the work begun in 1895 on the proteids of leguminous seeds has been diligently prosecuted. The seeds studied have been yellow lupin, blue lupin, horse bean, lentil, yellow soy bean, Kiyusuki daidzu, soy bean, cow pea and white podded adzuki bean. Further study has been made of the maize kernel including determinations of the quantities of the several proteids in yellow corn.

The Work of the Mycologist.

The work of Dr. Sturgis during the past year is briefly as follows:

1. A continuation of the experiments of 1894 and 1895, upon the use of fungicides under various conditions, for the prevention of potato scab. This general subject was studied in the light of three separate experiments, and included investigations upon the danger to the crop arising from the use of scabby seed as compared with clean seed, infested land as compared with clean land, and barn-yard manure as compared with fertilizer chemicals. The fungicides tested were corrosive sublimate, sulphur and a new material called Lysol, highly recommended as a fungicide and insecticide by French and German investigators.

2. The susceptibility to potato scab of eight common root-crops and the application of fungicides to the soil by way of preventive treatment.
3. A test of the fungicidal value of dry Bordeaux mixture as compared with the usual liquid form.
4. Study of the supposed winter condition of the shot-hole fungus of peach, plum and apricot.
5. Study of a mildew attacking rose-bushes and distinct from the form common on rose leaves.
6. An investigation of the causes of the so-called "shelling" of grapes, and plans for treatment.
7. An investigation of a new and serious disease attacking growing tobacco in the South, and liable to occur in the North.
8. Continued work upon the San José Scale.

Horticultural Work.

Dr. Jenkins and Mr. Britton, with the coöperation of the chemical department, have continued the study of the relative availability of organic nitrogen in various forms, by vegetation experiments with maize and oats. Eighty-six experiments with maize grown in pots, charged with an artificial soil, and eighty-three in similar pots, charged with natural soils, have been carried out during the summer in a vegetation house built for the purpose.

The comparative availability of nitrogen in bone of different degrees of fineness, has been studied by forty-eight experiments with maize grown in cylinders sunk in the ground.

During the winter the fertilizer requirements of tomatoes, radishes and carnations were studied in the forcing-houses, the plants being grown for the purpose both in rich garden soil and also in a mixture of peat and anthracite coal ashes, to which fertilizer chemicals in the desired quantity were added.

Experiments have also been begun by Mr. Britton on the grafting of hickory trees.

Field Experiments.

Under the supervision of Dr. Jenkins, the extensive experiment on the effect of fertilizers upon quality and quantity of the tobacco crop, and the experiments noticed in our former reports on the growth of maize continuously on the same land, have been again repeated.

Three experiments on the fertilization of peach orchards have been undertaken, chiefly to study the effect of different amounts of potash salts and of the forms of nitrogen best adapted to the crop.

THE GRASS GARDEN.

Mr. J. B. Olcott has continued the study of native and foreign turf-making grasses in the grass garden at South Manchester, and during the year has visited the Sandwich Islands and Australia for the purpose of studying and collecting turf grasses. Turf gathered in these countries has been added to the large number of varieties already in the grass garden collected in England, France, Denmark and Austria, as well as in all parts of the United States.

STATION PUBLICATIONS.

The Nineteenth Report of this Station for the year 1895, a volume of three hundred and twenty pages, has been issued in an edition of twelve thousand copies and the seven thousand copies at the disposal of this Station, after satisfying our exchanges, have been distributed among the farmers of Connecticut. Less than fifty copies remain in our hands.

Bulletin No. 122, issued in May last, in an edition of four thousand copies, on cost of nitrogen, phosphoric acid and potash in Connecticut, contained sixteen pages.

Bulletin No. 123, issued in July, in an edition of five thousand copies, seventy-five pages, contained the first report of this Station on the Examination of Food Products.

The substance of these Bulletins will be reproduced in the Twentieth Report for 1896, now in course of preparation, which will contain a full account of all the work of the Station Staff during the State fiscal year.

ATTENDANCE AT FARM INSTITUTES AND OTHER FARMERS' MEETINGS.

In addition to the usual attendance at Farm Institutes and in response to requests, members of the Station Staff have attended a considerable number of meetings of farmers during the year, and read papers or made addresses.

CORRESPONDENCE.

During the year, nineteen hundred and thirty letters have been written by the Station Staff and eight hundred and fourteen manuscript reports of fertilizer and other analyses have been made.

MEETINGS OF THE BOARD.

During the year ending October 31st, the Board of Control has held three meetings.

All of which is respectfully submitted.

(Signed) WILLIAM H. BREWER, *Secretary*.

Nov. 1st, 1896.

REPORT ON FOOD PRODUCTS.

To his Excellency, O. Vincent Coffin, Governor of Connecticut:

As required by statute, I herewith submit the first Report of this Station upon Adulterated Food Products.

Very respectfully yours,

S. W. JOHNSON, *Director*.

The Conn. Agricultural Experiment Station,
New Haven, July 15th, 1896.

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REPORT ON FOOD PRODUCTS.

The General Assembly of this State, at the January Session, 1895, passed an act regulating the manufacture and sale of food products; which was approved June 26th, 1895, and went into effect on August 1st of that year.

The text of the law is as follows:—

CHAPTER CCXXXV.

PUBLIC ACTS, JANUARY SESSION, 1895.

An Act regulating the Manufacture and Sale of Food Products.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Manufacture or sale of misbranded or adulterated food.

SECTION 1. It shall be unlawful for any person, persons, or corporation within this state to manufacture for sale, offer, or expose for sale, have in his or their possession for sale, or to sell, any article of food which is adulterated or misbranded within the meaning of this act.

Term food defined. Term misbranded defined.

SEC. 2. The term food, as used in this act, shall include every article used for food or drink by man, horses, or cattle. The term misbranded, as used in this act, shall include every article of food and every article which enters into the composition of food, the package or label of which shall bear any statement purporting to name any ingredient or substance as not being contained in such article, which statement shall be untrue in any particular; or any statement purporting to name the substance or substances of which such article is made, which statement shall not give fully the names of all substances contained in such article in any measurable quantity.

When an article shall be deemed to be adulterated.

SEC. 3. For the purposes of this act, an article shall be deemed adulterated:

First, if any substance or substances be mixed or packed with it so as to reduce or lower or injuriously affect its quality or strength;

Second, if any inferior substance or substances be substituted wholly or in part for the article;

Third, if any valuable constituent of the article has been wholly or in part abstracted;

Fourth, if it be an imitation of or sold under the name of another article;

Fifth, if it is colored, coated, polished, or powdered whereby damage is concealed, or if it is made to appear better or of greater value than it is;

Sixth, if it contains poisonous ingredients which may render such article injurious to the health of a party consuming it, or if it contain any antiseptic or preservative not evident and not known to the purchaser or consumer;

Seventh, if it consists, in whole or in part, of a diseased, filthy, decomposed, or putrid substance, either animal or vegetable, unfit for food, whether manufactured or not, or if it is in any part the product of a diseased animal, or of any animal that has died otherwise than by slaughter;

Provided, that an article of food product shall not be deemed adulterated or misbranded within the meaning of this act in the following cases:

(*a*) In the case of mixtures or compounds which may be now or from time to time hereafter known as articles of food under their own distinctive names, and not included in definition fourth of this section;

(*b*) In the case of articles labeled, branded, or tagged, so as plainly or correctly to show that they are mixtures, compounds, combinations, or blends;

(*c*) When any matter or ingredient is added to a food because the same is required for the protection or preparation thereof as an article of commerce in a fit state for carriage or consumption and not fraudulently to increase the bulk, weight, or measure of the food or to conceal the inferior quality thereof;

(*d*) When a food is unavoidably mixed with some extraneous matter in the process of collection or preparation.

Connecticut Agricultural Experiment Station to m[ake] analyses.

SEC. 4. The Connecticut Agricultural Experiment Station shall make analyses of food products on sale in Connecticut suspected of being adulterated, at such times and places and to such extent as it may determine, and may appoint such agent or agents as it deems necessary; who shall have free access, at all reasonable hours, for the purpose of examining, into any place wherein it is suspected any article of food adulterated with any deleterious or foreign ingredient or ingredients exists, and such agent or agents upon tendering the market price of said article may take from any person, firm, or corporation samples of any article suspected of being adulterated as aforesaid, and the said station may adopt or fix standards of purity, quality, or strength when such standards are not specified or fixed by statute.

Notice to prosecuting officers. SEC. 5. Whenever said station shall find by its analysis that adulterated food products have been on sale in the state, it shall forthwith transmit the facts so found to a grand juror or prosecuting attorney of the town in which said adulterated food product was found.

Report. SEC. 6. The said station shall make an annual report to the governor upon adulterated food products, in addition to the reports required by law, which shall not exceed one hundred and fifty pages, and said report may be included in the report which said station is already authorized by law to make, and such annual reports shall be submitted to the general assembly at its regular session.

Appropriation. SEC. 7. To carry out the provisions of this act, the additional sum of twenty-five hundred dollars is hereby annually appropriated to said Connecticut Agricultural Experiment Station, which sum shall be paid in equal quarterly installments to the treasurer of the board of control of said station, upon the order of the comptroller, who is hereby directed to draw his order for the same.

Penalty. SEC. 8. Any person who, either by himself, his agent, or attorney, with the intent that the same may be sold as unadulterated, adulterates any food products for man, or horses, or cattle, or knowing that the same has been adulterated, offers for sale or sells the same as unadulterated, or without disclosing or informing the purchaser that the same has been adulterated, shall be fined not more than five hundred dollars, or imprisoned not more than one year.

Action not to be maintained on illegal sale. SEC. 9. No action shall be maintained in any court in this state on account of any sale or other contract made in violation of this act.

SEC. 10. All acts and parts of acts inconsistent herewith are hereby repealed.

Approved, June 26th, 1895.

The fourth, fifth and sixth sections of this act lay certain duties upon this Station as follows:

1st. To make analyses of food products suspected of being adulterated.

2d. Whenever it shall find by its analysis that adulterated food products have been on sale, it shall forthwith transmit the facts so found to a prosecuting officer in the town where the adulterated food product was found.

3d. The Station shall make an annual report.

The law also provides that the Station may adopt or fix standards of purity, quality, or strength, when such standards are not specified or fixed by statute.

All articles used as food or drink by men, horses or cattle are included under the provisions of the law and are subject to the inspection and investigation of the Station. It is obvious that because of this wide scope of the law, and also because of the limited appropriation made for the work, it is quite impossible that the whole field should be covered in any one year.

That due diligence has been shown in examining food products during the twelve months covered by this report is shown by the work described on the following pages.

Authorized agents of this Station have visited forty cities and villages of Connecticut for the purpose of purchasing articles of food liable to adulteration.

These places are distributed as follows:

Litchfield County	3	places.
Hartford "	9	"
Tolland "	1	"
Windham "	5	"
New London "	5	"
Middlesex "	1	"
New Haven "	10	"
Fairfield "	6	"
	40	"

There have thus been secured 934 samples of food products of the following kinds:

Maple Syrup	72	samples.
Maple Sugar	7	"
Syrup	4	"
Cane Sugar	16	"

Comb Honey	12	samples.
Strained Honey	48	"
Lard and Lard substitutes	162	"
Pepper	114	"
Mustard	74	"
Cream of Tartar	103	"
Cereal Foods	9	"
Coffee	124	"
Milk	105	"
Cheese	72	"
Miscellaneous	25	"
	947	"

In collecting these samples no effort has been made to select places in which it might be supposed that adulterated goods would be most abundant, but it was rather sought to get as many different brands of each article as was possible. To this end the agents purchased from "fancy" groceries, as well as from the cheaper places which supply the poorer part of the population.

The State having already specially provided for the inspection of butter, molasses and vinegar by a dairy commissioner and his deputy, inspection of these three food products by the Station is uncalled for.

It should be said, however, that all samples drawn by the dairy commissioner or his deputy are referred by them to this Station for examination and report.

The examination of the samples bought by Station agents has been entirely done by Messrs. Winton, Ogden and Mitchell, as will be seen from their papers on the following pages.

In every case where certain proof of adulteration was found, the facts, as required by the law, have been forthwith transmitted to a grand juror or other prosecuting officer of the town or borough where the adulterated food products were sold.

The duties of this Station end here. In order to prosecute successfully it is necessary for the State not only to prove the sale of adulterated food products, but also to prove that the seller knew that the articles sold were adulterated.

MAPLE SYRUP AND MAPLE SUGAR.

By A. W. Ogden.

Maple syrup, obtained by evaporating the sap of the sugar maple, contains essentially the same sugars that exist in sugar made from sugar cane and beet root, but it is specially prized for its peculiar flavor. This flavor is said to be more or less successfully imitated, and, according to popular belief, it is quite possible to prepare, from the ordinary white or brown sugar of the stores, a syrup or a sugar which cannot be certainly distinguished from genuine maple syrup or maple sugar.

It is probable that genuine maple syrup or sugar may be melted with water and a large proportion of ordinary sugar to make a mixture which has enough maple flavor to be in demand and to be extensively sold as maple sugar or maple syrup.

In Table I, page 9, are given analyses of 61 samples of "maple syrup," bought by Station agents in 22 different cities and towns of this State.

Of most of these it is impossible to say whether or not they are genuine and unadulterated.

But the last eight samples in the table of analyses are certainly adulterated and consist wholly or in part of glucose syrup. The five samples which immediately precede in the table those marked adulterated, and which are numbered 5094, 5093, 5461, 5397 and 5043 contain some substance which has a strong right-handed polarization and is not "inverted" by the action of acids. Such a substance is not known in pure maple syrup or sugar, but a mixture of syrup with a moderate quantity of glucose would give the polarization observed in these samples.

Method of Testing Sugars and Syrups.

Sugar, syrup and honey are tested generally by the polariscope, other tests being made in special cases.

In our work one-half the normal quantity for polariscopic test* was dissolved in water and clarified when necessary with 1^{cc} each of alum cream and basic lead acetate solution. After making up the volume to 100^{cc} and filtering, the solution was polarized in a 200^{mm} tube. 50^{cc} of the solution were treated with 5^{cc} of strong hydrochloric acid, heated at 68° to 70° C. for ten minutes and polarized a second time, after inversion.

The results in the table are calculated in all cases to the normal quantity.

* 13.024 grams.

EXPLANATIONS OF THE TABLE OF ANALYSES.

The last column in Table I gives the per cent. of cane sugar deduced from the polarizations. This ranges in the "maple syrups" from 47 per cent. in No. 5371 to 66 per cent. in No. 5460. Most of the samples contain 60 per cent. or over. The other 30 per cent. is in some cases mostly and in all largely water, but besides cane sugar and water there are larger or smaller amounts of "invert sugar" (a mixture of "glucose" and "fructose" sugars), which always results when cane sugar solutions containing acids (juice or sap) are heated and boiled as in open pan sugar-making. A properly prepared solution of pure dry cane sugar polarizes +100 degrees. After heating with hydrochloric acid the cane sugar is changed to "invert sugar," which polarizes $-36\frac{1}{2}°$ at a temperature of 15° C. In most cane sugars and in syrups containing cane sugar only, the same relation holds so that such a syrup, giving direct polarization of +50°, would polarize −18.25° after inversion and would accordingly contain 50 per cent. of cane sugar.

But sugars or syrups that already contain invert sugar, show in consequence a less direct +polarization and a greater −polarization than those which contain a like amount of cane sugar *without* invert sugar. Thus in the sample of maple syrup first in Table I the 56 per cent. of cane sugar corresponds to +56° of direct polarization and about − 19.3° after inversion. The difference—2.9 degrees—represents the polarizing effect of invert sugar, with small quantities possibly of other optically active substances.

Assuming, however, that cane and invert sugar are the only optically active things present, the amount of invert sugar is 1.44 per cent.

Table II, page 12, gives the analyses of seven samples of "Maple Sugar."

Whether these were made entirely from maple juice or are imitations of maple sugar cannot, in the present state of knowledge, be certainly determined by chemical examination.

They contain 10 to 15 per cent. of moisture.

TABLE I.—MAPLE SYRUPS.

Station No.	Label on Package.	Manufacturer, Producer, or Wholesaler.	Dealer.	Cost per Package.	Polarization. Direct. Degrees	Polarization. After Inversion. Degrees	Polarization. After Inversion. Temperature. C.	Sucrose or Cane Sugar. Per cent.
5488	Pure Maple Syrup	Hildreth Bros. & Segelken, N. Y.	A. J. Finney, 202 Main St., Stamford	$0.22	+53.1	−22.2	19.0	56.0
5298	Leonard's Pure Vermont Maple Syrup	D. C. Leonard & Son, Wilmington, Vt.	Newton & Robertson, Hartford	.35	+56.7	−20.0	24.6	58.3
5096	Maple Syrup	C. L. Houghton & Co, Northampton, Mass.	Grocery, S. W. corner Wallace & Walnut Sts., New Haven	.25	+57.5	−17.6	27.8	57.7
5384	Golden Crown, Pure Sap Maple Syrup	Clark, Chapin & Bushnell, N. Y.	W. H. Bronson, 234 Main St., Ansonia	.25	+58.8	−20.2	21.3	59.3
5380	Golden Crown, Pure Sap Maple Syrup	Clark, Chapin & Bushnell, N. Y.	R. D. Baldwin, Bridge St., Winsted	.25	+58.8	−20.5	21.3	59.4
5302	The Vt. Maple Sugar Ex. &c. Guarantees This Maple Syrup Strictly Pure	The Vermont Maple Sugar Ex., Brattleboro, Vt.	H. J. Case & Co., Hartford	.35	+58.8	−21.6	24.0	60.8
5301	Warranted Strictly Pure Maple Syrup	B. Frank Steele & Co., Springfield, Mass.	Earnest Glaeser, Rockville	.25	+59.2	−19.6	25.0	59.7
5383	Maple Sap Syrup. Put up and Guar. by	Welch Bros. Maple Co., Burlington, Vt.	Waterbury Grocery Co., 163 Bank St., Waterbury	.25	+59.5	−20.7	22.2	60.3
5497	Irving's Vermont Maple Syrup	Not known	Fitch A. Hoyt, Stamford, Conn.	.22	+59.6	−21.9	18.8	60.6
5422	None		T. W. Potter, New London, Conn.	1.00*	+59.6	−21.5	21.6	60.8
5369	Pure Maple Syrup. Put up by	David H. Geer & Son, Boston, Mass.	Grocery, 234 E. Main St., Bridgep't	.12	+59.6	−20.6	21.8	60.2
5376	Pure Vermont Maple Syrup	D. Trubee & Co., Bridgeport, Conn.	E. L. Sullivan, 436 E. Main St., Bridgeport	.25	+60.0	−20.2	22.5	60.4
5092	Hazen's Vt. Maple Syrup, Warranted Pure	Not known	Gilbert & Thompson, New Haven	.45	+60.6	−20.1	26.0	61.6
5042	None	Clark, Chapin & Bushnell, N. Y.	L. D. Chidsey, New Haven	.75 can	+60.3	−20.4	25.0	61.3
5381	Famous Vt. Maple Syrup. Strictly Pure	The Vt. Maple Sugar Ex., Brattleboro, Vt.	N. W. Heater, Waterbury, Conn.	.20	+61.1	−20.2	22.3	61.4
5309	Pure Maple Syrup		H. I. Palmer, Norwich, Conn.	.75†	+61.5	−21.8	23.4	62.9
5097	None	Said to be Thompson, Northampton	D. S. Cooper Co., 470 State St., New Haven	.25	+61.7	−20.0	26.3	62.4
5499	Hampshire County Maple Syrup	Leslie, Dunham & Co., Pittsfield, Mass.	N. Y. Cash Grocery, Norwalk, Conn.	.20	+62.0	−22.0	18.3	62.3

* Gallon. † One-half gallon.

TABLE I.—MAPLE SYRUPS—*Continued.*

Station No.	Label on Package.	Manufacturer, Producer, or Wholesaler.	Dealer.	Cost per Package.	Polarization. Direct.	Polarization. After Inversion.		Sucrose or Cane Sugar.
					Degrees	Degrees	Temperature. C.	Per cent.
5312	Climax Pure Maple Syrup	C. T. & J. C. Joslyn, Waitsfield, Vt., and Malden, Mass.	J. P. Halloway, Norwich, Conn.	$0.30	+62.0	−20.9	23.4	62.6
5303	Maple Sap Syrup. Put up and Guaranteed by	Green Mountain Maple Asso.	W. W. Walker, Hartford	.24	+62.5	−21.0	24.7	63.4
5426	Maple Syrup	The Crystal Conserve Co., N. Y.	Logan Bros., Main St., Bridgeport	.10	+62.6	−21.3	21.9	63.1
5313	Vermont Maple Syrup. Warranted 1st Quality	J. H. Barker & Co., Rutland, Vt.	Welcome A. Smith, Norwich	.35	+62.6	−21.7	23.7	63.8
5385	Warranted Strictly Pure Vt. Maple Syrup		Dillon's Cash Grocery, Ansonia	.25	+62.8	−20.8	22.2	62.9
5387	Vermont Maple Syrup	Hildreth Bros. & Segelken, 28 & 30 W. Broadway, N. Y.	The Clarke & Stevens Grocery, Shelton	.35	+62.8	−20.7	22.8	63.6
5396	The Crystal Conserve Co. Maple Syrup	F. H. Leggett & Co., N.Y., Prop.	A. H. Armington, Danielson	.18	+62.8	−21.1	22.0	63.1
5098	Strictly Pure. Made in Wyndham Co., Vt.	Thompson & Cromack, Northamptor.	Berry & Bailey, 946 Grand Ave., New Haven	.25	+63.0	−19.5	27.5	63.3
5044	Pure Vt. Maple Syrup. Put up expressly for	D. M. Welch & Son, New Haven, Conn.	D. M. Welch & Son, New Haven	.22	+63.0	−20.0	26.8	63.6
5386	None	F. H. Pratt, Tolland, Mass.	J. C. O'Brien, Main St., Ansonia	.40	+63.0	−21.0	23.1	63.4
5379	Maple Syrup	The Crystal Conserve Co., N. Y.	McGraw & Baldwin, Danbury	.25	+63.1	−21.0	21.3	63.3
5311	None	J. C. Worth, Norwich	Wheeler Bros., Norwich	.30	+63.2	−22.2	22.5	63.6
5465	None		P. W. Hiller, New Britain	.15	+63.3	−21.2	22.9	63.8
5299	Mascot Brand, Pure Maple Syrup	R. N. Fitzgerald, 142 State St., Hartford	Purinton & Reade, Willimantic	.35	+63.4	−21.2	24.8	64.3
5095	Superb Pure Maple Syrup	Not known	Coe & Field, New Haven, Conn.	.25	+63.4	−20.7	26.6	64.4
5500	None	Not known	Betts & Farrington, Norwalk, Conn.	.10	+63.5	−22.0	19.0	63.5
5395	None	W. J. Lamb, W. Somerville, Mass.	W. H. Brown, Moosup	.25	+63.7	−20.6	21.5	63.2
5300	Pure Maple Syrup. Orange Co., Vt.	W. J. Lamb, W. Somerville, Mass.	Ransom Bros., Rockville	.30	+64.1	−20.9	24.8	64.6
5374	Pure Maple Syrup. Enosbury, Vt.	D. H. Geer & Son, Boston, Mass.	Store at 47 White St., Danbury	.15	+64.2	−21.5	22.5	64.5
5462	Warranted Strictly Pure Maple Syrup. Put up for	F. M. Hotchkiss, Meriden, Conn.	N. P. Lamontague, Meriden	.25	+64.3	−21.9	22.6	64.9
5372	Vermont Maple Syrup		Gustav. E. Friedrich, So. Norwalk	.30	+64.4	−21.6	22.0	64.4
5046	Warranted Pure Vt. Maple Syrup	Stoddard, Kimberly & Co., N. H.	H. S. Dailey, 97 Whalley Ave., N. H.	.35	+64.6	−20.7	27.4	65.5
5375	Green Mountain Maple Syrup. Pure and Delicious	Austin, Nichols & Co., N. Y.	Doran's Cash Grocery, Danbury	.25	+64.6	−22.2	22.5	65.4

TABLE I.—MAPLE SYRUPS—*Continued.*

Station No.	Label on Package.	Manufacturer, Producer, or Wholesaler.	Dealer.	Cost per Package.	Polarization. Direct.	Polarization. After Inversion.		Sucrose or Cane Sugar.
					Degrees	Degrees	Temperature. C	Per cent.
5463	Thompson's Absolutely Pure Maple Syrup	J. E. Thompson	Sovereigns' Trading Co., N. Britain	$0.25	+64.7	−19.6	23.3	63.7
5464	Warranted Strictly Pure Maple Syrup	G. W. Moseley & Son, Hartford	Lee Bros. & Co., New Britain, Conn.	.30	+64.8	−21.0	21.9	64.5
5045	Pure Maple Syrup. Woodstock, Vt.	F. P. Adams & Co., Boston, Mass.	P. Jente & Bro., Broadway, N. H.	.23	+65.1	−21.1	25.6	65.7
5447	Warranted Strictly Pure Maple Syrup	G. W. Moseley & Son, Hartford, Conn.	Hill Grocery, 552 Asylum St., H'tf'd	.28	+65.2	−23.3	18.9	65.7
5460	Home Brand, Warranted Strictly Pure Vermont Maple Syrup	Bryan, Miner & Reed, New Haven	E. F. Buhles, Meriden	.25	+66.4	−22.3	19.2	66.0
5371	Vermont Maple Syrup	J. H. Green, 150 Flushing Ave., Brooklyn, N. Y.	Cenn. Am. Tea Co., 856 Main St., Bridgeport, Conn.	.10	+41.2	−21.2	22.5	47.0
5377	None	Unknown	Grocery, 87 White St., Danbury	.30	+49.6	−20.6	22.7	52.9
5094	Pure Maple Syrup	H. D. Gloyd, Charlestown, Mass.	J. H. Dore, 763 Grand Ave, N. H.	.23	+61.1	−11.7	25.6	55.5
5093	Thompson's Absolutely Pure Maple Syrup	J. E. Thompson	C. E. Hart & Co., 350 State St., "	.30	+71.0	− 8.7	26.0	60.8
5461	Pure Vermont Maple Syrup	James Butler, 406 Greenwich St., N. Y.	Russell Bros., Meriden	.10	+69.6	− 5.0	19.2	55.5
5397	Mayflower Brand Pure Maple Syrup	R. N. Fitzgerald, Hartford, Conn	Perkins & Bliss, Willimantic	.30	+74.3	− 5.9	22.8	60.5
5043	Pure Vermont Maple Syrup		Johnson & Bro., 411 State St., N. H.	.35	+72.1	− 0.2	25.3	55.1
	Adulterated "Maple Syrups," Consisting of or Containing Glucose Syrup.							
5316	The Champion Brand Pure Maple Syrup	C. A. Reed, Medford, Mass.	James M. Young, Preston	.25	+80.0	+18.9	22.0	
5370	Vermont Maple Syrup	J. H. Green & Sons, Brooklyn, N. Y.	Store cor. E. Main and Clarence Sts., Bridgeport	.10	+85.0	+37.6	22.1	
5388	Pure Maple Syrup for Family Use	Silas F. Jones, Hancock, Vt	J. Burkhardt & Co., Shelton	.25	+93.7	+48.3	22.5	
5394	Said to be	W. J. Lamb, W. Somerville, Mass.	Quinnebaug Store, Danielson	.25	+95.0	+58.7	23.1	
5498	Pure Maple Syrup		Finney & Benedict, Norwalk	.25	+96.4	+37.7	20.3	
5279	Pure Maple Syrup for Family Use	Fournier & Schiller Co., Rochester, Vt.	H. Dion, Willimantic	1.00*	+97.4	+61.2	24.0	
5446	Hudson Brand Maple Syrup	Hudson M'f'g Co., 61 Hudson St., N. Y.	C. F. Cleaveland, Windsor Locks	.25	+100.0	+45.6	19.0	
5373	Thompson's Maple Syrup	259 Greenwich St., N. Y.	Chas. Starr, New Milford, Conn.	.25	+105.0	+50.9	21.5	

* Gallon.

TABLE II.—MAPLE SUGARS.

Station No.	Label.	Producer or Wholesaler.	Dealer.	Cost per Package.	Polarization. Direct. Degrees.	Polarization. After Inversion. Degrees.	Polarization. After Inversion. Temperature. C.	Sucrose, or Cane Sugar.
5100	None	Not known	D. S. Cooper Co., 470 State St., New Haven	$0.12	+84.1	−28.8	25.0	85.9
5308	None	W. J. Lamb, W. Somerville, Mass.	Brainard & Bartlett, Putnam	.15	+85.8	−27.3	22.9	85.3
5099	Genuine Vt. Maple Sugar	C. T. & J. C. Joslyn, Malden, Mass.	Coe & Field, 422 State St., New Haven	.15	+86.1	−27.6	27.2	87.2
5304	None	W. J. Lamb, W. Somerville, Mass.	Ransom Bros., Rockville	.15	+87.5	−27.5	26.0	87.8
5382	None	Hildreth Bros. & Segelken, N. Y.	The Clark & Stevens Store, Shelton	.18	+87.7	−28.3	21.9	87.2
5389	Gem Pure Vt. Maple Sugar	Clark, Chapin & Bushnell, N. Y.	W. H. Bronson, 234 Main St., Ansonia	.15	+88.0	−28.3	22.5	87.6
5317	None	W. J. Lamb, W. Somerville, Mass.	H. D. Rallion, 45 Broadway, Norwich	.20	+88.4	−29.3	22.0	88.5

SUGARS.

BY A. W. OGDEN.

Three samples of granulated sugar, ten of powdered sugar and three of brown sugar, have been examined, with the results given in Table III.

Powdered sugar is sometimes suspected by purchasers of being adulterated with flour or terra alba because of a real or imagined lack of sweetness, but no evidence of adulteration has been found in any of the samples here examined.

The powdered and granulated sugars contain from 98 to 99.5 per cent. of pure sugar; the brown sugars, like the maple sugars, contain from 10 to 15 per cent. of moisture.

TABLE III.—SUGAR.

No.	By Whom Sold.	Price. Cents per Pound.	Per cent. of Pure Sugar. (Sucrose.)
	Granulated Sugar.		
5051	Benjamin Blumenthal, 229 Market St., Hartford	6	99.0
5052	Isaac Lechner, 203 Front St., Hartford	5	99.2
5053	Joseph Malley, 137 Front St., Hartford	5	99.2
	Powdered Sugar.		
5057	——— Davis, 228 Shelton Ave., New Haven	8	98.4
5058	J. Casseriego, Cor. Starr St. and Shelton Ave., New Haven	8	99.4
5059	Voelcker Bros., Cor. Gibbs St. and Shelton Ave., New Haven	8	99.4
5060	I. Strack, Cor. Munson St. and Shelton Ave., New Haven	8	99.0
5061	A. C. Tillman, 7 Shelton Ave., New Haven	8	99.0
5062	A. A. Eissele, Cor. Henry St. and Dixwell Ave., New Haven	8	99.4
5063	C. Kipp, 292 Dixwell Ave., New Haven	8	99.4
5064	C. Richards, 181 Dixwell Ave., New Haven	10	98.8
5065	J. T. Pohlman, 140 Dixwell Ave., New Haven	....	99.2
5066	P. Jente & Bro., Broadway, New Haven	7	98.8
	Brown Sugar.		
5055	Joseph Malley, 137 Front St., Hartford	5	84.8
5055	Benjamin Blumenthal, 229 Market St., Hartford	5	89.2
5056	Isaac Lechner, 203 Front St., Hartford	5	84.8

"SYRUP."

Table IV gives analyses of four articles bearing this name. Nos. 5502, 5378 and 5278 are glucose syrups; No. 5501 is apparently a cane sugar syrup.

As no distinct claim is made regarding either of these articles they cannot be considered adulterated.

TABLE IV.—"SYRUPS."

Station No.	Name of Brand.	Manufacturer or Wholesaler.	Retail Dealer.	Cost per Package.	Direct Polarization.	Polarization after Inversion.	Temperature.
5501	Sold for Sugar Syrup	----	S. Comstock, Jr., 72 N. Main St., South Norwalk	$0.03 ½ pt.	+ 36.5	− 13.2	22.3
5502	Queen Syrup	G. Boyd & Sons, 8th and Cantrell Sts., Phila.	D. S. Davenport, S. Norwalk.	.25	+ 97.5	+ 68.2	22.0
5378	Queen Syrup	G. Boyd & Sons	P. D. Vroom, 5 Keeler Street, Danbury	.30	+113.8	+ 93.6	23.8
5278	Sold for Sugar Syrup	Halpin & Green, N. Y.	W. W. Walker, Hartford	.50 gall.	+129.4	+114.1	24.5

HONEY.

By A. W. Ogden.

Honey consists of the nectar of flowers elaborated by the bee and laid down in the cells of the honey comb.

This is in substance the definition given in the dictionaries and recognized by writers on food products and food adulterations.

It is a not uncommon practice to feed bees, when flowers are scarce, with sugar in some form to carry them along till they can get a full supply of nectar from flowers. But in order to lessen the work of the hive and so to increase production, cane sugar is sometimes fed abundantly and continuously when it is not at all essential to the bees.

This cane sugar, more or less converted by the bees into invert sugar, is laid down in the comb; but according to the definition given above, is not, strictly speaking, true honey.

Thus it happens, as in sample 5050 in Table V, p. 16, that "honey" bought in a comb which has not been removed from the frame into which it was built by the bees, and therefore, where direct adulteration by a dealer is in the nature of things impossible, may yet contain a large percentage amount of cane sugar. It was most probably taken by the bees from their artificial food and was laid down within the cells without conversion into invert sugar.

The buyer of honey, *in the comb*, therefore is not sure of getting honey made wholly from the nectar of flowers.

Invert sugar and glucose syrup are common adulterants of the "strained honey" of the shops and a dead bee or a fragment of comb floating on the surface is no sure sign that the liquid beneath is not glucose syrup with some coloring and flavoring matter.

Forty-eight samples of strained honey and twelve samples of comb honey have been bought by agents of the Station in nineteen cities and villages, and the results of their examination are given in the following table.

Honey in the Comb.

Table V contains 12 samples of this class. Of these we consider the first six, numbers 5610, 5611, 5049, 5105, 5486 and 5490, to be genuine.

TABLE V.—COMB HONEYS.

Station No.	Label.	Producer or Wholesaler.	Dealer.	Price per Package.	Polarization. Direct. Degrees.	Direct. Temperature C.	After Inversion. Degrees.	After Inversion. Temperature C.
	Probably genuine.							
5610	None.*	C. H. Chittenden, Killingworth, Conn.	A. B. Stevens, 61 Broadway, N. H.	$0.18	— 0.6	24.9	— 6.6	24.5
5611	" †	" " " "	" " " "	.18	— 4.7	25.0	—10.1	25.0
5049	"	Austin, Nichols & Co., Hudson St., N. Y.	Johnson & Bro., 411 State St., New Haven	.15	— 7.3	21.5	—14.1	24.7
5105	"	Said to come from Westville, Conn.	E. E. Nichols, 378 State St., New Haven	.25	— 6.2	21.5	— 9.2	24.7
5486	"	Not known	Geo. A. Ferris, 184 Main St., Norwalk	.18	— 6.7	23.8	—10.3	22.5
5490	"	" "	Betts & Farrington, Wall St., "	.20	— 9.7	23.3	—15.4	20.2
	Possibly from bees fed with Sugar.							
5104	None on box	On crate, J. E. Hetherington, Cherry Valley, N. Y.	Coe & Field, 422 State St., N. Haven	.20	—12.3	23.6	—15.4	25.0
5367	"	Not known	Wilcox & Adams, Winsted, Conn.	.18	—11.8	23.6	—14.2	24.9
5366	From the apiary of Ward Lamkin, Ledyard, N. Y. Comb Honey	Ward Lamkin, Ledyard, N. Y.	E. L. Sullivan, 436 E. Main St., Bridgeport, Conn.	.18	—16.4	23.4	—18.0	24.4
5365	None on box	From the apiary of F. Greiner, Naples, N. Y.	Foot Bros., W. Main St., Waterbury.	.18	—16.6	23.0	—17.8	24.3
5368	"	Not known	D. M. Welch & Son., New Haven	.10	—19.5	23.4	—20.5	24.0
	Containing Cane Sugar.							
5050	New England No. 7 apiary	H. D. Davis & Co., So. Newbury, Vt.	Johnson & Bro., 411 State St., New Haven	.15	+18.5	25.2	— 9.0	24.0

* From sumach, tulip and basswood.　　† From sumach, and possibly some basswood.

The next five, numbers 5104, 5367, 5366, 5365, 5368, may represent "honeys" from bees fed more or less with sugar.

No. 5050 is probably from bees which had been abundantly fed with cane sugar in some form. It contains 20.8 per cent. of cane sugar.

The per cents. of ash in the four samples, Nos. 5049, 5105, 5104 and 5050, were .24, .26, .46, and .03 respectively.

STRAINED HONEYS.

Table VI contains the tests of 48 samples of this class. Seven of them, as indicated in the table, are probably genuine. Thirty-four are suspected of representing honey from bees fed on sugar or of being adulterated with invert sugar.

Two others contain considerably larger amounts of cane sugar, which either came from the sugar on which the bees were fed or was added to the honey as an adulterant.

The last five in the table, Nos. 5360, 5270, 5273, 5314, 5352, are unquestionably adulterated with glucose syrup.

Samples numbered 5359, 5354 and 5363 contain 14.6, 29.3, and 23.1 per cent. of cane sugar respectively.

The per cents. of ash in samples numbered 5101, 5048, 5103, 5102, and 5091 are .20, .02, .09, .36, and .09 respectively.

A considerable number of samples of "honey" were in packages identical in form and size and bearing labels of the same size, form and wording, but the contents of these packages were nevertheless quite unlike in quality.

These are included in Table VII. The first column gives the numbers of the samples, with brackets enclosing those which were contained in packages of one kind; the second column gives the label, common to the packages, while the following columns give the results of the examination.

Thus it is seen that there were two samples, 5360 and 5425, both in packages (bottles) of the same shape and size and both bearing the label, "Pure California Honey, put up expressly for family or medical use." The label bore the picture of a busy bee-hive. One of these bottles contained glucose syrup (5360), and the other (5425) invert sugar or possibly honey made from bees fed with cane sugar.

There were five samples, 5352, 5467, 5492, 5494, and 5047, put up in glass "tumblers" of precisely the same size and shape,

TABLE VI.—STRAINED HONEYS.

Station No.	Label.	Manufacturer or Producer.	Dealer.	Price per package.	Polarization. Direct. Degrees.	Direct. Temperature, C.	After inversion Degrees.	After inversion Temperature, C.
	Probably Pure.							
5276	Pure Extracted Honey	Helen Johnson, Middle Haddam, Ct.	Hills & Co., Hartford, Conn.	$0.50	— 1.0	23.8	— 5.1	24.8
5485	Pure Honey	Wm. T. Gregory, Norwalk, Conn.	Finney & Benedict, Norwalk, Conn.	.25	— 3.6	22.8	— 8.4	24.0
5449	Choice Honey	C. A. Stanton, Newington, Conn.	J. A. Pilgard, 138 Front St., Hartford, Conn.	.25	— 5 1	23.8	—11.0	22.3
5467	Pure Honey	Not known	Rudolph Bros., Meriden, Conn.	.20	— 7.9	23.3	—11.2	22.0
5310	Choice Extracted Honey. Strictly Pure	E. C. Hazard & Co., New York	H. I. Palmer, Norwich, Conn.	.20	— 5.6	23.2	—16.5	24.0
5423	Pure Orange Blossom Honey. Eagle Brand	Not known	Doran's Cash Grocery, 150 Main St., Danbury, Conn.	.20	— 6 8	25.1	—15.6	22.4
5362	None	Sold for native honey	M. H. Tilley, Derby, Conn.	.18	— 7.2	23.8	—14.0	24.2
	Possibly from bees fed with sugar, or the honey adulterated with invert sugar.							
5355	None	Not known	J. B. Sullivan, E. Main St., Bridgeport	.20	—10.1	23.3	—14.1	24.7
5361	None	Said to be Lamb	L. P. & A. M. Guilfoile, Bank St., Waterbury	.20	—10.3	23.4	—14.7	24.2
5364	Pure California Honey	D. H. Geer & Son, Andrew Sq., Boston	J. B. Vallee, 21 Grand St., Waterbury	.25	—11.0	22.7	—16.2	23.6
5424	Choice Extracted Honey. Strictly Pure	E. C. Hazard & Co., New York	Waterbury Grocery Co., 163 Bank St., Waterbury	.25	—11.8	25.1	—14.5	22.5
5420	1 Pound Pure Honey	Not known	W. S. Chappell, 148 State St., New London	.25	—12.0	24.7	—17.3	22.5
5495	None	Said to be native from New Canaan	T. Leeds, Stamford, Conn.	.18	—12.4	22.6	—17.2	18.5
5492	Pure Honey	Said to be native	D. S. Davenport, N. Main St., South Norwalk	.18	—12.7	23.7	—16.9	21.2

TABLE VI.—STRAINED HONEYS—*Continued.*

Station No.	Label.	Manufacturer or Producer.	Dealer.	Price per package.	Polarization. Direct. Degrees.	Direct. Temperature, C.	After inversion Degrees.	After inversion Temperature, C.
5448	1 Pound Pure Honey	Said to be Phelps	C. F. Cleaveland, Windsor Locks	$0.25	—13.2	22.5	—16.1	18.4
5351	None	Said to be W. J. Lamb	M. S. Burgess, Derby Junction	.25	—13.4	23.3	—16 5	25.0
5315	Pure Honeysuckle Honey	W. J. Lamb	H. D. Rallion, Norwich	.25	—13.7	22.0	—16.1	24.4
5356	None	Said to be farmer's honey	McGraw & Baldwin, Danbury	.20	—13.9	22.8	—16.5	25.2
5421	None	Said to be Cal. honey. From Am. Grocery Co., New York	T. W. Potter, 72 State St., N. London	.25	—14.3	23.5	—19.1	22.9
5277	Pure Extracted White Clover Honey	H. A. Whittlesey, Newington, Conn.	Newton & Robertson, Hartford	.25	—14.4	24.0	—17.4	24.5
5496	None	Said to be native from New Canaan	W. & E. Osterbanks, Norwalk	.30	—14.6	22.0	—19.3	19.6
5494	Pure Honey	Not known	Addison Brown, Wall St., Norwalk	.20	—14.9	23.7	—17.6	22.9
5353	None	Said to be native from farmers	Chas. Starr, New Milford	.15	—15.1	23.3	—17.6	25.4
5357	Strained Honey	Francis H. Leggett & Co., New York	Logan Bros., Bridgeport	.25	—16.2	22.3	—19.4	25.0
5491	None	Not known	G. W. Raymond, Norwalk	.15	—16.6	22.9	—19.9	20.8
5101	Pure White Clover Honey	W. J. Lamb	S.S. Adams, 412 State St., New Haven	.15	—16.8	25.7	—19.1	26.5
5275	Pure Strained Honey	The Crystal Conserve Co., New York	Hills & Co., Hartford	.25	—17.3	23.5	—20.5	24.6
5358	None	Said to come from Leggett	Barnum & Reed, 307 Main St., Danbury	.25	—17.4	22.6	—18.7	24.6
5274	None. Sold for Orange Blossom	Hildreth Bros. & Segelken, New York	W. W. Walker, Hartford	.15	—17.6	24.5	—18.9	24.6
5048	Pure Clover Dell Honey	D. M. Welch & Son	D. M. Welch & Son, Congress Ave., New Haven	.10	—18.1	25.5	—21.3	24.1
5047	Pure Honey	Not known	F. H. Kearney, Cor. Hill and Congress Ave., New Haven	.15	—18.2	22.7	—19.6	23.7
5103	Pure White Cal. Honey	F. P. Adams & Co., Boston, Mass.	F. A. Basserman, 621 Grand Ave., New Haven	.25	—18.4	21.9	—20.2	24.4
5272	Pure Honeysuckle Honey	W. J. Lamb	F. Farrenkopf, Rockville, Conn.	.20	—18.4	24.0	—20.5	24.7

TABLE VI.—STRAINED HONEYS—*Continued.*

Station No.	Label.	Manufacturer or Producer.	Dealer.	Price per package.	Polarization. Direct. Degrees	Direct. Temper-ature, C.	After inversion. Degrees.	After inversion. Temper-ature, C.
5489	Orange Blossom Honey, &c.	Leslie, Dunham & Co., Brooklyn, N.Y.	A. J. Finney, 202 Main St., Stamford	$0.25	−18.5	23.1	−23.1	22.2
5466	Choice Honey	C. A. Stanton, Newington	Sov. Trading Co., 282 Main St., New Britain	.18	−18.8	21.4	−21.5	22.2
5493	Pure Orange Blossom Honey. Eagle Brand	Not known	W. R. Bates, Norwalk, Conn.	.18	−19.0	22.8	−22.1	20.7
5271	None	Said to be Lamb	Ransom Bros., Rockville, Conn.	.20	−19.6	24.2	−19.8	24.7
5102	Pure Extracted Honey	H. D. Gloyd, Boston, Mass.	Daniel Dore, 577 Grand Ave., New Haven	.15	−20.4	23.0	−22.7	25.6
5425	Pure California Honey	Not known	Not known	.18	−20.8	24.8	−25.1	21.7
5091	Orange Blossom Honey, &c.	Leslie, Dunham & Co., Brooklyn, N.Y.	Gilbert & Thompson, New Haven	.30	−21.2	22.3	−24.0	26.1
5359	Pure Orange Blossom Honey. Eagle Brand	Not known	Village Store Co., E. Main St., Bridgeport	.18	+ 1.2	24.5	−18.2	23.6
	Contain Cane Sugar.							
5354	Pure Clover Honey	Vermont Maple Syrup Co., Bridgeport	D. Hallett, 470 E. Main St., Bridgeport	.20	+24.2	23.3	−14.5	23.7
5363	Durkee's Choice Extracted Clover Honey	J. W. Durkee & Co., New York	E. F. Platt, 37 E. Main St., Waterbury	.10	+15.0	23.2	−15.6	23.0
	Consist of or contain glucose syrup.							
5360	Pure California Honey (&c.)	Not known	M. Blanchette, S. Main St., Waterbury	.20	+30.2	23.5	+27.2	24.0
5270	Pure Strained California Honey	Hildreth Bros. & Segelken, New York	E. Glaeser, Rockville	.20	+38.4	23.3	+35.6	24.0
5273	Choice Clover Honey	Chas. Israel & Bro., New York	H. J. Case & Co., Hartford	.20	+43.2	24.7	+38.2	24.4
5314	Choice Golden Rod Honey (&c.)	Wm. Thompson, Wayne Co., N. Y.	W. A. Smith, Norwich	.25	+53.5	23.7	+50.5	23.8
5352	Pure Honey	Not known	79 White St., Danbury	.18	+58.8	23.6	+56.4	24.0

each bearing a label showy with flowers, with the highly idealized picture of a bee in the center, over the picture of a hive, and the words, "Pure Honey." "Trademark."

No two samples were alike in composition. One was probably pure honey, another was certainly glucose syrup, the three others were perhaps honey, but of doubtful purity.

TABLE VII.—SAMPLES OF HONEY PUT UP IN SIMILAR PACKAGES.

No.	Label of Packages.	Polarization. Direct. Degrees.	Direct. Tempera-ture, C.	After Inversion. Degrees.	After Inversion. Tempera-ture, C.
5420	1 Pound Pure Honey. (Blown in bottle.)	−12.0	24.7	−17.3	22.5
5448		−13.2	22.5	−16.1	18.4
5359	Pure Orange Blossom Honey. Eagle Brand	+ 1.2	24.5	−18.2	23.6
5423		− 6.8	25.1	−15.6	22.4
5493		−19.0	22.8	−22.1	20.7
5360	Pure California Honey. Put up expressly for family or medical use	+30.2	23.5	+27.2	24.0
5425		−20.8	24.8	−25.1	21.7
5272	Lamb's Pure Honeysuckle Honey	−18.4	24.0	−20.5	24.7
5315		−13.7	22.0	−16.1	24.4
5352	Pure Honey	+58.8	23.6	+56.4	24.0
5467		− 7.9	23.3	−11.2	22.0
5492		−12.7	23.7	−16.9	21.2
5494		−14.9	23.7	−17.6	22.9
5047		−18.2	22.7	−19.6	23.7
5310	Choice Extracted Honey. E. C. Hazard & Co.	− 5.6	23.2	−16.5	24.0
5424		−11.8	25.1	−14.5	22.5
5449	C. A. Stanton. Choice Honey, Newington, Conn.	− 5.1	23.8	−11.0	22.3
5466		−18.8	21.4	−21.5	22.2
5091	Orange Blossom Honey. Leslie, Dunham & Co., Brooklyn, N. Y.	−21.2	22.3	−24.0	26.1
5489		−18.5	23.1	−23.1	22.2

EXAMINATION OF LARD.

By A. L. Winton.

Pure Lard.

Pure lard is the fat of swine, separated from the animal tissue by the process of "rendering." It should contain less than one per cent of water and foreign matters.

The choicest lards are made from the whole "leaf," or from the residue, after rendering the leaf at low temperatures and expressing the "neutral lard" which is used in the manufacture of oleomargarine. A good quality of lard is also made from back-fat and leaf rendered together. Fat from the head and intestines goes to make cheaper grades.

Lards may be either kettle or steam-rendered; the kettle process being usually employed for the choicer fat parts of the animal, while head and intestinal fat furnish the so-called "steam lard." Steam lard, however, is sometimes made from the leaf, and on the other hand other parts than the leaf are often kettle-rendered. Kettle-rendered lard usually has a fragrant cooked odor and a slight color, while steam lard often has a strong animal odor.

Adulterations of Lard.

Bell (1881) stated that water is the only adulterant which came under his notice in England. Dietzsch (1883) cited water as the chief adulterant, but added that "American refined lard" is a mixture of hog fat, oleomargarine, stearin and beef tallow.

The celebrated case of McGeoch, Everingham & Co. vs. Fowler Bros., which was tried before the Chicago Board of Trade in 1883, developed the facts that the mixing of cotton seed oil, beef stearin, etc., with lard at that time was practiced in Chicago. The chief, and at present, apparently the only adulterants of lard in common use, are other cheaper fats, of which cotton seed oil and "stearin"* are the ones mostly used; the former especially because of its cheapness, the latter in order to give solid consistence to the mixture.

* By rendering at a low temperature, and subsequently straining and pressing, beef fat is separated into two parts; "oil," which finds use in the manufacture of oleomargarine or imitation butter, and "stearin," the more solid fat used in making lard substitutes or imitations.

The misleading term "refined lard," which, until 1889, was used to designate imitations, composed largely of cotton seed oil and beef stearin, has since been abandoned, and such mixtures are now branded as "lard compounds."

N. K. Fairbank & Co. and Swift & Co. have gone a step further and manufacture, under the names of cottolene and cotosuet, mixtures of cotton seed oil and beef fat, which are not sold as imitations of lard, but as substitutes, under copyrighted trade names.

Neither of the materials used as lard adulterants are considered to be at all injurious to health. But the mixture of cotton seed oil and stearin is cheaper than pure lard, and by many people is considered inferior for culinary operations.

Methods of Detecting Lard Adulterations.

The most complete work on the subject of lard adulteration was published by Wiley as Part IV, Bulletin 13, of the U. S. Department of Agriculture, Division of Chemistry. In this are described in detail the processes used in the manufacture of lard and lard adulterants, the properties of these fats, the methods of identification, and the results of the examination of numerous samples of pure and adulterated lards, cotton seed oil, various stearins, etc.

Of the numerous methods which have been proposed for the detection of foreign fats, three have been selected as best suited for our purpose.

1.—Bechi's silver test as modified by Dudley is described in detail by Wesson, in a recent article on lard adulteration (Jour. Amer. Chem. Soc. xvii, 724). The author, whose experience in this kind of work has been very extensive, states that this is the best single test for cotton seed oil we have. In doubtful cases the lard should be treated with nitric acid, as recommended by Wesson.

2.—Hübl's Iodine absorption number: I have followed in all essentials Hübl's directions as given in Bulletin 13, Part IV, of the Division of Chemistry, U. S. Dept. of Agriculture, p. 462.

For weighing the fat, however, I have used, as recommended by Wesson, flat-bottomed glass cylinders, 10 mm. in diameter and 20 mm. high. These weigh less than 2 grams and do not change weight perceptibly from one weighing to another.

Five to seven c.c. of the melted fat (according as the iodine number is high or low), are measured into a weighed cylinder from a delicate pipette. After cooling, the cylinder and fat are weighed and introduced into the glass-stoppered vial in which the subsequent operations are performed.

3.—Belfield's microscopic test modified by Gladding: The details of this process were kindly furnished by Mr. T. S. Gladding, and have since been published by him, Jour. Am, Chem. Soc. xviii, p. 189.

Examination of Lard from the Connecticut Market.

One hundred and sixty-two samples have been collected by agents of the Station, in twenty-one cities and villages of Connecticut, between the third of October and twenty-third of November, 1895.

These samples fall into three classes :

1st.—Pure lard.

2d.—Lard substitutes, "compound lards," cottolene, cotosuet, etc., sold under their trade names, but not as pure lard.

3d.—Adulterated lard, or imitations sold as lard.

Some samples were evidently duplicates of well known brands, already examined, and were not tested.

Pure Lard.—In Table VIII are given the results of examination of sixty-four samples of this class.

The first six samples are stated to have been rendered by the butchers from whom they were purchased. The nine samples which follow them were probably all kettle-rendered. Of the remainder a considerable number were undoubtedly steam lards. The prices paid for these pure lards ranged from nine to fourteen cents per pound. The average price was 11.4 cents.

Bechi's test, applied directly, usually gave with these pure lards no color at all or only a slight color. In a few samples, probably steam lards, a decided purple color was obtained, but after purification of the fat by nitric acid as described by Wesson, Bechi's test produced only a slight coloration.

The highest iodine number is 68.3, the lowest 54.5. The lower numbers were found in the kettle-rendered samples. Microscopic examination in each case revealed the presence of the lard stearin in crystals, and in no case were the characteristic beef stearin forms present.

Lard Compounds and Lard Substitutes.—In Table IX are described eleven samples of this kind, sold for what they really were : that is, not pure lard, but fat mixtures resembling lard, and having the same culinary use. They are not adulterated goods, in accordance with provisions *a* and *b*, Section 3, of the Connecticut Pure Food Law of 1895. The prices of these lard substitutes and compounds ranged from 8 to 10 cents per pound.

All of these samples, when tested with Bechi's reagent, formed a mirror of reduced silver and became discolored, acquiring in some cases a dark brown, in others a purple black tint. Previous purification of the lard samples did not change the result.

The lowest iodine number found in any case was 81.5, the highest 92.6. Armour's lard compound, which was formerly so mixed as to have about the same

Table VIII.—Pure Lard.

Station No.	Brand.	Dealer.	Price per Pound in Cents.	Chemical Examination.		Microscopic Examination.
				Bechi Test.	Iodine Number	
5294	Butcher's Lard	J. R. Allen, 122 W. Main St., Norwich	10	Colorless.	65.6	Lard Stearin.
5295	" "	Elijah Tracey's Market, Norwich	12	Slight Color.	64.2	" "
5318	" "	E. Dutton, Agt., Winsted	12	Colorless.	56.6	" "
5332	" "	Lockhart's Market, Main Cor. Grand St., Bridgeport	12	"	54.5	" "
5477	" "	Menz Market, 5 Pacific St., Stamford	12	Slight Color.	66.8	" "
5416	" "	W. C. Wade, State St., Hartford	10	Slight Brown.	59.9	" "
5306	Pure Lard, Kettle-rendered, White, Perry & Dexter, Worcester, Mass.	Brainard & Bartlett, Putnam	10	Colorless.	59.1	" "
5305	Pure Leaf Lard, White, Perry & Dexter, Worcester, Mass.	A. L. Allen, Norwich	13	"	60.8	" "
5346	Pure Kettle-rendered Lard, Meriden Provision Co.	West End Cash Market, 453 W. Main St., Waterbury	13	Slight Color.	60.3	" "
5411	Pure Lard, Meriden Provision Co.	J. Kerin, 62 North St., New Britain	10	Colorless.	64.1	" "
5409	" " " "	A. M. Bidwell, 344 Main St., Middletown	12	Slight Brown.	63.9	" "
5331	" " McElroy Bros., Bridgeport	White Front Market, 466 East Main St., Bridgeport	12	Colorless.	62.3	" "
5404	Kettle-rendered Pure Lard, Providence Beef Co.	W. S. Chappell, 148 State St., New London	10	"	65.2	" "
5337	Pure Leaf Lard, F. A. Bartram & Co., Bridgeport	McGraw & Baldwin, White St., Danbury	13⅛*	Slight Color.	58.5	" "
5119	Pure Lard, Plumb & Winton, Bridgeport	Manufacturer	....	Colorless.	65.0	" "
5284	" " C. H. Davis & Co., Norwich	J. A. Turner, Willimantic	10	"	65.6	" "
5391	" " " " "	Bodo Bros., Moosup	9	"	63.4	" "
5009	Choice Leaf Lard, Warranted Strictly Pure, S. E. Merwin & Son, New Haven	Manufacturer	14†	"	64.2	" "
5008	Choice, Strictly Pure Elm City Lard, S. E. Merwin & Son, New Haven	Manufacturer	12†	Light Brown.	66.3	" "
5020	S. E. Merwin & Son, New Haven	J. Casseriego, Shelton Ave., New Haven	12	"	67.7	" "
5010	"Pure" (Red Label), Sperry & Barnes, New Haven	L. D. Chidsey, Church St., New Haven	14†	Colorless.	63.5	" "

* In 3 pound pail. † In 5 pound pail.

TABLE VIII.—PURE LARD—*Continued.*

Station No.	Brand.	Dealer.	Price per Pound in Cents.	Chemical Examination. Bechi Test.	Chemical Examination. Iodine Number	Microscopic Examination.
5341	"Pure" (Red Label), Sperry & Barnes, New Haven	J. M. Bristol & Son, Central Market, Ansonia	12	Colorless.	59.5	Lard Stearin.
5017	Sperry & Barnes, New Haven	Henry Hahn, 1327 W. Chapel St., New Haven	12	Slight Color.	66.7	" "
5339	Steam Refined Lard, Sperry & Barnes, New Haven	E. D. Booth, 200 Main St., Birmingham	13	Colorless.	63.3	" "
5016	Sperry & Barnes, New Haven	Shelton Ave. Cash Store, 228 Shelton Ave., New Haven	12	Slight Color.	66.4	" "
5013	Sperry & Barnes, New Haven	P. Jente & Bro, Broadway, New Haven	11	" "	64.8	" "
5281	Pure Lard, Comstock, Providence, R. I.	Bert Thompson, Willimantic	12	Slight Color.§	61.6	" "
5113	Pure Leaf Lard, Swift & Co., Chicago	C. E. Hart & Co. 350 State St., New Haven	14	Colorless.	61.6	" "
5110	" " " "	Grand Ave. Market, 830 Grand Ave., New Haven	12	Colorless.§	63.8	" "
5403	Pure Lard, Warranted, J. B. Mason & Sons, Providence	Joseph Kopp, 207 Bank St., New London	10	Colorless.	65.0	" "
5399	Pure Lard, J. B. Mason & Sons, Providence	W. A. Murray, 672 Bank St., New London	10	"	64.0	" "
5340	Warranted Pure Lard, The L. C. Bates Co., New Haven	P. McEnerney, 130 Main St., Birmingham	12	Slight Color.	65.8	" "
5392	Warranted Pure Lard, The L. C. Bates Co., New Haven	Holden Arnold, Willimantic	10	Colorless.	63.4	" "
5327	Warranted Pure Lard, The L. C. Bates Co., New Haven	Smith & Burns, Cor. Liberty and Keeler Sts., Danbury	12	"	62.7	" "
5334	Pure Lard, Lee & Hoyt, New Haven	Kinney's, Bank St., New Milford	13	Slight Color.	63.0	" "
5286	Pure Lard, G. H. Hammond, Indiana	Purinton & Reade, Willimantic	12	Colorless.	66.4	" "
5325	" " "	Chas. Starr, New Milford	13	"	62.9	" "
5479	" " "	Sam'l Comstock, Jr., 72 N. Main St., S. Norwalk	12	"	66.3	" "
5308	Warranted Pure Lard, Robinson Brand, John F. Crocker & Co., Boston	P. M. Leclair, Putnam	10	"	63.6	" "
5285	Pure Lard, North Packing & Provision Co., Boston	H. C. Hall, Willimantic	12	"	66.0	" "

§ After treatment with nitric acid.

TABLE VIII.—PURE LARD—*Continued.*

Station No.	Brand.	Dealer.	Price per Pound in Cents.	Chemical Examination. Bechi Test.	Chemical Examination. Iodine Number	Microscopic Examination.
5288	Choice Grocery Lard, Strictly Pure, North Packing & Provision Co., Boston	J. S. Hennessy, Willimantic	10	Colorless.	64.5	Lard Stearin.
5280	Pure Lard, John P. Squire & Co., Boston	Frank Larrabee, Willimantic	12	"	65.4	" "
5480	Best Lard, Absolute Purity, Finest Quality, Geo. C. Napheys & Co., Philadelphia	W. & E. Osterbanks, 53 Main St., Norwalk	11¾	Slight Color.§	66.3	" "
5453	Pure Lard, Armour & Co., Chicago	Patrick Costello, 153 Pratt St., Meriden	10	Slight Color.	68.3	" "
5109	Pure Leaf Lard, Armour & Co., Chicago	Booth Meat Co., 370 State St., New Haven	12	Colorless.	65.7	" "
5019	Pure Lily Leaf Lard, Nelson, Morris & Co., Chicago	Geo. M. Coombs, Whalley Ave., New Haven	12	"	67.7	" "
5454	Pure Lard, H. L. Handy, Springfield, Mass.	C. M. Shipple, 141 Turnbull St., Hartford	8	"	65.2	" "
5410	" " " " "	Boston Branch Grocery, 238 Main St., New Britain	12	"	66.5	" "
5287	" " J. B. Mason & Sons, Providence	H. Dion, Willimantic	12	"	65.7	" "
5324		McNamara, 396 E. Main St., Bridgeport	10	"	59.9	" "
5458		Pacnam & Cook, 26 W. Main St., Meriden	10	Colorless.§	63.2	" "
5473		Firmey & Benedict, 41 Wall St., Norwalk	12	Slight Color.	62.6	" "
5457		Wm. J. Cashmann, 133 Pratt St., Meriden	10	"	65.5	" "
5418		I. W. Buckley, Hartford	12	Colorless.	67.3	" "
5419	Kettle-rendered Lard	I. C. Duvan, Windsor Locks	12	"	64.2	" "
5414		H. Jonas, Temple St., Hartford	12	"	64.1	" "
5483		Geo. A. Ferris, 184 Main St., Stamford	10	Colorless.§	65.5	" "
5445		John A. Pilgard, 138 Front St., Hartford	10	Colorless.	61.2	" "
5015		F. H. Kearney, Cor. Congress Ave., and Hill St., New Haven	10	Slight Color.	65.8	" "
5107		Pagter Bros., 800 Grand Ave., New Haven	12	"	64.5	" "
5114		Coe & Field, 422 State St., New Haven	10	Slight Color.§	63.8	" "
5329		T. R. Hoyt & Co., 7 West St., Danbury	12	Colorless.	63.7	" "
5320		T. Kilmartin, 495 W. Main St., Waterbury	12	"	66.1	" "
5328		E. L. Sullivan, 436 E. Main St., Bridgeport	10	Slight Color.	66.6	" "

§ After treatment with nitric acid.

iodine number as pure lard, thus making Hübl's iodine absorption test of no value in detecting the presence of cotton seed oil, is now apparently compounded according to another formula.

The presence of beef stearin was readily detected by the microscope in every instance. Cottolene and cotosuet, which are claimed to be made of cotton seed oil and beef suet and to contain no lard, react like "compound lards" with the reagents mentioned.

Lard Compounds and Imitations, sold as Lard.—In Table X are given analyses of forty-three samples of this class. In every case the purchasing agent asked for lard and there was sold to him an imitation or substitute without any statement or hint that it was not pure lard. The prices paid ranged from seven to twelve cents per pound and averaged 9.3 cents.

TABLE IX.—LARD COMPOUNDS AND LARD SUBSTITUTES SOLD UNDER THEIR TRADE NAMES, BUT NOT AS PURE LARD.

Station No.	Brand.	Dealer.	Price per Pound in Cents.	Chemical Examination.		Microscopic Examination.
				Bechi Test.	Iodine Number	
5117	Refined Lard Compound, N. K. Fairbank & Co.	N. Stein, 811 Grand Ave., New Haven	10	Dark Brown.	91.5	Beef Stearin.
5108	Lard Compound, Armour & Co.	Booth Meat Co., 370 State St., New Haven	8	"	85.8	"
5115	Superior Lard Compound, Armour & Co., Kansas City	Peoples' Market, 448 State St., New Haven	8	"	83.3	"
5012	Lard Compound, Nelson, Morris & Co.	J. C. Kelley, Boulevard Cash Store, New Haven	8	"	81.5	"
5289	Lard Compound, G. H. Hammond	Holden Arnold, Willimantic	8	"	91.1	"
5290	Superior Compound Lard, Swift & Co., Chicago	A. A. Trudeau, Willimantic	8	"	83.6	"
5291	Royal Lard Compound, Whitford & Bartlett, Providence, R. I.	Bert. Thompson, Willimantic	8	"	87.1	"
5116	Lard Compound, Stoddard, Kimberly & Co., New Haven	Geo. W. Cooper, junction Grand Ave. and St. John St., New Haven	10	"	87.6	"
5112	Lard Compound	D. Dore, 577 Grand Ave., New Haven	10	Purple Black.	84.7	"
5021	Cotosuet, Swift & Co., Chicago	P. Jente & Bro., Broadway, New Haven	10*	Dark Brown.	85.5	"
5468	Cottolene, N. K. Fairbank & Co., Chicago	D. M. Welch & Son, Congress Ave., New Haven	8⅓*	"	92.6	"

* In three pound pails.

TABLE X.—LARD COMPOUNDS SOLD FOR LARD.

Station No.	Dealer.	Price per Pound in Cents.	Chemical Examination. Bechi Test.	Chemical Examination. Iodine Number.	Microscopic Examination.
5408	J. H. Shieferman, Main St., Middletown	9	Dark Brown.	91.9	Beef Stearin.
5406	W. J. Trevithick, Rapella Ave., Middletown	9	"	91.2	" "
5455	A. D. Cook, 56 Market St., Hartford	10	"	92.3	" "
5456	Chas. S. Kelley, 154 Front St., Hartford	10	"	90.5	" "
5118	Wallace St., next to R. R. Bridge, New Haven	10	"	91.7	" "
5475	Betts & Farrington, Wall St., Norwalk	12	"	93.4	" "
5345	——— 251 S. Main St, Waterbury	10	"	91.8	" "
5398	Wm. S. O'Brien, 729 Bank St., New London	8	"	95.5	" "
5402	S. D. Ameco, 64 Main St., New London	10	"	94.7	" "
5401	Geo. F. Barnstorf, 45 Main St., New London	10	"	86.5	" "
5349	M. M. Smith, Main St., Winsted	8	"	94.4	" "
5336	Mrs. Clancy, 925 Main St., Bridgeport	10	"	89.7	" "
5482	Lorenzo Dibble, N. Main St., S. Norwalk	7	"	95.7	" "
5407	Sam. Kennedy, 648 N. Main St., New Britain	10	"	87.3	" "
5405	Lee Bros. & Co., 500 Main St., New Britain	9	"	92.6	" "
5319	Branch York State Butter Co., 844 Bank St., Waterbury	9	"	87.0	" "
5321	Frank Pepe, 4 Middle St., Waterbury	10	Purple Black.	88.4	" "
5347	——— 843 Bank St., Waterbury	8	Dark Brown.	91.5	" "
5344	Ladd's, 96 S. Main St., Waterbury	10	"	94.6	" "
5342	John B. Vallee, 21 Grand St., Waterbury	10	Purple Black.	92.9	" "
5350	King's Market, Cor. Keeler and Liberty Sts., Danbury	10	Dark Brown.	80.0	" "
5338	P. D. Vroom, 5 Keeler St., Danbury	8	Purple Black.	89.4	" "

TABLE X.—LARD COMPOUNDS SOLD FOR LARD—*Continued.*

Station No.	Dealer.	Price per Pound in Cents.	Chemical Examination. Bechi Test.	Chemical Examination. Iodine Number.	Microscopic Examination.
5390	Geo. A. Robertson, 70 State St., Bridgeport	9	Purple Black.	87.6	Beef Stearin.
5333	——— 102 N. Washington Ave., Bridgeport	10	Dark Brown.	88.0	" "
5330	J. J. Donovan, Cor. E. Main and Steuben Sts., Bridgeport	9	"	77.1	" "
5326	D. Sullivan, 881 Main St., Bridgeport	10	Purple Black.	91.3	" "
5323	Centennial American Tea Co., 856 Main St., Bridgeport	10	"	90.5	" "
5322	D. Hallett, 470 E. Main St., Bridgeport	10	"	90.5	" "
5348	P. T. Gloster & Co., Main St., Winsted	10	Dark Brown.	90.9	" "
5400	T. Manning, 407 Bank St., New London	10	"	94.5	" "
5111	——— 40 (?) Walnut St., New Haven	10	"	82.4	" "
5011	H. C. Dingwall & Co., 68 Congress Ave., New Haven	9	"	90.1	" "
5459	Russell Bros., 2 Colony St., Meriden	8	"	92.4	" "
5471	New York Cash Grocery, N. Main St., Norwalk	7	"	81.1	" "
5474	W. R. Bates, Norwalk	7	"	94.5	" "
5412	C. H. Russell, New York Butter and Grocery House, 383 Main St., Hartford	9	"	90.2	" "
5415	Joseph Hagarty, 75 Front St, Hartford	10	Purple Black.	91.2	" "
5417	H. Bacharach, 13 Park St., Hartford	10	Dark Brown.	96.0	" "
5451	Foley's Market, 487 Main St., Hartford	10	"	89.6	" "
5452	E. M. Palmer, 124 Albany Ave., Hartford	10	"	89.6	" "
5413	John Bonora, Windsor Locks	10	Dark Green.	87.3	" "
5478	New York Grocery Co., 206 Main St., Stamford	8	Dark Brown.	94.7	" "
5484	A. J. Finney, 202 Main St., Stamford	9	"	96.0	" "
5014	Italian Grocery, cor. Oak and Factory Sts., New Haven	10	"	85.6	" "

EXAMINATION OF PEPPER.

By A. L. Winton.

A considerable part of the chemical work described in this paper was done by Mr. W. L. Mitchell.

Nature of Pepper.—Both the white and the black pepper of commerce are the fruit of *Piper nigrum*, a climbing perennial plant, indigenous to Malabar and cultivated in various other tropical countries.

The berries or peppercorns grow close to the stems in long spikes, twenty to fifty berries in each spike, and change color as they ripen, from green to red and finally to black.

The black peppercorns of commerce are prepared by picking and drying the unripe spikes as soon as some of the berries begin to turn red. During the drying process the berries shrivel somewhat and turn black.

"White peppercorns" are the ripe berries from which the outer shell has been removed. They are grey in color and have a smooth surface. White pepper is not so pungent as the black kind, but is considered by many to have a finer flavor.

Long pepper, although produced by a plant (*Piper longum*) belonging to the same genus as the true pepper, is very different in its looks and flavor. The small berries are very closely crowded together in elongated clusters often an inch or more in length. It has a spicy taste, but none of the fine flavor of true pepper, to which it is sometimes added as an adulterant. Long pepper is apt to have earth adhering to it.

Cayenne, often called "red pepper," is the fruit of several species of *Capsicum* quite similar to our garden peppers and is radically different from the kinds of pepper already named. It is also used as an adulterant of black pepper, to restore the "bite," which has been lost by the addition of tasteless foreign matters.

Pepper is the most important commercially of all the spices and condiments. It is almost entirely imported in the form of peppercorns, which are admitted free of duty.

According to the Report on "Imports for Consumption into the United States, 1894 and 1895," prepared by the Bureau of Statistics, U. S. Treasury Department, 19,937,422 pounds of whole pepper, having a value (at four cents per pound) of

$791,853.93, were brought into the United States during the year 1895. A larger quantity of pepper was imported than of any other single spice or condiment, and the money value of the imported pepper was more than one-third of all unground spices taken together.

Assuming that all this pepper is annually consumed in the country and that Connecticut consumes a quantity proportional to the population (one per cent.), nearly 200,000 pounds must be annually used in the State.

The wholesale price of this, unground, would be nearly $8,000, but the retail price would be $56,000. This does not take into account the enormous quantities of adulterants, for which the consumer usually pays about the same price as for pure pepper.

The Adulteration of Pepper.—Ground pepper, the form in which most of the pepper is sold to consumers, is perhaps the most extensively adulterated of all food products. The list of things which have been used as adulterants includes bran, hulls and other by-products from wheat, maize, rice, oats, buckwheat and other grains, ground linseed, olive and rape seed cake, shells (often roasted or charred) of cocoanut, almonds and other nuts, sawdust, mustard husks, cayenne, long pepper, pepper shells, terra alba.

In order to get a proper mixture of light and dark particles, it is customary to use two or more adulterants, the one dark, the other light-colored; as for example: Roasted cocoanut shells and wheat middlings; buckwheat hulls and buckwheat middlings.

Cayenne reinforces the pungency which has been reduced by dilution. Mustard husks also give a certain "bite" to the mixture.

Wheat or buckwheat middlings furnish adulterants for white pepper which closely resemble the genuine pepper in appearance.

Pepper shells or dust consists of the hulls removed from white pepper with adherent dirt and often other waste material.

Examination of Samples of Pepper from the Connecticut Market.

One hundred and fourteen samples have been bought by our sampling agents from stock sold in bulk as well as in manufacturers' packages. The results of the examinations appear in the following tables and discussion:

Methods of Examination.

Microscopic Examination.—A portion of the sample was first viewed in water with ordinary illumination, using magnifying powers of 74 and 392 diameters. The character and size of the starch granules were noted and the results supplemented by examination with polarized light and also by viewing portions treated with iodine. The foreign tissues could often be identified without use of clearing agents.

The same portion which had been viewed directly was then treated with potash and again examined.

The crude fiber separated in the course of chemical analysis furnished material in which much of the denser tissues, such as "stone cells," was brought out distinctly and could be easily identified. The presence of charcoal or charred shells was also shown in this material, as it remains black after the treatment with acid and alkali, while the tissue of genuine pepper and of most adulterants, even buckwheat hulls, is of a light brown color. The presence of charred material was confirmed by bleaching tests with nitric acid and chlorate of potash.

Chemical Analysis.—Water, ether extract, fiber and ash, were determined by the methods which are used for the analysis of feeding stuffs. The drying in hydrogen was continued until constant weight was secured, which required about eight hours. The loss represents not only water, but also a part of the volatile oil. The extraction with absolute ether was complete at the end of eight hours. The same weighed portion was used for determination of water, ether extract and fiber.

The ether extract from pure pepper consists of piperine and resin, and the former invariably crystallizes out from the resin on cooling; but when the pepper is adulterated with stuff which contains fat or oil, the latter may completely hide the piperine crystals if it does not prevent their forming in the extract. We regard the absence of crystals in the ether extract as certain evidence of adulteration.

If the fat or oil introduced in the adulterant brings up the weight of ether extract to the amount which is found in pure pepper, a nitrogen determination in the extract from 10 grams of pepper will disclose its real nature.

Pure piperine contains 4.91 per cent. of nitrogen, but the ether extract of pepper consists in part of resin, which lowers the percentage considerably. Thus a sample of pure white pepper gave an ether extract containing 3.25 per cent. nitrogen, and of pure black pepper 2.64 per cent. In adulterated samples the ether extract had less than two per cent. of nitrogen.

Adulterated peppers, as a rule, contain: 1. Either less ether extract, or, 2. less nitrogen in the ether extract, or, 3. more fiber, or, 4. more mineral matter than pure ground pepper. It would be difficult to find adulterants which could be used in any considerable quantity and yet fail to be detected by one or more of these tests.

Pure Black Pepper.—In Table XI are grouped all those samples, fifty-nine in number, in which no foreign substance was detected with the microscope and which within reasonable limits agree in chemical composition with samples of undoubted purity.

It is possible that some of these samples are adulterated with

Table XI.—Probably Pure Black Pepper.

Station No.	Brand (taken from label on package in which goods were sold).	Dealer.	Price paid per ¼ pound. Cents.	Microscopic Examination.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
	Peppercorns ground at Station.							
5623	West Coast Sumatra Black Pepper		--	Pepper Starch and Tissue	10.33	8.30	11.49	4.85
5631	Singapore Black Pepper		--	" " "	10.74	7.57	12.07	3.74
	Ground Pepper in labeled packages.							
5568	Absolutely Pure Pepper. D. & L. Slade Co., Boston	Holden Arnold, Willimantic	10	" " "	11.24	7.66*	12.48	4.21
5071	Pure Pepper, warranted strictly pure Bennett, Sloan & Co.	Geo. M. Coombs, 195 Whalley ave., New Haven	10	" " "	10.72	7.02	14.30	4.96
5566	S. I. Specially Imported Ground Shot Pepper. Thurber Whyland Co., New York	G. D. Strickland, South Manchester	10	" " "	8.77	6.72	11.39	4.39
5567	Pepper. O. H. Blanchard	H. Dillon, Willimantic	10	" " "	10.18	7.26	13.10	4.71
5569	Genuine Malabar Black Pepper. Bennett, Simpson & Co., London	Waterbury Grocery Co., 163 Bank street, Waterbury	10	" " "	8.69	8.09	12.84	4.65
5570	Pure Pepper. Boardman & Sons., Hartford	J. Kerin, 62 North St., New Britain	10	" " "	10.63	7.84	12.86	4.10
5573	Crescent Mills Pure Pepper. John P. Augur, New Haven	Foote & Westwood, West Main street, Waterbury	10	" " "	10.13	7.65	10.90	3.90
5574	Blue Ribbon Pure Black Pepper. Austin, Nichols & Co., New York	Geo. Farley, Putnam	10	" " "	11.89	8.15	12.72	4.60
5576	Pepper. Lincoln, Seyms & Co., Hartford	E. F. Platt, 37 E. Main St., Waterbury	10	" " "	10.89	7.11	12.85	4.82
5577	Ground Black Pepper, warranted pure. Bryan, Miner & Read, New Haven	P. McEnerney, Main St., Birmingham.	10	" " "	9.36	7.30	12.70	4.17
5581	Pure Black Pepper. Bryan, Miner & Read, New Haven	Holden Arnold, Willimantic	10	" " "	11.18	7.81	15.41	5.23
5583	XXX Pepper. E. R. Durkee & Co., New York	Thomas Nolan 250 Pratt St., Meriden	10	" " "	12.23	7.62	12.84	5.75
5585	Red Shield Pepper. Jas. G. Powers & Co., New York	G. A. Ray, Norwich	9	" " "	11.34	8.33	14.50	5.88
5588	Pure Pepper. Clark, Chapin & Bushnell, New York	R. D. Baldwin, Bridge St., Winsted	10	" " "	10.79	8.33	13.23	5.61

* 2.64% nitrogen in ether extract.

TABLE XI.—PROBABLY PURE BLACK PEPPER—*Continued.*

Station No.	Brand (taken from label on package in which goods were sold).	Dealer.	Price paid per ¼ pound. Cents.	Microscopic Examination.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
5590	Pure Pepper, Adams & Howe, New York	—— 79 White St., Danbury	10	Pepper Starch and Tissue	8.30	8.34	14.48	5.93
5591	Pure Black Pepper. W. H. Mansfield & Co., Putnam, Conn.	W. H. Mansfield & Co., Putnam	10	" " "	11.30	7.96	12.73	4.46
5592	Pure Pepper. Union Spice Co.	Union Pacific Tea Co., 253 Main street, Danbury	10	" " "	11.04	7.79	12.67	5.74
5593	Pure Pepper. Swain, Earle & Co., Boston	James M. Young, Preston	10	" " "	11.00	7.32	12.80	4.22
5595	Strictly Pure Pepper. Barnum & Reed, Danbury	Barnum & Reed, 307 Main St., Danbury	12	" " "	10.26	6.62	13.53	4.68
5596	Strictly Pure Pepper. L. Battey & Son, Moosup	L. Battey & Son, Moosup	8	" " "	9.69	7.09	13.70	3.94
5597	Strictly Pure Pepper. C. H. Lyon, New London	C. H. Lyon, 42 Coit St., New London	10	" " "	10.41	6.76	12.23	3.97
5598	Pepper. Grand Union Tea Co., New York	Grand Union Tea Co., 237 Main street, Birmingham	10	" " "	11.34	8.11	13.63	5.56
5599	Strictly Pure Pepper, Excelsior Mills. A. R. R. Palmiter	George M. Spring, 214 Main St., Birmingham	12	" " "	11.06	8.06	12.60	5.87
5600	Pure Pepper. E. P. Hornick, New York	John P. Murphy, Norwich	10	" " "	10.19	7.46	12.17	5.62
	Ground Pepper sold in bulk.							
5516		—— 793 Bank St., Waterbury	10		10.48	7.70	12.82	5.75
5518		Corkey & Gannon, 29 Main St., New London	8		10.61	7.91	14.22	5.78
5521		—— 152 E. Main St., Bridgeport	10		11.97	8.60	11.83	6.58
5522		Dillon's Cash Grocery Store, 158 Main St., Ansonia	7		10.38	9.09	13.79	5.90
5524		M. Ahern, 160 Pratt St., Meriden	10		11.85	7.57	12.09	4.36
5528		W. H. Brown, Moosup	10		10.18	8.02	11.86	4.45
5529		D. E. Ketcham & Co., 33 Elm St., Danbury	8		11.61	7.34	11.09	4.37
5530		James M. Young, Preston	10		10.84	7.45	13.29	4.21
5532		Fred. H. Lewis, 98 W. Main St., Meriden	8		11.71	7.40	8.57	4.20

TABLE XI.—PROBABLY PURE BLACK PEPPER—*Continued.*

Station No.		Dealer.	Price paid per ¼ pound. Cents.	Microscopic Examination.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
	Ground Pepper sold in bulk.							
5536		McGraw & Baldwin, White St., Danbury	8		11.30	8.51	11.20	5.39
5538		Purinton & Reade, Willimantic	10		11.58	7.25	14.66	6.12
5539		—— 102 N. Washington Ave., Bridgeport	10		10.71	7.46	13.81	4.41
5540		Johnson's Cash Grocery, Main street, Winsted	10		10.29	7.76	13.44	5.87
5547		H. C. Hall, Willimantic	10		12.13	8.12	12.50	5.02
5551		Keeney Bros.	8		11.31	7.59	12.70	4.57
5552		W. S. Chappell, 148 State St., New London	10		11.21	8.13	11.52	3.79
5553		G. A. Ray. Norwich	5		9.63	8.64	14.13	6.10
5557		P. M. Leclair, Putnam	10		9.37	7.12	13.85	4.57
5558		D. W. Lawton, Main St., Winsted	12		9.47	7.62	13.83	6.00
5559		James Sullivan, Putnam	10		10.31	7.96	11.37	4.99
5560		The Clark & Stevens Cash Grocery, Howe St., Shelton	8		9.80	7.57	12.84	4.21
5562		Putnam Mfg. Co. Stores, Putnam	10		9.17	8.22	12.89	4.97
5563		T. Kilmartin, 495 W. Main St,, Waterbury	9		10.47	8.28	13.70	5.78
5564		M. H. Tilley, Main St., Birmingham	8		9.84	7.40	13.45	4.58
5571		W. A. Murray, 672 Bank St., New London	5		10 51	7.18	13.18	5.20
5507		Finney & Benedict, 41 Wall St., Norwalk	10		11.23	7.46	12.22	4.99
5506		Addison Brown, Norwalk	10		10 76	7.30	13.06	4.15
5504		Betts & Farrington, Norwalk	10		11.02	7.83	12.27	4.77
5067		Henry S. Dailey, 97 Whalley Ave., New Haven	10		11.08	7.86	11.33	4.45
5068		F. H. Kearney, cor. Hill St. and Congress Ave., New Haven	8		10.92	7.20	11.42	4.40
5070		Henry Hahn, 1327 West Chapel St., New Haven	9		10.90	8.00	12.88	4.80
5520		Jacob Walz, 54 Temple St., Hartford	10		11.22	6.59	15.52	6.42
5549		John B. Vallee, 21 Grand St., Waterbury	10		10.23	8.80	12.41	6.30

pepper shells, but not with appreciable quantities of other foreign matters. Twenty-six of these samples were sold in packages bearing the name and address of the manufacturers, and thirty-three were sold by grocers in bulk.

The lowest per cent. of ether extract found in any sample was 6.62. The highest per cents of fiber and ash were 15.41 and 6.42 per cent. respectively.

Adulterated Black Pepper.—In Table XII are given results of examinations of twenty-nine samples of this kind, seven sold in packages bearing the name of the manufacturer or dealer, and twenty-two sold in bulk.

All of these samples were condemned both by the chemical and microscopic investigation. With the microscope one or more of the following things were found in each sample: cayenne, starch, wheat, buckwheat, cocoanut shells, charred matter, sawdust and chaff.

In noting the character of the adulterants, we name in most cases the seed or the article from which the adulterant was derived. It is not always possible to state positively the particular product used. For example: where wheat starch and wheat tissue were identified, we have given wheat as the adulterant without attempting to say whether wheat middlings, wheat flour or wheat bran was used. The buckwheat products used were in some cases largely the black hulls, in others almost entirely the inner seed envelopes with starchy matter.

Whenever cocoanut shells and charred matter were both detected in the same sample, it is probable that the latter was derived from the former, although it was not always possible to identify the cocoanut "stone cells" in the blackened opaque masses.

Generally it is not possible to determine the exact per cent. of adulteration. In some samples, however, there was no evidence that any real pepper was present and the per cent. of ether extract showed that a number of samples did not contain more than 50 per cent. and in two cases not more than 20 per cent. of pure pepper. This does not disclose the full extent of adulteration, as most of the adulterants yield a considerable amount of ether extract.

In the columns giving the results of the chemical analyses, those figures which are abnormal, that is to say below 6.50% for ether extract, or above 16% for fiber, and 6.50% for ash, are printed in heavy faced type.

Table XII.—Adulterated Black Pepper.

Station No.	Brand (taken from label on package in which goods were sold).	Dealer.	Price paid per ¼ pound. Cents.	Microscopic Examination—Adulterants detected.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
	Ground Pepper in labeled packages.							
5572	First Quality Black Pepper	W. K. Spencer, 96 Main St., Middletown	8	Farinaceous Matter	8.72	**4.99**	15.97	6.43
5575	Strictly Pure Black Pepper. Stocker & Brill, Newburgh, N. Y.	—— 79 White St., Danbury	10	Buckwheat, Wheat, Cocoanut Shells	10.54	**5.33**	**19.42**	**8.63**
5578	Pepper. E. B. Worthington, Norwich, Conn.	A. L. Allen, Norwich	10	Buckwheat, Wheat	8.50	**4.45**	**24.14**	4.42
5584	XX Pepper. The Challenge Mills, New York	A. J. Hopkins, Boston Branch, Norwich	10	Buckwheat, Cocoanut Shells, Charred matter, Cayenne	8.96	**5.45**	**26.63**	4.02
5594	Pure pepper. E. S. Kibbe & Co., Hartford	S. E. Amidon, Willimantic	10	Buckwheat, Wheat, Cocoanut Shells, Charred matter, Cayenne	8.70	**4.59**	**18.34**	3.93
5601	A. & P. Pepper. Sultana Spice Mills	Atlantic and Pacific Tea Co., 269 East Main St., Bridgeport	15	Buckwheat, Wheat, Cocoanut Shells, Charred matter	9.92	**4.94**	14.06	3.91
5602	Windmill Brand Black Pepper. Loudon & Johnson, 181 Chambers St., New York	Ernest Glaeser, Rockville	8	Wheat, Sawdust, Cocoanut Shells, Charred matter	9.46	**4.16**	**21.67**	**7.60**
	Ground Pepper in bulk.							
5069		Keating's Store, cor. Oak and York Sts., New Haven	9	Wheat, Cayenne	10.49	**3.27**	13.72	**6.71**
5106		D. Dore, 377 Grand Ave., New Haven	5	Wheat	11.00	**5.24**	**16.80**	**8.19**
5450		B. Fowler, 6 High St., Hartford	10	Buckwheat, Wheat, Cocoanut Shells, Charred matter, Cayenne	8.09	**6.32***	**22.28**	4.17
5487		Geo. A. Ferris, 184 Main St., Norwalk	7	Buckwheat, Cayenne	9.64	7.90†	15.88	5.54
5503		N. Y. Cash Grocery, 206 Main street, Stamford	7	Wheat, Grain Hulls, Cocoanut Shells, Charred matter, Cayenne	8.61	**3.63**	**22.67**	**12.31**
5505		N. Y. Grocery Co., 15 N. Main St., S. Norwalk	8	Wheat, Grain Hulls, Cocoanut Shells, Charred matter, Cayenne	8.01	**3.68**	**23.01**	**12.18**

* 1.35% Nitrogen in Ether Extract. † 1.88% Nitrogen in Ether Extract.

TABLE XII.—ADULTERATED BLACK PEPPER—*Continued.*

Station No.	Brand (taken from label on package in which goods were sold).	Dealer.	Price paid per ¼ pound. Cents.	Microscopic Examination—Adulterants detected.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
	Gronnd Pepper in bulk.							
5514		F. W. Tracey, Preston	10	Wheat, Grain Hulls, Cocoanut Shells, Charred matter	9.55	**3.09**	**17.06**	3.71
5517		Kinney's, Bank St., New Milford	10	Wheat (cracker crumbs), Cayenne	10.03	**4.41**	14.69	5.65
5519		Wm. W. Blakeman, Derby Junction	8	Wheat, Cocoanut Shells, Charred matter, Cayenne	9.45	**5.12**	**23.62**	4.48
5523		—— 191 East Main St., Bridgeport	10	Buckwheat, Wheat, Cocoanut Shells, Charred matter	9.67	**5.24**	**23.64**	3.81
5526		D. Hallett, 470 E. Main St., Bridgeport	8	Buckwheat Hulls, Cayenne	10.41	**2.09**	**27.04**	**7.37**
5531		Mrs. J. McGovern, 122 N. Washington Ave., Bridgeport	8	Buckwheat Hulls, Cayenne	10.96	**1.40**	**27.71**	**7.81**
5534		A. J. Hopkins, Boston Branch, Norwich	10	Buckwheat, Cocoanut Shells, Charred matter, Cayenne	8.46	**5.51**	**23.84**	6.05
5537		—— 87 White St., Danbury	7	Wheat (cracker crumbs), Cayenne	9.98	**4.36**	11.29	6.13
5541		C. A. Allison, 31 Main St., Middletown	10	Wheat, Grain Hulls, Cocoanut Shells, Charred matter	9.60	**2.71**	15.24	3.95
5544		Joseph Connor & Sons, Norwich	10	Buckwheat, Cocoanut Shells, Charred matter, Cayenne	7.74	**4.08**	**27.59**	5.35
5546		J. B. Sullivan, cor. E. Main and Steuben Sts., Bridgeport	10	Buckwheat Hulls, Cayenne	10.96	**1.38**	**26.42**	**8.83**
5548		Sam'l Z. D. Durand, 183 Main street, Birmingham	10	Wheat	10.04	**5.74**	15.85	**6.80**
5550		Morris Sheild, 142 Main St., Birmingham	5	Wheat, Cocoanut Shells, Charred matter, Cayenne	8.49	**5.38**	**25.04**	4.05
5555		Foote Bros., W. Main St., Waterbury	10	Wheat, Cocoanut Shells, Charred matter, Cayenne	8.34	**3.52**	**18.96**	4.22
5556		E. A. Fitch, 64 Broadway, Norwich	10	Wheat, Cocoanut Shells, Chaffy matter, Cayenne	9.41	**3.05**	**20.01**	3.42
5565*		A. L. Allen, Norwich	10	Buckwheat, Wheat	12.01	**6.35**	7.97	4.56

* 1.35% Nitrogen in Ether Extract.

In eight samples the percentage of all three constituents was beyond the standard limits. The same was true in 14 cases of two constituents and in five cases of one constituent.

Only one sample, No. 5487, was not condemned by any of these three determinations, but the ether extract from this showed no crystals of piperine and contained but 1.88% of nitrogen.

Two samples of buckwheat middlings analyzed at this Station (see Report for 1886, p. 111 and for 1888, p. 152) contained 7.55% and 8.06% respectively, of ether extract. A pepper may have the normal percentage of extract and yet be grossly adulterated with this product. Fortunately we have other means for detecting the admixture with certainty.

Black Pepper Suspected of Adulteration.—In Table XIII are included four samples of this class from packages bearing the name of the manufacturer or dealer, and eight sold in bulk.

No foreign matters were detected in these samples by the microscope, but chemical analysis indicates either the addition of pepper shells, or that the samples were ground from uncleaned peppercorns.

An analysis of a sample of "pepper shells" offered to the "trade" at one and three-quarter cents per pound in 25 ton lots, is given below, together with an analysis of long pepper.

	Station No.	Water.	Ether Extract.	Fiber.	Total Ash.	Sand.
Pepper shells or dust	5630	8.36	6.98	22.88	9.19	2.28
Long pepper, ground at the Station	5634	9.87	7.24	7.38	8.10	.55

TABLE XIII.—BLACK PEPPER SUSPECTED OF ADULTERATION.

Station No.	How sold.	Price per ¼ pound. Cents.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash. (Total.)	Sand.
5589	In labeled package	10	8.54	8.18	**16.63**	**6.61**	1.75
5587	" " "	10	10.73	**6.43**	**17.62**	**6.67**	1.00
5580	" " "	10	11.73	6.77	15.66	**7.30**	1.43
5579	" " "	8	10.91	7.96	15.17	**6.95**	1.35
5561	In bulk	8	10.21	8.16	**16.97**	**7.85**	1.91
5535	" "	10	10.51	7.34	**18.87**	**6.90**	1.05
5525	" "	7	10.54	6.96	**20.29**	**6.56**	.88
5533	" "	8	10.48	**5.14**	**20.27**	**6.83**	1.04
5554	" "	10	10.42	7.43	14.01	**6.82**	1.70
5543	" "	10	10.07	7.85	12.32	**7.15**	1.80
5515	" "	6	11.32	9.41	14.09	**6.56**	1.35
5527	" "	10	10.21	7.59	12.56	**7.03**	2.10

White Pepper, Pure and Adulterated.—In Table XIV are given analyses of seven samples of white pepper, two of which are adulterated.

To recapitulate: 102 samples of pepper have been examined.

64	samples were probably pure pepper.
12	samples were suspected of adulteration.
31	samples were certainly adulterated.
107	

About 66 per cent. of the samples in packages were pure, about 52 per cent. of samples sold in bulk were pure.

TABLE XIV.—WHITE PEPPER, PURE AND ADULTERATED.

Station No.	Brand.	Dealer	Price paid per ¼ pound. Cents.	Microscopic Examination. Adulterants detected.	Chemical Examination. Water.	Ether Extract.	Fiber.	Ash.
	Peppercorns ground at the Station.							
5633	Singapore White Pepper			Pure	11.88	7.07	3.65	.99
5632	Siam White Pepper			Pure	11.73	6.80	4.16	1.69
	Ground Pepper in labeled boxes.							
5766	White Pepper. Absolutely Pure. D. & L. Slade & Co., Boston			Pure	12.31	*6.58	3.32	1.70
5586	Pure White Pepper. Packed expressly for Hills & Co., Harford	Hills & Co., 368 Asylum St., Harford	10	Pure	10.93	7.45	4.13	1.93
5582	White Pepper. Strictly Pure. Stocker & Brill, Newburgh, N. Y.	79 White St., Danbury	10	Wheat	12.57	3.62	2.27	.68
	Ground Pepper in bulk.							
5545		Murray & Dorsey, 4 Truman St., New London	9	Pure	11.90	6.98	3.74	3.14
5542		Waterbury Cheap Grocery, 171 S. Main St., Waterbury	6	Buckwheat, Cayenne	9.40	†7.14	3.64	5.57

* 3.25 per cent. nitrogen in ether extract.
† 0.59 per cent. nitrogen in ether extract.

MUSTARD.

By A. L. Winton.

A portion of the chemical work described in this paper was done by Mr. W. L. Mitchell.

The genuine mustard of commerce is made chiefly, if not wholly, from the seeds of the black mustard (*Brassica nigra*), and white mustard (*Brassica alba*).

Cabbage, cauliflower, turnip and other well known plants belong to the same genus, *Brassica*, and their seeds are like those of the mustards in form and structure.

Black mustard seed is about as large as dust shot, and varies in color from light brown to black. When rubbed up with water there is formed the volatile oil of mustard, which has a penetrating and highly pungent odor as well as taste.

White mustard seed is several times as large as seed of the black species, has a buff color, and when pulverized and moistened emits no odor of mustard oil, but has a sharp, acrid taste.

The pure ground mustard of commerce consists of the ground seed of one, or of a mixture of both the black and white species, the husks being separated by bolting. Oftentimes a portion of the fatty oil of the seed is extracted, as the pungency is not thereby affected and the mustard meal is said to keep better.

Adulterations of Mustard.—The common adulterants of mustard are make-weights: such as starchy matters (wheat flour, etc.) and plaster or terra alba—and coloring matters: such as turmeric and Martius' yellow.

The use of flour in mustard has been defended on the ground that pure mustard does not keep well and is too pungent for ordinary use.

To color mustard, turmeric is generally used. It is prepared from the root of a plant allied to ginger, and its bright yellow color and spicy taste make it sought after for the purpose.

The use of Martius' yellow is objectionable, as it is distinctly poisonous.

These dyes hide the presence of white adulterants and have a brilliant yellow color. The natural color of pure ground and hulled mustard seeds is, however, a very pale yellow.

Examination of Samples of Mustard from the Connecticut Market.

Methods.—Ash or mineral matter was determined by direct incineration.

Turmeric was detected by its characteristic color reaction with ammonia. The method given in Allen's Commercial Organic Analysis, Vol. III, Part 1, p. 154, was followed in testing for Martius' yellow.

Starch was detected by microscopic examination.

Pure Uncolored Mustard.—In Table XV are included 15 samples of this kind. These samples were not only free from starchy and mineral adulterants, but contained no coloring matter foreign to the mustard seed. They were without exception of a dull yellow color and contrasted strongly with the vivid yellow of mustards dyed with turmeric or Martius' yellow. The per cent. of ash ranged from 4.20 to 7.82.

Mustard Artificially Colored.—Table XVI includes 24 samples of this class in which no foreign matter, except coloring, was detected. Martius' yellow was present in four samples, turmeric in the remaining 20 samples.

Mustard Adulterated or "Compounded" with Starchy Matter or Gypsum.—There are grouped under this head in Table XVII "mustards," 30 in number, in which either flour or plaster was present in considerable quantity. Three of these, Nos. 5665, 5666 and 5672, were conspicuously labeled mustard on the broader sides of the boxes, and on one of the narrower sides it was stated, in much smaller type and in the words given in the table, that the article is a compound.

Of the 30 samples examined, 26 contained considerable quantities of wheat flour or other starchy matter and four were adulterated with gypsum or terra alba. Twenty-four were colored with turmeric, four with Martius' yellow and two appeared to be colored, although no dye was identified. Eleven were in labeled boxes, the remainder sold in bulk.

The quantity of lime present was determined in the four samples adulterated with gypsum and the equivalent sulphate of lime (anhydrous) ranged from 12.97 to 15.34 per cent., but the actual percentage of adulterant present was probably greater, owing to combined water.

TABLE XV.—PURE UNCOLORED MUSTARD.

Station No.	Brand.	Dealer.	Price paid per ¼ pound. Cents.	Ash.
	In labeled packages.			
5775	Oxford Mustard, Absolutely Pure, D. & L. Slade Co., Boston	Lorenzo Dibble, N. Main St., S. Norwalk	10	6.28
	In bulk.			
5664		W. S. Chappell, 148 State St., New London	13	4.73
5691		P. T. Gloster & Co., Winsted	10	5.94
5694		T. Kilmartin, 495 W. Main St., Waterbury	13	6.51
5074		Keating's Store, Cor. York & Oak Sts., New Haven	9	5.62
5659		Keeney Bros., Rockville	10	7.79
5073		Henry Hahn, 1327 W. Chapel St., New Haven	9	5.57
5075		F. H. Kearney, Cor. Congress Ave. and Hill St., New Haven	10	7.78
5640		Beckwith & Keefe, 125 Bank St., New London	10	6.20
5646		J. E. St. John, Bank St., New London	10	6.63
5682		Village Store Co., East Main St., Bridgeport	6	5.60
5681		McGraw & Baldwin, White St., Danbury	12	5.93
5677		James Sullivan, Putnam	10	4.20
5675		P. M. LeClair, Putnam	10	6.48
5647		W. H. Brown, Moosup	10	7.82

TABLE XVI.—MUSTARD ARTIFICIALLY COLORED—OTHERWISE PURE.

Station No.	Brand.	Dealer.	Price paid per ¼ pound. Cents.	Ash.	Color.
	In labeled packages.				
5645	Pure Durham Mustard, Howard & Co. Guaranteed absolutely pure	T. W. Potter, 72 State St., New London	10	6.00	Martius' yellow.
5638	Pure Mustard, Boardman & Sons, Hartford	J. Kerin, 62 North St., New Britain	15	5.89	Turmeric.
5650	Strictly Pure Mustard, L. Battey & Son, Moosup	L. Battey & Son, Moosup	10	6.27	"
5654	Pure Mustard, J. H. Beard, Full Weight	Shelton Cash Store, J. H. Beard, Prop., 476 Howe Ave., Shelton	9	4.73	"
5669	Mansfield's Pure Mustard, W. H. Mansfield & Co., Putnam	Mansfield & Co., Putnam	10	7.11	"
5670	Gauntlet Brand Mustard, E. R. Durkee & Co., New York	G. A. Ray, Norwich	10	5.30	"
5680	Pure Mustard, Union Spice Co.	Union Pacific Tea Co., 253 Main St., Danbury	10	5.60	"
5700	Mustard, O. H. Blanchard, All goods bearing my trade mark strictly pure	Joseph Copland, Cor. North and Clark St., New Britain	10	5.73	"
5643	Pure Mustard, Warranted strictly pure, Bennett, Sloan & Co., New York	Wm. S. O'Brien, New London	10	4.19	"
5652	Mustard, Grand Union Tea Co., New York	Grand Union Tea Co., 237 Main St., Birmingham	10	6.58	"
	In bulk.				
5653		Dillon's Cash Grocery Store, 158 Main St., Ansonia	7	5.42	"
5657		Morris Sheild, 142 Main St., Birmingham	5	4.98	"
5688		D. W. Lawton, Main St., Winsted	12	6.29	"
5686		Stevens' Cash Grocery, 398 E. Main St., Bridgeport	8	5.94	"
5679		Barnum & Reed, 307 Main St., Danbury	12	5.52	"
5678		John P. Murphy, Norwich	10	5.46	"
5662		F. W. Tracy, Preston	10	5.76	"
5648		W. N. Arnold, Danielson	10	7.15	"
5649		Perkins & Bliss, Willimantic	10	7.11	"
5656		Sam'l Z. D. Durand, 183 Main St., Birmingham	10	7.44	"
5703		A. D. Cook, 56 Market St., Hartford	8	5.85	"
5660		Purinton & Reade, Willimantic	12	6.19	Martius' yellow.
5690		——— 793 Bank St., Waterbury	10	5.84	"
5701		Boston Branch Grocery, 238 Main St., New Britain	10	6.20	"

TABLE XVII.—MUSTARD ADULTERATED OR "COMPOUNDED" WITH STARCHY MATTER OR PLASTER.

Station No.	Brand.	Dealer.	Price paid per pound. Cents.	Ash.	Coloring.	Adulterants detected.
5685	A. & P. Mustard, Sultana Spice Mills	Atlantic & Pacific Tea Co., 269 E. Main St., Bridgeport	15	3.96	Turmeric.	Starchy matter.
5639	Celebrated English Mustard, Cole & Firth, London	Murray & Dorsey, 4 Truman St., New London	10	9.14	"	" "
5692	Crescent Mills Pure Mustard, Warranted Pure, John P. Augur, New Haven	Foote & Westwood, W. Main St., Waterbury	15	3.98	"	" "
5651	Mustard, Lincoln, Seyms & Co., Hartford. All goods bearing our signature are strictly pure and warranted	E. F. Platt, 37 E. Main St., Waterbury	15	20.08*	"	Sulphate of lime or plaster.
5693	London Mustard, Warranted extra strong	Johnson's Cash Grocery, Main St., Winsted	12	3.32	"	Starchy matter.
5683	Selected Mustard	Kinney's, Bank St., New Milford	10	3.44	"	" "
5671	Pure Mustard, Alert Mills, New York	W. H. Cardwell, Norwich	15	10.62†	"	Lime and starchy matter.
5674	Pure Mustard, Packed for Hills & Co., Hartford	Hills & Co., 368 Asylum St., Hartford	10	17.68‡	"	Sulphate of lime or plaster.
5665	Colman's Mustard, Mfd. in England, warranted to be the finest mustard compound	Frank Larrabee, Willimantic	15	3.94	?	Starchy matter.
5672	Keene's Mustard, London. This is an admixture in which no injurious ingredients are used	W. H. Cardwell, Norwich	17	3.49	?	" "
5666	Colburn's A Mustard. The A. Colburn & Co., Philadelphia. The finest compound for table or medicinal use	A. A. Trudeau, Willimantic	12	4.17	Turmeric.	" "
5705		F. H. Lewis, 98 W. Main St., Meriden	10	4.06	"	" "
5702		Jacob Walz, 54 Temple St., Hartford	10	3.55	"	" "
5699		Jos. Copland, Cor. North & Clark Sts., New Britain	10	4.18	"	" "
5698		C. A. Allison, 31 Main St. Middletown	10	4.24	"	" "
5695		Foote Bros., W. Main St., Waterbury	10	4.93	"	" "
5689		King & Gay, Main St., Winsted	12	2.20	"	" "
5687		Wilcox & Adams, Main St., Winsted	10	3.99	"	" "
5641		W. A. Murray, 672 Bank St., New London	10	2.42	"	" "
5676		Joseph Connor & Sons, Norwich	10	2.93	"	" "
5661		E. A. Fitch, 64 Broadway, Norwich	15	3.79	"	" "
5658		H. W. Steele & Co., Main St., Birmingham	9	3.98	"	" "
5655		Wm. W. Blakeman, Derby	10	5.75	"	" "
5642		S. D. Amico & Co., 64 Main St., New London	10	4.61	"	" "
5673		Morse Mills Store, Putnam	10	4.87	"	" "
5684		W. S. Cornwall, 173 E. Main St., Bridgeport	10	4.31	Martius' yellow.	" "
5696		Thos. Walsh, 486 Main St., Middletown	8	4.49	"	" "
5704		M. Ahern, 160 Pratt St., Meriden	10	4.04	"	" "
5697		J. B. Patterson, 110 Main St., Middletown	10	19.64§	Turmeric.	Sulphate of lime or plaster.
5072		Henry S. Dailey, 97 Whalley Ave., New Haven	10	21.10‖	"	" " "

* Of which 6.18 per cent. calcium oxide, equivalent to 15.03 per cent. calcium sulphate. † Of which 4.41 per cent. calcium oxide (not as sulphate).
‡ Of which 6.10 per cent. calcium oxide, equivalent to 14.83 per cent. calcium sulphate. § Of which 6.30 per cent. calcium oxide, equivalent to 15.34 per cent. calcium sulphate. ‖ Of which 5.34 per cent. calcium oxide, equivalent to 12.97 per cent. calcium sulphate.

CHEESE.

BY A. L. WINTON.

Seventy-two samples of cheese have been examined with special reference to the possible presence of oleo-oil, which is said to be extensively used as a "filler." "Filled cheese" is made from an emulsion of oleo-oil and skim-milk.

In none of the samples was the presence of oleo or other foreign fats discovered.

Method of Examination. Volatile fatty acids were determined in the fat obtained from the cheese by grinding with anhydrous copper sulphate and extracting with ether, as directed for the determination of fat in cheese by Short's method.*

If desired, the percentage of fat and the volatile acids in the fat may be determined in one weighed portion, thus ascertaining whether the cheese was made from whole or skim milk, and whether or not it has been "filled." As there is no restriction on the sale of skim milk cheese in Connecticut, the percentage of fat was disregarded.

In order to have sufficient material for two extractions, 20 grams of cheese and 40 grams of anhydrous copper sulphate were ground to a powder. It was found necessary to perform this operation soon after receiving the samples, as cheese open to the air soon dries and becomes hard and horny; and on the other hand, if kept in a closed jar it moulds. The ground mixture of cheese and copper salt, however, keeps indefinitely, and the subsequent processes may be carried out whenever convenient.

The extract (corresponding to 10 grams of cheese) was collected in a tared flask so that after removal of the ether the weight of the extract could be taken. If more than 2.5 grams were obtained, a portion was removed. In the cases of skim milk cheeses the extract weighed less than 2.5 grams, but was sufficient for the determination of volatile fatty acids, being in all cases more than 1 gram.

The Leffmann & Beam modification of the Reichert process was employed,† using half quantities of reagents to correspond with the half quantity of fat taken. The saponification was carried out in the flasks used for the extraction.

The names and addresses of the dealers from whom samples were obtained are given in the following list. The prices paid ranged from 10 to 18 cents per pound.

Ansonia, **W. H. Bronson, 234 Main St.; York State Butter Store, 176 Main St.**

* U. S. Dept. Agr. Div. Chem. Bull. **43**, **371**.

† Analyst, 1891, XVI, 153.

Birmingham, H. W. Steele & Co., 99 Main St.; D. M. Welch & Co., Main St.

Bridgeport, Geo. A. Robertson, 70 State St.; New York Butter House, 12 Fairfield Ave.

Colchester, W. S. Curtis, Broadway.

Collinsville, N. Bachand.

Danbury, York State Butter House, Main St., Danbury; Butter Store, 43 White St.

Danielson, A. H. Armington, Railroad Sq.; Waldo Bros., Main St.; W. N. Arnold, Main St.

Hartford, W. W. Walker, 269 Main St.; John A. Pilgard, 138 Front St.; M. J. Feeley, 26 Front St.

Manchester, Fitch & Drake.

Meriden, D. C. Huggins & Co., 31 E. Main St.; Russell Bros., N. Y. Butter and Grocery Store; E. O. Chapman, 64 E. Main St.

Middletown, B. Carbo, Rapello Ave.; Gardner, 121 Main St.

Naugatuck, C. N. Todd's Cash and Exchange Store; Dillon's Cash Grocery Store.

New Britain, Boston Branch Grocery, 238 Main St.; Vermont Butter Store, Main St.; Wm. Cowlishan, 420 Main St.

New Haven, John Franklin, 71 Nash St.; M. C. Dingwall, 66 Congress Ave.; McGovern Bros., 1037 State St.; Broadway Butter Store, 153 Broadway; A. Duhan, 1134 State St.; New Haven Butter Store, 116 Congress Ave.; D. M. Welch & Son, Congress Ave.; D. Dore, 579 Grand Ave.; Butter Store, 391 Grand Ave.; C. T. Downes & Son, 1 Broadway.

New London, Thos. W. Gardner, State St.; M. Pick, 6 Main St.; Chappell, 148 State St.; J. E. St. John, Bank St.

Norwalk, The New York Grocery, Main St.; W. R. Bates, Main St.

Norwich, Bailey & Connell, 40 Broadway; C. W. Hill, Franklin St.; Appley & Jordan, 88 W. Main St.; Somers Bros., 224 Main St.

Plainfield, Walter Tillinghast, Main St.; Kingsley's Store.

Putnam, Brainard & Bartlett, 72 Main St.; W. H. Mansfield & Co.

Rockville, L. Young; Union St. Grocery, 30 Union St.

S. Norwalk, Lorenzo Dibble, N. Main St.

Stonington, James Pendleton, Water St.

Thompsonville, Henry King.

Torrington, The Torrington Coöperative Co., 47 Main St.; Philip Aperion, S. Main St.; G. S. Weeks, 184 Main St.

Wallingford, M. N. Brainerd; F. H. Smith; W. Murray.

Warehouse Point, Aaron Smith.

Waterbury, Brownell, Boston Butter House, 147 S. Main St.; Branch of York State Butter Co., 844 Bank St.; L. P. & A. M. Guilfoile, 777 Bank St.

Willimantic, H. C. Hall, 17 Union St.; Bert Thompson, 798 Main St.; Holden Arnold, 999 Main St.

Windsor Locks, Ed. Coogan.

Birmingham, H. W. Steele & Co., 99 Main St.; D. M. Welch & Co., Main St.

Bridgeport, Geo. A. Robertson, 70 State St.; New York Butter House, 12 Fairfield Ave.

Colchester, W. S. Curtis, Broadway.

Collinsville, N. Bachand.

Danbury, York State Butter House, Main St., Danbury; Butter Store, 43 White St.

Danielson, A. H. Armington, Railroad Sq.; Waldo Bros., Main St.; W. N. Arnold, Main St.

Hartford, W. W. Walker, 269 Main St.; John A. Pilgard, 138 Front St.; M. J. Feeley, 26 Front St.

Manchester, Fitch & Drake.

Meriden, D. C. Huggins & Co., 31 E. Main St.; Russell Bros., N. Y. Butter and Grocery Store; E. O. Chapman, 64 E. Main St.

Middletown, B. Carbo, Rapello Ave.; Gardner, 121 Main St.

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New London, Thos. W. Gardner, State St.; M. Pick, 6 Main St.; Chappell, 148 State St.; J. E. St. John, Bank St.

Norwalk, The New York Grocery, Main St.; W. R. Bates, Main St.

Norwich, Bailey & Connell, 40 Broadway; C. W. Hill, Franklin St.; Appley & Jordan, 88 W. Main St.; Somers Bros., 224 Main St.

Plainfield, Walter Tillinghast, Main St.; Kingsley's Store.

Putnam, Brainard & Bartlett, 72 Main St.; W. H. Mansfield & Co.

Rockville, L. Young; Union St. Grocery, 30 Union St.

S. Norwalk, Lorenzo Dibble, N. Main St.

Stonington, James Pendleton, Water St.

Thompsonville, Henry King.

Torrington, The Torrington Coöperative Co., 47 Main St.; Philip Aperion, S. Main St.; G. S. Weeks, 184 Main St.

Wallingford, M. N. Brainerd; F. H. Smith; W. Murray.

Warehouse Point, Aaron Smith.

Waterbury, Brownell, Boston Butter House, 147 S. Main St.; Branch of York State Butter Co., 844 Bank St.; L. P. & A. M. Guilfoile, 777 Bank St.

Willimantic, H. C. Hall, 17 Union St.; Bert Thompson, 798 Main St.; Holden Arnold, 999 Main St.

Windsor Locks, Ed. Coogan.

EXAMINATION OF COFFEE.

By A. L. Winton.

Coffee is the seed of a small tree whose fleshy fruit is about the size of a small cherry and contains two seeds joined on their flat sides, which when freed from the pulp and the enveloping membrane are the coffee "beans" of commerce.

The money value of coffee annually imported into this country exceeds that of any other single import, except possibly sugar.

During the year ending June 30, 1895, 532,938,473 pounds were imported, having a wholesale value (at a little over 16 cents per pound) of $87,372,901.61. The imports of ground chicory during the same year amounted to 9,544,186 pounds, and were valued (1.7 cents per pound) at $158,142. In addition to the above, 463,579 pounds of unground chicory and 2,807,360 pounds of dandelion root and other coffee substitutes came into the country.

Adulterants of Coffee.

Among the materials which, either dried or roasted, have been used to mix with and adulterate pure coffee are the following: roots of chicory, dandelion, beets and carrots; wheat, rye, barley and other grains; peas, beans and other leguminous seeds; acorns; figs; imitation coffee, sometimes moulded into artificial beans, sometimes in masses, granules, etc.

Examination of Samples Purchased in Connecticut.

One hundred and twenty-four samples collected by the Station agents have been examined. These may be classified as pure and adulterated ground coffee, coffee substitutes and compound coffees. All were in the roasted state.

Methods of Examination.

By careful sorting, the adulterants in whole coffee were readily separated and in some cases the percentage of adulteration was determined. Microscopic examination of the foreign material was necessary in order to positively determine its nature.

Fragments of foreign material may usually be recognized without the aid of a lens and picked out from adulterated coffee after it has been ground to the usual degree of fineness. This preliminary examination is greatly facilitated by separating the finer from the coarser material by means of a sieve.

Another easy method of separation is to shake a portion of the sample with cold water. The particles of coffee for the most part float, whereas the common adulterants sink.

Material of suspicious character, separated by either of the methods just named, was examined microscopically to fully determine its nature.

Fragments which, from their sweet taste and the color imparted to water were believed to be chicory, were usually found under the microscope to have the pitted ducts and other characteristic tissues of chicory. No attempt was made to distinguish between chicory and the other roots which often are used as an adulterant of, or substitute for, chicory. The term "chicory," as used in this paper, refers to what is known in the trade under that name.

In order to identify the various leguminous seeds, the size and form of the palisade and "supporting" cells of the hull were observed either in sections or, more conveniently in my experience, in portions which had been heated on a slide for a short time with dilute potash and gently crushed with a cover glass. By this latter method, after a few preliminary tests to get potash solution of the proper concentration and to heat for the proper length of time, cells of both layers were easily isolated without being seriously altered in size and form. The palisade cells when thus detached rested on their sides, and with proper care many of the "supporting" cells were in the same position so that it could be seen whether they were prismatic (as in the bean) or spool-shaped, as in most other legumes.

It was difficult and sometimes impossible to distinguish fragments of wheat kernels from rye, either by the shape of the fragments, size of starch granules or cell structure, because these characters had been obscured or wholly destroyed by roasting.

It was not always possible to determine the kind of starch present in the imitation coffee, described on page 54, because the granules were often distorted as if they had been heated. The presence of vegetable hairs and fragments of tissue, however, aided identification.

Unground Coffee.

Although the larger part of the coffee on sale in this State is in the bean, still only a few purchases of the unground coffee were made since in many of the stores visited by the Station's agents the coffee was found on inspection to be of undoubted purity.

Pure unground coffee.—Two samples of genuine coffee beans were purchased in labeled packages as follows:

5987. Union Club Coffee, Lincoln, Seyms & Co., Hartford. Bought of A. Wilson, Norwich, 38 cents per pound.

6006. Winslow, Rand & Watson's Red Label Java and Mocha Coffee. Bought of Carten Tea Co., Bridgeport.

The remainder of the samples of genuine coffee beans were bought of the following dealers, the price ranging from 25 to 38 cents per pound:

The Original India Tea Co., *Bridgeport.* N. Bachand, Chas. McAleer, Frank Perri, *Danbury.* Waldo Bros., *Danielson.* M. J. Feeley, Mrs. Kramer, *Hartford.* Bissell & Brough, *Manchester.* Lane & Peters, *Milford.* Unite L. Frank Tea Co., Frank E. Hull, Store 1152 State St., New England Tea Co., H. Frank & Son, *New Haven.* Thomas & Gumble, Store junction Bank and Truman Sts., Corkey & Gannon, Keefe & Davis, M. Winslow Dart, *New London.* Brainard & Bartlett, *Putnam.* L. Young, *Rockville.* D. S. Davenport, Brown & Wilcox, *S. Norwalk.* Moses Pendleton, *Stonington.* J. F. O'Hear, M. Mitchell, *Thompsonville.* W. Murray, *Wallingford.* Aaron Smith, *Warehouse Point.* The N. Y. and China Tea Co., *Waterbury.* S. E. Amidon, Bert Thompson, *Willimantic.*

Adulterated unground coffee.—Eleven samples were purchased, and the results of their examination are given in Table XVIII. The adulterants detected were chicory, crushed and roasted peas and lumps of "imitation coffee."

By the term imitation coffee we refer to certain masses of brown, starchy material sometimes found in adulterated coffee. These are made chiefly of wheat flour or middlings mixed sometimes with pea hulls or pea meal. This mixture, in form of a paste, is apparently moulded in sticks or cylinders about half an inch in diameter, which after drying can be crushed or ground with the coffee.

Imitation coffee, moulded in form of coffee beans, instead of sticks, has not been found in any samples which we have examined.

In general, the presence of the adulterants which we have encountered in whole coffee would hardly escape the notice of the careful observer, if he had opportunity to glance at the mixture before it was ground, an opportunity which, in the experience of our sampling agents, is not always accorded to him.

Ground Coffee.

Pure Ground Coffee.—In Table XIX are given five brands of pure ground coffee which were sold in sealed and labeled packages.

Only two samples of pure ground coffee sold in bulk were found on sale. These were purchased of James Pendleton, Water St., Stonington (34 cts. per pound), and Chappell's Store, 148 State St., New London (38 cts. per pound).

Table XVIII.—Adulterated Whole or Broken Coffee, Sold in Bulk.

Station No.	Dealer.	Adulterants Detected	Price per Pound. (Cents.)
5973	F. W. Miner, Wallingford	‡Peas, chicory	25
6011	C. T. Downes & Son, 1 Broadway, New Haven	‡Peas, chicory	25
6004	A. Duhan, Cedar Hill Cash Grocery, 1134 State St., New Haven	26% peas, 19% chicory	25
6009	*M. C. Dingwall, 66 Congress Ave., New Haven	Chicory, "imitation coffee"	20
6003	John Franklin, 71 Nash St., New Haven	42% chicory and "imitation coffee"	25
5983	R. A. Nichols, 60 Courtland St., Bridgeport	‡Peas, chicory, "imitation coffee"	25
5997	F. M. Miller, 38 W. Main St., Meriden	23% peas, 45% chicory and "imitation coffee"	25
5994	Geo. W. Gates, Main St., Windsor Locks	24% peas, 31% chicory and "imitation coffee"	25
5989	†Doran's Cash Grocery, 150 Main St., Danbury	14% peas, 21% chicory and "imitation coffee"	24
6002	New Haven Provision Co., 398 Grand Ave., New Haven	12% peas, 22% chicory and "imitation coffee"	25
5979	Walter Tillinghast, Plainfield	‡"Imitation coffee"	25

* Coffee sold for Coffee Screenings. Was almost as fine as ground coffee. † Sold for "crushed Java."
‡ Ground by dealer, hence the percentage of adulteration could not be readily determined.

TABLE XIX.—PURE GROUND COFFEE, SOLD IN LABELED PACKAGES.

Station No.	Brand.	Dealer.	Price per Pound. Cents.
5972	Café Royal Coffee, Benedict & Thomas, New York	Gilbert & Thompson, New Haven	45
5958	Seal Brand Java and Mocha Coffee, Chase & Sanborn, Boston (powdered)	James' Cash Grocery, Danielson	38
5959	Seal Brand Java and Mocha Coffee, Chase & Sanborn, Boston (ground)	The Torrington Coöperative Co., 47 Main St., Torrington	40
5957	Union Club Coffee, Lincoln, Seyms & Co., Hartford	W. D. Mead, Collinsville	35
5948	High Life Java and Mocha Coffee, Winslow, Rand & Watson	H. C. Hall, 17 Union St., Willimantic	38

Adulterated Ground Coffee.—Fifty-eight out of sixty-four samples sold as "ground coffee" were found to be adulterated.

Of these, five were sold in labeled packages, giving the name of grinder, or wholesaler, without any statement to indicate that they were mixtures of coffee with other materials.

These were the following:—

5964. Sealed package labeled: "The American Java Coffee (W. G. & B.) Company." "Office of the American Java Coffee Co., 233, 235 and 237 Washington St., New York," etc. Bought of Lorenzo Dibble, South Norwalk. Price 22 cents per pound package. A gilt band cup and saucer given away with a pound.

Contains *chicory and peas.*

5965. Sealed package labeled: "Genuine Mocha Coffee, John P. Augur, Crescent Mills, New Haven." Bought of Adam Wagner, Ashmun St., New Haven. Price 25 cents per pound package.

Contains *chicory and peas.*

6050. Sealed package labeled: "Welcome Coffee gives uniform satisfaction. Manufactured only by Bryan, Miner & Read, New Haven, Conn. The buyer of this coffee receives free with each package 1 bar of Welcome soap. One pound fresh ground." Bought of Geo. W. Gates, Windsor Locks. Price 25 cents per package.

Contains *chicory and peas.*

5960. Sealed package labeled: "Boardman & Sons' Celebrated Excelsior Coffee, 304 Asylum St., Hartford." Bought of R. Fowler, Ford St., Hartford. Price 15 cents per pound package.

Contains *chicory, peas and "pellets."*

6015. Labeled on package from which sample was taken and on bag into which it was put: "Old Style Java, S. H. Brownell & Co., 26 to 31 Canal St., Providence, R. I." Bought (for coffee and chicory) of James' Cash Grocery, Danielson. Price 25 cents per pound.

Contains *imitation coffee.*

The detailed descriptions of the other adulterated samples, sold in bulk, fifty-three in number, are given in Table XX.

The foreign materials detected were chicory, roasted peas, wheat and rye, "imitation coffee" (such as has been described on page 54) and an adulterant consisting of pea hulls made into little granules with bran or middlings. These, for convenience, we have designated as "pellets."

COFFEE COMPOUNDS.

Under this head are grouped eleven mixtures which, as regards their composition and appearance, are like the adulterated ground coffees, but since they were sold in packages with statements on the labels (often, however, in very small type and obscurely placed) as to their character, they are separately considered.

6018. "Columbus Coffee, Chris. Columbus Coffee Company, 245 and 249 Washington St., New York. The contents of this package is a mixture or a Compound of Choice Roasted Coffee, Cereals and Chicory, Blended in such proportions as to produce a good beverage." Bought for coffee of Chas. Brenker, Torrington. Price 22 cents per pound package.

Contains *coffee, peas* and *chicory.*

5963. "Palmer's Compound Dandelion Coffee, Palmer's Dandelion Coffee Company, Norwich." Bought of C. W. Hill, Norwich. Dealer stated it was a compound. Price 20 cents per pound.

Contains *coffee, peas, chicory,* possibly other ingredients.

6051. "Red Star Blended Java. A blend of choicest Padang Java with roasted cereals," etc. Bought for coffee of the Torrington Coöperative Company. Price 25 cents per pound.

Contains *coffee, peas* and *chicory.*

Table XX.—Adulterated Ground Coffee, sold in Bulk.

Station No.	Dealer.	Adulterants detected.	Price per pound. Cents.
5901	C. N. Todd's Cash and Exchange Store, Naugatuck	Chicory, Peas	25
5902	Dillon's Cash Store, Naugatuck	" "	25
5903	Healy's South End Groceries, 622 S. Main St., Waterbury	" "	25
5913	Ransom Bros., 17 Market St., Rockville	" "	24
5920	W. H. Bronson, 234 Main St., Ansonia	" "	25
5923	Ed. Coogan, Windsor Locks	" "	25
5925	M. N. Brainerd, Wallingford	" "	25
5926	Willis L. Pond, Torrington	" "	20
5927	The Union Pacific Tea Co., 204 Main St., Ansonia	" "	25
5928	Samuel Z. D. Durand, 193 Main St., Birmingham	" "	25
5938	John P. Murphy, W. Main St., Norwich	" "	25
5945	Adam Wagner, Ashmun St., New Haven	" "	25
5951	Grand Union Tea Co., 88 State St., New London	" "	25
5953	Thos. W. Gardner, State St., New London	" "	20
5969	Geo. E. Cleaveland, 200 State St., Bridgeport	" "	25
5974	O. Coledezky, 68 Morgan St., Hartford	" "	25
5947	B. Carbo, Rapallo Ave, Middletown	Chicory, Wheat or Rye	24
5968	New England Tea Co., 442 Main St, Middletown	Chicory, "Imitation Coffee"	25
5907	Branch of York State Butter Co., 844 Bank St., Waterbury	" " "	25
5908	L. P. & A. M. Guilfoile, 777 Bank St., Waterbury	" " "	25
5910	Logan Bros., 863 Main St., Bridgeport	" " "	25
5911	John Driscoll, Cor. Main and High Sts., Bridgeport	" " "	25
5924	Henry King, Thompsonville	" " "	25
5967	The New York Grocery Co., Main St., Norwalk	" " "	20
5931	F. H. Smith, Wallingford	" " "	25
5905	Jas. F. Phelan, 41 E. Main St., Waterbury	Chicory, "Pellets"	25
5906	Moore's Cash Grocery, 804 Bank St., Waterbury	" "	28

Table XX.—Adulterated Ground Coffee, sold in Bulk.—*Continued.*

Station No.	Dealer.	Adulterants detected.	Price per pound. Cents.
5914	Village Store Co., Cor. State and Broad Sts., Bridgeport	Chicory, "Pellets"	25
6068	The Great Atlantic and Pacific Tea Co., 29 E. Main St., Waterbury	" "	25
5970	J. McEwen, 117 Saltonstall Ave., New Haven	Chicory, Peas, "Imitation Coffee," Pellets	25
5912	Union Street Grocery, 30 Union St, Rockville	" " " " "	25
5921	Grant's Tea and Coffee Store, Cor. State and Main Sts., Meriden	" " " " "	25
5944	McGovern Bros., 1037 State St., New Haven	" " " " "	25
5909	Chas. W. Starr, New Milford	Chicory, Peas, "Imitation Coffee," "Pellets," Wheat or Rye	25
5916	The Union Pacific Tea Co, cor. Main and Golden Hill Sts., Bridgeport	Chicory, Peas, "Imitation Coffee"	25
5922	James Keevers, Main St., Windsor Locks	" " " "	25
5930	York State Butter Store, 176 Main St., Ansonia	" " " "	25
5932	Holden Arnold, 999 Main St., Willimantic	" " " "	25
5935	H. A. Wheaton, Spring St., Danielson*	" " " "	25
5937	A. H. Armington, Railroad Square, Danielson	" " " "	28
5954	Gardner's Store, Elm St., Stonington	" " " "	20
5929	H. A. Willard, 268 Main St., Ansonia	Chicory, Peas, Wheat or Rye	25
5943	W. G. Graves, 341 Grand Ave, New Haven	" " " "	25
5946	Daniel Dore, 579 Grand Ave., New Haven	" " " "	12
5949	S. E. Amidon, 877 Main St., Willimantic	" " " "	25
5950	Hong Kong Tea Co., 210 Main St., Norwich	" " " "	35
5917	G. S. Weeks, 184 Main St., Torrington	"Pellets," Wheat or Rye	25
5904	American Tea Co., Wright & Weible, 42 E. Main St., Waterbury	"Pellets," "Imitation Coffee"	25
5918	B. Moffitt, 373 Main St., New Britain	"Imitation Coffee"	30
5934	Edward Mullan, 25 Main St., Putnam	" "	25
5962	Brainard & Bartlett, 72 Main St., Putnam	" "	25
5915	C. A. Wills, 364 Fairfield Ave., Bridgeport	Chicory	25
5919	Barry's New York Store, 374 Main St, Ansonia	"	25

* Sold for mixture of Java and Mocha screenings.

6007. "Eclipse blended crushed Coffee. In compounding this coffee we have selected goods that will give a much stronger and richer flavor than many of the so called pure coffees. A compound roasted and packed on the day shipped. Eclipse Coffee Co., 61 Hudson Street, New York." Bought for coffee of W. R. Bates, Norwalk. Price 23 cents per pound in a quart fruit jar. It was unground.

It contains 40 per cent. *coffee beans* whole or broken.
20 " *crushed peas.*
40 " *imitation coffee* and *chicory* (not separated).

6016. "Arabian Ground Coffee, full weight. 130 Franklin St., New York. This package contains ground coffee." The word "compound" was on another part of the package. Bought of T. W. Potter, New London. Price 15 cents per pound.

Contains *coffee, chicory* and *peas.*

5956. "Old reliable Java Coffee Company, New York." The following statement was printed in small type, "made of pea berry coffee and chicory." Bought of C. H. Bailey, 34 Enterprise St., Colchester. Price 25 cents per pound. A cup and saucer given away with each pound.

Contains *chicory, peas* and *cereals.*

5971. "Excelsior French Breakfast Coffee Compound. From Dwinell, Wright & Co., Boston, Mass." Bought for coffee of J. E. Sullivan, Putnam. Price 10 cents per pound.

Contains *chicory, peas, cereals;* coffee was not detected.

5961. "Hayward & Co., French Breakfast Coffee Compound. Dwinell, Wright & Co., Boston." This was put up in the same kind of package as No. **5971** with a similar label. Bought of W. W. Walker, 269 Main St., Hartford, for coffee. Price 8 cents per pound.

Contains *chicory, peas, cereals;* coffee was not detected.

6049. "Enterprise Compound Breakfast Coffee, Lincoln, Seyms & Co., Hartford." Bought for coffee of Ed. Coogan, Windsor Locks. Price 25 cents per pound.

Contains *coffee, chicory* and *peas.*

6080, 6019. "*Old Grist Mill Entire Wheat Coffee*, Potter & Wrightington, Boston, Mass." A sealed package of this article was sent to this station with the request that it be examined for real coffee, which it was claimed not to contain.

It was stated on the label: "Is a perfect hygienic product of the Entire Wheat Kernel. It is not ground from the coffee berry, and while possessing all the delicate flavor of Java or Mocha it contains none of their injurious qualities."

Another package of the Old Grist Mill Entire Wheat Coffee was bought by a station agent of N. A. Fullerton, New Haven, for 20 cents, a loaf of entire wheat bread being given away with it. The label was in all respects the same as the first with two exceptions. First, in place of the above quotation the following was substituted:

"Is a perfect hygienic product containing the entire wheat kernel, roasted and ground. It has all the delicate flavor of Java and Mocha; but, unlike these coffees, it does not produce biliousness or irritate the nerves."

Second. The statement was added, "It is in every sense a Pure Health Food."

Both packages contained *some coffee, mixed with wheat and with a considerable quantity of ground peas.*

Coffee Substitutes.

The following preparations from roasted cereals, etc., contain no real coffee and no such claim is made for them:

6017. "Ayers Hygienic Substitute for Coffee, M. S. Ayer, Boston." Bought of Sliver's Grocery, Stonington. Price 20 cents per pound.

6014. "New Era Improved Hygienic Coffee, E. C. Rich Co., New York and Boston." Bought of W. W. Walker, Hartford. Price 20 cents per pound.

5966. "Shredded Cereal Coffee, The Cereal Machine Co., Boston." Bought of H. C. Hall, Willimantic. Price 20 cents per pound.

6013. "J. W. Clark's Phosphi Cereal Nervine Coffee, a wholesome and nutritious substitute for the coffee bean, tea and chocolate. Clark & Alden, N. Woburn, Mass." Bought of Boston Branch Grocery, New Britain. 20 cents per pound.

Recapitulation.

The 122 samples which have been examined may be classified as follows:

Unground Coffee.

	In labeled packages.	In bulk.	Total.
Pure	2	31	33
Adulterated	0	11	11

Ground Coffee.

Pure	5	2	7
Adulterated	5	53	58
Coffee Compounds	11	0	11
Coffee Substitutes (no real coffee)	4	0	4
Total			124

It appears that most of the unground coffee on sale is pure, although 11 samples were purchased which were found to contain one or more of the following adulterants in quantities ranging from 12 to 42 per cent.: crushed peas, imitation coffee (moulded from starchy materials) and chicory.

89 per cent. of the ground coffee found on sale was grossly adulterated. The adulterants detected were peas, "imitation coffee," "pellets" (pea hulls and starchy matter made into granules) wheat, rye and chicory. Only two samples of pure ground coffee sold in bulk were found on sale.

MILK.

By E. H. Jenkins and A. L. Winton.

During the month of May one hundred and five samples of milk were bought by agents of the Station from grocers and a few bakeries in all parts of the city of New Haven.

The analyses of these samples show the general quality of the milk sold by grocers, which is quite likely to be rather poorer than that delivered by milkmen to families.

The per cents. of total solids in these samples were as follows:

Over 13 per cent. solids,	16 samples.
Between 12 and 13 per cent. solids,	51 samples.
Between 11.5 and 12.0 per cent. solids,	19 samples.
Between 11.0 and 11.5 per cent. solids,	12 samples.
Between 10.5 and 11.0 per cent. solids,	6 samples.
Under 10.5 per cent.	1 sample.
Total	105

The per cents. of fat found were:

Over 5.0 per cent. fat,	3 samples.
Between 4.5 and 5.0 per cent. fat,	2 samples.
Between 4.0 and 4.5 per cent. fat,	36 samples.
Between 3.5 and 4.0 per cent. fat,	37 samples.
Between 3.0 and 3.5 per cent. fat,	17 samples.
Between 2.5 and 3.0 per cent. fat,	10 samples.
Total	105

The following twelve samples judged by the commonly received standards are adulterated:

No.	Dealer.	Specific Gravity.	Solids.	Fat.	Solids not fat.
7728	Mrs. P. E. Davis, 228 Shelton Ave.	29.2*	11.35	3.14	8.21
7749	M. Maremma, 76 Oak St.	30.7	11.03	2.80	8.23
7769	Cor. Washington and Portsea Sts.	20.6	10.00	3.72	6.28
7773	185 Columbus Ave. cor. Liberty St.	28.7	11.39	3.50	7.89
7783	Cor. Lawrence, opposite Forsyth's Dye Works	30.4	11.45	3.20	8.25
7787	Ferry St., cor. Pierpont St.	31.0	10.38	2.29	8.09
7799	398 Grand Ave.	28.4	11.43	3.60	7.83
7800	D. Dore, Grand Ave	30.5	11.48	3.20	8.28
7817	Stier's Bakery, 127 Congress Ave.	28.5	11.09	3.30	7.79
7821	Mrs. P. E. Davis, 228 Shelton Ave.	30.3	10.92	2.60	8.32
7827	N. Stein, 815 Grand Ave.	29.0	10.55	2.89	7.66
7828	Bakery, cor. State and Olive Sts.	29.5	10.59	2.60	7.99

* Read 1.0292.

Eleven samples beside these, whether adulterated or not, were of such inferior quality as not to be fairly marketable.

Twenty-three samples of milk, therefore, or more than one-fifth of the whole number examined, were either adulterated, or of such inferior quality that their sale might justly be prohibited by statute or city ordinance.

It is a perfectly familiar fact that pure milk from healthy cows has no fixed and constant composition.

Differences of breed, individual differences among cows of one breed, the age of the cows, the feed, and the period of lactation, all affect the chemical composition of the milk in a very marked degree.

The differences in chemical composition of pure milk are, however, very much smaller when comparison is made between the mixed milk of many cows rather than between the milk of individual cows.

Milk which is sold in our cities represents, almost without exception, the mixed milk of a number of cows or of herds.

State and municipal governments, boards of health and associations of official chemists have from time to time adopted "standards" of composition of milk, fixing minimum percentages of solids, fat and solids not fat, or a specific gravity which shall serve to distinguish pure or marketable milk from adulterated or unmarketable milk.

Thus, in the State of New York, a seller is liable to prosecution if the milk has less than 12 per cent. of solids and 3 per cent. of fat.

In Massachusetts, milk must contain 13 per cent. of solids in all months except May and June, and in those months must have at least 12 per cent. of solids.

The standard adopted by the Society of Public Analysts of England is

Solids	11.50
Fat	3.00
Solids, not fat	8.50

The standard which is fair for one country or section or State is not necessarily fair for another.

If the standard is a reasonable one it will sometimes happen that pure, unadulterated milk of very inferior quality will fall below its requirements and thus be condemned as adulterated when it is not.

But the public ought to be protected from genuine milk of a very poor quality as well as from richer milk which has been adulterated.

We believe that in this State milk which is sold at the usual market rates ought to have a specific gravity between 1.029 and 1.033, with not less than 3.5 per cent. of fat and 11.50 per cent. of solids; and if any two of the three fall below the minimum named, the milk should be declared unsalable.

We consider these as the lowest limits which should be recognized in this State and leave the question open for the present whether they are not too low.

It would seem to be wise to forbid the sale, under penalty, of any milk which does not come up to the prescribed quality, leaving the question of wilful adulteration out of the issue.

All of the samples of milk examined were tested for preservatives, but none were found in any of them.

The use of preservatives in milk without notice to the purchaser is clearly forbidden in the sixth provision of section 3 of the pure food law.

CREAM OF TARTAR.

By A. W. Ogden.

Cream of tartar is made from argol, an incrustation formed during the fermentation of wines, and is brought into commerce as a white crystalline solid or powder having a pleasant, sour taste.

It is, chemically considered, acid potassium tartrate, which when chemically pure contains 25.0 per cent. of potash.

"It usually contains from 2 to 7 per cent. of calcium tartrate, an amount admissible in samples for medical use, but it sometimes contains from 8 to 13 per cent. of tartrate of calcium."—(*U. S. Dispensatory, 15th Ed., 1153.*)

It is used in cookery to "raise" bread by setting free carbonic acid from the salæratus or "soda" which is mixed with dough.

One hundred and three samples bought by the Station agents for cream of tartar have been examined.

Thirty-five were in packages bearing the manufacturer's, grinder's or packer's name and brand. Of these, seven were adulterated, as will be seen in Table XXI.

The samples bearing the names of the following firms were unadulterated: Austin, Nichols & Co., N. Y., Berry Wisner, Lohman & Co., N. Y., Bugbee and Brownell, Providence, R. I., Clark, Chapin & Bushnell, N. Y., Francis H. Leggett & Co., N. Y., Lincoln, Seyms & Co., Hartford, Ct., James P. Powers & Co., N. Y., James Pyle, N. Y., D. & L. Slade Co., Boston, Mass., Stickney & Poor, Boston, Mass., Thurber, N. Y.

Sixty-eight samples of cream of tartar were bought in bulk from retail grocers in different parts of the State.

Twenty-four of these were variously adulterated, some of them containing no cream of tartar at all.

Partial analyses of them, with statement of the adulterants, are given in Table XXI.

In addition to the adulterants named in the table, all of the samples, with exception of Nos. 537, 539, 557, 665 and 1500, also contained starch.

Table XXI.—Adulterated Cream of Tartar.

No.	Manufacturer or Wholesaler.	Retailer.	Analysis. Potash.	Soda.	Lime.	Sulphuric Acid.	Phosphoric Acid.	Nitrogen.	Nature of Adulteration.
543	Sold in bulk.	H. Glover & Son, Wall St., Norwalk	.19	3.59	20.37	8.96	38.94	----	Acid phosphate of lime.
644	"	Philip Aperion, 8 Main St., Torrington	trace.	2.48	25.06	12.96	33.01	.10	" " "
572	"	M. Blanchette, 263 So. Main St., Waterbury	----	2.36	21.84	13.24	32.18	.12	" " "
1439	"	Appley & Jordan, 88 West Main St., Norwich	.85	2.10	24.28	21.63	23.74	----	" " "
574	"	Healey's South End Groceries, 622 So. Main St., Waterbury	----	1.84	20.04	23.87	23.67	.44	" " "
1434	"	A. Wilson, 78 Franklin St., Norwich	trace.	2.91	23.68	20.42	22.20	----	" " "
649	"	York State Butter Store, 176 Main St., Ansonia	----	1.38	16.94	21.54	21.98	.50	" " "
700	Coburn & Co. First Quality.	W. G. Graves, 341 Grand Ave., New Haven	1.23	1.50	19.78	25.95	15.94	.52	" " "
544	Sold in bulk.	————, 53 Main St., Norwalk	.22	2.20	29.80	32.05	15.46	----	" " "
1450	"	H. A. Wheaton, Spring St, Danielson	.21	1.30	13.50	12.91	13.75	----	" " "
622	Challenge Mills, N.Y.	J. A. Pillgard, 138 Front St., Hartford	----	----	----	----	----	----	" " "
527	" " "	C. H. Reid, 476 Main St., Bridgeport	7.33	1.55	18.22	14.88	18.45	.09	" " "
632	Sold in bulk.	R. Fowler, Ford St., Hartford	15.07	1.67	7.50	10.34	1.66	----	Sulphate and phosphate of lime.
1458	"	Kingsley's Store, Plainfield	14.87	1.15	10.20	8.79	9.56	----	" " " "
1431	"	E. A. Fitch, Broadway, Norwich	14.20	1.63	10.34	9.14	10.00	----	" " " "
593	"	D. M. Welch & Son, Congress Ave., New Haven	12.23	1.61	12.72	19.43	----	.18	Plaster.
659	"	" " " Main St., Derby	11.59	1.43	10.92	18.48	----	.18	"
658	"	Barry's New York Store, 374 Main St., Ansonia	10.95	1.42	12.60	19.98	----	.20	"
539	"	Gustav E. Friedrich, South Norwalk	9.70	1.25	17.88	24.90	----	----	"
557	Bennett, Sloan & Co.	M. McPhelan, White St., Danbury	8.22	1.33	18.46	27.13	----	.20	"
1500	" " "	J. McEwen, 117 Saltonstall Ave., Fair Haven	----	----	----	----	----	----	"
1476	Sold in bulk.	S. C. Amidon, 877 Main St., Willimantic	6.83	1.69	8.74	21 27	6.56	1.08	Sulphate and phosphate of lime.
1427	"	Keefe and Davis, 125 Bank St., New London	4.51	2.37	17.94	13.02	13.78	----	" " " "
637	Crescent Mills, New Haven.	G. S. Weeks, 184 Main St., Torrington	4.46	1.50	15.38	23.12	12.51	.60	" " " "
1497	Crescent Mills, New Haven.	New Haven Provision Co., 398 Grand Ave., Fair Haven	----	----	----	----	----	----	" " " "
554	Sold in bulk.	Mastin & Co., 79 White St., Danbury	----	1.85	27.42	38.80	---	----	Plaster.
548	"	New York Grocery Co., Main St, Norwalk	1.16	1.29	26.04	36.34	----	trace.	"
665	"	Morris Sheild, Main St., Derby	2.01	1.48	26.00	39.14	----	.30	"
610	"	Geo. W. Gates, Main St., Windsor Locks	.17	1.27	30.94	39.34	9.40	----	Sulphate and phosphate of lime.
611	"	James Keevers, Main St, Windsor Locks	.23	5.22	31.30	38.63	10.76	----	" " " "
537	"	A. Malmo's Market, Main St., So. Norwalk	----	1.84	27.74	38.69	9.43	trace.	" " " "

CEREAL FOODS.

By A. L. Winton.

Nine samples have been examined. No corn starch or tissue was found in any of them.

No wheat was found in the oat meals. All appeared to be properly branded and unadulterated.

The brands examined were the following:—

Oat Preparations.

H. O., made by Hornby's Oatmeal Co., New York.

Quaker Rolled White Oats, made by the American Cereal Co., Chicago, Ill.

Street's Perfection Rolled White Oats, and Toasted White Oats, made by S. H. Street & Co., New Haven, Ct.

Wheat Preparations.

Fould's Wheat Germ Meal, made by Fould's Milling Co., Cincinnati.

Wheatlet, made by Franklin Mills Co., Lockport, N. Y.

Eli Pettijohn's Best, made by Eli Pettijohn Cereal Co., Minneapolis.

Pettijohn's Breakfast Gem, C. S. Lanmeister.

Ralston Health Club Breakfast Food, made by Robinson-Danforth Co., St. Louis, Mo.

Street's Perfection Wheatine, made by S. H. Street & Co., New Haven.

Wheatena.

SUMMARY.

As appears in the following table, this report contains the results of examination of 849 articles of food of thirteen different kinds.

With the exception of Martius' yellow, found in minute quantity in certain samples of mustard, no poisonous adulterants have been found.

Table XXII.

	Examined.	Pure.	Doubtful.	Adulterated.
Maple Syrup	61	48	5	8
" Sugar	7	7	--	--
Sugar	16	16	--	--
Syrup	4	4	--	--
Strained Honey	48	43	--	5
Comb "	12	12	--	--
Lard	118	75	--	43
Pepper	102	62	8	32
Mustard	69	15	--	54
Cheese	72	72	--	--
Coffee	124	53	--	69
Milk	105	82	11	12
Cream of Tartar	103	72	--	31
Cereal Foods	9	9	--	--
	848	570	24	254

Of the whole number examined

67.2 per cent. were pure.

2.9 " were doubtful.

29.9 " were adulterated within the meaning of the act.

STATE LAWS REGARDING ADULTERATION OF FOOD AND DRUGS.

The following laws regarding special forms of adulteration of food or drugs are now on the statute books of this State and, with the Pure Food Law already printed on page 2, give a complete view of our legislation on this subject.

The statute regulating the sale of imitation butter created the office of Dairy Commissioner, who is charged with the execution of the laws regarding the sale of butter, molasses and vinegar. Numerous prosecutions have been brought for violation of these laws.

No one is charged with the execution of the laws regarding Adulteration of Milk, Adulteration of Candy, Adulteration of Spirituous and Intoxicating Liquors, and Adulteration of Drugs and Medicines. Boards of Health are *permitted* to act under the statute regarding the Adulteration of Food, but we cannot learn that any action was ever brought under any of these statutes, which do not make it the duty of some official or institution to see to their enforcement.

ADULTERATION OF BUTTER.

[G. S. 1888, Ch. CLVI.]

[Amended by Ch. CXIV, Public Acts, Jan. Sess. 1893, and Ch. XXXII, Public Acts, Sess. 1895.]

Sec. 2614. Any article resembling butter in appearance and not made wholly, salt and coloring excepted, from the milk of cows, shall be imitation butter within the meaning of this chapter. The words "butter," "dairy," or "creamery" shall form neither the whole nor a part of the name of any imitation butter, or appear upon any article, or upon any box, tub, or package containing imitation butter.

Sec. 2615. No person by himself, or his agents, or servants, shall render or manufacture, sell, offer for sale, expose for sale, take orders for the future delivery of, or have in his possession with intent to sell, any article, product or compound made wholly or partly out of any fat, oil or oleaginous substance or compound thereof, not produced from unadulterated milk or cream from the same, which shall be in imitation of yellow butter produced from pure unadulterated milk or cream of the same; provided that nothing in this act shall be construed to prohibit the manufacture or sale of oleomargarine in a separate and distinct form and in such manner as will advise the consumer of its real character free from coloration or any ingredient that causes it to look like butter. No imitation butter shall be sold or exposed for sale or delivered except under the following conditions: First, the seller shall maintain in plain sight, over or next the main outer entrance of the premises where the selling is done, a sign bearing in plain, black roman letters, not less than two inches wide and four inches long, on a white ground, the words "sold here," preceded by the name of the imitation article. If the selling is done from a wagon, or other vehicle, such vehicle shall conspicuously bear upon its outside, on both sides of said wagon or vehicle, such a sign. If the delivering is done from a wagon or other vehicle, such vehicle shall conspicuously bear, upon its outside, on both sides of said wagon or vehicle, a sign bearing in plain, black, roman letters, not less than two inches wide and four inches long, on a white ground, the words "delivered here," preceded by the name of the imitation article. Second, all imitation butter shall be kept in an enclosing package which shall bear on the outside of its body, and also of its cover, at all times in plain sight of a beholder of the package, in black, roman letters, not less than one inch wide, and two inches long, on a white or light-colored ground, the name of the imitation article.

Third, the seller shall orally inform each buyer at each sale that the article he buys is not butter, and shall give the buyer the name of the imitation article.

Fourth, every person, copartnership, or corporation, selling, or offering for sale, any imitation butter, and every keeper of a hotel boarding-house, or restaurant, temporary or permanent, who shall furnish any guest with any imitation butter, or food containing it, shall within fifteen days after the passage of this act, or within fifteen days after commencing said business, and annually on the first day of May, or within fifteen days thereafter, register in a book kept by the Dairy Commissioner for that purpose, the name and the town, street and number of street of the place of business of said person, copartnership, corporation, keeper of hotel, boarding-house, or restaurant. All signs prescribed in sections

2615, 2616 and 2617 of the General Statutes, shall be provided by the Dairy Commissioner, and all signs required, under provisions of section 2515 of the General Statutes, to be maintained in plain sight, over or next the main outer entrance of the premises where the selling is done, shall be placed in position, under the direction of the Dairy Commissioner or his deputy. All signs so furnished by the Dairy Commissioner shall be paid for by the parties receiving the same, the same to be furnished at the actual cost thereof.

SEC. 2616. No baker or vender of food shall sell or expose for sale any article of food containing imitation butter unless such baker or vender shall maintain the same kind of a sign as hereinbefore first prescribed, in the way and manner prescribed in that connection, except that the word "used" shall be substituted for the word "sold." If the selling be done from a wagon, or other vehicle, such vehicle shall conspicuously bear such a sign.

SEC. 2617. No keeper of a hotel, boarding-house, or restaurant, temporary or permanent, shall furnish any guest with any imitation butter, or food containing it, unless such keeper shall maintain in plain sight of all guests sitting at tables where food is served such a sign or signs as hereinbefore prescribed, except that the word "used" shall be substituted for the word "sold."

SEC. 2618. The Governor shall appoint a citizen of the State as a Dairy Commissioner, who shall hold office for two years from and after the first day of May succeeding his appointment, and until his successor is appointed, unless sooner removed by the Governor for cause; and in case of his death, resignation, or removal, the Governor shall fill the vacancy. It shall be the duty of the Dairy Commissioner to attend to the enforcement of this chapter throughout the State. A room in the Capitol shall be set apart for the Dairy Commissioner. He may appoint and remove a deputy, who may also act as clerk. The Dairy Commissioner and his deputy shall have free access, at all reasonable hours, for the purpose of examining into any suspected violation of this chapter, to all places and premises, apartments of private families keeping no boarders excepted, where the Dairy Commissioner or his deputy suspects imitation butter to be made, sold, or used; and on tender of the market price of good butter for the same may take from any person, firm, or corporation, samples of any articles suspected to be imitation butter. The Dairy Commissioner may have samples suspected to be imitation butter

analyzed at the Connecticut Experiment Station, or by any State chemist, and a sworn or affirmed certificate of the analyst shall be *prima facie* evidence of the ingredients and constituents of the sample analyzed. Any one refusing the Dairy Commissioner, or his deputy, access, in a reasonable manner and at a reasonable time, to premises for said purpose of examination, or refusing to sell samples as hereinbefore provided for, shall incur the penalty hereinafter first provided for violation of this chapter.

The Dairy Commissioner shall make an annual report to the Governor, and such annual reports shall be submitted to the General Assembly at its regular session.

SEC. 2619. Any person violating any of the provisions of sections 2614, 2615 or 2616, and any person except a boarding-house keeper violating section 2617, shall for the first offence be fined not more than one hundred dollars, or imprisoned not more than sixty days, or both; for any subsequent offence said fine and imprisonment shall be doubled. Any boarding-house keeper violating section 2617 shall for the first offence be fined twenty-five dollars, or imprisoned not exceeding thirty days, or both; for any subsequent offence, said fine and imprisonment last mentioned shall be doubled. Evidence of any violation of this chapter, shall be *prima facie* evidence of wilful violation, with knowledge.

ADULTERATION OF MILK.

[G. S. 1888, Ch. CLVIII.]

SEC. 2658. Whoever shall knowingly sell, supply, or bring to be manufactured to any butter or cheese manufactory in this State any milk diluted with water, or adulterated by the addition of any foreign substance, or from which any milk or cream or milk commonly known as strippings has been taken; or whoever shall knowingly bring or supply milk to any butter or cheese manufactory that is tainted or partly sour, shall forfeit not less than twenty-five nor more than one hundred dollars, with costs of suit, for the benefit of the person or persons upon whom such fraud shall be committed.

SEC. 2659. The usual test for quality and the certificate of analysis of the Director of the Connecticut Agricultural Experiment Station shall be deemed *prima facie* proof of adulteration.

SEC. 2660. No person shall sell, offer or expose for sale any milk from which the cream, or any part thereof, has been removed, without distinctly and durably affixing a label, tag, or mark of metal in a conspicuous place upon the outside, and not more than six inches from the top of every can, vessel, or package containing such milk, and such metal label, tag, or mark shall have the words "Skimmed Milk" stamped, printed, or indented thereon in letters not less than one inch in height; and such milk shall only be sold or retailed out of a can, vessel, or package so marked.

SEC. 2661. No person shall sell or offer for sale, or shall have in possession with intent to sell or offer for sale, any impure or adulterated milk.

SEC. 2662. Every person who shall violate any of the provisions of the two preceding sections shall be fined not more than seven dollars, or imprisoned not more than thirty days, or both.

SEC. 2663. A printed notice of this and the five preceding sections shall be conspicuously posted in all public places, creameries or factories where milk is received or sold.

SEC. 2664. Any person who shall knowingly sell, or expose for sale, milk, or any product of milk, from any cow which shall have been adjudged, by the Commissioners upon Diseases of Domestic Animals, affected with tuberculosis, or other blood disease, shall be fined not more than seven dollars, or imprisoned not more than thirty days, or both.

ADULTERATION OF MOLASSES.

[G. S. 1888, Ch. CLVII.]

[Amended by Ch. CCXXXVIII, Public Acts, Jan. Sess., 1889.]

SEC. 2620. It shall be the duty of the Dairy Commissioner to attend to the enforcement of the law against the adulteration of molasses and the sale of adulterated molasses, and for the purpose of examining into suspected violations of such law, he shall, at all reasonable hours, have free access to all places and premises where he suspects that molasses is adulterated or adulterated molasses is sold, and, on tender of the market price of good molasses for the same, he may take from any person, firm or corporation, samples of molasses which he suspects is adulterated; and he may have samples of molasses suspected to be adulterated analyzed by any State chemist or by the Experiment Station, and a sworn or affirmed certificate of such analyst shall be *prima facie* evidence of the ingredients and constituents of the sample analyzed; and if such analysis shall show that the molasses is adulterated, he shall make complaint to the proper prosecuting officer that the person or persons who adulterated said molasses, or sold or exposed for sale such adulterated molasses, may be prosecuted.

SEC. 2621. Any person refusing the Dairy Commissioner or his deputy access in a reasonable manner and at a reasonable time for said purpose of examination, or refusing to sell samples as hereinbefore provided, shall be fined not more than seven dollars, or imprisoned not more than thirty days, or both.

SEC. 2622. Any person who shall adulterate any molasses, or who shall sell, or offer, or expose for sale, or who shall solicit or receive any order for the sale or delivery within this State, or for delivery without this State for shipment into this State, of any molasses adulterated with salts of tin, terra alba, glucose, dextrose, starch sugar, corn syrup, or other preparation of or from starch, shall be fined not more than five hundred dollars, or imprisoned not more than one year, or both. The delivery of any of the above mentioned preparations upon any order solicited or received within this State, shall be conclusive evidence that the order, upon which such delivery was made, was for such articles, and shall render the person soliciting or receiving such order liable to the penalty above prescribed.

ADULTERATION OF CANDY.

[Chapter CLXXXIII, Acts of Session of 1895.]

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Any person who shall adulterate candy with terra alba, barytes, talc, or any other mineral substance, or with poisonous colors or flavors, or knowingly sell or offer for sale candy so adulterated, shall be punished by a fine of not more than one hundred dollars.

AN ACT TO PREVENT FRAUD IN THE MANUFACTURE AND SALE OF VINEGAR.

[Chap. LX, Acts of Session of 1889, as amended by Chap. CCXXXIV of Acts of same Session.]

Be it enacted by the Senate and House of Representatives in General Assembly convened:

SECTION 1. No person shall make and sell, or make for sale, as cider vinegar, any vinegar not produced wholly from the juice of apples. No person shall add to any vinegar, or to any article sold or to be sold as vinegar, any drug, any hurtful or foreign substance, any coloring matter, or any acid, other than acetic. Any person violating this section of this act shall be fined fifty dollars for a first offense, and for a second or later offense he shall be fined one hundred dollars and imprisoned thirty days.

SEC. 2. No person shall make and sell, or make for sale, any vinegar not having an acetic acidity equivalent to the presence therein of not less than four per centum by weight of absolute acetic acid, and in the case of cider vinegar, not less than two per centum by weight of cider vinegar solids upon full evaporation over boiling water. No maker of vinegar shall sell the same without conspicuously branding, stenciling or painting upon the head of the barrel, cask, keg, or package containing the same, the name of the maker, his residence or place of manufacture, and in the case of cider vinegar, the words "cider vinegar," *provided* that this clause concerning marking shall not apply to retail sales, at the place of manufacture, in quantities of less than five gallons, and in open packages. Any person violating this section of this act shall be fined ten dollars for a first offense, and for a second or later offense fifty dollars.

SEC. 3. No person shall sell, or offer, or expose for sale, or exchange, or solicit, or receive any order for the sale or delivery within this State, or for delivery without this State for shipment into this State: first, any vinegar, as cider vinegar, not wholly produced from the juice of apples; or second, any vinegar, or article sold or to be sold as vinegar, in which has been added any drug, or any hurtful or foreign substance, or any coloring matter, or any acid other than acetic; or third, any vinegar not having an acetic acidity equivalent to the presence therein of not less than four per centum by weight of absolute acetic acid, and in case of cider vinegar, not less than two per centum by weight of cider vinegar solids upon full evaporation over boiling water; or fourth, any vinegar made in this State and purchased by the person last mentioned of the maker in a barrel, cask, keg or other package not branded, stenciled or painted as required by a previous section of this act. Any person violating this section of this act shall be fined ten dollars for a first offense, and for a second or later offense fifty dollars. The delivery of any of the above mentioned articles upon any order solicited or received within this State shall be conclusive evidence that the order upon which such delivery was made was for such articles, and shall render the person soliciting or receiving such order liable to the penalty above prescribed.

SEC. 4. It shall be the duty of the Dairy Commissioner to attend to the enforcement of this act; and, for the purpose of examining into suspected violations thereof, he shall at all reasonable hours have free access to all places and premises where he suspects that any provision of this act is violated, and on tender of the market price of good vinegar therefor, he may take from any person, firm or corporation, samples of vinegar which he suspects of being made or sold in violation of this act; and he may himself analyze such samples, or have such samples analyzed by any State chemist or by the Experiment Station; and a sworn or affirmed certificate by such analyst shall be *prima facie* evidence of the ingredients and constituents of the sample analyzed; and if such analysis shall show that such sample does not conform to any requirement of this act, and shall give the Dairy Commissioner reasonable ground for belief that any provision of this act has been violated he shall make complaint to the proper prosecuting officer, to the end that the violator may be prosecuted.

SEC. 5. Any person refusing the Dairy Commissioner or his deputy access, in a reasonable manner and at a reasonable time, for said purpose of examination, or refusing to sell samples as hereinbefore provided, shall be fined not more than seven dollars, or imprisoned not more than thirty days, or both. Evidence of any violation of this act shall be *prima facie* evidence of wilful violation with knowledge.

ADULTERATION OF SPIRITUOUS AND INTOXICATING LIQUORS.

[G. S. 1888, Ch. CLXXXVII, Sec. 3100.]

Every person who shall manufacture, sell, or keep for sale, any spirituous or intoxicating liquors, or any liquors made or compounded in imitation thereof, which are adulterated with any deleterious or poisonous substance, shall be fined not more than two hundred and fifty dollars, which fine shall be paid, one-half to him who shall prosecute to effect, and the other half to the town in which such offense is committed.

ADULTERATION OF DRUGS AND MEDICINES.

[G. S. 1888, Ch. CLXXXVIII, Sec. 3129.]

Every person who shall knowingly adulterate or cause any foreign or inert substance to be mixed with any drug, or medicinal substance or preparation recognized by any pharmacopœa or employed in medical or medicinal practice, so as to weaken or destroy its medicinal effect, or shall sell such drug, or compound, knowing it to be so adulterated or mixed, shall be fined not less than ten, nor more than one hundred dollars, and upon conviction, all such adulterated or mixed articles in his possession may be seized upon a warrant issued by the court in which such conviction is had, and destroyed by the officer by whom such seizure shall be made.

ADULTERATION OF FOOD.

[G. S. 1888, Ch. CLVIII.]

Sec. 2648. The boards of health of the several cities, boroughs, and towns, in this State, may from time to time, at their discretion, procure from any dealer in provisions, groceries, medicines, or other articles of consumption, samples of such articles, and cause the same to be analyzed by one of the State chemists, and if on such analysis it shall be found that the article analyzed is adulterated with any deleterious or foreign ingredient or ingredients, other than is represented verbally and in a conspicuous label by the seller, the chemist making the analysis shall issue his certificate setting forth the kind and quantity, as near as may be, of deleterious and foreign ingredients found in the article analyzed, and the board of health causing such analysis to be made shall cause said certificate to be published in some paper published in the city, borough, or town, or one nearest thereto, where the article analyzed was obtained, for such length of time as they may think proper, and the cost of analysis, together with the cost of the publication of the certificate, shall be paid by the person or firm from whom the article analyzed was obtained; and if such person or firm shall so elect, he or they may annex to said certificate his or their sworn affidavit, setting forth from whom the article analyzed was purchased by him or them.

Sec. 2649. In all cases where an analysis has been made according to the provisions of the preceding section, and the article or articles analyzed shall have been found pure and free from foreign ingredients, the cost of the analysis shall be paid by the city, borough, or town, whose board of health, or any officer thereof, caused such analysis to be made.

Sec. 2650. Every person, who shall adulterate any sugar, or who shall knowingly sell, or offer or expose for sale any sugar which has been adulterated with salts of tin, terra alba, glucose, dextrose, starch sugar, corn syrup, or other preparation from starch, shall be fined not more than five hundred dollars, or imprisoned not more than one year.

COMMERCIAL FERTILIZERS.

During 1896 fifty-two manufacturing firms have entered for sale in this state two hundred and fifty-five distinct brands of fertilizers, viz:

Special manures for particular crops	91
Other nitrogenous superphosphates	104
Bone manures and "bone and potash"	33
Chemicals, including fish, tankage and castor pomace	27
	255

The duties of this Station regarding fertilizers are prescribed by law as follows:

THE FERTILIZER LAW OF CONNECTICUT.

The General Assembly, in 1882, passed an Act concerning Commercial Fertilizers, which, as amended in 1893, is now in force.

Attention is specially called to the following requirements of the law, the full text of which is printed on pages 83 and 84.

1. In case of *all* fertilizers or manures, except stable manure and the products of local manufactures 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 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 Station, 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 provisions of the foregoing sections of this chapter shall be fined one hundred dollars for the first offense, 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, 1897.

Firm.	*Brand of Fertilizer.*
Baker, H. J. & Bro., 93 William St., New York City.	Special Corn Manure.
	Special Potato Manure.
	A. A. Ammoniated Superphosphate.
	Special Tobacco Manure.
	Special Onion Manure.
	Harvest Home Fertilizer.
	Castor Pomace.
Berkshire Mills, Bridgeport, Conn.	Berkshire Complete Fertilizer.
	" Ammoniated Bone Phosphate.
	" Fish and Potash.
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 Potato Manure.
	" Hill and Drill Phosphate.
	" Farm and Garden Phosphate or Ammoniated Bone Fertilizer.
	" Bone and Potash, Square Brand.
	" Tobacco Grower.
	" Sure Crop Phosphate.
	" Market Garden Manure.
	Nitrate of Soda.
	Dissolved Bone Black.
	Muriate of Potash.
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.

Firm.	Brand of Fertilizer.
Bradley Fertilizer Co., 92 State St., Boston, Mass.	Bradley's Original Coe's Superphosphate. " Farmer's New Method Fertilizer. " High Grade Tobacco Manure. " Eclipse Phosphate. " Potato Fertilizer.
Burwell, E. E., New Haven, Conn.	Dried Blood and Meat. Dissolved Bone Black. Double Sulphate Potash and Magnesia. Muriate of Potash. Nitrate of Soda.
Clark's Cove Fertilizer Co., Farlow Building, State St., Boston, Mass.	Bay State Fertilizer. Bay State Fertilizer G. G. Great Planet Manure. Potato and Tobacco Fertilizer. King Philip Guano.
Cleveland Dryer Co., 92 State St., Boston, Mass.	Cleveland Superphosphate. " Potato Phosphate. " Fertilizer.
Clinton, Elbert, Clintonville, Conn.	Ground Bone.
Coe Co., The E. Frank, 133-137 Front St., New York City.	E. Frank Coe's High Grade Potato Fertilizer. E. Frank Coe's High Grade Ammoniated Bone Superphosphate. E. Frank Coe's Alkaline Bone Phosphate. E. Frank Coe's Ground Bone and Potash. " " Gold Brand Excelsior Guano.
Cooper's Glue Factory, Peter, 17 Burling Slip, New York City.	Bone Dust.
Crocker Fertilizer and Chemical Co., Buffalo, New York.	Crocker's General Crop Phosphate. " Universal Grain Grower. " New England Tobacco Grower. " Ammoniated Bone Superphosphate. " Potato, Hop and Tobacco Phosphate. " Ammoniated Wheat and Corn Phosphate. " New Rival Ammoniated Superphosphate. " Special Potato Manure. " Vegetable Bone Superphosphate. " Practical Ammoniated Superphosphate. " Special Connecticut Tobacco Manure. " Pure Ground Bone.

Firm.	Brand of Fertilizer.
Cumberland Bone Phosphate Co., State St. and Merchants Row, Boston, Mass.	Cumberland Superphosphate. " Potato Fertilizer. " Concentrated Phosphate. " Fertilizer.
Darling Fertilizer Co., The L. B., Pawtucket, R. I.	Potato and Root Crop Manure. Animal Fertilizer. Garden and Lawn. Tobacco Grower. Fine Bone. Animal "G."
Downs & Griffin, Derby, Conn.	Ground Bone.
Eastern Farm Supply Association, Montclair, N. J.	Carteret Manure for General Use.
Ellsworth, F., Hartford, Conn.	Shoemaker's Swift Sure Bone Meal. " " Superphosphate.
Great Eastern Fertilizer Co., Rutland, Vermont.	Great Eastern General Fertilizer. " " Northern Corn Special Fertilizer. " " Soluble Bone and Potash. " " Vegetable, Vine and Tobacco. " " Garden Special.
Hartford Fertilizer Co., Hartford, Conn.	Ground Bone.
Jefferds, John G., Worcester, Mass.	Ground Bone.
Kelsey, E. R., Branford, Conn.	Bone, Fish and Potash.
Lister's Agricultural Chemical Works, Newark, N. J.	Standard Superphosphate of Lime. Success Phosphate. Special Potato. Animal Bone and Potash.
Lowell Fertilizer Co., Lowell, Mass.	Lowell Bone Fertilizer. " Animal Fertilizer. " Potato Phosphate. " Vegetable and Vine. " Lawn Dressing. " Tobacco Fertilizer.
Luce Bros, Niantic, Conn.	Giant's Neck Superphosphate. Pure Dry Fish Guano. Bone, Fish and Potash.
Ludlam, Frederick, 108 Water St., New York City.	Cecrops or Dragon's Tooth. Cereal Brand.
Lyman, Chas. E., Middlefield, Conn.	Corn Manure. Potato Manure.

Firm.	Brand of Fertilizer.
Mapes' Formula and Peruvian Guano Co., 143 Liberty St., New York City.	Potato Manure. Complete Manure for General Use. Fruit and Vine Manure. Corn Manure. Fine Bone Dissolved. Complete Manure for Light Soils or Vegetable Manure. Tobacco Starter. Grass and Grain Spring Top-Dressing. Complete Manure "A" Brand. Tobacco Manure, Wrapper Brand. Seeding Down Manure.
Miles, G. W., Milford, Conn.	Fish Guano. IXL Ammoniated Bone Superphosphate. "Ceres" Complete.
Miller, G. W., Middlefield, Conn.	Ground Bone. Unexcelled Phosphate.
Milsom Rendering and Fertilizer Co., 963 William St., E. Buffalo, N. Y.	Buffalo Fertilizer. Potato, Hop and Tobacco Phosphate. Vegetable Bone Fertilizer. Wheat, Oats and Barley Phosphate. Potato, Hop and Tobacco Phosphate, Long Island Brand. Special Potato Fertilizer. Bone Meal. Erie King. Buffalo Guano. Cyclone Bone Meal. Dissolved Bone and Potash. Dissolved Bone. Buffalo Fertilizer (Long Island Brand).
Niagara Fertilizer Works, Buffalo, New York.	Niagara Wheat and Corn Producer. " Triumph. " Grain and Grass Grower. " Potato, Tobacco and Hop Fertilizer.
National Fertilizer Co., Bridgeport, Conn.	Chittenden's Complete Fertilizer. " Ammoniated Bone Phosphate. " Fish and Potash. " Market Garden. " Potato Phosphate. " Fine Ground Bone.
Nuhn, Frederick, Waterbury, Conn.	Self-Recommending Fertilizer.
Olds & Whipple, Hartford, Conn.	O. & W. Special Phosphate.
Pacific Guano Co., Box 1368, Boston, Mass.	Soluble Pacific Guano. Special Potato Manure. Nobsque Guano. High Grade General Fertilizer.

Firm.	Brand of Fertilizer.
Packers' Union Fertilizer Co., Box 1528, New York City.	Potato Manure. Gardeners' Complete Manure. Animal Corn Fertilizer. Oats and Clover Fertilizer. Universal Fertilizer.
Parks, C. D., Danbury, Conn.	Bone Meal. Nameless Fertilizer. Potato Manure.
Peck Bros., Northfield, Conn.	Pure Ground Bone.
Plumb & Winton Co., Bridgeport, Conn.	Ground Bone.
Pouleur, August, Windsor, Conn.	Pure Bone Meal.
Preston Fertilizer Co., Greenport, L. I.	Bone. Superphosphate. Potato, Hop and Onion Fertilizer.
Quinnipiac Co., 92 State St., Boston, Mass.	Quinnipiac Phosphate. " Potato Manure. " Market Garden Manure. " Ammoniated Dissolved Bone. " Fish and Potash, Crossed Fishes. " Fish and Potash, Plain. " Phosphate, Pine Island. " Havana Tobacco Fertilizer. " Grass Fertilizer. " Corn Manure. " Pure 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. Fish and Potash. Vegetable and Vine. Practical Potato Special.
Rogers & Hubbard Co., Middletown, Conn.	The Rogers & Hubbard Co's Pure Raw Knuckle Bone Flour. The Rogers & Hubbard Co's Pure Raw Knuckle Bone Meal. The Rogers & Hubbard Co's Strictly Pure Fine Bone. The Rogers & Hubbard Co's Oats and Top-Dressing. The Rogers & Hubbard Co's Soluble Potato Manure. The Rogers & Hubbard Co's Soluble Tobacco Manure.

Firm.	*Brand of Fertilizer.*
Rogers & Hubbard Co., Middletown, Conn.	The Rogers & Hubbard Co's Grain and Grass Fertilizer. Fairchild's Corn Formula and General Crops. The Rogers & Hubbard Co's Fruit Fertilizer.
Rogers Mfg. Co., Rockfall, Conn.	Potato Manure. Corn Manure. Complete Manure. Pure Ground Bone. Top-Dressing and Oat Manure. Tobacco Manure. Grass and Grain Manure.
Russia Cement Co., Gloucester, Mass.	Essex XXX Fish and Potash. " Manure for Corn and Grain. " Manure for Potatoes and Roots.
Sanderson, L., New Haven, Conn.	Old Reliable Superphosphate. Formula A. Pulverized Bone and Meat. Blood. Bone and Meat. Fine Ground Bone. Muriate of Potash. High Grade Sulphate of Potash. Sulphate of Potash. Nitrate of Soda. Sulphate of Ammonia. Dissolved Bone Black.
Standard Fertilizer Co., Farlow Building, State St., Boston, Mass.	Standard Fertilizer. " Potato and Tobacco Fertilizer. " Guano. " Fine Ground Bone. " Complete Manure.
Walker, Stratman & Co., Pittsburgh, Pa.	Four Fold. Potato Special. Smoky City. Butchers' Bone Meal. Pure Raw Bone Meal. Big Bonanza.
Wheeler & Co., M. E., Rutland, Vermont.	High Grade Fruit Fertilizer. Grass and Oats. Potato Manure. High Grade Corn. Superior Truck. Electrical Dissolved Bone.
Wilcox Fertilizer Works, Mystic, Conn.	Wilcox Potato, Onion and Tobacco Manure. Wilcox Ammoniated Bone Phosphate. " Complete Bone Superphosphate. " High Grade Fish and Potash. " Dry Ground Fish Guano.

Firm.	*Brand of Fertilizer.*
Wilkinson & Co., Box 1807, New York City.	Economical Bone Fertilizer.
Williams & Clark Fertilizer Co., 27 William St., New York City.	Americus High Grade Special. " Ammoniated Bone Superphosphate. " Potato Phosphate. " Fine Wrapper Tobacco. " Corn Phosphate. Royal Bone Phosphate. Fish and Potash. Grass Manure. Pure Bone Meal. Americus Potato and Tobacco Fertilizer. Dry Ground Fish Guano.

SAMPLING AND COLLECTION OF FERTILIZERS.

During April, May and June, Mr. C. L. Backus of Andover, the sampling agent of this Station, visited ninety-four towns and villages of Connecticut to draw samples of Commercial Fertilizers for analysis. These places were distributed as follows:

Litchfield County,	8
Hartford "	23
Tolland,	10
Windham "	7
New London "	10
Middlesex "	5
New Haven "	16
Fairfield "	15
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In these places the agent drew 589 samples, representing 229 brands of fertilizers.

In this way one or more samples were secured of most of the brands of fertilizers which are 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 agent is 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 taken—

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 must be drawn in strict accordance with 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.

ANALYSES OF FERTILIZERS.

During the year, 492 samples of commercial fertilizers and manurial waste-products have been analyzed. A classified list of them is given on page 100.

On a few of these samples analyses were made for private parties and charged for accordingly. A few samples also were analyzed at the 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.

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 correction 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 directly assimilable by various low vegetable organisms, and 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 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 often 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 chemical change 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, wherein 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 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 paragraphs, 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 the 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 upon 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 disinte-

* Prepared and revised by the Director.

grated 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 ashes of wood and of cotton-seed hulls 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 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 1896.*

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 1895, were as follows:

* Adopted at a conference of representatives of the Connecticut, Massachusetts, New Jersey and Rhode Island Stations held in March, 1896.

	Cts. per lb.
Nitrogen in ammonia salts	15
nitrates	13½
Organic nitrogen in dry and fine ground fish, meat and blood and in mixed fertilizers	14
in cotton seed meal	12
in fine* bone and tankage	13½
in fine-medium* bone and tankage	12
in medium* bone and tankage	9
in coarse* bone and tankage	3
Phosphoric acid, water-soluble	5½
citrate-soluble †	5
of dry ground fine fish, bone and tankage	5
of fine-medium bone and tankage	4
of medium bone and tankage	2½
of coarse bone and tankage	2
of fine ground fish, cotton seed meal, castor pomace and wood ashes	4½
of mixed fertilizers (insoluble in ammonium citrate)	2
Potash as high-grade sulphate and in forms free from muriate (or chlorides)	5
as muriate	4½

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 tbe 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.

* Fine signifies smaller than $\frac{1}{50}$ inch; fine-medium between $\frac{1}{50}$ and $\frac{1}{25}$ inch; medium between $\frac{1}{25}$ and $\frac{1}{12}$ inch; coarse larger than $\frac{1}{12}$ inch.

† 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.

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, 14 cents.

Insoluble Phosphoric Acid is reckoned at 2 cents per pound. Potash is rated at 4¼ 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 5 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 1896 the average selling price of Ammoniated Superphosphates and Guanos was $31.56 per ton, the average valuation was $21.18 and the difference $10.38, an advance of 49.0 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 $36.19, the average valuation $25.64 and the difference $10.55 or 41.1 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 and Tankage*, the sample is sifted into the four grades just specified (see foot note, page 97), 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. See page 97.

Uses and Limitations of Fertilizer Valuation.

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

1. To show whether a given lot or brand of fertilizer 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	12
Sulphate of Ammonia	2
Dried Blood	1
Horn and Hoof	1
Cotton Seed Meal	51
Linseed Meal	9
Castor Pomace	7
Mustard Seed Cake	1
Preparations of Leather	4

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

Odorless Phosphate	1
Dissolved Bone Black	5
Dissolved Rock Phosphate	8

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

High Grade Sulphate of Potash	7
Double Sulphate of Potash and Magnesia	8
Phosphate of Potash	1
Muriate of Potash	12
"Potash Salts"	1

4. *Containing Nitrogen and Phosphoric Acid.*

Bone Manures	51
Tankage	13
Fish	11

MIXED FERTILIZERS.

Bone and Potash	3
Nitrogenous Superphosphates	116
Special Manures	95
Home Mixtures	11

MISCELLANEOUS FERTILIZERS AND MANURES.

Cotton Hull Ashes	33
Wood Ashes	19
Lime Kiln Ashes	2
Tobacco Stems and Dust	4
Muck	1
Peas and Beans	2
	492

DESCRIPTION AND ANALYSES OF FERTILIZERS.*

The samples referred to in the following pages, unless the contrary is stated, were drawn by an agent of the Station.

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.

In rare cases cargoes have been found to contain sodium perchlorate which, even in small amount, is very injurious to vegetation.†

5801. Sold by the Mapes' Formula and Peruvian Guano Co., N. Y. Sampled and sent by H. G. Manchester, West Winsted.

5802. Sold by L. Sanderson, New Haven. Sampled and sent by H. G. Manchester.

6099. Sold by Quinnipiac Co., through Olds & Whipple, Hartford.

6100. Sold by Mapes' Branch, Hartford.

6142. Sold by L. Sanderson, New Haven. Sampled and sent by C. B. Sheldon, West Suffield.

6244. Sold by Taylor & Brush, N. Y. City. Sampled and sent by W. F. Whitney, Yalesville.

6261. Sold by Bowker Fertilizer Co., through W. O. Goodsell, Bristol.

6263. Sold by E. E. Burwell, East Haven. Sampled and sent by him.

6290. Sold by Taylor & Brush, N. Y. City. Sampled and sent by A. E. Plant, Branford.

6340. Sold by Bradley Fertilizer Co., Boston. Sampled and sent by C. J. Dewey, Buckland.

6344. Sold by L. Sanderson, New Haven.

6479. Bought by the Station of L. Sanderson for use in vegetation experiments.

All these samples, as is shown in the table, were of average composition, the per cent. of nitrogen ranging from 15.53 to 16.21. The cost of nitrogen per pound has varied from 12.7 to 15.0 cents.

* This chapter, pp. 101 to 168, with exception of pp. 156 to 163, has been prepared for publication by Dr. Jenkins. The analyses of fertilizers have all been made by Messrs. Winton, Ogden and Mitchell, chemists of the Station, with the assistance of Mr. Lange.

† Landw. Presse XXIII: 1896, 615.

Analyses of Nitrate of Soda.

	5801	5802	6099	6100	6142	6244	6261	6263	6290	6340	6344	6479
Moisture	2.36	2.50	1.00	2.09	2.23	1.70	2.00	2.28	1.54	2.49	1.75	----
Insoluble in Water	.19	.30	.11	.08	.33	.12	.15	.17	.11	.33	.19	----
Common Salt	.70	.95	.46	.74	1.71	.41	1.72	.64	.43	.37	.89	----
Sodium Sulphate	.27	2.12	.12	.18	.34	.14	.30	.24	.11	.46	.20	----
Sodium Nitrate	96.48	94.13	98.31	96.91	95.39	97.63	95.83	96.67	97.81	95.35	96.97	----
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
Equivalent Nitrogen	15.90	15.53	16.21	15.98	15.73	16.10	15.81	15.94	16.14	15.73	15.99	15.77
Cost per ton		----	$46.00	44.00	45.00		45.00	48.00		40.00	48.00	
Nitrogen costs cents per pound		----	14.2	13.8	14.3	----	14.2	15.0	----	12.7	15.0	----

Sulphate of Ammonia, or Ammonium Sulphate.

This article, now made on a large scale as a by-product of gas works and coke ovens, 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.

6300. Sold by the Quinnipiac Co., Boston, through Olds & Whipple, Hartford.

6343. Sold by L. Sanderson, New Haven.

Analyses of Sulphate of Ammonia

	6300	6343
Nitrogen	20.92	20.84
Equivalent Ammonia	25.40	25.30
Cost per ton	$65.00	70.00
Nitrogen costs cents per pound	**15.5**	**16.8**

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 nearly black in color, and rich in nitrogen that is quickly available to vegetation.

A sample of this material, **6021,** used in the Station vegetation experiments, contained 13.58 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, **6020,** obtained for vegetation experiments, contained 15.33 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

Analyses of Decorticated Cotton Seed Meal.

Station No.	Dealer.	Sampled by	Nitrogen.	Phosphoric Acid.	Potash.	Cost per Ton.	Nitrogen costs cents per pound.
6054	Olds & Whipple, Hartford	Walter W. Pratt, East Hartford	8.09	2.81	1.85	$22.50	11.2
6068	Olds & Whipple, Hartford	Eugene Brown, Windsor	8.17	2.81	1.85	23.00	11.3
6144	D. L. Brockett, Suffield	Chas. B. Sheldon, Suffield	7.67	2.81	1.85	22.00	11.5
6293	W. F. Fletcher, Southwick, Mass.	L. R. Griffin, Granby	7.85	2.81	1.85	22.50	11.5
6296	L. J. Grant, Wapping	Station Agent	8.12	2.81	1.85	23.00	11.5
6113	James Perkins	James P. Spencer, Suffield	7.36	2.81	1.85	21.50	11.6
6171	American Cotton Oil Co.	R. W. Cowles, Tariffville	7.30	2.81	1.85	21.50	11.7
6151	C. H. Dexter's Sons, Windsor Locks	James Tobin, Windsor Locks	7.28	2.81	1.85	21.50	11.8
6172	C. M. Cox & Co., Boston, Mass.	R. W. Cowles, Tariffville	6.76	2.81	1.85	20.50	12.9
6028	Daniels Mill Co , Hartford	William Daly, East Windsor Hill	7.11	2.81	1.85	21.50	12.0
6045	J. E. Perkins, Suffield	F. B. Hathaway, Windsor Locks	7.06	2.81	1.85	21.50	12.1
6103	C. H. Dexter's Sons, Windsor Locks	John Mackey, Windsor Locks	7.26	2.81	1.85	22.00	12.1
6152	Daniels Mill Co., Hartford	Dan. O. King, Windsor Locks	7.18	2.81	1.85	22.00	12.3
6108	C. H. Dexter & Son, Windsor Locks	Charles D. Cannon, Windsor Locks	7.16	2.81	1.85	22.00	12.3
6069	Arthur Sykes, Suffield	E. M. Barnes, Thompsonville	7.22	2.81	1.85	22.25	12.3
6319	David Brockett, Suffield	Francis Granger, East Granby	7.50	2.81	1.85	23.00	12.4
5440	Olds & Whipple, Hartford	William S. Pinney, Suffield	7.09	2.81	1.85	22.00	12.4
5811	J. M. Williams, Manchester	W. H. Olcott, South Manchester	7.28	2.81	1.85	22.50	12.4
6140	C. H. Dexter & Son, Windsor Locks	John P. Griswold, Poquonock	7.12	2.81	1.85	22.00	12.4
6187	H. S. Chapman, 211 Broadway, N.Y.	H. S. Chapman & Co., Thompsonville	6.85	2.81	1.85	21.50	12.5
6037	James Perkins, Suffield	Charles H. Wells, Suffield	6.89	2.81	1.85	21.75	12.6
5888	Daniels Mill Co., Hartford	E. F. Thompson, Warehouse Point	6.81	2.81	1.85	21.50	12.6

Analyses of Decorticated Cotton Seed Meal.—*Continued.*

Station No.	Dealer.	Sampled by	Nitrogen.	Phosphoric Acid.	Potash.	Cost per Ton.	Nitrogen costs cents per pound.
6339	C. M. Cox & Co., Boston, Mass.	C. J. Dewey, Buckland	7.00	2.81	1.85	$22.00	12.6
5890	James Perkins, Suffield	Charles A. Birge, Suffield	7.00	2.81	1.85	22.00	12.6
5765	F. W. Brode & Co,	Lowell H. Brewer, Hockanum	6.96	2.81	1.85	22.00	12.7
6294	W. F. Fletcher, Southwick, Mass.	Alfred H. Griffin, Granby	7.11	2.81	1.85	22.50	12.7
6240	August Pouleur, Windsor	A. C. Bedortha, Windsor	7.13	2.81	1.85	22.75	12.9
6241	August Pouleur, Windsor	A. C. Bedortha, Windsor	7.04	2.81	1.85	22.75	13.0
6262	Chas. Cox & Co., Boston, Mass.	Carey Brothers, Windsor	7.06	2.81	1.85	22.75	13.0
6275	W. S. Pinney, Suffield	J. Edgar Phelps, Thompsonville	7.14	2.81	1.85	23.00	13.0
6053	W. W. Cooper, Suffield	C. D. Woodworth, Thompsonville	6.90	2.81	1.85	22.50	13.1
6036	W. W. Cooper, Suffield	Charles H. Wells, Suffield	6.91	2.81	1.85	22.50	13.1
6047	H. C. Aborn & Son, Ellington	H. W. Kibbe, Ellington	7.00	2.81	1.85	23.00	13.3
6112	W. W. Cooper, Suffield	O. C. Rose, West Suffield	6.71	2.81	1.85	22.50	13.5
6094	Joel H. Brewer, Hillstown	Station Agent	6.82	2.81	1.85	23.00	13.6
6117	W. W. Cooper, Suffield	E. J. Sheldon, West Suffield	6.66	2.81	1.85	22.50	13.6
5889	Daniels Mill Co., Hartford	Charles Pomroy, Suffield	6.28	2.81	1.85	21.50	13.6
6249	S. D. Viets, Springfield, Mass.	Virgil E. Viets, Copper Hill	6.68	2.81	1.85	22.50	13.6
6368	I. B. Phelan & Son, Windsor Locks	Charles A. Birge, Suffield	6.52	2.81	1.85	22.25	13.7
6150	James Perkins, Suffield	Charles A. Birge, Suffield	6.36	2.81	1.85	21.75	13.7
6110	W. W. Cooper, Suffield	Henry M. Rose, West Suffield	6.54	2.81	1.85	22.50	13.8
6046	J. E. Perkins, Suffield	E. S. Seymour, Windsor Locks	6.32	2.81	1.85	22.00	13.9
6029	T. B. Atwater, Plantsville	Miss M. A. Neale, Southington	6.32	2.81	1.85	24.00	15.5

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.

Nitrogen alone has been determined in most of the samples whose analyses follow. In these cases the per cents. of phosphoric acid and potash given in the table are the averages derived from all the analyses of decorticated meal made in the last two years at this Station. The per cent. amounts of phosphoric acid and potash in clear cotton seed meal do not vary so much in different samples as to make their determination necessary in order to determine the general quality of the sample.

Decorticated (hulled) Cotton Seed Meal.

In the table on pages 104 and 105 are given the analyses of forty-three samples of this material.

In the last column of the table is given the cost of nitrogen in each sample, valuing the phosphoric acid and potash in each at $4\frac{1}{2}$ and 5 cents per pound respectively.

It appears that the nitrogen of decorticated meal has ranged from 8.17 to 6.28, averaging 7.05 per cent.

The retail cash cost per pound of nitrogen has ranged from 11.2 to 15.5 cents per pound, and the average cost has been 12.7 cents.

Decorticated Cotton Seed Meal continues to be the cheapest source of available nitrogen. Experiments indicate that it is as rapidly and fully available as the best forms of animal matter.

Undecorticated (Unhulled) Cotton Seed Meal.

The following analyses of dark, undecorticated meal, show the average composition of such goods:

6048 and **6134,** sent by Edgar Brewer, Hockanum.

5625. Sold as a mixture of hulls and meal by F. W. Brode & Co., Memphis, Tenn. Sampled and sent by L. H. Brewer, Hockanum.

ANALYSES OF UNDECORTICATED COTTON SEED MEAL.

	6048	6134	5625
Nitrogen	4.42	4.20	3.89
Phosphoric Acid	----	2.06	----
Potash	-- -	1.59	----
Cost per ton	$17.00	17.00	17.00
Nitrogen costs cents per pound	----	16.1	

Since the unhulled meal is sold for $5.00 less per ton than the bright yellow decorticated meal, it has been questioned whether the former might not be a cheaper source of nitrogen than the latter.

The analysis 6134 shows that nitrogen in the unhulled dark meal costs about $3\frac{1}{2}$ cents per pound more than in prime yellow meal, and that it is a waste of money to buy "low grade" rather than "high grade" meal for use as a fertilizer at present prices.

LINSEED MEAL.

This material is the ground residue left after the extraction of oil either by pressure or solvents from linseed (flax seed). It has long been prized as a cattle feed, and during the season of 1896 was sold at prices which induced a considerable number of tobacco growers to use it as a fertilizer, apparently with good effect.

6052. Sold by Olds & Whipple, Hartford. Sampled and sent by J. A. DuBon, Poquonock.

6078. Sold by W. E. Pinney, Suffield. Sampled and sent by A. C. Russell, Suffield.

6276. Sold by Daniels Mill Co., Hartford. Sampled and sent by E. P. Brewer, Silver Lane.

6077. Specially prepared and screened New Process Linseed Meal. Made by Cleveland Oil Co., Cleveland, O. Sold by Olds & Whipple, Hartford. Sampled and sent by Clark Bros., Poquonock.

5627. Same stock as **6077.** Sampled by Olin Wheeler, Buckland.

6102. Sample of a car load bought of Cleveland Linseed Oil Co. Sampled and sent by E. F. Miller.

6217. Stock used in the Station tobacco experiments.

6027. Stock used in the Station vegetation experiments.

ANALYSES OF LINSEED MEAL.

	6052	6078	6276	6077	5627	6102	6217	6027
Nitrogen	6.93	6.62	6.28	6.67	6.48	6.28	6.72	5.10
Phosphoric Acid	1.96	1.92	1.83	1.69	1.66	1.69	1.89	----
Potash	1.24	1.07	1.30	1.05	1.41	1.26	1.30	----
Cost per ton	$20.00	19.50	19.00	20.00	20.00	20.00	----	
Nitrogen costs cents per pound	12.3	12.6	12.8	13.0	13.2	13.7	----	

The average cost per pound of nitrogen in these samples has been about 13 cents, .3 cents per pound higher than in cotton seed meal.

CASTOR POMACE.

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

6297. Sold by Bowker Fertilizer Co., Boston. Stock of S. T. Weldon, Simsbury, and H. K. Brainard, Thompsonville.

6114. Made by H. J. Baker & Bro., N. Y. City. Stock of Webster & Atwater, New Britain.

6295. Stock of W. S. Pinney, Suffield. Sampled and sent by G. A. Harmon, Suffield.

6483. Stock of S. T. Weldon, Simsbury. Sampled and sent by A. L. Eno, Simsbury.

6220. Bought for use in the Station tobacco experiments.

6022. Red Seal Castor Pomace used in Station vegetation experiments.

6024. Collier Pomace used in Station vegetation experiments.

ANALYSES OF CASTOR POMACE.

	6297	6114	6295	6483	6220	6022	6024
Nitrogen	4.92	4.85	4.74	4.30	4.72	4.96	4.73
Phosphoric Acid	1.87	2.98	1.79	1.29	1.89	----	----
Potash	1.00	1.00	1.10	1.10	1.06	----	
Cost per ton	$18.00	20.50	20.00	20.00	---		
Nitrogen costs cents per pound	15.6	17.3	18.2	20.6			

Castor Pomace is an expensive form of organic nitrogen at present prices and is used chiefly by certain tobacco growers who still prefer it to cotton seed meal. The Poquonock experiments indicate that cotton seed meal in equivalent quantity yields tobacco of the same quality in all respects as castor pomace, and at a much lower cost for fertilizers.

MUSTARD SEED CAKE.

A sample of this material **6133,** sent by the Oil Seeds Pressing Co., N. Y. City, contained 4.93 per cent. of nitrogen, 2.00 of phosphoric acid and 1.12 of potash.

If sold for $16.00 or less per ton it would be as cheap a source of nitrogen as cotton seed and linseed meal.

PREPARATIONS OF LEATHER.

As has been proved abundantly by experiment, leather, whether in its untreated state or steamed, or roasted and pulverized, has little value as a fertilizer. The State fertilizer law wisely forbids its use in any form as an ingredient of commercial fertilizers without explicit printed certificate of the fact, "such certificate to be conspicuously affixed to every package," etc.

The materials on which the following analyses were made were used in vegetation experiments to be described on following pages.

6134. Hemlock-tanned sole leather.

6135. Steamed leather, prepared from a portion of sample **6134** by heating it with water in the autoclave for two hours, under a pressure of 60 pounds to the square inch and drying the resulting gummy mass on the water bath.

6131. Roasted leather prepared from **6134** by heating the powdered leather, at 240° C. for four hours.

6136. Dissolved leather. 148 grams of sample **6134** and 100 grams of oil of vitriol, sp. gr. 1.84, were heated gradually, with constant stirring, till fumes of sulphurous acid appeared. Water was added and the mass digested, evaporated to dryness, and heated till sulphurous acid was evolved. Water was again added, the acid was nearly neutralized with carbonate of lime, and the whole dried on the water-bath.

ANALYSES OF LEATHER.

	Raw Leather. 6134	Steamed Leather. 6135	Roasted Leather. 6131	Dissolved Leather, etc. 6136
Nitrogen	6.76	7.40	8.66	2.51

II. RAW MATERIALS OF HIGH GRADE CONTAINING PHOSPHORIC ACID AS THE CHIEF VALUABLE INGREDIENT.

Odorless Phosphate.

This material is pulverized basic Slag, a bye-product from the steel manufacture, similar to so-called Thomas Slag.

6444. Sold by Jacob Reese, 400 Chestnut St., Phila. Sampled from stock of A. J. Palmer, Branford.

It contained 18.72 per cent. of phosphoric acid, of which 7.81 per cent. is soluble in ammonium citrate by the conventional method used in the analysis of superphosphates.

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.

5899. Sold by L. Sanderson, New Haven.

6305. Sold by Bowker Fertilizer Co., through H. K. Brainard, Thompsonville.

6267. Sold by E. E. Burwell, Fair Haven. Sample sent by him.

5803. Sold by Mapes' F. & P. G. Co., N. Y. Sampled and sent by H. G. Manchester, West Winsted.

5804. Sold by L. Sanderson. Sampled and sent by H. G. Manchester, West Winsted.

Dissolved Rock Phosphate or Acid Rock.

This material, made by treating various mineral phosphates with oil of vitriol, is the most common source of the phosphoric acid of factory-mixed fertilizers.

6089. Sold by the Quinnipiac Co. through Olds & Whipple, Hartford.

6415. Electrical Dissolved Bone, made by M. E. Wheeler & Co., Rutland, Vt. From stock of Chas. J. Abell, Lebanon.

6428. Dissolved Bone, made by the Milsom Rendering and Fertilizer Co., Buffalo, N. Y., and sampled by them.

5900. Sold by the Berkshire Mills, Bridgeport.

6245. Sold by G. F. Taylor & Brush, New York City. Sample sent by W. F. Whitney, Yalesville.

6503. Sold by Taylor & Brush, New York City. Sampled and sent by J. L. Rising, West Suffield.

	Analyses of Dissolved Bone Black.					Analyses of Dissolved Rock Phosphate.					
	5899	6305	6267	5803	5804	6089	6415	6428	5900	6245	6503
Soluble Phosphoric Acid	19.59	13.94	9.45	16.70	15.89	11.55	8.50	5.46	11.89	13.52	9.78
Reverted " "	.54	1.66	6.80	.18	.28	3.15	4.40	6.23	1.81	1.45	1.63
Insoluble " "	.39	.20	.66	.02	.04	1.39	.88	.44	.77	.38	.60
Total	20.52	15.80	16.91	16.90	16.21	16.09	13.78	12.13	14.47	15.35	12.01
Cost per ton	$24.00	20.00	24.00	....	....	20.00	20.00	....	....	....	11.00
"Available" phosphoric acid costs cents per pound	5.9	6.5	7.4	....	....	6.6	7.6	....	....	....	4.7

The prices of available phosphoric acid, here given, range from 5.9 to 7.4 cents per pound. In mixed car lots it has been bought for a little over 3 cents per pound.

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.

6336. Sold by Bradley Fertilizer Co., Boston, Mass. Sampled and sent by C. J. Dewey, Buckland.

6032. Sold by L. Sanderson, New Haven.

6096. Sold by Mapes' F. & P. G. Co., Hartford Branch.

5797. Sold by Mapes' F. & P. G. Co. and **5799,** sold by L. Sanderson; both sampled and sent by Harry Manchester, West Winsted.

6218. Bought for use in the Station tobacco experiment.

6031. Bought for use in the Station vegetation experiments.

The analyses are given on page 114.

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.

6301. Sold by the Quinnipiac Co., Boston, Mass., through E. A. Halliday, Suffield.

6033. Sold by L. Sanderson, New Haven.

6264. Sold by E. E. Burwell, Fair Haven.

6095. Sold by Olds & Whipple, Hartford.

6097. Sold by Mapes' F. & P. G. Co., Hartford Branch.

6243. Sold by Taylor & Brush, N. Y. City. Sampled by W. F. Whitney, Yalesville.

6219. Bought for use in the Station tobacco experiment.

Analyses on page 114.

Phosphate of Potash.

6030. A sample of this material, used in the vegetation of experiments of 1896, contained:

Phosphoric Acid	37.48	per cent.
Potash	52.10	"

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.

6034. Sold by L. Sanderson, New Haven.

6265. Sold by E. E. Burwell, Fair Haven. Sample drawn by him.

6035. Sold by Preston Fertilizer Co., Greenpoint, N. Y., to S. D. Woodruff & Sons, Orange.

6338. Sold by Bradley Fertilizer Co., Boston, to C. J. Dewey, Buckland.

6143. Sold by L. Sanderson, New Haven. Sampled and sent by Chas. B. Sheldon, West Suffield.

6098. Sold by Mapes' F. & P. G. Co., Hartford Branch.

6303. Sold by Quinnipiac Co., Boston, through Olds & Whipple, Hartford.

6302. Sold by Bowker Fertilizer Co., Boston, Mass. Stock of J. E. Collins, Wapping.

Analyses on page 114.

Potash Salts.

6337. Sold by the Bradley Fertilizer Co. to C. J. Dewey, Buckland. Apparently is kainit.

Potash	18.18	per cent.
Cost	$14.00	"
Potash costs, cents per pound	**3.9**	

The cash retail prices of potash as high grade sulphate have ranged from 4.9 to 5.2 cents per pound; as double sulphate from 4.9 to 6.3 cents; as muriate from 3.9 to 4.4 cents per pound.

ANALYSES OF HIGH GRADE SULPHATE OF POTASH.

	6336	6032	6096	5797	5799	6218	6031
Equivalent Sulphate of Potash	90.5	91.4	91.4	90.8	90.8	90.7	99.5
Potash	48.89	49.42	49.40	49.10	49.07	48.98	53.79
Cost per ton	$48.00	50.00	51.00		----		
Potash costs, cents per pound	4.9	5.0	5.2		----		

ANALYSES OF DOUBLE SULPHATE OF POTASH AND MAGNESIA.

	6301	6033	6261	6095	6097	6243	6219
Equivalent Sulphate of Potash	47.3	51.8	48.1	47.7	46.8	51.8	48.8
Potash	25.56	28.01	25.98	25.76	25.30	28.00	26.44
Cost per ton	25.00	30.00	28.00	32.00	32.00	----	
Potash costs, cents per pound	4.9	5.3	5.4	6.2	6.3		

ANALYSES OF MURIATE OF POTASH.

	6034	6265	6035	6338	6143	6098	6303	6302
Potash	54.13	52.06	52.16	50.38	49.51	51.83	51.78	47.50
Equivalent Muriate of Potash	86.0	82.8	82.9	80.1	78.7	82.4	82.4	75.5
Cost per ton	$42.50	42.00	43.00	42.00	42.50	45.00	45.00	42.00
Potash costs, cents per pound	3.9	4.0	4.1	4.2	4.3	4.3	4.3	4.4

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 explained on page 98.

1. *Bone Manures Sampled by Station Agents.*

In the following table are given analyses of twenty-two samples of bone drawn by the Station agents. See pages 116 and 117.

The average cost per ton has been $31.18; the average valuation $28.17, showing that the Station schedule of valuations for bone has been somewhat lower than is justified by the average selling price of bone.

Analyses calling for Special Notice.

Mechanical analyses of the three brands of The Rogers & Hubbard Co.'s bone as represented by samples **6120, 6121** and **6122**, having shown the bone to be coarser than in 1895, at request of the manufacturers other samples of each brand, **6332,**

Bone Manures. Sampled by Station Agent. Analyses.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers' cash price per ton.	Valuation per ton.	Percentage Diff. between cost and valuation.	Chemical Analysis. Nitrogen.	Chemical Analysis. Phos. Acid.	Mechanical Analysis. Finer than $\frac{1}{50}$ inch.	Mechanical Analysis. From $\frac{1}{50}$ to $\frac{1}{25}$ inch.	Mechanical Analysis. From $\frac{1}{25}$ to $\frac{1}{12}$ inch.	Mechanical Analysis. Coarser than $\frac{1}{12}$ inch.
				•		Valuation exceeds cost.						
6441	Chittenden's Ground Bone.	National Fertilizer Co., Bridgeport.	H. T. Childs, Woodstock.	*$30.00	$31.49	4.7	1.80	29.18	74	18	6	2
			F. Hallock & Co., Birmingham.	32.00								
5891	Ground Bone.	Berkshire Mills, Bridgeport.	Manufacturer.	**30.00**	31.32	4.2	2.00	28.57	72	20	6	2
6440	Bone Meal.	C. D. Parks, Danbury.	Raymond Bros., South Norwalk.	**29.00**	30.22	4.0	4.22	20.29	77	20	3	
			Manufacturer.	30 00								
6435	Pure Ground Bone.	Downs & Griffin, Derby.	Manufacturer.	**30.00**	30.42	1.4	2.44	29.56	48	30	22	
						Cost exceeds valuation.						
6090	Bone Meal.	Hartford Fertilizer Co., Hartford.	Manufacturer.	**25.00**	24.93	.3	3.00	22.64	45	30	13	12
6443	Self-Recommending Fertilizer.	Frederick Nuhn, Waterbury.	Apothecaries Hall, Waterbury.	**28.00**	27.92	.3	4.16	22.00	58	19	11	12
6439	Plumb & Winton's Bone.	Plumb & Winton Co., Bridgeport.	Manufacturer.	**30.00**	29.40	2.0	4.04	21.81	64	22	13	1
6156	Swift-Sure Bone Meal.	M. L. Shoemaker & Co., Philadelphia, Pa.	E. A. Buck & Co., Willimantic.	**35.00**	34.24	2.2	5.86	21.88	58	33	9	
6442	Bone Meal.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	W. J. Warner, Gilead.	**30.00**	29.12	3.0	3.61	24.43	56	21	19	4
6437	Ground Bone.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. A. Lewis, Willimantic.	**30.00**	28.84	4.0	3.08	23.62	61	29	10	
6154	Pure Bone Meal.	Quinnipiac Co., Boston, Mass.	W. L. L. Spencer, Lebanon.	**30.00**	28.58	4.9	2.94	24.49	58	27	14	1
			Olds & Whipple, Hartford.	30 00								
6436	Ground Bone Meal.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	A. C. Middlebrook, No. Wilton.	**36.00**	32.45	10.9	1.60	31.69	73	12	12	3
6157	Pure Ground Bone.	Rogers Mfg. Co., Rockfall.	Manufacturer.	**30.00**	26.75	12.1	4.67	21.35	28	38	34	
6120	The Rogers & Hubbard Co.'s Raw Knuckle Bone Flour.	The Rogers & Hubbard Co., Middletown.	Manufacturer.	**37.00**	32.71	13.1	3.66	25.45	62	35	3	
6122	The Rogers & Hubbard Co.'s Raw Knuckle Bone Meal.	Rogers & Hubbard Co., Middletown.	Manufacturer.	**36.00**	31.22	15.3	4.00	24.36	46	47	7	
6121	The Rogers & Hubbard Co.'s Strictly Pure Fine Bone.	Rogers & Hubbard Co., Middletown.	Manufacturer.	**30.00**	25.50	17.7	3.70	23.62	34	28	27	11
6434	Pure Bone Meal.	Williams & Clark Fertilizer Co., N. Y.	S. A. Flight, New Haven.	**30.00**	25.44	17.9	2.72	22.76	54	21	23	2
			Gavet Bros., Westport.	30.00								
6158	Pure Bone Dust.	Peter Cooper's Glue Factory, N.Y.	E. F. Miller, Ellington.	**30.00**	24.98	20.1	1.51	28.96	54	14	13	9
6092	Cyclone Bone Meal.	The Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford.	**36.00**	27.70	29.9	2.96	24.96	54	23	16	7
6438	Pure Ground Bone.	Peck Bros., Northfield.	W. H. Scott & Co., Terryville.	30.00	19.90	40.7	4.16	20.72	14	22	38	26
			Strong & Tanner, Winsted.	32.00								
				28.00								
6155	Fine Ground Bone.	Bradley Fertilizer Co., Boston, Mass.	J. B. Alexander, New Britain.	**33.00**	23.40	41.0	2.97	19.31	44	39	17	
5895	Ground Bone.	L. Sanderson, New Haven.	Manufacturer.	**33.00**	23.08	42.9	4.05	26.00	1	33	56	10

* The figures in heavy type, of this column, are used in calculating the percentage difference.

6331 and **6334**, were very carefully drawn at the factory and mechanically analyzed. The result for both years are as follows:

MECHANICAL ANALYSES.

	Raw Knuckle Bone Flour.		Raw Knuckle Bone Meal.		Strictly Pure Fine Bone.	
	1895	1896	1895	1896	1895	1896
	4774	**6120** **6332**	**4902**	**6122** **6331**	**4923**	**6121** **6334**
Fine, smaller than $\frac{1}{50}$ inch	71	62 53	60	46 50	45	34 28
Fine medium, from $\frac{1}{50}$ to $\frac{1}{25}$ inch,	29	35 45	27	47 38	23	28 25
Medium, from $\frac{1}{25}$ to $\frac{1}{12}$ inch	0	3 2	13	7 12	24	27 31
Coarse, larger than $\frac{1}{12}$ inch	0	0 0	0	0 0	8	11 16
	100	100 100	100	100 100	100	100 100

The samples taken in 1896 are seen to be somewhat coarser than those examined in 1895.

2. *Bone Manures Sampled by Manufacturers and by Private Individuals.*

In the table, page 119, are given analyses of six samples drawn by manufacturers and of thirteen drawn by private individuals.

Sample **6490** was sent to the Station as Electrical Dissolved Bone, with a printed statement guaranteeing only phosphoric acid in the three forms. There is evidently some mistake in the name of the brand, for the sample was clearly a bone meal.

Burned Bone.

6138. Bought of the Rogers Manufacturing Co., Rockfall, Ct., by John B. Smith, Conn. Valley Orchard Co. Sampled by Earl Cooley, Berlin.

The sample was understood to represent ground bone which had been damaged in a fire at the storehouse. It contained .20 per cent. of nitrogen and 40.12 per cent. of phosphoric acid.

The nitrogen and phosphoric acid of bone ash are not readily available as fertilizers till they have been dissolved by an acid.

TANKAGE.

After boiling or steaming meat scrap, bone and other slaughter-house waste, fat rises to the surface and is removed, the soup is run off, and the settlings are dried and sold as tankage. As analyses show, "tankage" has a very variable composition. In general it contains more nitrogen and less phosphoric acid than bone.

BONE MANURES. SAMPLED BY MANUFACTURERS AND PRIVATE INDIVIDUALS.

Station No.	Name or Brand.	Manufacturer or Dealer.	Sampled and Sent by	Dealer's Cash Price per Ton.	Valuation per Ton.	Chemical Analysis. Nitrogen.	Chemical Analysis. Phos. Acid.	Mechanical Analysis. Less than $\frac{1}{50}$ inch.	From $\frac{1}{50}$ to $\frac{1}{25}$ inch.	From $\frac{1}{25}$ to $\frac{1}{12}$ inch.	Coarser than $\frac{1}{12}$ inch.
6191	Bone.	Elbert Clinton, Clintonville.	Manufacturer.	$26.50	$16.81	4.13	20.93	5	17	31	47
6431	Pure Ground Bone.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Manufacturer.	--------	25.84	4.12	25.38	24	19	55	2
6081	Ground Bone.	Downs & Griffin, Derby.	Manufacturer.	--------	31.66	2.06	28.68	72	20	7	1
6239	Bone.	August Pouleur, Windsor.	Manufacturer.	--------	31.62	2.29	29.77	60	24	15	1
6433	Pure Raw Bone Meal.	Walker, Stratman & Co., Pittsburgh, Pa.	Manufacturer.	--------	29.54	3.81	24.50	51	26	22	1
6432	Butcher's Bone Meal.	Walker, Stratman & Co., Pittsburgh, Pa.	Manufacturer.	--------	18.09	2.24	13.16	77	16	7	--
6137	Ground Bone.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	Earl Cooley, Berlin.	33.00	29.61	2.56	25.61	61	32	7	--
6105	Bone.	J. G. Jefferds, Worcester, Mass.	Perrin & Calkins, W. Woodstock.	31.00	33.88	2.06	30.27	75	22	3	--
5881	Ground Bone.	J. D. Leach, Willimantic,	C. B. Pomeroy, Jr., Willimantic.	25.00	17.48	4.00	20.33	14	17	21	48
5882	Ground Bone.	J. D. Leach, Willimantic.	C. B. Pomeroy, Jr., Willimantic.	25.00	22.39	3.85	21.97	14	31	51	4
6041	Bone Meal.	Monroe, Lalor & Co., Oswego.	Byron Loomis, Suffield.	30.00	28.63	3.92	23.64	54	22	15	9
5269	Fine Ground Bone.	L. Sanderson, New Haven.	F. E. Blakeman, Stratford.	--------	20.84	3.18	17.71	37	28	33	2
6141	Fine Ground Bone.	L. Sanderson, New Haven.	Chas. B. Sheldon, W. Suffield.	32.00	26.00	3.66	21.79	44	26	30	--
6342	Ground Bone.	L. Sanderson, New Haven.	Geo. F. Platt & Son, Milford.	-------	24.78	3.86	24.42	14	36	49	1
6238	Ground Bone.	Taylor & Brush, New York City.	W. F. Whitney.	--------	30.43	2.72	27.63	54	30	15	1
6292	Bone.	Taylor & Brush, New York City.	A. E. Plant, Branford.	--------	32.83	3.14	26.14	81	13	5	1
6447	Ground Bone.	Geo. F. Taylor & Brush, N. Y.	H. C. C. Miles, Milford.	24.00	31.45	2.62	27.25	72	17	10	1
6490	Electrical Dissolved Bone.	M. E. Wheeler & Co., Rutland, Vermont.	Chas. Sanford, Roxbury.	--------	27.09	2.79	25.77	47	27	16	10
6277	Fine Ground Bone.	Wilcox Fertilizer Works, Mystic.	Lawrence Daly, E. Windsor Hill.	29.00	31.98	2.24	28.63	72	20	6	2

Sampled by Station Agents.

6091. Tankage. Sold by the Quinnipiac Co., Boston, through Olds & Whipple, Hartford.

5897. Blood, Bone and Meat, and **5898,** Pulverized Bone and Meat, both sold by L. Sanderson.

6104. Tankage. Sold by L. B. Darling Fertilizer Co., Pawtucket, R. I. Sample from stock of J. H. Webb, New Haven.

5896. Tankage. Sold by Taylor & Brush, New York City. Sample from stock of S. D. Woodruff & Sons, Orange.

Sampled by Seller.

6266. Dried Blood and Meat. Sold by E. E. Burwell, Fair Haven.

Sampled by Private Parties.

5805. Tankage. Sold by L. B. Darling Fertilizer Co. Sample sent by J. H. Webb.

5883. No. 1 Tankage. Made by J. D. Leech, Willimantic. Sampled and sent by C. B. Pomeroy, Willimantic.

5629. Tankage. Made by Plumb & Winton, Bridgeport. Sampled and sent by S. E. Curtis, Stratford.

5794. Tankage. Sold by L. Sanderson, New Haven. Sampled and sent by J. H. Webb, New Haven.

5795. Tankage. Made by Sperry & Barnes, New Haven. Sampled and sent by J. H. Webb.

6446. Tankage. Sold by Taylor & Brush, New York City. Sampled and sent by H. C. C. Miles, Milford.

The low valuations of samples **5883** and **5795** are due to their coarse mechanical condition.

Dry Ground Fish.

This residue from the manufacture of fish oil is often sprinkled with diluted oil of vitriol, to hinder decay during drying, whereby the fish bones are softened and to some extent dissolved.

6304. Made by Luce Brothers, Niantic.

6087. Made by Geo. W. Miles, Agent, Milford. From stock of Olds & Whipple, Hartford.

6115. Sold by Quinnipiac Co., Boston, through F. S. Bidwell, Windsor Locks.

Analyses of Tankage.

	6091	**5897**	**5898**	**6104**	**5896**	**6266**	**5805**	**5883**	**5629**	**5794**	**5795**	**6446**
Mechanical Analysis.												
Fine, smaller than $\frac{1}{50}$ inch	66	45	58	59	69	61	68	10	61	61	35	83
Fine medium, from $\frac{1}{50}$ to $\frac{1}{25}$ inch	32	37	30	31	28	19	22	17	24	23	17	15
Medium, from $\frac{1}{25}$ to $\frac{1}{12}$ inch	2	14	12	9	3	16	10	28	14	13	27	2
Coarse, larger than $\frac{1}{12}$ inch	0	4	0	1	0	4	0	45	1	3	21	0
	100	100	100	100	100	100	100	100	100	100	100	100
Chemical Analysis.												
Nitrogen	5.65	6.50	5.28	6.22	5.42	7.55	6.08	4.47	5.71	6.70	6.79	4.69
Phosphoric Acid	15.97	12.86	16.75	13.88	16.46	10.46	12.92	8.24	10.08	12.92	9.59	17.28
Cost per ton	$27.00	33.00	36.00	....	....	28.00	....	30.00	25.00	....	....	....
Valuation per ton	$29.40	26.17	27.94	27.92	29.35	27.21	27.18	11.07	22.99	27.69	20.12	28.96

6345. Made by Wilcox Fertilizer Co., Mystic. From stock of John Thompson, Ellington.

6408. Sold by Williams & Clark Fertilizer Co., New York City, through F. C. Gould, Silver Lane.

5796. Made by Geo. W. Miles, Agent, Milford. Sampled by Geo. S. Gillette, Milford.

ANALYSES OF DRY GROUND FISH.

	6304	6087	6115	6345	6408	5796
Nitrogen as nitrates	----	.72	----	----	----	----
as ammonia	1.45	1.08	.42	.10	.50	1.02
organic	7.06	5.76	9.00	8.98	7.57	7.18*
Total nitrogen	8.51	7.56	9.42	9.08	8.07	8.20
Soluble phosphoric acid	.94	1.14	.86	.67	.58	1.13
Reverted phosphoric acid	5.41	5.20	3.39	5.03	8.19	4.72
Insoluble phosphoric acid	.23	.88	2.45	1.31	.91	.82
Total phosphoric acid	6.58	7.22	6.70	7.01	9.68	6.67
Cost per ton	$26.00	32.00	32.00	32.00	30.00	32.00
Valuation per ton	$30.65	28.11	31.78	31.73	31.89	29.45

* Includes some nitrate nitrogen.

MIXED FERTILIZERS.

BONE AND POTASH.

6192. Square Brand Bone and Potash, made by the Bowker Fertilizer Co., Boston, Mass. Stock of C. T. Leonard, Norwich, $29.00 per ton, and P. L. Lathrop, Coventry, $28.00 per ton.

6193. Bone and Potash, made by E. Frank Coe, N. Y. Sampled from stock of H. B. Sherwood, Southport, $26.00 per ton, and J. A. Isham, Columbia, $29.00 per ton.

6145. Dissolved Bone and Potash, made by The Milsom Rendering and Fertilizer Co., Buffalo, N. Y. Sampled from stock of G. M. Cox, Vernon, $30.00 per ton.

MECHANICAL ANALYSES OF BONE AND POTASH.

	6192	6193	6145
Fine, smaller than $\frac{1}{50}$ inch	64	62	----
Fine medium, from $\frac{1}{50}$ to $\frac{1}{25}$ inch	24	22	----
Medium, from $\frac{1}{25}$ to $\frac{1}{12}$ "	10	12	----
Coarse, larger than $\frac{1}{12}$ "	2	4	----
	100	100	100

CHEMICAL ANALYSES OF BONE AND POTASH.

Organic Nitrogen	1.71	2.10	----
Soluble Phosphoric Acid	----	----	6.67
Reverted " "	----	----	2.07
Insoluble " "	----	----	.22
Total " "	13.50	15.79	8.96
Potash	2.30	2.90	2.05*
Cost per ton	$29.00	26.00	30.00
Valuation per ton	$18.36	21.51	11.44

* Partly as sulphate.

No. **6145.** Contains no nitrogen, and is a mixture of acid phosphate and potash salts, but not "bone and potash" in the usually accepted meaning of the term.

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 128 to 137 are tabulated the analyses of eighty-seven brands, made on samples collected by the Station agents.

GUARANTEES.

Of the eighty-eight analyses of nitrogenous superphosphates, given in the tables, twenty-seven are below the maker's minimum guarantee in respect of one ingredient and five in respect of two ingredients. Thus thirty-six per cent., or more than one-third of these fertilizers, do not fulfil the manufacturers' guarantees.

In twenty-five cases the deficiency is in potash, and numerous protests have been made by manufacturers who claimed that their goods were mixed to contain decidedly more potash than was shown by the Station analysis. In every case the Station has repeated the potash determination in response to the protest, in many cases has drawn other samples of the same brand for analysis, has referred some samples to other chemists, and has most carefully tested and demonstrated the accuracy of our methods of analysis. In no instance has any error been found in the results first reported.

The following analyses, we are advised by the manufacturers, show less potash than the goods were believed to contain. The special cases are here given in detail to indicate the care which the Station exercises in doing the work of fertilizer analysis which is required by law.

6320. Great Planet A brand and **6322,** King Philip Alkaline Guano, both made by the Clark's Cove Fertilizer Co. On receiving the protest of the manufacturer a re-test of potash was made in each sample, which confirmed the test already reported.

6326. General Crop Phosphate, made by the Crocker Fertilizer Co., Buffalo. Repetition of the potash determination confirmed the result previously reported.

6380. Cumberland Concentrated Phosphate, made by the Cumberland Bone Fertilizer Co., Boston. The manufacturers called for a portion of our sample, in which their chemist found 8.27 per cent. of potash, while the figure reported by the Station was 6.22. Careful repetition of our determination gave 6.24 per cent. The amount guaranteed was 7 per cent.

6359. Chittenden's Complete Fertilizer, sold by the National Fertilizer Co., Bridgeport. This sample was a mixture of equal weights of eight samples drawn in various places. The per cent. of potash found was 4.82.

The manufacturer protested that the per cent. of potash found was not only below their guarantee, but below the calculated composition of the goods, and below what had been found by their chemist in samples of the product of each day's manufacture at the works.

A re-test of the sample with specially prepared reagents gave 4.90 per cent. A portion of the same sample was sent to the chemist of the company, by request, who reported 5.48 per cent.

At the same time, for another purpose, the reagents and method of potash determination used in the Station laboratory were subjected by Mr. Winton to a thorough re-examination with the result that potash was determined with uniform accuracy, both in pure salts and in mixtures containing all the impurities found in commercial fertilizers, the total error being less than 0.3 per cent. of the quantity of potash present; *i. e.* in a mixture containing 5.00 per cent. of potash, repeated analyses would show figures ranging from 4.985 to 5.015 per cent.

Potash was next separately determined in each of the eight samples from which No. **6359** had been prepared, with the following results, 4.47, 5.45, 3.49, 5.46, 5.14, 4.01, 3.76, 5.79. These determinations show the range of composition observed in different lots of the same brand; the average, 4.74, is nearly the same figure which was first obtained by analysis of the mixture No. **6359.**

A new mixture was then made of equal weights of these eight samples and analyzed by this Station. It was also divided with the greatest care into five portions, which were sent to the laboratories of two Agricultural Stations, to two commercial chemists, and to the chemist of a fertilizer works, requesting in each case a determination of the potash soluble in water. No explanation regarding the sample was given. Following are the reports received:

	Average.
Station I, Chemist A, 4.83, 4.89, 4.89	4.87
" B, 5.00, 4.90	4.95
" C, 5.01	5.01
Average of all determinations	4.92
Station II, 4.89, 4.90	4.90
This Station, 4.78, 4.80, 4.87, 4.80, 4.74, 4.88, 4.81*	4.81
Chemist of Fertilizer Works	4.89
Commercial Chemist A	5.11
" " B	5.26

* One or more determinations in each of the five samples.

A sample of the same brand, No. **6492,** drawn by our agent at the company's works in Bridgeport, from a stock of 20 tons, the full analysis of which appears in the table, page 133, contained considerably more potash, 5.46 per cent.

In sample No. **6363,** Chittenden's Ammoniated Bone Superphosphate, the manufacturers claim more than two per cent. of potash. This Station found 1.91. Small samples were sent by us at request of the manufacturer to two commercial chemists, who found 2.41 and 2.45 per cent. respectively.

6289. Soluble Pacific Guano, made by the Pacific Guano Co., Boston, Mass. This sample is guaranteed to contain over 2 per cent. of potash. Our analysis showed but 1.9, which was objected to by the manufacturer.

As the same brand contained, however, two per cent. more of available phosphoric acid than the guarantee, it is likely that some inequality in mixing accounts for both discrepancies.

6386. High Grade General Fertilizer, made by the Pacific Guano Co., Boston.

6.16 per cent. of potash was found by the Station analysis. The manufacturer asked for a portion of the sample, and in this their chemist reported 8.25 per cent. A re-test made at this Station showed 6.07 per cent. The manufacturers reported that on receipt of the second test they referred their sample to a commercial chemist, who found 8.45 per cent.

The whole remaining original sample was then finely pulverized and divided into three portions. One of these was sent to another Station laboratory, and the second to a commercial chemist, with the request to determine potash soluble in water. The results reported were:

		Average.
Commercial Chemist		6.35
Station Chemist A, 5.89		
" " B, 5.99	Average	5.92
" " C, 5.80		
Conn. Station, 5.70, 5.80, 5.77		5.78

Messrs. M. L. Shoemaker & Co., manufacturers of No. **6251**, Swift Sure Superphosphate, protested that no chlorides were used in the manufacture of their goods, and that the amount of chlorine found, 1.87 per cent., was inexplicable except by error in the determination. The analysis was repeated with the same result.

Another sample of Swift Sure Superphosphate, No. **6456**, was sent by F. Ellsworth, of Hartford, with request for a chlorine determination.

Our analysis showed .59 per cent. This determination was unsatisfactory to the manufacturer, who requested us to send samples to two commercial chemists, each of whom reported only a trace. After correspondence, one of them repeated the test with certain precautions which we had found necessary and then reported .53 per cent., substantially the same percentage as we at first reported.

6360. Royal Bone Phosphate, made by the Williams & Clark Fertilizer Co., N. Y., was found by our analysis to contain 1.90 per cent. of potash.

The manufacturer protested that this figure did not represent the average composition of the goods, but a re-test confirmed the accuracy of the test first reported.

Analysis No. **6384** is of a sample drawn by our agent from stock of L. H. Grant, Broadbrook, that purported to be Ceres Complete Fertilizer, made by George W. Miles, Agent, Milford. The analysis of this fertilizer is as follows:

Nitrogen as nitrates	.29
Nitrogen as ammonia	.56
Nitrogen, organic	2.14
Total nitrogen	2.99
Soluble phosphoric acid	5.10
Reverted " "	2.22
Insoluble " "	2.21
Total " "	9.53
Potash as muriate	2.44
Total potash	4.86
Cost	$38.00
Valuation	21.78

The manufacturer protests that this analysis does not at all correspond with the guaranteed composition of the Ceres brand, the widest discrepancy being in the potash, of which ingredient 7 per cent. is guaranteed, and that so far as the nitrogen and phosphoric acid are concerned, it corresponds very closely with the composition of the IXL Ammoniated Superphosphate, made by him, which is given in the table, page 128, Analysis No. **6167**.

As the manufacturer's protest did not reach the Station till these pages were ready for the printer, it has not been possible to secure and analyze another sample of the Ceres brand.

Cost and Valuation.

Cost.

The method used to ascertain the retail cost 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.

Nitrogenous Superphosphates and Guanos, Sampled by the Station.

Analyses.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealers Cash Price per Ton.	Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen: Found.	Total Nitrogen: Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid, Total: Found.	Phosphoric Acid, Total: Guaranteed.	Phosphoric Acid, Available: Found.	Phosphoric Acid, Available: Guaranteed.	Potash, Found: As Muriate.	Potash, Found: Total.	Potash: Guaranteed.
6414	Carteret Manure for general use.	Eastern Farm Supply Association, Montclair, N. J.	F. S. Bidwell, Windsor Locks.	$29.00	$25.52	13.6	.59	.46	2.51	3.56	*2.5*	4.16	5.45	.62	10.23	----	9.61	*8.0*	5.82	5.82	*5.0*
6197	Bone, Fish and Potash.	E. R. Kelsey, Branford.	J. E. Wooding, New Haven	20.00	20.19	13.9	----	.86	3.04	3.90	*3.3*	2.64	2.47	.14	5.25	*4.0*	5.11	----	.37	3.71	*4.0*
			Wilson & Burr, Middletown.	26.00																	
				23.00																	
6088	Pure Fine Bone Dissolved in Sulphuric Acid.	Mapes' Formula and Peruvian Guano Co., N. Y. City.	Mapes' Branch, Hartford.	**30.00**	25.82	16.2	----	----	2.18	2.18	*2.1*	7.48	10.75	.92	19.15	----	18.23	*12.0*	----	----	----
6406	Unexcelled Phosphate.	Geo. W. Miller, Middlefield.	Manufacturer.	**30.00**	25.72	16.6	----	----	2.00	2.00	*1.5*	4.06	6.86	1.30	12.22	*11.5*	10.92	----	9.19	9.19	*8.0*
6389	Fish and Potash, Pequot Brand.	Quinnipiac Co., Boston, Mass.	A. I. Martin, Wallingford.	**22.00**	18.22	20.7	.62	.23	1.72	2.57	*2.5*	3.15	4.47	1.94	9.56	*7.0*	7.62	*6.0*	.80	2.40	*2.0*
6228	Harvest Home Phosphate.	H. J. Baker & Bro., N. Y. City.	Webster & Atwater, New Britain.	**27.00**	21.76	24.0	2.89	.30	.76	3.95	*1.0*	3.40	4.38	1.32	9.10	*9.0*	7.78	*8.0*	2.53	2.53	*2.0*
			Wm. G. Humphrey, Canton Center.	27.50																	
6230	Lowell Bone Fertilizer.	Lowell Fertilizer Co., Lowell, Mass.	Bugbee Bros., Willimantic.	**27.00**	21.76	24.0	----	----	2.66	2.66	*2.5*	4.22	6.27	.42	10.91	*6.0*	10.49	*5.0*	3.59	3.59	*3.0*
6252	Essex XXX Fish and Potash.	Russia Cement Co., Gloucester, Mass.	W. H. Anderson, Putnam.	30.00	22.34	25.3	----	----	2.37	2.37	*2.1*	4.13	7.38	3.75	15.26	*12.0*	11.51	*10.0*	2.53	2.53	*2.2*
			J. A. Lewis, Willimantic.	**28.00**																	
6282	Animal Fertilizer, G. Brand.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. H. Lynch, Ellington.	28.00	23.09	25.6	----	----	----	2.40	*2.1*	5.09	5.78	1.28	12.15	*7.0*	10.87	*6.0*	4.98	4.98	*4.0*
			F. S. Bidwell, Windsor Locks.	30.00																	
				29.00																	
6226	Quinnipiac Market Garden Manure.	Quinnipiac Co., Boston, Mass.	L. A. Grannis, Fair Haven.	**35.00**	27.24	28.5	1.21	.50	2.01	3.72	*3.3*	5.07	4.29	1.22	10.58	*9.0*	9.36	*8 0*	7.20	7.20	*7.0*
			C. H. Banks, Greenfield Hill.	35.00																	
			F. S. Bidwell, Windsor Locks.	38.00																	
			Olds & Whipple, Hartford.	38.00																	
6367	Ammoniated Bone Superphosphate.	Preston Fertilizer Co., Greenpoint, L. I.	Calvin G. Wilcox, Merrow.	**30.00**	23.29	28.8	----	----	2.57	2.57	*2 5*	5.37	6.77	2.39	14.53	----	12.14	*9.0*	.63	2.53	*2.0*
			Newell St. John, Simsbury.	30.00																	
6371	Old Reliable Superphosphate.	L. Sanderson, New Haven	Manufacturer.	**30.00**	23.13	29.7	.11	.22	2.63	2.96	*1.7*	6.77	4.39	.85	12.01	*10.0*	11.16	*7.0*	2.92	2.92	*2.0*
6395	Complete Bone Superphosphate.	Wilcox Fertilizer Works, Mystic.	Browning & Gallup, New London.	**29.00**	22.21	30.6	----	----	2.54	2.54	*2.1*	6.00	5.08	.77	11.85	*9.0*	11.08	*8.0*	3.45	3.45	*3.0*
6203	Gardeners' Complete Manure.	Packers' Union Fertilizer Co., N. Y. City.	W. H. Terry, Willimantic.	**34.00**	25.93	31.1	1.05	----	1.67	2.72	*2.5*	6.38	1.29	.65	8.32	*10.0*	7.67	*8.0*	10.93	10.93	*10.0*
6392	Ammoniated Dissolved Bone.	Quinnipiac Co., Boston, Mass.	Gault Bros., Westport.	**28.00**	21.36	31.1	.14	----	2.34	2.48	*1.7*	4.74	5.67	1.64	12.05	*10.0*	10.41	*9.0*	3.21	3.21	*2.0*
6386	High Grade General Fertilizer.	Pacific Guano Co., Boston, Mass.	J. A. Paine, Danielson.	**34.00**	*25.91	31.2	1.42	----	2.14	3.56	*3.3*	5.02	4.63	.99	10.64	*10.0*	9.65	----	6.16	6.16	*7.0*
6167	IXL Ammoniated Bone Superphosphate.	George W. Miles, Milford.	H. B. Sherwood, Southport.	**26.00**	19.64	32.4	----	.90	2.14	3.04	*2.8*	4.96	1.68	2.85	9.49	----	6.64	*8.0*	2.97	2.97	*2.0*
6251	Swift Sure Superphosphate.	M. L. Shoemaker & Co., Philadelphia, Pa.	L. S. Ellsworth, Simsbury.		*26.37	32.8	.86	----	2.20	3.06	*2.5*	7.30	4.45	1.73	13.48	----	11.75	*9.0*	2.49	4.97	*4.0*
			E. A. Buck & Co., Willimantic.	**35.00**																	
			F. Ellsworth, Hartford.	36.00																	
5893	Complete Fertilizer.	Berkshire Mills, Bridgeport.	Manufacturer.	**35.00**	26.00	34.6	.59	----	2.22	2.81	*2.5*	6.75	3.12	1.62	11.49	*10.0*	9.87	*8.0*	.21	6.83	*6.0*
6376	Garden Special.	Great Eastern Fertilizer Co., Rutland, Vt.	J. G. Schwink, Meriden.	**35.00**	25.69	36.2	.46	----	2.78	3.24	*3.3*	5.38	2.27	.82	8.47	----	7.65	*6.0*	9.05	9.05	*8.0*
6394	High Grade Fish and Potash.	Wilcox Fertilizer Works. Mystic.	Browning & Gallup, New London.	**30.00**	21.91	36.9	----	----	3.68	3.68	*3.3*	3.15	3.34	.41	6.90	*6.0*	6.49	*5.0*	5.16	5.16	*4.0*

* See page 126.

NITROGENOUS SUPERPHOSPHATES AND GUANOS, SAMPLED BY THE STATION.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6396	Ammoniated Bone Phosphate.	Wilcox Fertilizer Works, Mystic.	Browning & Gallup, New London.	**$31.00**
6313	Complete Manure A. Brand.	Mapes' F. & P. G. Co., N. Y. City.	Mapes' Branch, Hartford.	**34.00**
6174	High Grade Universal Fertilizer.	Packer's Fertilizer Co., N. Y. City.	W. H. Terry, Willimantic. Thos McClimon, Greenville. Nathan S. Bushnell, Taftville.	25.00 **26.00** 26.00
6308	Animal Fertilizer.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	F. S. Bidwell, Windsor Locks.	**34.00**
6194	Formula A.	L. Sanderson, New Haven.	L. A. Granniss Fair Haven.	**35.00**
6377	Superior Truck Fertilizer.	M. E. Wheeler & Co., Rutland, Vt.	E. A. Hoyt, Ridgefield.	**36.00**
6325	Standard Pure Bone Superphosphate.	Lister's Agricultural Chemical Works. Newark, N. J.	Albertus N. Clark, Milford.	**30.00**
6183	Market Garden Manure.	Bowker Fertilizer Co., Boston, Mass.	Browning & Gallup, New London. C. T. Leonard, Norwalk.	**38.00** 40.00
6165	Complete Fertilizer.	Rogers Mfg Co., Rockfall.	Manufacturer.	**32.00**
6314	Complete Manure for Light Soils.	Mapes' F. & P. G. Co., N. Y. City.	Mapes' Branch, Hartford.	**41.00**
6355	Giant's Neck Superphosphate.	Luce Bros., Niantic.	Manufacturer.	**30.00**
6327	Success Fertilizer.	Lister's Agricultural Chemical Works, Newark, N. J.	Albertus N. Clark, Milford.	**26.00**
6320	Great Planet A.	Clark's Cove Fertilizer Co., Boston, Mass.	John Dolbear, Poquetanuck. W. H. Phillips, Chaplain.	**37.00** 40.00
6380	Cumberland Concentrated Phosphate.	Cumberland Bone Fertilizer Co., Boston, Mass.	A. J. Palmer, Branford.	**38.00**
6207	Vegetable Bone Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	F. B. Newton, Plainville. Orlando Jones. Highwood. Joseph Pierpont, North Haven.	**40.00** 43.00 34.00
6361	Formula A.	L. Sanderson, New Haven.	E. B. Clark & Sons, Milford. S. A. Chalker, Saybrook.	**35.00** 35.00
6381	Complete Manure for General Use.	Mapes' F. & P. G. Co., N. Y. City.	Mapes' Branch, Hartford.	**37.00**
6369	Gold Brand Excelsior Guano.	E. Frank Coe Co., N. Y. City.	J. A. Isham, Columbia. Walkley & Damery, Wethersfield.	34.50 37.00 **35.00**
6229	A. A. Ammoniated Bone Superphosphate.	H. J. Baker & Bro., N. Y. City.	Strong & Tanner, Winsted. Webster & Atwater, New Britain.	**35.00** 37.50
6362	Chittenden's Market Garden Manure.	National Fertilizer Co., Bridgeport.	G. A. & H. B. Williams, Silver Lane.	**33.00**
6257	Hill and Drill Phosphate.	Bowker Fertilizer Co., Boston, Mass.	D. N. Benton, Guilford. P. L. Lathrop, Coventry. H. B. Coger, Hawleyville.	33.00 35.00 36 00 **33.00**

ANALYSES.—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found. As Muriate.	Found. Total.	Guaranteed.
$22.57	37.4	----	.55	2.73	3.28	2.5	1.65	5.92	1.79	9.36	7.0	7.57	6 0	5.36	5.36	5.0
24.73	37.5	.73	1.84	.38	2.95	2.5	7.68	4.80	.53	13 01	12.0	12.48	10.0	2.97	3.02	2.5
18.89	37.6	trace	----	1.49	1.49	.8	7.12	1.96	.89	9.97	----	9.08	8.0	5.08	5.08	5.0
24.69	37.7	----	.55	3.37	3.92	3.3	1.55	5.73	1.59	8.87	10.0	7.28	6.0	5.42	5.42	4.0
25.32	38.2	.53	.28	2.44	3.25	3.3	6.86	3.43	1.25	11.54	10.0	10.29	----	5.27	5.27	6.0
25.95	38.7	.78	----	2.72	3.50	3.3	5.97	2.37	.62	8.96	----	8.34	7.0	7.81	7.81	8.0
21.53	39.3	----	.44	2.05	2.49	2.3	9.38	1.68	2.04	13.10	----	11.06	10.0	1.83	1.83	1.5
27.17	39.9	1.25	----	1.45	2.70	2.5	6.32	2.75	3.35	12.42	8.0	9.07	6.0	9.65	9.65	10.0
22.62	41.5	.77	----	1.63	2.40	2 2	5.95	5.05	1.08	12.08	10.0	11.0	----	4.39	4.39	5.0
28.91	41.8	1.02	.65	3.26	4.93	4.9	4.05	4.28	.94	9.27	8.0	8.33	6.0	6.62	6.62	6.0
21.08	42.3	----	.62	2.56	3.18	3.3	4.64	1.12	.10	5.86	5.0	5.76	----	.25	5.81	5.0
18.24	42.5	----	----	1.47	1.47	1.2	8.98	1.80	2.10	12.88	----	10.78	9.5	.74	1.67	2.0
*25.96	42.6	1.75	----	1.84	3.59	2.9	4.77	4.27	.89	9.93	----	9.04	8.0	6.89	6.89	7.0
*26.48	43.5	1.23	----	2.31	3.54	3.3	5.15	5.02	1.00	11.17	10.0	10.17	8.0	6.22	6.22	7.0
27.85	43.6	----	----	5.24	5.24	4.9	5.71	.93	.40	7.04	----	6.64	6.0	6.46	6.46	5.0
24.30	44.0	1.04	.27	1.93	3.24	3.3	4.66	3.65	.76	9.07	10.0	8.31	8.0	4.08	6.61	6.0
25.39	45.7	.76	.32	2.52	3.60	3.3	3.04	7.29	.74	11.07	10.0	10.33	8.0	4.88	4.88	4.0
23.84	46.8	----	.85	1.79	2.64	2.5	7.68	1.44	.78	9.90	----	9.12	8.0	.53	6.13	6.0
23.69	47.7	.40	1.42	1.26	3.08	2.5	9.49	1.47	.39	11.35	----	10.96	10.0	3.06	3.06	2.0
22.10	49.3	----	----	2.40	2.40	2.5	1.01	7.93	1.78	10.72	8.0	8.94	7.0	6.26	6.26	6.0
22.07	49.5	.84	----	1.84	2 68	2.5	8.00	3.17	1.41	12.58	12.0	11.17	9.0	2.36	2.36	2.0

* See page 124.

NITROGENOUS SUPERPHOSPHATES AND GUANOS, SAMPLED BY THE STATION.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6365	Standard Complete Manure.	Standard Fertilizer Co., Boston, Mass.	Nathan S. Bushnell, Taftville. A. L. Kuren, Tolland.	**$38.00** 40.00
6366	Chittenden's Fish and Potash.	National Fertilizer Co., Bridgeport.	G. A. & H. B. Williams, Silver Lane. T. H. Eldridge, Norwich.	**30.00** 32.00
5892	Ammoniated Bone Phosphate.	Berkshire Mills, Bridgeport.	Manufacturer.	**30.00**
6213	Americus Brand Ammoniated Bone Superphosphate.	Williams & Clark Fertilizer Co., N. Y. City.	F. C. Gould, Silver Lane. F. B. Austin, Silver Mine. Edw. L. Strong, Colchester.	**33.00** 33.00 34.00
6403	Smoky City Phosphate.	Walker, Stratman & Co., Pittsburgh, Pa.	White and Juno, Rockville.	30.00
6352	Ammoniated Bone Superphosphate.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Carlos E. Kibbe, Wapping.	**33.00**
6184	Farmers' New Method Fertilizer.	Bradley Fertilizer Co., Boston, Mass.	D. L. Clark, Milford. J. B. Alexander, New Britain.	**30.00** 33.00
6375	Buffalo Fertilizer.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	W. H. Bishop, Andover.	**30.00**
6212	Quinnipiac Phosphate.	Quinnipiac Co., Boston, Mass.	L. A. Granniss, Fair Haven. F. S. Bidwell, Windsor Locks. A. I. Martin, Wallingford.	32.00 **33.00** 34.00
6385	Vegetable Bone Fertilizer.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	E. A. Halliday, Suffield.	**40.00**
6132	O. & W. Special Phosphate.	Olds & Whipple, Hartford.	Manufacturer.	**36.00**
6492	Chittenden's Complete Fertilizer.	National Fertilizer Co., Bridgeport.	Manufacturer.	**38.00**
6359	Chittenden's Complete Fertilizer.	National Fertilizer Co., Bridgeport.	E. B. Clark & Sons, Milford. G. A. & H. B. Williams, Silver Lane. H. T. Child, Woodstock. H. J. Humphrey, Simsbury. L. H. Grant, Broad Brook. F. Hallock & Co., Birmingham.	35.00 **38.00** 38.00 40.00 40 00 40.00
6196	Patent Superphosphate.	Bradley Fertilizer Co., Boston, Mass.	Raymond Bros., So. Norwalk. F. S. Bidwell, Windsor Locks. Manchester Elevator Co., Manchester.	33.00 **34.00** 36.00
6349	Nameless Fertilizer.	C. D. Parks, Danbury.	Manufacturer.	**30.00**
6410	Bay State Fertilizer.	Clark's Cove Fertilizer Co., Boston, Mass.	John Ballard, Thompson. H. F. Standish, Andover.	**34.00** 34.00
6398	Fish and Potash.	Williams & Clark Fertilizer Co., N. Y. City.	George H. Sloan, Windsorville.	**30.00**
6175	High Grade Ammoniated Bone Phosphate.	E. Frank Coe Co., N. Y. City.	J. A. Isham, Columbia. Walkley & Damery, Wethersfield.	31.00 33.25 **32.00**
6256	Sure Crop Phosphate.	Bowker Fertilizer Co., Boston, Mass.	City Coal and Wood Co., New Britain.	**28.00**

ANALYSES.—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen, Organic.	Nitrogen: Total Nitrogen: Found.	Nitrogen: Total Nitrogen: Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid: Total: Found.	Phosphoric Acid: Total: Guaranteed.	Phosphoric Acid: Available: Found.	Phosphoric Acid: Available: Guaranteed.	Potash: Found: As Muriate.	Potash: Found: Total.	Potash: Guaranteed.
$25.20	50.8	1.65	----	1.83	3.48	*3.3*	4.80	4.55	1.26	10.61	*9.0*	9.35	*8.0*	5.88	5.88	*7.0*
19.88	50.9	----	----	2.46	2.46	*2.8*	1.46	5.70	4.00	11.16	*8.0*	7.16	----	4.22	4.50	*4.0*
19.77	51.7	----	----	1.95	1.95	*1.7*	7.63	3.24	1.62	12.49	*10.0*	10.87	*8.0*	2.26	2.26	*2.0*
21.64	52.5	.29	---	2.38	2.67	*2.5*	6.40	4.71	1.64	12.75	*10.0*	11.11	*9.0*	1.99	1.99	*2.0*
19.63	52.9	----	----	1.44	1.44	*1.2*	9.66	3.04	.90	13.60	*15.0*	12.70	*12.0*	1.74	1.74	*2.0*
21.48	53.6	----	----	2.74	2.74	*2.9*	9.34	2.02	.49	11.85	----	11.36	*10.0*	1.47	1.47	*1.1*
19.53	53.6	.27	----	1.85	2.12	*1.7*	5.60	4.16	1.37	11.13	*10.0*	9.76	*8.0*	3.06	3.06	*3.0*
19.44	54.3	----	----	2.76	2.76	*1.9*	7.30	2.06	.50	9.86	----	9.36	*8.0*	.65	1.48	*1.5*
21.33	54.7	.32	----	2.34	2.66	*2.5*	6.56	4.40	1.32	12.28	*10.0*	10.96	*9.0*	1.97	1.97	*2.0*
25.77	55.2	----	----	3.80	3.80	*4.1*	8.35	1.39	.37	10.11	*9.0*	9.74	*8.0*	4.89	4.89	*5.0*
22.92	57.0	.75	----	2.65	3.40	*2.5*	6.38	3.50	1.38	11.26	*10.0*	9.88	*9.0*	.72	2.47	*2.0*
*24.01	58.3	.56	.48	2.33	3.37	*3.3*	3.70	5.34	.55	9.59	*10.0*	9.04	*8.0*	5.46	5.46	*6.0*
†23.89	59.0	.46	.55	2.22	3.23	*3.3*	3.55	6.25	.69	10.49	*10.0*	9.80	*8.0*	4.82	4.82	*6.0*
21.30	59.6	.33	----	2.47	2.80	*2.5*	6.72	3.91	1.22	11.85	*11.0*	10.63	*9.0*	1.89	1.89	*2.0*
18.75	60.0	.23	----	2.31	2.54	*2.1*	.40	6.92	1.17	8.49	*8.0*	7.32	----	4.26	4.26	*3.0*
21.10	61.1	.27	----	2.39	2.66	*2.5*	6.24	4.72	1.00	11 96	*10.0*	10.96	*9.0*	1.89	1.89	*2.0*
18.55	61.7	----	.20	2.16	2.36	*2.1*	2.78	5.31	1.16	9.25	*6.0*	8.09	*4.0*	3.41	3.41	*4.0*
19.77	61.8	----	----	2.22	2.22	*2.1*	7.66	2.38	2.25	12.29	*11.0*	10.04	*9.0*	.33	1.87	*1.8*
17.09	63.8	.29	----	.94	1.23	*.8*	7.29	3.39	2.70	13.38	*10.0*	10.68	*8.0*	1.32	1.32	*1.0*

* See p. 125.

† See p. 124.

Nitrogenous Superphosphates and Guanos, Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6105	Fish and Potash, A Brand.	Bradley Fertilizer Co., Boston, Mass.	Billings & Hallock, Meriden.	**$33.00**
6393	Standard Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Nathan S. Bushnell, Taftville.	**32.00**
6379	Big Bonanza, Welcome Brand.	Walker, Stratman & Co., Pittsburgh.	J. W. Euerle, Stratford.	**33.00**
6260	Sea Fowl Guano.	Bradley Fertilizer Co., Boston, Mass.	F. S. Bidwell, Windsor Locks.	**32.00**
6311	Cumberland Superphosphate.	Cumberland Bone Phosphate Co., Boston, Mass.	William Bartell, Ore Hill.	**32.00**
6211	Fish, Bone and Potash.	Read Fertilizer Co., N. Y.	L. D. Post, Andover. J. A. Silliman, New Canaan.	**30.00** 30.00
6350	Animal Bone and Potash.	Lister Agricultural Chemical Works, Newark, N. J.	Edward Hall, Plainfield.	**28.00**
6363	Chittenden's Ammoniated Bone Phosphate.	National Fertilizer Co., Bridgeport.	E. B. Clark & Sons, Milford. L. H. Grant, Broad Brook. T. H. Eldridge, Norwich. Horace Humphrey, Simsbury.	26.00 **30.00** 32.00 32.00
6321	Bay State Fertilizer G. G.	Clark's Cove Fertilizer Co, Boston, Mass.	W. H. Phillips, Chaplin. J. M. Burke, South Manchester.	**33.00** 34.00
6279	Soluble Bone and Potash.	Great Eastern Fertilizer Co., Rutland, Vt.	William L. Baxter, New Canaan. F. V. Cantrell, Darien Thomas Richmond, New Milford.	**26.00** 26.00 34.00
6180	Standard Superphosphate.	Read Fertilizer Co., New York.	John R. Babcock, Mystic. L. D. Post, Andover.	29.00 **30.00**
6322	King Philip Alkaline Guano.	Clark's Cove Fertilizer Co., Boston, Mass.	J. M. Burke, South Manchester.	**28.00**
6289	Soluble Pacific Guano.	Pacific Guano Co., Boston, Mass.	E. A. Burnham, Andover. George Webster, Rockville. Saxton & Strong, Bristol. John A. Paine, Danielson.	34.00 **35.00** 35.00 36.00
6326	General Crop Phosphate.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Bugbee Bros., Willimantic.	**23.00**
6374	Cumberland Fertilizer.	Cumberland Bone Phosphate Co., Boston, Mass.	A. J. Palmer.	**28.00**
6255	Farm and Garden Phosphate.	Bowker Fertilizer Co., Boston, Mass.	S. E. Brown, Collinsville. C. T. Leonard, Norwalk.	35.00 36.00 **32.00**
6391	Fish and Potash, Crossed Fishes Brand.	Quinnipiac Co., Boston, Mass.	Olds & Whipple, Hartford	**34.00**
6360	Royal Bone Phosphate.	Williams & Clark Fertilizer Co., New York City.	J. S. Buell, Madison. E. L. Strong, Colchester. J. H. Avery, Lebanon.	26.00 **28.00** 29.00
6205	New Rival Ammoniated Superphosphate.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	Orlando Jones, Highwood. E. A. Davis & Son, Danielson F. B. Newton, Plainville.	30.00 34.00 34 00 **33.00**

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.
$19.98	65.2	----	----	2.24	2.24	*2.1*	5.42	4.17	1.23	10.82	*12.0*	9.59	*8.0*	3.43	3.43	*4.0*
19.12	67.4	----	----	2.16	2.16	*2.1*	5.33	4.59	1.40	11.32	*10.0*	9.92	*8.0*	2.29	2.29	*2.0*
19.65	67.9	----	----	1.44	1.44	*1.7*	9.84	3.16	.88	13.88	----	13.00	*11.0*	1.43	1.43	*2.0*
19.01	68.3	.35	----	1.83	2.18	*2.1*	3.84	6.69	1.90	12.43	*10.0*	10.53	*8.0*	1.41	1.41	*1.5*
18.89	69.4	.35	----	1.84	2.19	*2.1*	5.84	3.97	1.51	11.32	*10.0*	9.81	*8.0*	2.00	2.00	*2.0*
17.54	71.0	----	----	2.88	2.88	*2.5*	3.50	1.55	.83	5.88	*5.0*	5.05	*4.0*	4.17	4.17	*4.0*
16.33	71.5	----	----	.42	.42	*.8*	8.10	1.84	.47	10.41	*10.0*	9.94	*9.0*	4.57	4.67	*5.0*
*17.42	72.2	----	----	1.83	1.83	*1.7*	.59	9.31	1.55	11.45	*9.0*	9.90	*7.0*	1.91	1.91	*2.0*
19.16	72.2	.32	----	1.90	2.22	*1.0*	6.14	3.68	1.86	11.68	*10.0*	9.82	*8.5*	2.01	2.01	*2.0*
14.93	74.1	----	----	----	----	----	8.32	3.75	.90	12.97	----	12.07	*11.0*	1.86	1.86	*2.0*
17.16	74.8	trace	----	1.20	1.20	*.8*	7.31	1.96	.68	9.95	*9.0*	9.27	*8.0*	3.92	3.92	*4 0*
†15.94	75.6	----	----	1.34	1.34	*1.0*	4.77	4.66	1.60	11.03	*9.0*	9.43	*8.0*	1.82	1.82	*2.0*
*19.81	76.7	----	----	2.34	2.34	*2.1*	5.65	4.79	1.34	11.78	*10.0*	10.44	*7.0*	1.90	1.90	*2.0*
†12.91	78.2	----	----	.97	.97	*.8*	5.39	2.06	3.31	10.76	----	7.45	*7.0*	.98	.98	*1.1*
15.67	78.7	----	----	1.16	1.16	*1.0*	4.94	4.83	1.31	11.08	*10.0*	9.77	*8.0*	1.82	1.82	*2.0*
17.85	79.3	.38	----	1.51	1.89	*1.7*	3.49	5.22	3.76	12.47	*10.0*	8.71	*8.0*	2.26	2.26	*2.0*
18.84	80.4	----	.34	2.99	3.33	*3.3*	1.55	4.16	1.76	7.47	*5.0*	5.71	*3.0*	.80	2.96	*3.0*
‡15.36	82.3	----	----	1.15	1.15	*1.0*	4.40	4.88	1.80	11.08	*8.0*	9.28	*7.0*	1.89	1.89	*2.0*
17.96	83.7	----	----	1.46	1.46	*1.2*	7.31	2.85	3.22	13.38	----	10.16	*10.0*	1.88	1.88	*1.5*

* See pp. 125. † See pp. 124. ‡ See pp. 126.

Nitrogenous Superphosphates and Guanos, Sampled by the Station.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6324	Fish and Potash.	Berkshire Mills, Bridgeport.	C. H. Youngs & Son, Yalesville.	**30.00**
			T. H. Eldridge, Norwich.	32.00
			H. R. Hoisington, Jr., Coventry.	32.00
			F. S. Bidwell, Windsor Locks.	34.00
6284	Nobsque Guano.	Pacific Guano Co., Boston, Mass.	Saxton & Strong, Bristol.	**30.00**
			John A. Paine, Danielson.	32.00
			J. O. Fox & Co., Putnam.	32.00
			Carlos Bradley, Ellington.	27.00
6373	Cleveland Fertilizer.	Cleveland Dryer Co., Boston. Mass.	D. F. Southwick, Putnam.	**30.00**
6378	Economical Bone Fertilizer.	Wilkinson & Co., N. Y. City.	W. W. Peck, Woodbridge.	**32.00**
6402	Four Fold Fertilizer.	Walker, Stratman & Co., Pittsburgh.	White & Juno, Rockville.	**31.00**
6086	Buffalo Guano.	Milsom Rendering and Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford.	**33.00**
6082	Erie King.	Milsom Rendering and Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford.	**32.00**

Analyses.—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen Organic.	Nitrogen: Total Nitrogen, Found.	Nitrogen: Total Nitrogen, Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid: Total, Found.	Phosphoric Acid: Total, Guaranteed.	Phosphoric Acid: Available, Found.	Phosphoric Acid: Available, Guaranteed.	Potash: Found, As Muriate.	Potash: Found, Total.	Potash: Guaranteed.
$16.26	84.5	.80	.22	1.73	2.75	*2.5*	1.28	3.04	2.65	6.97	*6.0*	4.32	....	3.43	3.43	*3.0*
15.87	89.0	....	....	1.31	1.31	*1.2*	4.42	4.88	1.54	10 84	*10.0*	9.30	*9.0*	2.04	2.04	*2.0*
15.74	90.6	....	....	1.11	1.11	*1.0*	5.28	4.61	1.11	11.00	*9.0*	9.89	*8.0*	1.97	1.97	*2.0*
16.51	93.8	....	....	1.50	1.50	*1.2*	4.88	3.00	2.21	10.09	....	7.88	*7.0*	3.40	3.40	*3.0*
15.95	94.4	....	....	1.29	1.29	*.8*	6.03	4.28	1.00	11.31	....	10.31	*8.0*	1.14	1.14	*1.0*
16.51	99.9	....	....	1.41	1.41	*.8*	6.74	1.29	1.77	9.80	*9.0*	8.03	*8.0*	1.18	3.27	*4.0*
14.30	123.8	....	....	1.05	1.05	*.8*	6.75	1.35	1.55	9.65	*9.0*	8.10	*7.0*	.71	2.03	*2.0*

Valuation.

The valuation has been computed in all cases in the usual manner as explained on page 98.

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 comparative value of different brands and to determine whether it is better economy to buy the commercial mixed fertilizers of which so many are now offered for sale, or to purchase and mix for himself the raw materials. This subject is further discussed on pp. 169 to 176 of this report.

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 $31.56. The average valuation is $21.18, and the percentage difference 49.0.

Last year the corresponding figures were:

Average cost $32.32, average valuation $23.37, percentage difference 38.2.

These valuations, it must be remembered, are based on the assumption that the nitrogen, phosphoric acid and potash in each fertilizer are of good quality and readily available to farm crops. Chemical examination shows conclusively whether this is true in respect of potash and phosphoric acid, but 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.

Since various inferior or agriculturally worthless forms of nitrogen are in the market and are known to be used in compounding fertilizers, and cannot as yet be detected with certainty by analysis, the only security of purchasers of mixed fertilizers is in dealing with firms which have the highest reputation and are able to satisfy their customers that they use the best raw materials, and in avoiding "cheap" goods offered by irresponsible parties.

2. *Sampled by the Manufacturer.*

In the following table, pages 140, 141, are twelve analyses made on samples deposited with the Director of this 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 Consumers.*

In the table just referred to are four analyses made on samples of this kind. The Station is not responsible for the accuracy of the sampling, though in each case it holds the written statement of the sampler that the Station's directions for sampling were strictly followed.

Nitrogenous Superphosphates Sampled by Manufacturers and Private Individuals. Analyses.

Station No.	Name or Brand.	Manufacturer.	Dealer or Purchaser.	Valuation per Ton.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found. As Muriate.	Found. Total.	Guaranteed.
6420	Eclipse Phosphate.	Bradley Fertilizer Co., Boston, Mass.	----	$20.24	.32	----	1.80	2.12	*1.0*	5.30	6.27	1.66	13.23	*12.0*	11.57	10.0	1.76	1.76	*1.5*
6421	Bone and Potash, Circle Brand.	Bradley Fertilizer Co., Boston, Mass.	----	23.38	----	----	1.95	1.95	*1.8*	2.32	10.95	4.42	17.69	*10.0*	13.27	6.0	----	2.65	*2.0*
6424	Bone and Potash, Anchor Brand.	Bradley Fertilizer Co., Boston, Mass.	----	21.10	----	----	3.72	3.72	*3.3*	3.07	3.61	1.12	7.80	*5.0*	6.68	*3.0*	3.38	3.58	*3.0*
6425	Practical Ammoniated Superphosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	----	15.62	----	----	1.16	1.16	*.8*	5.62	3.16	4.20	12.98	----	8.78	*8.0*	1.50	1.50	*1.1*
6476	General Crop Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	----	13.14	----	----	1.16	1.16	*.8*	2.83	4.83	2.31	9.97	----	7.66	*7.0*	1.14	1.14	*1.1*
6418	Fertilizer for Gardens and Lawns.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	----	28.32	.75	----	2.93	3.68	*3.3*	3.60	8.44	1.20	13.24	*10.0*	12.04	----	5.79	5.79	*5.0*
6452	Lowell Animal Fertilizer.	Lowell Fertilizer Co., Lowell, Mass.	----	29.36	.60	----	3.00	3.60	----	3.30	11.49	1.87	16.66	----	14.79	----	3.86	3.86	----
6419	Bone, Fish and Potash.	Luce Bros., Niantic.	----	20.43	----	.86	2.44	3.30	*3.3*	2.35	3.52	.22	6.09	*4.0*	5.87	----	.24	4.84	*4.0*
6481	Cereal Fertilizer.	Frederick Ludlam, N. Y. City.	----	15.40	.18	----	.77	.95	----	7.05	3.55	1.80	12.40	----	10.60	----	.80	.80	----
6482	Cecrops Fertilizer, Dragon's Tooth Brand.	Frederick Ludlam, N. Y. City.	----	24.39	1.35	----	1.93	3.28	----	3.81	3.77	2.35	9.93	----	7.58	----	7.15	7.15	----
6422	Buffalo Fertilizer, Long Island Brand.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	----	20.05	----	----	2.97	2.97	*2.5*	5.97	3.30	.43	9.70	*10.0*	9.27	*8.0*	1.88	1.88	*1.0*
6416	Niagara Triumph.	Niagara Fertilizer Works, Buffalo, N. Y.	----	20.35	----	----	2.99	2.99	*2.5*	6.61	2.12	.84	9.57	----	8.73	*8.0*	2.50	2.50	*2.2*
6487	Bowker's Fairfield Fertilizer.	Bowker Fertilizer Co., Boston, Mass.	Simeon Pease, Greenfield Hill.	25.89	1.72	----	1.76	3.48	----	5.68	2.87	1.44	9.99	----	8.55	----	7.37	7.37	----
6040	"All Soluble."		Monroe, Lalor & Co., Oswego, N. Y.	24.89	----	.45	2.65	3.10	----	2.60	6.80	1.63	11.03	----	9.40	----	----	5.81	----
6357	Conn. Valley Orchard Co's Fertilizer.	Quinnipiac Co., Boston, Mass.	Conn. Valley Orchard Co.	25.58	1.51	----	1.98	3.49	----	6.62	4.42	1.46	12.50	----	11.04	----	4.09	4.09	----
6449	"Fertilizer."	Williams & Clark Fertilizer Co., N. Y. City.	E. S. Miner, Burrville.	21.81	.78	----	2.08	2.86	----	2.69	4.50	1.74	8.93	----	7.19	----	5.12	6.23	----

Special Manures.

Here are included such mixed fertilizers, chiefly nitrogenous superphosphates, as are claimed by their manufacturers to be specially adapted to the needs of particular crops.

1. *Samples drawn by Station Agents.*

In the tables on pages 144 to 153, are tabulated the analyses of eighty-three brands made on samples drawn by the Station agents.

Guarantees.

Of the eighty-three brands of special manures here tabulated twenty-two are below the manufacturers' guarantee in respect of one ingredient and five in respect of two ingredients, so that nearly one-third of the whole number do not fulfill the manufacturers' claims.

In eighteen cases the deficiency was in potash.

The manufacturers of the following brands expressed disappointment at the low per cent. of potash reported by the Station, and asked for a re-test.

This was made in each case, and in every instance the per cent. of potash found was essentially the same as that found in the first test.

6281. Potato Fertilizer, made by the Bradley Fertilizer Co., Boston. Potash found, 2.95, guaranteed 3.2.

6312. Potato Fertilizer, made by the Cumberland Bone Phosphate Co., Boston. Potash found 2.92 per cent., guaranteed 3.0.

6280. Tobacco Grower, made by the L. B. Darling Fertilizer Co., Pawtucket, R. I. Potash 8.84 per cent., guaranteed 10.8. The manufacturer states that the per cent. of chlorine, 1.47, is also largely in excess of what was expected, as high grade sulphate was used as a source of potash. It was not possible to get other samples of this brand to make a re-test.

6407. Soluble Tobacco Manure, made by the Rogers & Hubbard Co., Middletown. Potash found, 9.40 per cent., guaranteed 10.0. The nitrogen, however, is fully one per cent. above the minimum guarantee.

6163. Tobacco Fertilizer, made by Rogers Manufacturing Co., Rockfall. The analysis showed 4.66 per cent. nitrogen, 6.93 phosphoric acid and 13.47 per cent. potash.

This differed so widely from the guaranteed composition, nitrogen 5.0, phosphoric acid 8.0 and potash 11.0, that the manufacturer asked that another sample be drawn and analyzed.

A Station agent therefore visited the factory and drew sample No. **6335**, page 148, which was found to contain: nitrogen 4.26, phosphoric acid 9.36, and potash 10.31 per cent.

6358. Standard Potato and Tobacco Fertilizer, made by the Standard Fertilizer Co., Boston. Potash found, 2.61 per cent., guaranteed 3.0 per cent.

6477. Potato Phosphate, made by the National Fertilizer Co., Bridgeport. Potash found, 7.28 per cent., guaranteed 8.00.

Cost, Valuation and Percentage Difference.

The average cost of eighty-three Special Manures was $36.19 per ton. The average valuation was $25.64. The difference, $10.55, is equivalent to a "percentage difference" of 41.1.

Last year the corresponding figures were, average cost $37.33, average valuation 27.94, percentage difference 33.6.

2. *Special Manures Sampled by Manufacturers.*

The following eight analyses were made on samples deposited by the manufacturers at the Station, as required by law.

The sampling agent did not find these brands on sale in the places visited by him.

6423. Special Connecticut Tobacco Manure, made by the Crocker Fertilizer and Chemical Co., Buffalo, N. Y.

6427. Special Potato Fertilizer, made by the Lister Agricultural Chemical Works, Newark, N. J.

6429. Potato Phosphate. **6430.** Tobacco Manure. **6451.** Lawn Dressing, and **6453.** Vegetable and Vine Fertilizer, all made by the Lowell Fertilizer Co., Lowell, Mass.

6426. Potato, Hop and Tobacco Phosphate, Long Island Brand, made by the Milsom Rendering Co., Buffalo, N. Y.

6417. Niagara Wheat and Corn Producer, made by the Niagara Fertilizer Co., Buffalo, N. Y.

Analyses of Special Manures.

	6423	6427	6429	6430	6451	6453	6426	6417
Nitrogen as Nitrates	----	----	1.04	3.60	3.94	.22	----	----
" " Ammonia	----	.26	----	----	----	----	----	----
" Organic	5.50	1.67	2.57	1.84	.31	2.82	2.74	1.78
Total Nitrogen	5.50	1.93	3.61	5.44	4.25	3.04	2.74	1.78
Soluble Phosphoric Acid	5.75	4.48	2.94	4.61	7.23	5.63	6.46	5.86
Reverted " "	1.25	3.91	10.74	5.48	.81	7.97	2.58	2.92
Insoluble " "	.20	2.59	1.34	.44	.07	.20	.36	.84
Total " "	7.20	10.98	15.02	10.53	8.11	13.80	9.40	9.62
Potash as Muriate	.86	2.83	6.39	.29	7.90	7.17	6.97	2.45
Potash as Sulphate	11.08	----	----	7.26	----	----	----	----
Valuation per ton	$34.91	17.89	30.27	33.12	27.41	29.18	23.77	16.90

SPECIAL MANURES, SAMPLED BY THE STATION.

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6346	Potato Fertilizer.	Chas. E. Lyman, Middlefield.	Manufacturer.	$25.00
6347	Corn Fertilizer.	Chas. E. Lyman, Middlefield.	Manufacturer.	20.00
6383	Manure for Seeding Down.	Mapes' F. & P. G. Co., N. Y. City.	Mapes' Branch, Hartford.	38.00
123	The Rogers & Hubbard Co's Fruit Fertilizer.	Rogers & Hubbard Co., Middletown.	Manufacturer.	41.00
6287	Potato and Root Crop Manure.	L. B. Darling Fertilizer Co. Pawtucket, R. I.	J. H. Lynch, Ellington. F. S. Bidwell, Windsor Locks	34.00 35.00
6162	Corn Fertilizer.	Rogers Mfg. Co., Rockfall.	Manufacturer.	46.00
6407	The Rogers & Hubbard Co's Soluble Tobacco Manure.	Rogers & Hubbard Co., Middletown.	H. W. Andrews, Wallingford.	42.00
6126	The Rogers & Hubbard Co's Fairchild's Formula for Corn and General Crops.	Rogers & Hubbard Co., Middletown.	Manufacturer.	46.00
6281	Potato Fertilizer.	Bradley Fertilizer Co., Boston, Mass.	D. L. Clark, Milford. John R. Babcock, Mystic.	30.00 33.00
6199	Essex Complete Manure for Corn, Grain and Grass.	Russia Cement Co., Gloucester, Mass.	J. A. Lewis, Willimantic. E. N. Pierce & Co., Plainville.	38.00 40.00
6161	High Grade Fertilizer for Grass and Grain.	Rogers Mfg. Co., Rockfall.	Manufacturer.	38.00
6323	Potato and Tobacco Fertilizer.	Clark's Cove Fertilizer Co., Boston, Mass.	W. H. Phillips, Chaplain. J. M. Burke, So. Manchester.	33.00 36.00
6127	The Rogers & Hubbard Co's Soluble Potato Manure.	Rogers & Hubbard Co., Middletown.	Manufacturer.	38.00
6125	The Rogers & Hubbard Co's Fertilizer for Oats and Top Dressing.	Rogers & Hubbard Co., Middletown.	Manufacturer.	50.00
6198	Essex Complete Manure for Potatoes, Roots and Vegetables.	Russia Cement Co., Gloucester, Mass,	J. A. Lewis, Willimantic. John O. Peckham, Greenville. E. N. Pierce & Co., Plainville.	38.00 38.00 40.00
6477	Potato Phosphate.	National Fertilizer Co., Bridgeport.	G. A. & H. B. Williams, Silver Lane.	34.00
6164	High Grade Fertilizer for Oats and Top Dressing.	Rogers Mfg. Co., Rockfall.	Manufacturer.	42.00
6124	The Rogers & Hubbard Co's Grass and Grain Fertilizer.	Rogers & Hubbard Co., Middletown.	Manufacturer.	37.50
6285	Potato, Onion and Tobacco Manure.	Wilcox Fertilizer Works, Mystic.	Browning & Gallup, New London. John Thompson, Ellington. C. M. Smith, East Hartford.	34.00 34.00 37.00
6280	Tobacco Grower.	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. H. Lynch, Ellington. F. S. Bidwell, Windsor Locks	38.00 40.00

ANALYSES.

Station No.	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.
6346	$25.64	*2.5	----	----	3.38	3.38	2.5	3.34	4.47	.84	8.65	10.0	7.81	-- -	8.56	8.56	10.0
6347	21.93	*8.8	----	----	----	----	----	9.00	2.75	.31	12.06	11.0	11.75	----	10.18	10.18	10.0
6383	34.35	10.6	.82	----	2.03	2.85	2.5	----	----	----	18.42	18.0	- - -	----	10.83	10.83	10.0
123	36.29	12.9	.15	----	2.91	3.06	2.5	----	----	----	19.12	17.5	-----	----	12.49	12.49	12.5
6287	29.38	15.7	----	.35	3.31	3.66	2.9	3.04	6.58	2.48	12.10	10.0	9.62	6.0	5.93	7.75	7.0
6162	38.91	18.2	4.60	----	1.66	6.26	5.4	-	----	----	12.22	12.0	-----	----	12.68	12.68	12.5
6407	‖35.44	18.5	1.75	.10	3.96	5.81	4.9	1.41	8.10	.67	10.18	10.0	9.51	----	-----	9.40	10.0
6126	38.24	20.3	4.05	----	2.07	6.12	5.5	----	----	----	12.00	12.0	-----	----	12.54	12.54	13.0
6281	24.79	21.0	.18	----	2.14	2.32	2.1	4.90	5.32	1.43	11.65	----	10.22	9.0	2.95	2.95	3.2
6199	31.37	21.1	.74	----	3.39	4.13	3.7	5.18	4.31	1.13	10.62	10.0	9.49	7.5	10.47	10.47	9.5
6161	31.05	22.4	trace	----	3.16	3.16	3.0	----	----	----	15.79	17.0	-----	----	13.73	13.73	15 0
6323	26.64	23.9	.23	----	2.18	2.41	2.1	5.60	4.84	1.37	11.81	9.0	10.44	8.0	3.09	3.09	3.0
6127	30.56	24.3	1.49	.07	3.32	4.88	5.0	1.71	6.75	2.62	11.08	10.0	8.46	7.0	1.88	6.49	5.0
6125	39.87	25.4	7.48	----	1.40	8.88	9.0	----	----	----	9.13	8.0	-----	----	8.77	8.77	8.5
6198	30.13	26.1	.60	----	3.47	4.07	3.7	4.80	3.90	.93	9.63	9.0	8.70	7.0	1.20	9.36	8.5
6477	‡26.96	26.1	----	----	2.43	2.43	2.1	.59	6.58	1.36	8.53	----	7.17	8.0	7.28	7.28	8.0
6164	33.23	26.4	4.10	----	2.40	6.50	5.5	2.72	5.14	.74	8.60	9.0	7.86	----	7.79	7.79	7.5
6124	29.66	26.4	----	----	2.84	2.84	2.5	----	----	----	18.83	16.5	-----	----	11.55	11.55	12.5
6285	26.81	26.8	.83	----	3.01	3.84	3.3	4.66	4.26	.67	9.59	8.0	8.92	7.0	.56	6.54	6.0
6280	‖31.47	27.1	----	1.75	3.30	5.05	4.9	1.63	5.75	1.88	9.26	10.0	7.38	----	1.47	8.84	10.8

‖ See p. 142. * Valuation exceeds cost. ‡ See p. 143.

SPECIAL MANURES, SAMPLED BY THE STATION.—*Continued.*

ANALYSES.—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.	Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen Organic.	Nitrogen: Total Nitrogen. Found.	Nitrogen: Total Nitrogen. Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid: Total. Found.	Phosphoric Acid: Total. Guaranteed.	Phosphoric Acid: Available. Found.	Phosphoric Acid: Available. Guaranteed.	Potash: Found. As Muriate.	Potash: Found. Total.	Potash: Guaranteed.
6388	Quinnipiac Havana Seed Leaf Tobacco Fertilizer.	Quinnipiac Co., Boston, Mass.	Olds & Whipple, Hartford.	**$45.00**	$35.29	27.5	----	3.10	3.07	6.17	*5.7*	3.97	2.21	.84	7.02	*6.0*	6.18	*5.0*	.92	10.56	*10.0*
6253	Complete Onion Manure.	H. J. Baker & Bro., N. Y. City.	C. O. Jelliff & Co., Southport.	**38.00**	29.59	28.4	.43	2.20	2.42	5.05	*4.9*	4.02	1.36	.42	5.80	*5.5*	5.38	*4.5*	7:25	9.82	*9.0*
6351	New England Tobacco Grower.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	Carlos E. Kibbe, Wapping.	**31.00**	23.86	29.9	----	----	3.38	3.38	*3.3*	5.22	1.53	2.90	9.65	----	6.75	*6.0*	.81	6.05	*5.4*
6329	Stockbridge Tobacco Manure.	Bowker Fertilizer Co., Boston, Mass.	H. K. Brainard, Thompsonville. L. H. Grant, Broad Brook.	**48.00** 50.00	36.58	31.2	2.90	----	2.91	5.81	*5.8*	1.09	5.74	4.50	11.33	----	6.83	*4.0*	.56	10.12	*10.0*
6387	Potato, Hop and Onion Fertilizer.	Preston Fertilizer Co., Greenpoint, L. I.	E. A. Buck & Co., Willimantic.	**32.00**	24.37	31.3	.11	----	2.82	2.93	*2.5*	1.92	8.09	.63	10.64	*9.0*	10.01	----	6.35	6.35	*5.0*
6328	Complete Tobacco Manure.	H. J. Baker & Bro., N. Y. City.	L. J. Grant, Wapping. W. F. Andross, East Hartford.	**40.00** 40.00	30.12	32.8	----	2.64	1.76	4.40	*4.5*	4.27	.99	.37	5.63	----	5.26	*4.0*	.85	11.51	*10.0*
6160	High Grade Soluble Potato Manure.	Rogers Mfg. Co., Rockfall.	Manufacturer.	**38.00**	28.58	32.9	.69	----	3.26	3.95	*3.5*	2.19	6.27	1.44	9.90	*9.0*	8.46	----	.73	8.40	*8.8*
6445	Complete Manure for Potatoes and Vegetables.	Lowell Fertilizer Co., Lowell, Mass.	J. P. Barstow & Co., Norwich.	**35.00**	26.10	34.1	.42	----	2.02	2.44	*2.5*	10.12	4.49	.31	14.92	*8.0*	14.61	*7.0*	3.97	3.97	*4.0*
6400	Fine Wrapper Tobacco Grower.	Williams & Clark Fertilizer Co., N. Y. City.	G. H. Clark, Granby.	**48.00**	35.56	34.9	----	2.80	3.15	5.95	*5.8*	2.00	4.83	.95	7.78	*6.0*	6.83	*5.0*	.48	10.98	*10.0*
6235	High Grade Special.	Williams & Clark Fertilizer Co., N. Y. City.	S. A. Flight, New Haven. Edward L. Strong, Colchester. F. B. Austin, Silver Mine. F. C. Gould, Silver Lane. Greenwoods Co., New Hartford.	35.00 36.00 38.00 39.00 38.00 **37.00**	27.22	35.9	1.21	.25	2.28	3.74	*3.7*	5.26	4.39	1.10	10.75	*8.0*	9.65	*7.0*	6.89	6.89	*7.0*
6382	Tobacco Manure, Wrapper Brand.	Mapes' F. & P. G. Co., N. Y. City.	Hartford Branch, Hartford.	**46.00**	33.80	36.0	1.78	2.28	2.14	6.20	*6.2*	.35	4.40	.69	5.44	*4.5*	4.75	----	.77	11.17	*10.5*
6163	Tobacco Fertilizer.	Rogers Mfg. Co., Rockfall.	Manufacturer.	**45.00**	*33.04	36.2	1.25	----	3.41	4.66	*4.9*	1.30	4.93	.70	6.93	*8.0*	6.23	----	----	13.47	*11.0*
6233	Stockbridge Top-Dressing.	Bowker Fertilizer Co., Boston, Mass.	W. O. Goodsell, Bristol. Balch & Platt, Norfolk.	38.00 **40.00**	29.07	37.6	2.91	----	2.19	5.10	*4.9*	4.54	3.00	2.39	9.93	*6.0*	7.54	----	6.81	6.81	*6.0*
6258	High Grade Tobacco Manure.	Bradley Fertilizer Co., Boston, Mass.	Loomis Bros., Granby. C. F. Tallard & Son, Broad Brook.	**46.00** 46.00	33.40	37.7	----	3.12	2.65	5.77	*5.8*	1.76	3.70	1.32	6.78	*4.0*	5.46	*7.0*	.76	10.53	*10.8*
6250	Grass and Grain Spring Top-Dressing.	Mapes' F. & P. G. Co., N. Y. City.	Mapes' Branch, Hartford. Edward L. Strong, Colchester.	**38.00** 39.00	27.42	38.6	1.04	.75	2.86	4.65	*4.1*	3.15	4.17	.60	7.92	*7.0*	7.32	*5.0*	7.19	7.19	*5.0*
6206	Special Potato Manure.	Crocker Fertilizer & Chemical Co., Buffalo., N. Y.	H. C. Aborn & Son, Ellington. Orlando Jones, Highwood. F. B. Newton, Plainville.	**36.00** 40.00 42.00	25.93	38.8	----	----	4.12	4.12	*3.7*	5·87	2.36	.98	9.21	----	8.23	*8.0*	5.75	5.75	*5 5*
6318	Potato Manure.	C. D. Parks, Danbury.	Manufacturer.	**35.00**	24.92	40.4	.12	----	2.88	3.00	*2.9*	.59	8.10	1.98	10.67	*8.0*	8.69	----	6.90	6.90	*7.0*
6210	Complete Potato Manure.	H. J. Baker & Bro., N. Y. City.	C. O. Jelliff & Co., Southport. H. T. Miner, Vernon. Saxton & Strong, Bristol. Webster & Atwater, New Britain.	38.00 **40.00** 41.00 42.50	28.49	40.4	.47	1.30	2.09	3.86	*3.3*	5.42	1.52	.57	7.51	*6.5*	6.94	*5.0*	5.33	10.29	*10.0*

* See page 142.

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

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6232	Corn Manure.	Mapes' F. & P. G. Co., New York City.	Mapes' Branch, Hartford. Willoughby Bros., Tariffville.	**$35.00** 37.00
6259	Comp ete Manure for Corn and Grain.	Bradley Fertilizer Co., Boston, Mass.	Strong & Tanner, Winsted. M. Beach & Son, New Milford.	**38.00** 40.00
6225	Potato Manure.	Mapes' F. & P. G. Co., New York City.	Mapes Branch, Hartford. A. Martin, Lakeville.	**40.00** 42.00
6173	High Grade Potato Manure.	Packers' Union Fertilizer Co., New York City.	Nathan S. Bushnell, Taftville. W. H. Terry, Willimantic. Thomas McClimon, Greenville.	**32.00** 32.00 33.00
6335	High Grade Soluble Tobacco Manure.	Rogers Manufacturing Co., Rockfall.	Manufacturer.	**45.00**
6181	High Grade Potato Fertilizer.	E. Frank Coe Co., New York City.	I. W. Dennison & Co., Mystic. J. A. Isham, Columbia. Walkley & Damery, Wethersfield.	**33.00** 33.00 37.00
6315	Tobacco Starter.	Mapes' F. & P. G. Co., New York City.	F. S. Bidwell, Windsor Locks.	**36.00**
6411	Tobacco Grower.	Bowker Fertilizer Co., Boston, Mass.	E. F. Miller, Ellington.	**34.00**
6286	Corn Fertilizer.	M. E. Wheeler & Co., Rutland, Vt.	John Bransfield, Portland. Dwight Gallup, Old Mystic. D. P. Bullis, Wallingford. N. E. Lord, Hebron. E. K. Chamberlain, East Woodstock.	**30.00** 30.00 30.00 ------ 32.00
6313	Fruit and Vine Manure.	Mapes' F. & P. G. Co., New York City.	Mapes' Branch, Hartford, Ct.	**38.00**
6372	Potato Phosphate.	Cleveland Dryer Co., Boston, Mass.	D. F. Southwick, Putnam.	**30.00**
6209	Complete Manure for Potatoes and Vegetables.	Bradley Fertilizer Co., Boston, Mass.	J. B. Alexander, New Britain. E. N. Pierce & Co., Plainville.	**39.00** 42.00
6364	Quinnipiac Corn Manure.	Quinnipiac Co., Boston, Mass.	W. L. L. Spencer, Lebanon. C. R. Hall, Coventry.	**28.00** 32.00
6370	Potato Manure.	Bowker Fertilizer Co., Boston, Mass.	Balsh & Platt, Norfolk. S. T. Welden, Simsbury.	**33.00** 33.00
6179	Stockbridge Corn and Grain Manure.	Bowker Fertilizer Co., Boston, Mass.	City Coal and Wood Co., New Britain. J. A. Lewis, Willimantic. C. T. Leonard, Norwalk.	38.00 **40.00** 40.00
6254	Complete Corn Manure.	H. J. Baker & Bro., New York City.	H. T. Miner, Vernon.	**40.00**
6204	Animal Corn Fertilizer.	Packers' Union Fertilizer Co., New York City.	B. E. Eddy, E. Woodstock. Thomas McClimon, Greenville.	**30.00** 30.00
6401	Complete Manure for Top Dressing Grass and Grain.	Bradley Fertilizer Co., Boston, Mass.	Billings & Hallock, Meriden.	**35.00**

Analyses.—*Continued.*

Valuation per Ton.	Percentage Diff between Cost and Valuation.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found. As Muriate.	Found. Total.	Guaranteed.
$24.88	40.7	.58	.28	1.76	2.62	*2.5*	6.97	3.62	.39	10.98	*10.0*	10.59	*8.0*	6.77	6.77	*6.0*
26.85	41.5	1.16	----	2.09	3.25	*3.3*	5.04	7.21	1.66	13.91	*13.0*	12.25	*12.0*	4.96	4.96	*3.0*
28.24	41.6	1.96	.45	1.26	3.67	*3.7*	5.26	4.86	.52	10.64	*8.0*	10.12	----	.67	7.28	*6.0*
22.50	42.2	----	----	2.30	2.30	*2.1*	7.07	2.14	.82	10.03	*9.0*	9.21	*8.0*	6.46	6.46	*6.0*
*31.48	42.9	1.54	.15	2.57	4.26	*5.0*	3.41	5.50	.45	9.36	*8.0*	8.91	----	.69	10.31	*10.0*
23.12	42.7	----	.48	1.95	2.43	*2.5*	7.04	2.21	1.91	11.16	*9.0*	9.25	*9.0*	.33	5.54	*6.0*
25.17	43.0	1.40	.45	1.15	3.00	*2.5*	6.42	6.08	.86	13.36	*12.0*	12.50	*8.0*	.54	3.39	*2.5*
23.74	43.3	.75	----	1.91	2.66	*2.5*	8.22	2.65	.96	11.83	*9.0*	10.87	*7.0*	.36	4.33	*4.0*
20.85	43.9	.06	----	2.92	2.98	*1.7*	7.01	2.38	.77	10.16	*9.0*	9.39	*8.0*	2.34	2.31	*2.0*
26.32	44.4	.38	.18	1.49	2.05	*1.7*	4.58	2.82	.53	7.93	*7.0*	7.40	*5.0*	.91	12.60	*10.0*
20.72	44.8	.35	----	2.22	2.57	*2.1*	4.64	5.32	1.21	11.17	*10.0*	9.96	*8.0*	2.94	2.94	*3.0*
26.80	45.5	1.52		2.38	3.90	*3.7*	5.01	4.41	1.21	10.63	*9.0*	9.42	*8.0*	6.27	6.27	*6.0*
19.05	46.9	.32	----	1.82	2.14	*2.1*	4.49	5.87	2.10	12.46	*10.0*	10.36	*9.0*	1.60	1.60	*1.5*
22.42	47.2	.59	----	2.00	2.59	*2.5*	6.78	3.31	1.19	11.28	*10.0*	10.09	*8.0*	4.42	4.42	*4.0*
27.08	47.7	1.78	----	1.88	3.66	*3.3*	8.27	2.88	1.21	12.36	*10.0*	11.15	*8.0*	5.05	5.05	*4.0*
26.64	50.2	.17	2.41	1.55	4.13	*4.9*	6.05	1.51	.36	7.92	----	7.56	*6.2*	7.00	7.00	*7.0*
19.95	50.4	trace	----	2.74	2.74	*2.5*	7.01	2.13	1.00	10.14	*9.0*	9.14	*8.0*	2.27	2.27	*2.0*
22.72	54.0	5.00	----	----	5.00	*4.9*	1.95	3.43	1.22	6.60	*6.0*	5.38	*5.0*	.98	2.75	*2.5*

* See page 143.

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

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6283	Potato Manure.	M. E. Wheeler & Co., Rutland, Vt.	N. E. Lord, Hebron. E. K. Chamberlain, East Woodstock. John Bransfield, Portland. E. Murray, Newtown.	----- $34.00 **35.00** 36.00
6278	Vegetable, Vine and Tobacco.	Great Eastern Fertilizer Co., Rutland, Vt.	R. D. Wilson, Winsted. F. V. Cantrell, Darien. W. L. Baxter, New Canaan.	33.00 36.00 36.00 **35.00**
6176	Stockbridge Special for Potatoes and Vegetables.	Bowker Fertilizer Co., Boston, Mass.	E. B. Clark & Sons, Milford. J. A. Lewis, Willimantic. P. L. Lathrop, Coventry. Browning & Gallup, New London.	36.00 38.00 **40.00** 40.00
6413	Fruit Fertilizer.	M. E. Wheeler & Co., Rutland, Vt.	Dwight & Gallup, Old Mystic.	**29.00**
6397	Americus Potato and Tobacco Fertilizer.	Williams & Clark Fertilizer Co., N. Y. City.	W. B. Martin, Rockville.	**34.00**
6231	Potato Manure.	Quinnipiac Co., Boston, Mass.	C. H. Banks, Greenfield Hill. F. S. Bidwell, Windsor Locks L. A. Grannis, Fair Haven. A. J. Martin, Wallingford. Olds & Whipple, Hartford.	32.00 33.00 **34.00** 35.00 35.00
6083	Potato Special Fertilizer.	Milsom Rendering and Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford	**39.00**
6288	Special Potato Manure.	Pacific Guano Co., Boston, Mass.	Carlos Bradley, Ellington. S. A. Burnham, Andover. Geo. Webster, Rockville.	31.00 34.00 35.00 **33.00**
6234	Americus Potato Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	S. A. Flight, New Haven. F. B. Austin, Silver Mine. John H. Avery, Lebanon. Edward L. Strong, Colchester. G. H. Clark, Granby. S. E. Brown, Collinsville. A. B. Garfield, East Canaan.	32.00 33.00 **34.00** 34.00 35.00 35.00 36.00
	Grain and Grass Fertilizer.	Great Eastern Fertilizer Co., Rutland, Vt.	W. L. Baxter, New Canaan. F. V. Cantrell, Darien.	**36.00** 36.00
6208	Potato, Hop and Tobacco Phosphate.	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	H. C. Aborn & Son, Ellington Orlando Jones, Highwood E. A. Davis & Son, Danielson F. B. Newton, Plainville.	34.00 **35.00** 36.00 38.00

Analyses—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen. Found.	Total Nitrogen. Guaranteed.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total. Found.	Total. Guaranteed.	Available. Found.	Available. Guaranteed.	Potash. Found. As Muriate.	Found. Total.	Guaranteed.
$22.70	54.2	----	----	2.42	2.42	2.1	7.04	2.26	.84	10.14	9.0	9.30	8.0	6.20	6.20	3.2
22.61	54.8	----	----	2.28	2.28	2.1	7.09	2.27	.82	10.18	9.0	9.36	8.0	6.47	6.47	6.0
25.76	55.3	1.49	----	1.93	3.42	3.3	3.38	3.23	2.42	9.03	8.0	6.61	5.0	9.36	9.36	10.0
18.50	56.8	----	----	----	----	----	5.87	4.47	1.02	11.36	12.0	10.34	10.0	7.95	7.95	8.0
21.63	57.2	.35	----	2.17	2.52	2.1	4.69	6.00	1.51	12.20	9.0	10.69	8.0	3.15	3.15	3.0
21.21	60.3	.23	----	2.51	2.74	2.5	3.84	3.35	1.78	8.97	7.0	7.19	6.0	5.87	5.87	5.0
24.15	61.5	----	----	1.97	1.97	1.7	7.73	2.13	.78	10.64	10.0	9.86	8.0	.59	7.75	8.0
20.36	62.0	.63	.20	1.91	2.74	2.5	3.07	4.02	1.66	8.75	7.0	7.09	5.0	5.17	5.17	5.0
20.70	64.3	.38	.12	2.12	2.62	2.5	4.00	3.70	1.59	9.29	7.0	7.70	6.0	5.14	5.14	5.0
21.90	64.4	----	----	3.20	3.20	2.9	7.14	2.52	1.12	10.78	9.0	9.66	8.0	2.35	2.35	2.0
21.06	66.2	----	----	2.17	2.17	2.1	7.57	3.20	1.04	11.81	10.0	10.77	10.0	3.37	3.37	3.2

SPECIAL MANURES, SAMPLED BY THE STATION.—*Continued.*

Station No.	Name or Brand.	Manufacturer.	Dealer.	Dealer's Cash Price per Ton.
6182	Vegetable and Vine Fertilizer.	Read Fertilizer Co., N. Y. City.	L. D. Post, Andover. J. A. Silliman, New Canaan.	**$34.00** 35.00
6312	Cumberland Potato Fertilizer.	Cumberland Bone Phosphate Co., Boston, Mass.	Wm. Bartell, Ore Hill.	**34.00**
6227	Ammoniated Wheat and Corn Phosphate.	Crocker Fertilizer & Chemical Co., Buffalo, N. Y.	H. C. Aborn & Son, Ellington. C. H. Wheeler, East Canaan.	**33.00** 35.00
6310	Potato, Tobacco and Hop Fertilizer.	Niagara Fertilizer Works, Buffalo, N. Y.	Wm. Higgins, New London.	**32.00**
6399	Americus Corn Phosphate.	Williams & Clark Fertilizer Co., N. Y. City.	G. H. Clark, Granby.	**35.00**
6401	Potato Special.	Walker, Stratman & Co., Pittsburgh, Pa.	White & Juno, Rockville.	**38.00**
6177	Potato Manure.	Bradley Fertilizer Co., Boston, Mass.	Raymond Bros., South Norwalk. D. L. Clark, Milford. J. B. Alexander, New Britain.	34.00 **35.00** 36.00
6202	Oats and Clover Fertilizer.	Packers' Union Fertilizer Co., N. Y. City.	B. E. Eddy, East Woodstock.	**25.00**
6358	Standard Potato and Tobacco Fertilizer.	Standard Fertilizer Co., Boston, Mass.	Nathan S. Bushnell, Taftville. A. L. Kuren, Tolland.	33.00 **35.00**
6085	Potato, Hop and Tobacco Phosphate.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford.	**39.00**
6178	Practical Potato Special.	Read Fertilizer Co., N. Y. City.	John R. Babcock, Mystic. Nathan S. Bushnell, Taftville.	**30.00** 30.00
6390	Grass Fertilizer.	Quinnipiac Co., Boston, Mass.	O. S. Olmstead, Melrose.	**31.00**
6084	Wheat, Oats and Barley Phosphate.	Milsom Rendering & Fertilizer Co., Buffalo, N. Y.	W. K. Ackley, East Hartford.	**33.00**
6317	Universal Grain Grower.	Crocker Fertilizer & Chemical Co , Buffalo, N. Y.	C. H. Wheeler, East Canaan.	**30.00**
6412	Grass and Oats.	M. E. Wheeler & Co., Rutland, Vermont.	C. K. Chamberlain, East Woodstock. E. E. Pitney, Ellington.	**28.00** ----
6309	Niagara Grain and Grass Grower.	Niagara Fertilizer Works, Buffalo, N. Y.	Wm. Higgins, New London.	**26.50**

ANALYSES.—*Continued.*

Valuation per Ton.	Percentage Diff. between Cost and Valuation.	Nitrogen: Nitrogen as Nitrates.	Nitrogen: Nitrogen as Ammonia.	Nitrogen: Nitrogen, Organic.	Total Nitrogen: Found.	Total Nitrogen: Guaranteed.	Phosphoric Acid: Soluble.	Phosphoric Acid: Reverted.	Phosphoric Acid: Insoluble.	Phosphoric Acid, Total: Found.	Phosphoric Acid, Total: Guaranteed.	Phosphoric Acid, Available: Found.	Phosphoric Acid, Available: Guaranteed.	Potash, Found: As Muriate.	Potash, Found: Total.	Potash: Guaranteed.
$20.40	66.7	trace	----	1.81	1.81	*1.7*	5.61	1.44	.63	7.68	*7.0*	7.05	*6.0*	8.30	8.30	*8.0*
*20.35	67.1	.47	----	1.85	2.32	*2.1*	5.36	4.71	1.65	11.72	*11.0*	10.07	*9.0*	2.92	2.92	*3.0*
19.64	68.0	----	----	2.26	2.26	*2.1*	7.89	2.45	1.42	11.76	*10.0*	10.34	*10.0*	1.80	1.80	*1.6*
18.71	71.0	----	----	2.18	2.18	*1.7*	5.68	1.78	3.73	11.19	*9.0*	7.46	*8.0*	3.43	3.43	*2.7*
20.35	72.0	.35	----	2.07	2.42	*2.1*	5.55	5.54	1.23	12.32	*10.0*	11.09	*9.0*	1.62	1.62	*1.5*
22.01	72.6	----	----	1.74	1.74	*1.7*	8.27	3.18	.91	12.36	----	11.45	*9.0*	----	4.50	*5.0*
20.04	74.6	.69	----	2.03	2.72	*2.5*	3.12	3.81	1.41	8.34	*8.0*	6.93	*6.0*	5.22	5.22	*5.0*
14.21	75.9	----	----	----	----	----	6.32	4.87	1.54	12.73	----	11.19	*11.0*	1.97	1.97	*2.0*
† 19.82	76.6	.46	----	1.88	2.34	*2.1*	4.43	5.40	1.76	11.59	*9.0*	9.83	*8.0*	2.61	2.61	*3.0*
22.03	77.0	----	----	2.58	2.58	*2.5*	7.11	1.47	.55	9.13	*9.0*	8.58	----	5.79	5.88	*6.0*
16.62	80.5	trace	----	1.05	1.05	*.8*	3.44	2.62	.48	5.54	*5.0*	6.06	*4.0*	7.88	7.88	*8.0*
18.61	82.7	3.64	----	----	3.64	*3.9*	2.21	3.43	1.18	6.82	*6.0*	5.64	*5.0*	.83	2.53	*2.0*
17.75	85.9	----	----	1.59	1.59	*1.2*	8.75	1.57	.59	10.91	*9.0*	10.32	*8.0*	.37	1.90	*2.0*
15.41	94.7	----	----	1.15	1.15	*.8*	5.41	1.58	3.32	10.31	----	6.99	*7.0*	3.70	3.70	*2.7*
14.32	95.5	----	----	----	----	----	5.95	5.46	.92	12.33	----	11.41	*11.0*	2.16	2.16	*2.0*
12.87	105.9	----	----	1.00	1.00	*.8*	5.12	1.97	3.78	10.87	*8.0*	7.09	*7.0*	1.07	1.07	*1.1*

* See page 142.

† See page 143.

Home Mixtures.

Many farmers buy fertilizer chemicals and make their own mixtures on the farm instead of buying ready-mixed goods.

In some cases before payment is made, the chemicals themselves are sent to the Station for analysis to learn whether they fully meet the seller's guarantee.

The mixtures themselves are also sometimes sent for analysis.

Eleven analyses of these home mixtures are given in the table on page 155, together with the formulas used.

In most cases the analysis of the mixture agrees well with its "calculated composition," which is reckoned from the weights and the average composition of the fertilizer chemicals used.

The schedule of trade values by which the valuations are calculated is the same as is used for factory-mixed goods, stated on page 98. The cost per ton, given in the table, does not in any case include cost of mixing, which may amount to one or two dollars per ton, but it covers the regular cash ton prices of the chemicals, excluding car-lot quotations or special discounts.

The average cost of eight samples of home mixtures is $27.66, or adding two dollars per ton for mixing, $29.66. The average valuation of the same is $26.05 and the percentage difference between cost and valuation is 13.9.

MISCELLANEOUS FERTILIZERS AND MANURES.

Cotton Hull Ashes.

In the table on page 157 are tabulated thirty-one analyses of this material, most of them from stock bought for fertilizing tobacco lands.

These analyses show the usual wide range of composition. Thus, the potash, *soluble in water*, which is the ingredient for which the ashes are specially bought, ranges from 15.40 (excluding No. **6169**) to 30.64 per cent., and the phosphoric acid from 5.96 to 11.68 per cent.

The *averages* of these two ingredients have been, respectively, 23.1 and 9.7 per cent.

Allowing 5½, 5 and 2 cents per pound, for the water-soluble, citrate-soluble and insoluble phosphoric acid, respectively, potash soluble in water has cost from 3.8 cents to 10.9 cents per pound and on the average 6.6 cents.

Home-Mixtures, Analyses and Valuations.

Station No.	Made by.	Formula, Pounds per ton of Mixture. Nitrate of Soda.	Cotton Seed Meal.	Castor Pomace.	Blood, Bone and Meat.	Tankage.	Acid Phosphate.	Dissolved Bone Black.	Ground Bone.	Muriate of Potash.	Analyses. Nitrogen as Nitrates.	Nitrogen as Ammonia.	Nitrogen, Organic.	Total Nitrogen.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Total Phosphoric Acid.	Potash.	Cost (Unmixed) and Valuation. Cost per Ton.	Valuation per Ton.
5891	S. D. Woodruff & Sons, Orange	150	900	----	----	----	700	----	----	250	.72	----	2.37	3.09	4.42	1.84	.48	6.74	6.61	$26.00	21.42
6118	S. D. Woodruff & Sons, Orange										.21	2.18	2.49	4.88	5.38	3.64	1.38	10.40	3.41	----	27.38
6119	S. D. Woodruff & Sons, Orange										1.19	----	3.02	4.21	3.89	4.38	1.77	10.04	9.55	----	29.64
6190	A. C. Lake, Bethlehem	125	500	----	----	500	600	----	----	275	.89	----	3.31	4.20	3.66	4.29	1.12	9.07	7.12	24.25	26.85
6200	F. S. Hopson, Stratford	125	----	----	800	----	----	800	----	275	1.22	----	2.71	3.93	5.29	4.81	1.36	11.46	7.73	28.99	29.01
6201	Andrew Ure, New Haven	100	----	800	----	----	800	----	----	300	.95	----	2.05	3.00	4.61	2.20	.33	7.14	6.79	20.00	21.82
6306	C. E. Scranton, Madison	100	----	800	----	----	800	----	----	300	.67	----	1.71	2.38	4.24	2.24	.44	6.92	8.15	26.37	21.02
6307	D Fenn, Milford	210	----	----	----	790	----	630	160	210	1.46	----	2.34	3.80	5.28	6.07	1.83	13.18	6.58	29.59	29.02
6353	G. E. Platt & Son, Milford	200	----	----	700	----	----	700	300	100	1.60	----	2.94	4.54	7.97	3.48	1.82	13.27	2.97	31.88	28.20
6356	N. D. Platt, Milford	100	----	----	666	----	----	666	166	166*	.99	.50	2.85	4.34	3.74	2.58	.81	7.13	12.91	34.19	31.06
6496	J. J. Wilcox, Meriden	100	----	----	----	750	----	750	----	400	.68	----	2.36	3.04	6.48	4.10	1.08	11.66	8.79	----	28.02

* Also 168 pounds of sulphate of potash and 68 pounds sulphate of ammonia.

This potash is in the form of carbonates and phosphates and is particularly prized for tobacco, though it is well suited for other crops.

The analyses which follow were made on samples of cotton hull ashes offered, but not yet sold, into this State.

5615. Offered to Edward Austin, of Suffield, by southern mills as cotton hull ashes. On receipt of the analysis he naturally declined to handle them.

6330. Offered to L. H. Brewer, Hockanum, by F. W. Brode & Co.

ANALYSES.

	5615	6330
Soluble Phosphoric Acid	----	.80
Reverted " "	----	4.00
Insoluble " "	----	1.19
Potash Soluble in Water	3.02	10.17
Valuation per ton	----	$15.53

WOOD ASHES.*

These are usually regarded as a potash-fertilizer, but are also and sometimes chiefly valuable as a source of lime, in the form of carbonate.

The twenty-two samples received this season have contained from 3 to 6.7 per cent. of potash soluble in water, and from 1 to 2.6 per cent. of phosphoric acid. In twenty-one samples lime has ranged from 24.5 to 40.8 per cent., carbonic acid from 16 to 28 per cent., sand or other insoluble mineral matters from 3 to 18 per cent. and charcoal from 1 to 7 per cent. The cost has varied from $6.69 to $14.00.

The averages are as follows: For comparison, the averages of 16 samples examined last year are also given (Station Report for 1895, p. 62).

AVERAGE COMPOSITION AND COST OF WOOD ASHES.

	1896	1895
Potash, soluble in water	5½ per cent.	4⅜ per cent.
Phosphoric acid	1½ "	1½ "
Lime	32½ "	34 "
Sand and soil	11 "	12¼ "
Charcoal	2½ "	2 "
Cost	$10.36	$10.75

* By S. W. Johnson. The analyses are on page 159.

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.
6298	John Willoughby, Tariffville	Alfred H. Griffin, Granby	3.71	7.70	.27	30.64	$35.00	$42.53	3.8
6180	Olds & Whipple, Hartford	E. P. Brewer, Silver Lane	2.83	9.72	.28	28.30	40.00	41 24	4.7
6139	C. N. Dexter & Son, Windsor Locks	John P. Griswold, Poquonock	2.72	7.38	.48	28.78	40.00	39.34	5.1
6149	F. S. Bidwell, Windsor Locks	Dan. O. King, Windsor Locks	3.10	7.68	.63	27.12	40.00	38.47	5.3
5444	R. A. Parker, Warehouse Point	Station Agent	1.60	8.64	.25	27.57	40.00	38.07	5.4
6153	I. L. Spencer, Suffield	Luke F. Woodworth, Thompsonville	2.61	7.43	.50	26.38	40.00	36.88	5.6
6044	I. L. Spencer, Suffield	E. S. Seymour, Windsor Locks	2.24	8.25	.60	26.04	40.00	36.99	5.6
5885	Olds & Whipple, Hartford	Olin Wheeler, Buckland	2.39	8.10	.27	30.01	45.00	40.85	5.7
5628	Olds & Whipple, Hartford	Ernest J. Brewer, Silver Lane	.77	8.69	.33	26.50	40.00	36.17	5.7
6130	I. L. Spencer, Suffield	Willard C. Sikes, Thompsonville	2.99	8.19	.50	24.72	40.00	36.40	5.7
6043	I. L. Spencer, Suffield	F. B. Hathaway, Windsor Locks	1.17	6.45	.23	27.92	40.00	35.75	5.8
6299	I. L. Spencer, Suffield	G. A. Harmon, Suffield	2.14	8.62	.55	23.44	40.00	34.63	6.1
6170	American Cotton Oil Co.	R. W. Cowles, Tariffville	.96	7.79	.51	19.26	32.00	28.31	6.2
5887	R. A. Parker, Warehouse Point	E. F. Thompson, Warehouse Point	1.07	8.67	.29	23.72	40.00	33.69	6.3
6116	I. L. Spencer, Suffield	C. J. Sheldon, W. Suffield	1.90	7.48	.69	23.78	40.00	33.63	6.4
5771	I. L. Spencer, Suffield	Chas. M. Owen, Suffield	trace	7.19	.36	25.04	40.00	32.37	6.5
6189	H. S. Chapman, New York City	H. S. Chapman & Co., Thompsonville	.72	9.12	.55	19.98	36.00	30.11	6.5
6079	Geo. Douglass, Thompsonville	A. C. Russell, Suffield	.91	9.20	.32	19.34	36.00	29.67	6.6
6188	H. S. Chapman, 271 Broadway, N. Y.	Arthur Sikes, Suffield	.81	6.68	.62	21.30	36.00	29.12	6.6
6012	I. L. Spencer, Suffield	F. B. Hathaway, Windsor Locks	1.18	7.01	.48	23.50	40.00	32.00	6.7
6450	I. L. Spencer, Suffield	I. O. Van Gelder, W. Suffield	1.06	7.59	.68	22.06	40.00	31.09	7.0
6038	W. W. Cooper, Suffield	Chas. H. Wells, Suffield	.54	7.81	.41	20.24	38.00	28.80	7.2
6039	Charles L. Spencer	Byron Loomis, Suffield	1.10	8.76	.30	19.98	40.00	30.07	7.4
5618	W. W. Cooper, Suffield	Oliver C. Rose, West Suffield	.51	6.61	.77	20.30	38.00	27.78	7.5
5886	G. A. Douglass, Thompsonville	C. D. Woodworth, Thompsonville	.79	8.40	.47	17.64	36.00	27.10	7.5
6111	I. Luther Spencer, Suffield	Henry M. Rose, West Suffield	1.28	7.76	.61	20.40	40.00	29.81	7.5
5707	W. W. Cooper, Suffield	Oliver C. Rose, W. Suffield	none	7.13	.55	18.52	38.00	25.87	8.3
6107	I. L. Spencer, Suffield	Chas. D. Cannon, Windsor Locks	1.01	9.11	.49	15.40	40.00	25.82	9.6
6168	I. L. Spencer, Suffield	Oliver C. Rose, W. Suffield	----	4.74	1.22	16.02	40.00	21.25	10.9
6169	American Cotton Oil Co.	R. W. Cowles, Tariffville	.80	2.75	1.35	4.82	32.00	8.99	29.0
5809	J. C. Eddy, agent for G. H. & J. H. Hale	D. L. Brockett, Suffield	----	6.84	.49	19.90	----	26.94	----

The variations in the composition and quality of these ashes are very considerable. Of the samples analyzed this year, ten contain less than 5 per cent. of water-soluble potash and nine less than 30 per cent. of lime. Of the latter, it is but just to state, that all except two contain over 28 per cent. of lime. The average composition has been nearly alike in the two years.

In collecting wood ashes from log-heaps on new-cleared land it is difficult to avoid taking up with them some of the underlying earth. It is very easy also to adulterate them purposely with leached wood ashes, coal ashes or soil. But when "sand and soil" amount to 20 per cent. or more, as was the case in three of last year's samples, it is a question whether the "goods" should not be sold by the acre instead of the bushel or ton.

On the other hand, unadulterated wood ashes may unavoidably include considerable proportions of sand and soil. In our Annual Report for 1879, p. 45, are given three analyses of ashes made in a house stove at Branford that contained, respectively, 18, 22 and 27 per cent. of sand, etc. In ashes carefully prepared at this Station from a weighed quantity of chestnut body wood, cut and seasoned on the premises and burned on a clean brick hearth, were found 15.8 per cent. of "sand and silica." See Annual Report for 1883, p. 69.

In the latter case about 1⅓ ounces of sand and soil adhered to the rough surfaces of 100 pounds of wood and bark. When this wood was burned there remained, all told, one-half of one per cent. or 8 ounces of ashes, from which the sand, etc., was separated and weighed in the process of analysis.

The low content of water-soluble potash, viz. 3.01 and 2.98 per cent. in **5612** and **5810**, respectively, which is but one-half that found in five other of these samples, does not necessarily indicate adulteration or partial leaching out of soluble matters by exposure to rain. The ashes of chestnut body wood, prepared at this Station as already mentioned, contained but 3 per cent. of water-soluble potash. In the ashes of pine wood less than 2 per cent. of water-soluble potash is sometimes present. Ashes from large or old trees grown on very poor land may contain much less potash, per cent., than exists in ashes of young wood produced on good soil. Ashes from new twigs yield the largest proportion of potash up to 20, 30 or more per cent., and the per cent. of potash in them is usually much greater in early spring than in the following autumn, as during the summer's growth

SOURCES, ANALYSES AND COST OF WOOD ASHES.

Station No.	Dealer.	Sampled or Sent by.	Potash Soluble in Water.	Potash Soluble Only in Acids.	Phosphoric Acid.	Lime, Calcium Oxide.	Carbonic Acid.	Sand and Soil.	Charcoal.	Cost per Ton.
5612*	A. Hartness, Detroit, Mich.	J. N. Barnes, Yalesville	3.09	0.80	1.41	29.07	18.84	12.34	2.35	$ 9.50
5613*	" " "	L. B. Yale, Meriden	6.10	0.77	1.71	29.37	17.59	16.95	2.20	9.50
5636*	" " "	A. E. Plant, Branford	6.66		1.47	29.15	16.66	13.86	1.71	9.50
5637*	" " " 2d car	" " "	6.55		1.65	28.60	16.09	14.17	1.81	9.50
5776	" " "	G. E. Pierce, Roxbury	4.98		1.30	----	----	----	---	11.00
6448	" " "	H. C. C. Miles, Milford	6.19		1.56	32.42	16.89	12.23	3.27	14.00
5810	" " "	John Ives, Meriden	2.98		1.39	36.69	23.69	16.29	3.31	6.69
6498	" " "	J. H. Webb, New Haven	4.75		1.24	28.80	17.55	11.72	1.44	9.25
6499*	" " "	J. Norris Barnes, Yalesville	4.81		1.39	24.46	16.27	16.90	2.30	10.00
6500*	" " "	" " "	3.79		1.14	28.49	18.06	10.17	1.37	10.00
6502	" " "	Geo. E. Pierce, Roxbury	5.70		1.71	40.76	28.14	7.35	0.99	11.50
5022†	Munroe, Lalor & Co., Oswego, N. Y.	" " "	4.25		1.32	36.00	22.16	11.28	1.50	11.00
6246*	" " " "	W. F. Whitney, Yalesville	3.90		1.05	32.37	18.46	11.14	3.69	10.00
6272	" " " "	J. H. Burton, New Haven	4.64		1.45	31.95	20.33	14.66	4.20	11.00
6488*	" " " "	A. N. Clark, Milford	3.44	1.05	2.65	29.43	19.37	6.96	1.62	10.50
6093*	" " " "	W. G. & F. Comstock, E. Hartford	5.97		1.51	37.16	21.94	5.12	2.09	12.00
6341	" " " "	T. D. Barclay, Kent	5.40		1.23	40.42	21.38	2.99	1.06	11.00
6273	" " " "	Atwater Brothers, New Haven	5.41		1.59	34.29	23.69	11.39	2.97	11.00
6274*	Allison, Stroup & Frost, New York City	W. H. H. Miller, Glastonbury	4.10		1.39	25.66	15.21	18.05	7.17	9.50
6148	James Perkins, Suffield	C. A. Birge, Suffield	4.09		2.10	37.82	24.32	7.47	4.49	11.00
6247	Schwartz Bros., Rockville	Talcott Bros., Talcottville	5.64		1.57	34.49	20.48	6.73	1.75	10.60
6505*		Dwight N. Clark. Woodbridge	5.16		1.49	38.44	22.10	4.28	---	10.00
		Highest per cent. or cost	6.66		2.65	40.76	28.14	18.05	7.17	14.00
		Lowest " "	2.98		1.05	24.46	16.09	2.99	0.99	6.69
		Average " "	5.53		1.51	32.65	19.96	11.05	2.56	$10.36

* Carloads.

† Contained 7.64 per cent. of moisture.

lime and magnesia accumulate in the wood and bark, while potash is largely transferred to the new-formed buds.

When ashes containing fine sand (quartz or silica), are intensely heated, some of the potash and silica may melt together, forming a slag or cinder, which does not yield its alkali to water and requires strong acids to dissolve out the potash. In samples **5612, 5613** and **6488** the amounts of potash soluble only in acids were determined. These amounts, respectively, were 0.80, 0.77 and 1.61 per cent.; this potash insoluble in water can be of little or no use to the land or crops.

In respect to **5612** it must be concluded that either the car load or the sample, or both, had been half leached. This is an inevitable inference from the statement that **5613** "was the same ashes as **5612** but from another car," and from the fact that, except as regards water-soluble potash, the two samples have practically the same composition.

As respects the cost of lime in these ashes we find that, taking the average price of the ashes, viz. $10.36 a ton, and allowing 5 cents a pound each for phosphoric acid and water-soluble potash, the average cost of pure lime (calcium oxide) in the 21 samples whose lime content is stated, would be 51 cents a hundred pounds. In **6499,** at $10.00 a ton, the hundred weight of lime cost 78 cents. The lime in **6448,** for which was paid $14.00 the ton, cost 96 cents a hundred weight. But in **5810,** bought for $6.69 per ton, lime was obtained for 32 cents per hundred.

Slacked Oyster Shell Lime can now be got in New Haven, of H. A. Stevens, 39 South Front St., for 12 cents per bushel, in bulk, f.o.b. cars. The bushel is stated by Mr. Stevens to weigh about 50 lbs. The ton of Oyster Shell Lime, accordingly, costs $4.80 on cars at New Haven. If containing 65½ per cent. of pure lime (calcium oxide), as did a sample analyzed by this Station in 1892, the hundred pounds of pure lime would cost 37 cents.

LIME KILN ASHES.*

5614. Sampled and sent by Canfield Bros., East Canaan.

6497. Bought of the Canaan Lime Co., Canaan. Sampled and sent by Lyman H. Francis, Meriden. Cost $3.75 per ton, delivered at Meriden.

* By S. W. Johnson.

ANALYSES.

	5614	6497
Potash soluble in water	1.47	1.75
Phosphoric acid	1.30	.65
Lime	38.52	36.57
Magnesia	17.32	17.45
Carbonic acid	27.58	---
Charcoal	1.14	6.59
Sand and Soil	2.01	1.89
Moisture, combined water and other matters (by difference)	27.98	35.10*
	100.00	100.00

These "Ashes" consist in large part of carbonates of lime and magnesia coming from the magnesian limestone which occurs in the Canaan region, and in smaller part of carbonates of potash and lime, of phosphoric acid, charcoal, etc., from the ashes of the fuel consumed in burning the limestone. For use as a fertilizer or amendment, applied to land, we may consider lime and magnesia as of equal value, and may class them together in comparing the value or cost of these materials with that of other sources of lime. In **6497** the cost of lime and magnesia was 51 cents per hundred pounds at Meriden.

These Lime Kiln Ashes are now put on cars at Canaan for $2.25 per ton in bulk, by the Canaan Lime Co. They weigh about 75 lbs. per bushel.

GROUND TOBACCO STEMS AND TOBACCO DUST.

6109. "Tobacco Dust," stated to be floor sweepings from a mill where tobacco stems are ground. It was packed in barrels and was "to be sold according as it analyzes." Sampled and sent by G. A. Harmon, Suffield, from stock of Wm. S. Pinney, Suffield.

5626. Ground Tobacco Stems from the Henderson Tobacco Co., Danville, Va. Sampled and sent by J. H. Hale. Cost per ton $7.50, f.o.b., Danville.

5884. Ground Tobacco Stems. Sold by Olds & Whipple Hartford. Sampled and sent by Wm. S. Pinney, Suffield.

6214. Ground Tobacco Stems. Sold by Olds & Whipple Hartford. Sampled and sent by H. S. Frye, Poquonock.

ANALYSES OF TOBACCO STEMS AND TOBACCO DUST.

	6109	5626	5884	6214
Nitrogen	1.91	1.18	2.58	3.13
Phosphoric acid	.52	.56	.70	.86
Potash	1.96	5.16	7.06	9.63
Chlorine				trace.
Cost per ton	$7.00	7.50*	20.00	20.00
Valuation per ton	$7.00	7.99	13.88	17.91

* f.o.b. Virginia (?).

For valuation, nitrogen, phosphoric acid and potash are reckoned at 12, 4½ and 5 cents per pound, respectively.

SWAMP MUCK.*

6491. A sample of swamp muck, received from E. R. Gillette, Colchester, is remarkable for containing one-third its weight of matters freely dissolved by cold water, consisting chiefly of sulphates and humates of iron, aluminum and manganese. Its composition was found as follows:

ANALYSIS OF SWAMP MUCK.

Soluble in water.	Sulphuric Acid (SO_3)	9.32	33.97
	Oxides of Iron, Aluminum and Manganese	9.80	
	Humic Acid (by difference)	14.85	
Insoluble in water.	Humus (by difference)	30.22	66.03
	Sand and Soil	35.81	
			100.00

The organic matter (humic acid and humus) contained 0.51 per cent of nitrogen.

The muck was half-dry when received. The analysis refers to the substance completely dried at 212° F.

This sample has the sourish odor that is characteristic of a mixture of vegetable matter and oil of vitriol. Its taste is acid and astringent like that of green vitriol (copperas, also known as protosulphate of iron and as ferrous sulphate), which is, in fact, its chief water-soluble ingredient.

Such muck is poisonous to vegetation. If well mixed with a quarter its weight of lime or wood ashes, the iron and aluminum sulphates will be decomposed, and after a little exposure to the air it will become harmless.

*By S. W. Johnson.

REVIEW OF THE FERTILIZER MARKET.

FOR THE YEAR ENDING NOVEMBER 1ST, 1896.

BY E. H. JENKINS.

NITROGEN.

Nitric Nitrogen.

The *wholesale* New York quotation of nitrogen in this form was 11.6 cents in November, 1895. It fell to 10.7 cents in April, and since then has risen gradually to 11.3 cents in October, 1896. The average of the monthly quotations (given on page 168) shows that nitrate of soda has ruled lower this year than for some years previously. The figures are as follows:

Year	1896	1895	1894	1893	1892	1891	1890
Average quotation	11.1	11.4	13.0	12.7	12.1	12.9	11.5

The *retail* price of nitrogen in nitrate in this State at freight centers has been about 14.2 cents per pound.

Ammonic Nitrogen.

The *wholesale* New York quotations of nitrogen in the form of sulphate of ammonia have been very much lower than in 1894 and 1895. The monthly quotation in November, 1895, was 12.0 cents per pound. It has fallen steadily since then, being quoted in October, 1896, at 10.5 cents per pound; less than the quotation for nitrogen in nitrate of soda during the same month.

The average of the year's monthly quotations has been 11.1.

The corresponding averages for the years 1895, 1894, 1893, 1892 and 1891 were respectively, 14.3, 17.3, 15.7, 14.5 and 15.6 cents, so that sulphate of ammonia has ruled lower than for a considerable term of years.

There has been but slight demand for sulphate of ammonia in the Connecticut retail market. Nitrogen in this form has cost at retail from 15½ to 17 cents per pound.

Organic Nitrogen.

The *wholesale* New York quotations of nitrogen in the forms of red blood, black or low grade blood and concentrated tankage for each month in the year are shown in the table on page 168. Azotin has not been quoted this year.

It will be seen that nitrogen in all these forms of animal matter has been cheaper than in the years 1894 and 1895, and that both high grade and low grade blood have declined in price since January.

But these forms of organic nitrogen do not often appear in our retail market.

Low grade tankage, fish, bone, and cotton seed meal are the forms most used by those who depend on home-mixing or the use of fertilizer chemicals rather than on factory mixtures.

Phosphatic Materials.

Rough bone and ground bone were quoted at $19.50 and $22.75 per ton, wholesale, until August, when the quotations were $18.70 and $22.55, respectively. In September and October they were $16.50 and $21.75.

Rock phosphate has shown no considerable changes in quotation during the year.

Sulphuric acid quotations have remained unchanged.

Available phosphoric acid in dissolved rock phosphate has been quoted during the season at prices ranging from 2.62 to 2.73 cents per pound, *wholesale*.

Dissolved phosphate rock has during the past year figured somewhat in our retail market, and there will no doubt be a further demand for it the coming season. For analyses see pages 110 and 111.

Potash.

Muriate of Potash.

Since January, potash in this form has been quoted, *at wholesale*, at 3.60 cents per pound, the same as in 1895.

The retail price in Connecticut has ranged from 3.9 to 4.4 cents per pound.

The Double Sulphate of Potash and Magnesia.

Since April last, the *wholesale cost* of potash in this salt has been 3.94 cents, nearly four-tenths of a cent per pound less than in 1895.

At retail, in Connecticut, it has cost from 4.9 to 6.3 cents per pound.

High Grade Sulphate of Potash.

The *wholesale* New York quotation of potash in this form, which was 4.34 cents per pound in November 1895, fell in April, 1896, to 4.10 cents, and has remained at that figure ever since.

At retail, in Connecticut, potash in high grade sulphate has been sold at prices ranging from 4.9 to 6.3 cents per pound, and averaging 5.6 cents.

The review of the market quotations indicates that red and black blood, nitrate of soda and sulphate of ammonia, have fallen in price somewhat during 1896, and concentrated tankage has remained quite steady, at the same price as in 1895, till within a few months, when it has declined.

There has also been a slight decline in the quotations of potash salts. Available phosphoric acid in dissolved rock has somewhat risen in price.

These quotations 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 usually 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 the purchase.

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

Blood, azotin and concentrated tankage 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 per cent. 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 "
" 1.70 " " " 10.3 "
" 1.60 " " " 9.7 "
" 1.50 " " " 9.1 "

Commercial sulphate of ammonia contains about 20.8 per cent. of nitrogen, though it varies somewhat in quality. With that per cent. of nitrogen (equivalent to 25.25 per cent. of ammonia),

If quoted at 2.6 cents per pound, Nitrogen costs 12.5 cents per pound.
" 2.5 " " " 12.0 "
" 2.4 " " " 11.5 "
" 2.3 " " " 11.1 "
" 2.2 " " " 10.6 "
" 2.1 " " " 10.1 "
" 2.0 " " " 9.6 "

Commercial nitrate of soda averages 95 per cent. of pure sodium nitrate, or 16 per cent. of nitrogen.

If quoted at 2.5 cents per pound, Nitrogen costs 15.6 cents per lb.
" 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 "
" 1.6 " " " 10.0 "
" 1.5 " " " 9.4 "

Commercial Muriate of Potash usually contains 50½ per cent. of "actual potash," or potassium oxide.

If quoted at 2.20 cents per pound, Potassium Oxide costs 4.35 cents per lb.
" 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 "

High Grade Sulphate of Potash, as it is found in the Connecticut market, contains about 49.2 per cent. of actual potash.

If quoted at 2.50 cents per pound, Potassium Oxide costs 5.1 cents per lb.
" 2.45 " " " 5.0 "
" 2.40 " " " 4.9 "
" 2.35 " " " 4.8 "
" 2.30 " " " 4.7 "
" 2.25 " " " 4.6 "
" 2.20 " " " 4.5 "
" 2.15 " " " 4.4 "
" 2.10 " " " 4.3 "
" 2.05 " " " 4.2 "
" 2.00 " " " 4.1 "

The Double Sulphate of Potash and Magnesia has about 26½ per cent. of potassium oxide.

If quoted at 1.00 cents per pound, 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 November, 1892. The price given for each month is the average of the four weekly quotations of that month. Sulphate of ammonia is assumed to contain 20.8 per cent. and nitrate of soda 16.0 per cent. nitrogen, muriate of potash 50½ per cent., high grade sulphate 49.0 per cent. and double manure salt 26.5 per cent. of actual potash.

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.
1892.	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	18.3	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
	November	14.1	13.1	14.0	12.3	13.2	16.4	4.13	5.04	4.85	3.00
	December	13.5	12.4	13.1	12.3	12.9	16.0	4.13	5.04	4.85	3.10
1895.	January	12.7	12.2	13.0	12.3	12.1	15.0	3.54	4.24	4.13	3.50
	February	11.9	11.2	----	12.3	11.4	15.0	3.54	4.24	4.13	3.37
	March	12.1	10.5	----	12.3	10.4	15.0	3.59	4.32	4.20	3.37
	April	11.7	10.6	----	12 3	10.3	15.0	3.59	4.32	4.20	3.37
	May	12.1	10.8	----	12.3	10.5	14.3	3.59	4.32	4.20	3.37
	June	11.7	10.9	----	12.3	11.0	13.6	3.59	4.32	4.20	3.37
	July	11.6	10.7	----	12.3	10.9	13.4	3.60	4.32	4.20	3.37
	August	11.5	10.2	----	12.3	10.8	13.1	3.60	4.32	4.20	3.37
	September	11.8	10.2	----	12.3	11.3	13.0	3.60	4.32	4.20	3.23
	October	11.8	10.2	----	12.3	11.7	12.2	3.60	4.32	4 20	2.62
	November	11.7	9.9	----	12.3	11.6	12.0	3.60	4.32	*4.34	2.62
	December	11.7	9.8	----	12 3	11.1	12.0	3 60	4.32	4.34	2.62
1896.	January	11.0	9.8	----	12.3	10.8	11.6	3.60	4.32	4.34	2.62
	February	10.8	9.8	----	12.3	10.7	11.3	3.55	3.99	4.13	2.62
	March	10.8	9.8	----	12.3	10.7	11.5	3.53	3.87	4.05	2.73
	April	10.8	9.8	----	12.3	10.7	11.1	3.60	3 94	4.10	2.73
	May	10.7	9.9	----	12.3	10.9	10.8	3.60	3.94	4.10	2.73
	June	10.5	9.8	----	12.3	10.8	10.8	3.60	3.94	4.10	2.73
	July	10.5	9.8	----	12.6	10.8	10.8	3.60	3.94	4.10	2.73
	August	10.5	9.8	----	11.4	10.8	10.7	3.60	3.94	4.10	2.73
	September	10.2	9.1	----	9.5	10.8	10.5	3.60	3.94	4.10	2.73
	October	10.3	9.0	----	9.5	11.3	10.5	3.60	3.94	4.10	2.73

* Calculated on basis of 49 per cent. potash in the salt.

THE PROPER USE OF TABLES OF ANALYSES OF FERTILIZERS AND FERTILIZER CHEMICALS.

By E. H. Jenkins.

On page 162 of the Report for 1895 is a paper by the Director of this Station, on The Best Economy of Concentrated Fertilizers.

The paper is designed to illustrate the facts that "the interests of those who buy as well as of those who sell commercial fertilizers can be best promoted by a knowledge, well applied, of all the factors of crop-production; that the plant, like the man, to flourish, not only requires an abundant and varied bill of fare, but also a suitable lodging and the comforts of a well-appointed home; that the best economy of commercial fertilizers is to be attained by intelligently investigating what special wants of the soil or crop their various grades are adapted to meet, and what further wants of soil or crop must be attended to in order to prevent that impoverishment of land and landholder which otherwise, sooner or later, is likely to ensue—the experience of which has led many agriculturists to the erroneous conclusion that concentrated fertilizers are 'stimulants and not nourishment,' and that they 'exhaust the soil,' whereas they merely aid the farmer to exhaust the soil by rapidly removing, in the crops, substances which the soil unaided can supply but slowly or insufficiently and by impairing or destroying one or several of those conditions which are indispensable to plant-production."

This knowledge the farmer can get, partly from books, but in part only by careful and constant observation and experiment on his own land.

He must know, for instance, whether the water supply and drainage and texture of his soil are such that fertilizers can come to effect on his crops; whether his soil is specially deficient in some one ingredient, as lime or potash; and what elements of plant food his several crops take off from his soil, and how much of them he can put back in crop residues and in stable manure.

Only when he knows these things can he make rational use of the analyses of commercial fertilizers and fertilizer chemicals, which are yearly published by this Station.

For it is clear that if his soil is cold and sour because of deficient drainage, or is parched with drought in summer, money spent in any kind of fertilizers is likely to be thrown away.

Again if his soil greatly lacks available nitrogen or potash, his first effort must be to supply these things by heavy dressings of nitrogenous manures or potash fertilizers, and until this is done, it will be of little use to apply phosphoric acid.

The question regarding commercial fertilizers to be settled with the help of this knowledge of his land and cropping is:—

For the given crop, how many pounds per acre of nitrogen, of phosphoric acid and of potash is it wise to apply?

It is in order to supply these three ingredients that commercial fertilizers are used. If these are not lacking in the soil, it is idle to use commercial fertilizers at all.

We will suppose that in the given case the purchaser has decided to use per acre 65 pounds of nitrogen,—20 of it in form of nitrate,—50 of phosphoric acid and 90 of potash.

He is now ready to avail himself of the facts which it is the business of this Station to supply, and which will be found, in part, in the pages of this Report.

In studying the tables of analyses the first question will not be —which brand of factory-mixed goods shows the highest Station valuation or the least difference between cost and valuation, but rather how can this 65 pounds of nitrogen, 50 of phosphoric acid and 90 of potash be bought in the most available forms and at the lowest price? To find this out he does not need to depend on Station "Valuations" for help.

He can *himself* make valuations more accurate *for his special use*, than the Station can make.

There are two reasons for this. The Station Valuations are a general approximation, not for any particular place, but for freight centers throughout the State. The buyer's valuation should be quite accurate for his particular town or village.

Again, the Station Valuations are based on average quotations for six months or a year. The buyer's valuation should be true for the week in which he makes his purchase.

The Station's duty is to show what different articles contain, what their agricultural value under test conditions is, to protect from frauds in fertilizers and to give what general information it can on the subject of fertilization.

It is the buyer's business, not the Station's, to learn what his fertilizers will cost him and in what particular way he can buy cheapest.

Now the 65 pounds of nitrogen, 50 of phosphoric acid and 90 of potash can be bought in one of two ways; either mixed, finely ground and ready to apply at once in commercial "Phosphates," "Superphosphates" and "Special Manures," or separately in form of agricultural chemicals, etc., to be pulverized if necessary, and mixed or applied to the land separately.

In any case, the next thing is to find out the actual cost of nitrogen, phosphoric acid and potash, when bought for cash, each by itself.

This the Station undertakes in order to fix its schedules of valuations and the business man would do the same before purchasing stock of any kind.

The system of valuation is correct in principle, and there is not a successful fertilizer manufacturer in the country who does not resort to it in buying his raw materials.

The system has been misrepresented as being an attempt to indicate what the fair price of a fertilizer is. It is nothing of the sort; but shows, and only claims to show, what the amounts of nitrogen, phosphoric acid and potash contained in a fertilizer would cost *on the average*, for cash, at freight centers in raw materials, unmixed.

This information is of great value as a general guide to buyers.

After twenty years experience under this system it is, however, believed that the progressive farmers of this State are perfectly capable of making valuations to suit their own particular cases, which will be more accurate for their own conditions of market than any which the Station can make.

In what follows it is shown how a valuation or schedule of valuations may be made, accurate for the time and place where made, and how it may be used by the practical farmer.

NITROGEN.

It has been shown on previous pages of this Report, that the materials now in the Connecticut retail market in which *organic nitrogen* is the leading ingredient, are dry fish, cotton seed meal, linseed meal and castor pomace.

(Dried blood is not generally offered at retail; the "tankage" in market—known to the trade as "bone tankage"—is more a phosphatic than a nitrogenous fertilizer.)

No better forms of organic nitrogen exist than the vegetable matters named above.

The experiments made at this Station during the last three years, as well as the experiments of Wagner, previously made in Germany, indicate that the nitrogen of dried blood, and that of cotton seed, linseed and castor pomace are about equally available; and are more available than the nitrogen of fish, bone, or tankage.

Therefore the choice must be determined chiefly by the cost of nitrogen, with due regard also to the mechanical condition of the material.

Linseed meal—screened for fertilizer use—and cotton seed meal are of equal fineness; the linseed drills rather easier because free from lint. Castor pomace is somewhat coarser.

It appears that the cost of nitrogen per pound in these various articles in the spring of 1896 has been as follows:—

	Average.	Extremes.
In Cotton Seed Meal	**12.7**	11.2–15.5
Linseed Meal	**12.9**	12.3–13.7
Castor Pomace	**17.9**	15.6–20.6
Dry Fish	**14.5**	11.4–16.6

It is seen that organic nitrogen has been obtainable for 13 cents per pound, and that it has cost as low as 11.2 or as high as 18.2 cents, depending on the purchaser's distance from large markets, his care in buying and the use he has made of the Station in testing the quality of the material offered him.

That is, he *may have* saved 7 cents per pound, or $4.55 for 65 pounds of nitrogen, by care in buying the one item of nitrogen.

He may reckon on getting the following quantities of nitrogen, phosphoric acid and potash in every 100 pounds of cotton seed meal, linseed meal, or castor pomace that he buys.

	Nitrogen.	Phosphoric Acid.	Potash.
In Cotton Seed Meal	6.9	2.8	1.8
Linseed Meal	6.6	1.8	1.2
Castor Pomace	4.8	3.0	1.0

But if buying considerable quantities, it will in any case be wise for the purchaser to send samples to the Station for analysis and in *all* cases to buy with a distinct guarantee.

We will assume that he can buy cotton seed meal at $22.00 per ton containing 6.9 per cent. of nitrogen, 2.81 per cent. of phosphoric acid and 1.85 per cent. of potash, in which therefore nitrogen costs him 12.8 cents per pound; and that he chooses this form of organic nitrogen.

The nitrogen of nitrates can only be bought economically in nitrate of soda, at a cost of from 12.7 to 15.0 cents per pound, as appears from the figures given on page 102.

We will assume that he can buy nitrate of soda, containing 16 per cent. of nitrogen, for $45.00 per ton.

Phosphoric Acid.

The two available forms in which this is found in market, practically free from other fertilizer ingredients, are "acid phosphate"—rock phosphate dissolved by oil of vitriol—and "dissolved bone black."

There is no reason to believe that the soluble or "reverted" phosphoric acid in one of these is any more easily available to plants than in the other.

The acid phosphate is the form used by most manufacturers of fertilizers on account of its greater cheapness. It has a tendency, however, to cake or set, especially when mixed with nitrate or potash salts, unless some dry material, like cotton seed or linseed meal, bone dust, or the like is added. Dissolved bone black, however, never sets in this way.

Available (water-soluble and citrate-soluble) phosphoric acid can be bought in dissolved bone black for 6.6 cents per pound.

In acid phosphate it costs considerably less, but for some reason acid phosphate is not commonly sold by retail dealers in Connecticut.

It is, however, extensively used by farmers in other States with excellent results, and can be readily bought in the New York and New Jersey markets at low prices.

In car lots it was laid down at freight centers for $10.60 per ton or less, in the spring of 1896, and if there were demand for it, could probably be retailed for $15 or less per ton, thus making the cost of available phosphoric acid about 4½ to 5c. per pound.

We assume, for the purpose of our illustration, that the purchaser can buy acid phosphate, containing 14 per cent. of available phosphoric acid, for $16.00 per ton.

POTASH.

Leaving ashes out of account, the chief sources of potash for agricultural use are imported potash salts, viz: muriate, high grade sulphate and double sulphate.

	Averages.	Extremes.
Potash in Muriate costs cents per pound	4.16	3.9–4.3
" " high grade Sulphate " "	5.10	4.9–5.2
" " low " " " "	5.60	4.9–6.3

Returning now to the assumed case in which the farmer wishes to get 20 lbs. of nitrate nitrogen, 45 lbs. of organic nitrogen, 50 lbs. of available phosphoric acid, 90 lbs. of potash:—

From the data furnished in this Report and the quotations given by dealers, he can calculate very accurately what they will cost laid down at his freight station as follows:—

We assume that he can buy nitrate of soda for $45 per ton, or $2.25 per 100 lbs.; cotton seed meal for $22.00, or $1.10 per 100 lbs.; acid phosphate for $16.00, or 80 cents per 100 lbs.; and muriate of potash for $42.50 per ton, or $2.13 per 100 lbs.

To get 20 lbs. of nitrate nitrogen he needs 125 lbs. of nitrate of soda, costing $2.82.

Forty-five lbs. organic nitrogen require 652 lbs. cotton seed meal, costing $7.17. This quantity of meal also carries about 2.8 per cent. or 18 lbs. of phosphoric acid and 1.8 per cent. or 11 lbs of potash.

To get the remaining 32 lbs. of phosphoric acid will require, say 230 lbs. of acid phosphate, costing $1.84, and the remaining 79 lbs. of potash will require 158 lbs. of muriate, costing $3.36.

125 pounds	Nitrate of Soda, costing	$2.82
652 "	Cotton Seed Meal "	7.17
230 "	Acid Phosphate "	1.84
158 "	Muriate of Potash "	3.37
1165 "	costing	$15.20

This represents a cost *per ton* of unmixed chemicals of $26.10, with the following composition:

Nitrogen as Nitrates	1.71 per cent.
" Organic	4.00 "
Available Phosphoric Acid	4.30 "
Potash as Muriate	7.72 "

The figures which represent the *actual costs of* nitrogen, phosphoric acid and potash in these unmixed chemicals are the careful purchaser's "Schedule of trade values," which he will apply to the ready-mixed goods that are offered to him, viz:

Nitrogen as Nitrates	14 cents.
" Organic	12.8 "
Available Phosphoric Acid	5.8 "
Potash as Muriate	4.2 "

To illustrate: one of the high-grade factory-mixed fertilizers recently analyzed contains:

Nitrogen as Nitrates	2.91 per cent.
" Organic	2.17 "
Available Phosphoric Acid	7.6 "
Potash as Muriate	6.8 "

and costs $38 per ton.

This contains somewhat less nitrogen and potash, and a good deal more phosphoric acid than the particular formula of chemicals above given; and on the whole contains per ton more cash value of fertilizer ingredients by about $1.75. Deducting this from $38.00, the cash price, we have $36.25.

This $36.25 is then the price at which the farmer could buy approximately the same amount of chemicals as his formula contains, finely ground, thoroughly mixed, bagged and ready to put on his land.

The difference between $36.25 and the cost, $26.10, of the chemicals unground and unmixed, namely, $10.15, is the price he must pay for having the work of grinding and mixing done for him.

This brings him to the last question of all: Which is the cheaper, to grind and mix myself or have it done for me.

If he is using only small quantities of fertilizer, half a ton or less, or if he does not attend to it till the pressure of spring work is upon him, unquestionably the latter course is cheapest; if the chemicals are, as is often the case, fine and dry, or can be bought milled fine, for only a slight advance, and the amount used is large, it will often pay well to do the mixing at home. No general rule can be given, each farmer must figure and experiment for himself.

In what has been said we have taken for illustration quickly available but also the cheapest forms of nitrogen, phosphoric acid and potash which are on the market.

These are not always the most economical to use.

For instance, muriate of potash on tobacco is fatal to the crop, and the quality of potatoes may be injured by it, so that the higher priced sulphate is used instead.

Again, some soils which are deficient in lime, as well as potash, are more economically supplied with both at once in form of wood ashes, than by separate applications of oyster shell or stone lime and a potash salt.

It is very likely that cotton hull ashes, by reason of the alkali in them, pay better to use on some soils than either the muriate or sulphate of potash, although the actual potash in them costs considerably more.

Where moist land is laid down to grass, fine bone is preferred by many to the more soluble and quickly available forms of nitrogen and phosphoric acid.

There is often great advantage, too, in changing the form of fertilizer from time to time, rather than in dressing the land year after year in the same way. Such a change prevents an undue accumulation in the soil of any one ingredient not assimilated by the crop in considerable quantity. For instance, the use of superphosphate year after year, for a long time, may cause an accumulation of sulphates which, by reducing the amount of carbonate of lime within the soil, or in other ways, may be injurious.

All these points demand the careful attention of the farmer and are matters which each individual must attend to for himself.

To recapitulate:—

1. Before buying fertilizers in any quantity the farmer should decide—from what he can find out about his land and the past and prospective cropping,—how many pounds of nitrogen, phosphoric acid and potash he will use per acre, and whether any particular forms of these ingredients are specially desirable.

This decision, involving as it does, some thought and study, though it may not accurately meet the needs of land and crop, will make clear to him the uses and limitations of fertilizers.

It is what no one can do for him, and it is certainly a great advance over the plan of putting on half a ton or a ton of "fertilizer" or "superphosphate" per acre, regardless of anything but the cost per ton. This last plan, followed by many, is like prescribing half a pint of "medicine" per week for a patient, without naming either dose or drug.

2. Then the farmer should get, from a number of sources, quotations of such fertilizer chemicals as will serve his purpose, with definite guarantees of composition and clear understanding as to rebates in case the goods are not as guaranteed, and in the ways indicated in the preceding pages, calculate what he must pay for the quantities of nitrogen, phosphoric acid and potash that he has decided upon, delivered at his freight station.

3. The purchaser should then reckon what he must pay in cash for an amount of factory-mixed fertilizer that contains nearly the quantities of fertilizer ingredients which he has determined to apply per acre. This cost of the factory-mixed goods will usually be considerably larger than the cost of unmixed chemicals.

This difference in cost between the two is to be offset against the cost to him of possible pulverizing, mixing and bagging the chemicals, and he has lastly to determine which will probably be the cheaper method, all things considered.

EXPERIMENTS ON THE AVAILABILITY OF FERTILIZER-NITROGEN.

BY S. W. JOHNSON, E. H. JENKINS AND W. E. BRITTON.*

These experiments are a continuation of work done in previous years on the same subject, which is described in the Station Reports: 1885, pp. 115-132; 1886, pp. 80-89; 1893, pp. 218-237; 1894, pp. 73-112; 1895, pp. 99-116.

I. ON THE AVAILABILITY OF ORGANIC AND NITRIC NITROGEN. MAIZE-CULTURES IN COAL ASHES AND PEAT. 1896.

POTS NOS. 1 TO 150.

In 1894 and 1895 we studied the availability of nitrogen in certain nitrogenous materials by vegetation experiments with maize and oats, grown in pots of soil composed of a mixture of anthracite coal ashes with small amounts of peat and carbonate of lime, and supplied with relatively small quantities of nitrogen in various fertilizers. The mixture itself contained only traces of available nitrogen as had been proved by vegetation experiments, but with the added fertilizers it contained all the elements of plant food excepting nitrogen, in excess of the crop requirements.

The availability of nitrogen was measured by the quantity of this element which the crop took from each material tested.

THE APPARATUS AND METHOD.

These have been described in our Report for 1894, p. 74, and in all points not specially noted in the following pages, the same apparatus and method were used in 1896.

* These investigations were planned, and the results prepared for publication, by the Director and Vice-Director. The filling of the vegetation pots and the care of them during growth has been wholly in Mr. Britton's charge. The analyses of the fertilizers used and of the crops harvested, with the necessary computations, have been made by the station chemists, Messrs. Winton, Ogden and Mitchell.

SOIL AND FERTILIZERS.

For the experiments now to be described, were used the pots and their contents as left at the conclusion of the corresponding trials of 1895, after storage in a very dry cellar during the winter.

Just before planting, in the spring of 1896, the contents of each pot were emptied out. Such roots as had not decayed were pulverized and, together with the fertilizer chemicals, were thoroughly mixed with the soil, which was then filled into the pot again. The pots were provided with a tube for ventilation and water supply as described in the Report of 1894, p. 78, but the layer of fine gravel there mentioned was omitted.

Each pot received 0.25 gram of sodium chloride, 1 gram of magnesium carbonate, 8 grams of calcium carbonate, 5 grams of potassium phosphate and 1 gram of potassium sulphate.

The potassium phosphate contained 52.1 per cent. of potash and 37.48 per cent. of phosphoric acid. The potassium sulphate contained 53.79 per cent. of potash.

The maximum maize crop in the experiments of 1895, pot 117, (Report 1895, p. 85), contained the quantities of ash ingredients or mineral matters named below. Here are also given the quantities of these ingredients added to each pot as fertilizers, in 1896.

	In largest crop of 1895.	In fertilizers, 1896.
Potash	2.96 grams.	3.14 grams.
Soda	.34 "	.14 "
Lime	.88 "	4.48 "
Magnesia	.49 "	.48 "
Chlorine	.56 "	.15 "
Sulphuric acid	.28 "	.46 "
Phosphoric acid	.31 "	1.87 "

The coal ashes themselves, as was proved by vegetation experiments, contained considerable quantities of available potash and phosphoric acid. The soil in each pot was impregnated with a watery infusion of rich garden soil.

The nitrogenous matters tested were in each case a part of the same stock from which last year's tests were made; the slight differences between the percentages of nitrogen found in 1895 and in 1896 being due to changes in water-content.

The nitrogenous materials were as follows:—

Nitrate of soda,	containing 16.15	per cent.	of nitrogen.
Dried Blood,	" 13.54	"	"
Castor Pomace, No. **4546**,	" 4.96	"	"
" **4545**,	" 4.73	"	"
Cotton Seed Meal,	" 8.30	"	"
Dry Ground Fish,	" 9.64	"	"
Ground Horn and Hoof,	" 15.33	"	"
Bone Tankage,	" 5.10	"	"
Linseed Meal,	" 6.41	"	"

These materials have been more fully described in the Report for 1895. All of them represent commercial articles bought for fertilizer purposes.

The preparations of leather, raw, steamed, roasted and dissolved, are described on page 109 of this Report.

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

The arrangement of the tests and the quantities of nitrogen used are shown in Table I.

Before planting, the pots received the maximum quantity of water which was to be supplied to them during the experiment, together with the soil-infusion already mentioned.

Seed and Planting.

The seed was the Longfellow field maize, a flint variety, each of the selected kernels weighing between 0.40 and 0.44 gram.

The seed was placed in the germinating apparatus on April 18th, and the sprouted seed was planted from April 21st to 24th, in the following way:—

Two pounds of the moist soil were taken from each pot, three seedlings were placed on the smoothed surface of what remained, and the soil that had been removed was put back, thus covering the seeds to a depth of one and a half inches.

The young plants began to appear on April 27th, and all had come up by May 4th. One additional kernel was planted in pot 112, to fill a vacancy.

Care During Growth.

After planting, the pots were removed to the summer vegetation house described in our Report for 1894, p. 76.

The water supply was kept between 80 and 60 per cent. of the water-holding capacity of the soil (see foot note, page 186).

On May 18th, all the plants in pots 13, 135 and 136 were noted as small and unthrifty. In pot 26 one plant was thrifty, the others were apparently dying. Pot 109 had two thrifty-looking plants and one of the same size as the others, but yellow and sickly. Pots 12 and 26 had each one unthrifty plant. At this date the largest plants were about one foot high.

On June 22d, 0.8 gram of nitrogen as nitrate of soda was added to pots 11 and 13, and on July 11th, this amount was again added to pot 13.

At harvest time one of the three plants in each of pots Nos. 7, 12, 14, 26, 109, and 117, was dead. Pot 111 had but one living plant.

Before harvest, staminate flowers appeared on plants in all the pots, but no ears had sufficiently developed to make it possible to take separate account of them.

Harvesting.

The crop was harvested July 21st to 24th. Each stalk was cut close to the soil surface. The roots are not included in the "crop."

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

2. The pot received 0.8 gram at planting time, and 0.8 gram later.
3. The pot received 0.8 gram at planting time and the same quantity at each of two intervals during growth.
4. The water in the pot was kept between 80 and 60 per cent. of the water-holding capacity of the soil.
5. The water in the pot was kept between 70 and 50 per cent. of the water-holding capacity of the soil.
6. The water in the pot was kept between 60 and 40 per cent. of the water-holding capacity of the soil.
7. The water in the pot was kept between 80 and 40 per cent. of the water-holding capacity of the soil.

TABLE I.—VEGETATION EXPERIMENTS, IN COAL ASHES AND PEAT. 1896. AVAILABILITY OF NITROGEN TO MAIZE.

Number of Pot.	Nitrogen supplied— In form of—	Nitrogen supplied— Quantities of Nitrogen supplied. (Grams.)	Crops. Weights of air-dry Crops, exclusive of roots (grams).	Crops. Weights of Water-free Crops, exclusive of roots (grams).	Crop-Nitrogen. Percentages of Nitrogen in the air-dry Crops.	Crop-Nitrogen. Total Nitrogen of Crops, exclusive of roots (grams).
5	Horn and Hoof	.8	78.5	69.0	.47	.369
6	" "	1.6	165.7	147.0	.45	.746
7	" "	2.4	35.5	31.6	2.20	.781
8	" "	3.2	60.4	56.0	1.88	1.136
9	Nitrate of Soda	.8	126.9	111.1	.38	.482
10	" "	1.6	138.3	119.9	.68	.940
11	" "	.8+.8[2]	152.0	138.5	.65	.988
12	" "	2.4	34.8	31 8	2.23	.776
13	" "	.8+.8+.8[3]	32.8	30.5	2.35	.771
14	Dried Blood	.8[4]	52.0	45.5	.56	.291
15	"	1.6[4]	144.2	127.9	.47	.678
16	"	.8[5]	93.7	83.2	.39	.365
17	"	1.6[5]	145.0	128.5	.42	.609
18	"	.8[6]	96.7	84.2	.36	.348
19	"	1.6[6]	137.0	126.3	.48	.658
20	"	.8[7]	99.6	87.2	.38	.378
21	"	1.6[7]	157.9	137.8	.44	.695
23	"	1.6	145.6	128.4	.41	.597
24	"	2.4	127.0	111.8	.64	.813
25	"	2.4	168.3	154.6	.53	.892
26	"	3.2	34.6	31.9	1.87	.647
27	"	3.2	124.5	109.2	.89	1.108
102	Castor Pomace **4545**	.8	79.3	69.1	.44	.349
103	" " "	1.6	142.2	125.8	.42	.597
104	" " "	2.4	145.1	129.2	.59	.856
105	" " "	3.2	171.3	157.2	.88	1.507
106	Castor Pomace **4546**	.8	85.0	74.8	.39	.332
107	" " "	1 6	158.8	141.5	.43	.683
108	" " "	2.4	158.5	144.7	.51	.808
109	" " "	3.2	31.5	28.0	2.39	.753
110	Cotton Seed Meal	.8	76.6	67.3	.42	.322
111	" " "	1.6	10.0	9.0	2.40	.240
112	" " "	2.4	144.3	132.8	.57	.823
113	" " "	3.2	164.1	150.5	.51	.837
114	Dry Fish	.8	94.1	84.4	.39	.367
115	"	1.6	159.4	147.6	.39	.622
116	"	2.4	151.1	139.8	.52	.786
117	"	3.2	157.4	139.7	.55	.866
123	Tankage	.8	85.1	74.1	.35	.298
124	"	1.6	135.2	120.2	.37	.500
125	"	2.4	167.6	149.3	.43	.721
126	"	3.2	206.2	187.3	.54	1.113
127	Linseed Meal	.8	82.9	72.0	.41	.340
128	" "	1.6	153.7	135.9	.38	.584
129	" "	2.4	198.4	181.9	.48	.952
130	" "	3.2	154.8	142.9	.64	.991
135	Raw Leather	.8	1.8	1.6	.71	.013
136	" "	1.6	1.5	1.3	.49	.007
137	Dissolved Leather	.8	47.0	41.3	.58	.273
142	Steamed Leather	.8	26.2	23.1	.42	.110
143	" "	1.6	43.7	40.0	.41	.179
144	" "	2.4	63.9	59.0	.43	.275
145	" "	3.2	59.9	54.7	.45	.270
146	Roasted Leather	.8	7.5	6.6	.47	.035
147	" "	1.6	14.0	12.2	.45	.063

TABLE II.—VEGETATION EXPERIMENTS OF 1894, 1895 AND 1896, IN COAL ASHES AND PEAT. ONE CROP (MAIZE) IN 1894, TWO CROPS (OATS FOLLOWED BY MAIZE) IN 1895, ONE CROP (MAIZE) IN 1896.

AVAILABILITY OF NITROGEN.

Number of Pot.	Source of the Fertilizer-Nitrogen.	Crop raised.	Year.	Quantities of Fertilizer-Nitrogen (grams).	Quantities of Crop-Nitrogen (grams).	Crop-Nitrogen expressed in percentages of Fertilizer-Nitrogen.	Yearly Averages from Figures of preceding column.	Corrected yearly Averages, excluding Figures in brackets.	Corrected Averages for the three years.
5	Horn and Hoof	Maize.	1894	.8	.307	38.4			
6	" "	"	"	1.6	.561	35.1			
7	" "	"	"	2.4	1.015	42.3	38.9	38.9	
8	" "	"	"	3.2	1.278	39.9			
5	" "	Oats and Maize.	1895	.8	.384	48.0			
6	" "	" "	"	1.6	.778	48.6	46.2	46.2	41.8
7	" "	" "	"	2.4	1.064	44.3			
8	" "	" "	"	3.2	1.404	43.9			
5	" "	Maize.	1896	.8	.369	46.1			
6	" "	"	"	1.6	.746	46.6			
7	" "	"	"	2.4	.781	32.5	40.2	40.2	
8	" "	"	"	3.2	1.136	35.5			
9	Nitrate of Soda	Maize.	1894	.8	.384	48.0			
10	" "	"	"	1.6	.867	54.2			
11	" "	"	"	.8+.8	.797	49.8	54.6	50.7	
12	" "	"	"	2.4	1.376	[57.3]			
13	" "	"	"	.8+.8+.8	1.531	[63.8]			
9	" "	Oats and Maize.	1895	.8	.658	82.2			
10	" "	" "	"	1.6	1.284	80.2			
11	" "	" "	"	.8+.8	1.265	79.1	82.2	80.5	63.8
12	" "	" "	"	2.4	1.992	[83.0]			
13	" "	" "	"	.8+.8+.8	2.070	[86.3]			
9	" "	Maize.	1896	.8	.482	60.3			
10	" "	"	"	1.6	.940	58.8			
11	" "	"	"	.8+.8	.988	61.8	49.1	60 3	
12	" "	"	"	2.4	.776	[32.3]			
13	" "	"	"	.8+.8+.8	.771	[32.1]			
22	Dried Blood	Maize.	1894	.8	.334	[41.8]			
23	" "	"	"	1.6	.604	37.7			
24	" "	"	"	2.4	.931	38.8			
25	" "	"	"	2.4	1.030	42.9	40.1	39.8	
26	" "	"	"	3.2	1.287	[40.2]			
27	" "	"	"	3.2	1.261	[39.4]			
22	" "		1895	----	----	----			
23	" "	Oats and Maize.	"	1.6	.897	56.0			
24	" "	" "	"	2.4	1.180	49.1			
25	" "	" "	"	2.4	1.289	53.1	45.9	52.7	42.9
26	" "	" "	"	3.2	1.134	[35.4]			
27	" "	" "	"	3.2	1.147	[35.9]			
23	" "	Maize.	1896	1.6	.597	37.3			
24	" "	"	"	2.4	.813	33.9			
25	" "	"	"	2.4	.892	37.2	32.6	36.1	
26	" "	"	"	3.2	.647	[20.2]			
27	" "	"	"	3.2	1.108	[34.6]			

TABLE II.—VEGETATION EXPERIMENTS, ETC.—*Continued.*

AVAILABILITY OF NITROGEN.

Number of Pot.	Source of the Fertilizer-Nitrogen.	Crop raised.	Year.	Quantities of Fertilizer-Nitrogen (grams).	Quantities of Crop-Nitrogen (grams).	Crop-Nitrogen expressed in percentages of Fertilizer-Nitrogen.	Yearly Averages from Figures of preceding column.	Corrected yearly Averages, excluding Figures in brackets.	Corrected Averages for the three years.
102	Castor Pomace No. 4545	Maize.	1894	.8	.351	43.9			
103	" " "	"	"	1.6	.680	42.5	45.9	45.6	
104	" " "	"	"	2.4	1.211	50.4			
105	" " "	"	"	3.2	1.499	[46.8]			
102	" " "	Oats and Maize.	1895	.8	.496	62.0			
103	" " "	" "	"	1.6	.968	60.5			
104	" " "	" "	"	2.4	1.432	59.7	57.4	60.7	48.4
105	" " "	" "	"	3.2	1.519	[47.5]			
102	" " "	Maize.	1896	.8	.349	43.6			
103	" " "	"	"	1.6	.597	37.3			
104	" " "	"	"	2.4	.856	35.7	40.9	38.9	
105	" " "	"	"	3.2	1.507	[47.1]			
106	Castor Pomace No. 4546	Maize.	1894	.8	.315	39.4			
107	" " "	"	"	1.6	.505	31.6			
108	" " "	"	"	2.4	.945	39.4	36.6	36.8	
109	" " "	"	"	3.2	1.148	[35.9]			
106	" " "	Oats and Maize.	1895	.8	.510	63.5			
107	" " "	" "	"	1.6	.931	58.2			
108	" " "	" "	"	2.4	1.348	56.2	52.4	59.3	45.1
109	" " "	" "	"	3.2	1.010	[31.6]			
106	" " "	Maize.	1896	.8	.332	41.5			
107	" " "	"	"	1.6	.683	42.6			
108	" " "	"	"	2.4	.808	33.7	35.3	39.3	
109	" " "	"	"	3.2	.753	[23.2]			
110	Cotton Seed Meal	Maize.	1894	.8	.330	41.3			
111	" " "	"	"	1.6	.589	[36.8]			
112	" " "	"	"	2.4	1.126	46.9	40.3	44.1	
113	" " "	"	"	3.2	1.157	[36.1]			
110	" " "	Oats and Maize.	1895	.8	.513	64.1			
111	" " "	" "	"	1.6	.927	[57.9]			
112	" " "	" "	"	2.4	1.232	51.3	52.1	57.7	46.4
113	" " "	" "	"	3.2	1.118	[35.0]			
110	" " "	Maize.	1896	.8	.322	40.2			
111	" " "	"	"	1.6	.240	[15.0]			
112	" " "	"	"	2.4	.823	34.3	28.9	37.3	
113	" " "	"	"	3.2	.837	[26.1]			
114	Dry Fish	Maize.	1894	.8	.297	37.1			
115	"	"	"	1.6	.531	33.2			
116	"	"	"	2.4	.929	[38.7]	35.5	35.2	
117	"	"	"	3.2	1.062	[33.2]			
114	"	Oats and Maize.	1895	.8	.423	52.9			
115	"	" "	"	1.6	.905	56.6			
116	"	" "	"	2.4	.861	[35.8]	44.0	54.8	44.1
117	"	" "	"	3.2	.988	[30.9]			
114	"	Maize.	1896	.8	.367	45.9			
115	"	"	"	1.6	.622	38.9			
116	"	"	"	2.4	.786	[32.8]	36.2	42.4	
117	"	"	"	3.2	.866	[27.1]			

TABLE II.—VEGETATION EXPERIMENTS, ETC.—*Concluded.*

AVAILABILITY OF NITROGEN.

Number of Pot.	Source of the Fertilizer-Nitrogen.	Crop raised.	Year.	Quantities of Fertilizer-Nitrogen (grams).	Quantities of Crop-Nitrogen (grams).	Crop-Nitrogen expressed in percentages of Fertilizer-Nitrogen.	Yearly Averages from Figures of preceding column.	Corrected yearly Averages, excluding Figures in brackets.	Corrected Averages for the three years.
123	Tankage	Maize.	1894	.8	.282	35.3			
124	"	"	"	1.6	.590	36.9	37.2	37.2	
125	"	"	"	2.4	1.024	42.7			
126	"	"	"	3.2	1.077	33.7			
123	"	Oats and Maize.	1895	.8	.360	45.0			
124	"	" "	"	1.6	.607	37.9	43.9	43 9	38.2
125	"	" "	"	2.4	1.102	45 9			
126	"	" "	"	3.2	1.502	46.9			
123	"	Maize.	1896	.8	.298	37.3			
124	"	"	"	1.6	.500	31.3	33.4	33.4	
125	"	"	"	2.4	.721	30.0			
126	"	"	"	3.2	1.113	34.8			
127	Linseed Meal	Maize.	1894	.8	.330	41.2			
128	" "	"	"	1.6	.635	39.7	35.2	37.5	
129	" "	"	"	2.4	.755	31.5			
130	" "	"	"	3.2	.909	[28.4]			
127	" "	Oats and Maize.	1895	.8	.439	54.9			
128	" "	" "	"	1.6	.987	61.7	50.1	56.8	44.6
129	" "	" "	"	2.4	1.290	53.8			
130	" "	" "	"	3.2	.934	[29.9]			
127	" "	Maize.	1896	.8	.340	42.5			
128	" "	"	"	1.6	.584	36.5	37.4	39.6	
129	" "	"	"	2.4	.952	39.7			
130	" "	"	"	3.2	.991	[30.9]			
135	Raw Leather	Maize.	1894	.8	.014	1.8	1.1	1.1	
136	" "	"	"	1.6	.009	.5			
135	" "	Oats and Maize.	1895	.8	.020	2.5	1.6	1.6	1.2
136	" "	" "	"	1.6	.011	.7			
135	" "	Maize.	1896	.8	.013	1.6	1.0	1.0	
136	" "	"	"	1.6	.007	.4			
137	Dissolved Leather	Maize.	1894	.8	.308	38.5	38.5	38.5	
137	" "	Oats and Maize.	1895	.8	.408	51.0	51.0	51 0	40.8
137	" "	Maize.	1896	.8	.273	32.9	32.9	32.9	
142	Steamed Leather	Maize.	1894	.8	.047	5.9			
143	" "	"	"	1.6	.053	3.3	4.1	4.1	
144	" "	"	"	2.4	.088	3.7			
145	" "	"	"	3.2	.116	3.6			
142	" "	Oats and Maize.	1895	.8	.081	10.1			
143	" "	" "	"	1.6	.136	8.5	8.8	8.8	8.0
144	" "	" "	"	2.4	.205	8.5			
145	" "	" "	"	3.2	.267	8.3			
142	" "	Maize.	1896	.8	.110	13.8			
143	" "	"	"	1.6	.179	11.2	11.2	11.2	
144	" "	"	"	2.4	.275	11.4			
145	" "	"	"	3.2	.270	8.4			
146	Roasted Leather	Maize.	1894	.8	.040	5.0	4.7	4.7	
147	" "	"	"	1.6	.071	4.4			
146	" "	Oats and Maize.	1895	.8	.062	7.8	8.2	8.2	5.7
147	" "	" "	"	1.6	.135	8.5			
146	" "	Maize.	1896	.8	.035	4.4	4.2	4.2	
147	" "	"	"	1.6	.063	3.9			

Discussion of Tables I and II.

The Water Supply.

In pots 14 and 15, Table I, the water in the soil was maintained between 80 and 60 per cent. of the water-holding capacity of the soil;* in pots 16 and 17 between 70 and 50 per cent.; in pots 18 and 19 between 60 and 40 per cent., and in pots 20 and 21 between 80 and 40 per cent.

In the other pots, the water-supply was maintained between 80 and 60 per cent., but was to be changed at any time, according to the indications of pots 14 to 21.

There was no apparent difference in the development of the crops in pots 14 to 21. The results given in Table I show, however, that the largest assimilation of nitrogen took place in pots 20 and 21, whose water-supply was maintained between the limits of 80 and 40 per cent. of the water-holding capacity of the soil. The assimilation of nitrogen was nearly ten per cent. larger in pots 20 and 21 than in pots 14 and 15.

Availability of the Fertilizer-Nitrogen.

The weight of dry matter in the crops is not a measure of the availability of fertilizer-nitrogen. This is true of tests in the field as well as of those in pots. Wherever the conditions of growth are unbalanced, the individual plants are likely to vary greatly in composition; some producing relatively little vegetable matter having a high percentage of nitrogen; others producing much, with a low content of nitrogen. In the experiments under discussion, one at least of the factors of growth, the nitrogen supply, was necessarily unfavorable to full crop production, for, in order to compare the relative effect of different forms of nitrogen, they must be used in quantities not sufficient to meet the requirements of a maximum crop.

In consequence, and possibly because of other unfavorable conditions—limited size of pots, crowding of plants, etc.—the crops in this series of tests vary widely in their percentage of nitrogen.

To illustrate:—as shown in Table I, the soils of pots 5, 6, 7 and

* The quantity of water which the perfectly saturated soil in a vegetation pot retains, measures the "water-holding capacity" of this soil. In these experiments this quantity of water was 3892 grams or 8.58 pounds. 80 per cent. of this is 3113 grams, or 6.86 pounds.

8 received 0.8, 1.6, 2.4 and 3.2 grams of nitrogen respectively. The weights of dry matter harvested were 69, 147, 31.6 and 56.0 grams respectively, weights which give no clue whatever to the availability of the fertilizer-nitrogen.

The last column of the table, however, states the actual quantities of fertilizer-nitrogen taken from the soil by the several crops. These quantities are 0.369, 0.746, 0.781 and 1.136 grams.* From them we reckon that in the four tests, 46.1, 46.6, 32.5, and 35.5 per cent. respectively of the fertilizer-nitrogen were taken up by the plants.

These figures give a basis for calculating the relative availability of the several forms of nitrogen.

We shall therefore consider only the quantities of nitrogen which the crops (exclusive of roots) took from the soil.

Table II gives a complete view of all the results obtained during the three years 1894, 1895 and 1896.

A considerable number of experiments made with Dried Blood as a source of nitrogen, to study the effect of increased or diminished water-supply, etc. are omitted from Table II because they are not strictly comparable with the others.

Certain figures in the table are inclosed in brackets and excluded from the general average. This has been done wherever it was evident, either during the growth of the crop, or on inspection of the weights of nitrogen harvested, that something had interfered with the proper development of the crop. The chief damage to the plants appears to have resulted from rapid decay of the organic matter of the fertilizers. This occurred where the larger quantities were used. It is probable that the roots were injured, and possibly a portion of the nitrogen of the decaying matter escaped in the free state, or otherwise became useless to the growing crop. But no such injury was observed where slowly available forms of nitrogen, as bone tankage or steamed leather, were employed. The experiments of three years have proved that, for the volume of soil which was used in these tests, 3.2 grams of nitrogen, in quickly decaying form, is more than can be safely

	Pot No. 5	Pot No. 6	Pot No. 7	Pot No. 8
* The Fertilizer-nitrogen ratios are as	10	20	30	40
Dry crop ratios are as	10	21	5	8
Crop-nitrogen ratios are as	10	20	21	31

employed and make probable that 2.4 grams is an excessive quantity.

In the column headed "Crop-Nitrogen expressed in per cent. of Fertilizer-Nitrogen" (Table II), we have a set of figures, obtained, in the first instance (pot 5), by the arithmetical proportion 0.8:100::0.307:38.4, which signifies that of 100 parts of fertilizer-nitrogen, in this case supplied by horn and hoof, 38.4 parts have been taken into the crop which was harvested from that pot.

The "crop," be it remembered, does not include roots.

Now the crop-nitrogen expressed in per cent. of the fertilizer-nitrogen (which in this paper we shall call the "per cent. availability") is not the same for the three years.

For example, as is shown in Table II, the average per cent. availability of nitrogen in Horn and Hoof was 38.9 in 1894, 46.2 in 1895, and 40.2 in 1896. These differences are no doubt caused in part by the different amounts of heat and light which the plants received in these three years, and also by the fact that two crops, oats and maize, were grown in 1895, and but one crop, maize, in 1894 and also in 1896.

Hence it would appear that, if the per cent. availability found in any single crop in one year is excluded from the average, the per cent. for each of the other years in the corresponding crop, should also be excluded in order to give the results of each season their true relative value in the average.

The column headed, "Yearly Averages from figures of preceding column," gives the average of *all* the figures from the preceding column, *including those inclosed in brackets.*

For reasons just mentioned, the figures in brackets are excluded from the "corrected averages," which are stated in the last two columns. It will be noticed that the greatest difference between the mean of the "yearly averages" and that of the "corrected yearly averages" occurs in case of Cotton Seed Meal, and amounts to 6.0 per cent. The other differences are for Dry Fish, 5.5; Linseed Meal 3.7; Castor Pomace No. 4546, 3.7; Blood 3.4; Nitrate of Soda 1.8; Castor Pomace, No. 4545, 0.3 per cent.; while there is no difference in case of horn and hoof, tankage and the preparations of leather.

It will be observed that in every case, except where the source of nitrogen was steamed leather, a larger proportion of the fertilizer-nitrogen was taken up in 1895 than in either 1894 or 1896. This is due to the fact that in 1895 two crops were grown in

each pot, oats followed by maize. The oat crops in those pots receiving the larger quantities of nitrogenous matter were in some cases badly damaged by the rapid decay of the fertilizer, but the following maize crop took up available nitrogen which the damaged oat crops could not assimilate.

In Table III is given a summary, showing for the years 1894, 1895 and 1896, both the Percentage Availability of Nitrogen in the materials tested and also the Nitrogen Availability in Percentage of that of nitrate of soda.

The percentage availability of nitrogen in any material may be expected to differ in different years, for reasons which have been noted above.

It is not so obvious why the nitrogen-availability reckoned on nitrate should differ so considerably from year to year, as appears in some cases in the table.

TABLE III.—PERCENTAGE AVAILABILITY OF NITROGEN.

	To Maize, 1894.		To Oats & Maize, 1895.		To Maize, 1896.	
	Percentage Availability of Nitrogen	Availability in Percentage of that of Nitrate.	Percentage Availability of Nitrogen.	Availability in Percentage of that of Nitrate.	Percentage Availability of Nitrogen.	Availability in Percentage of that of Nitrate.
Horn and Hoof	38.9	76.7	46.2	57.4	40.2	66.6
Nitrate of Soda	50.7	100.0	80.5	100.0	60.3	100.0
Dried Blood	39.8	78.5	52.7	65.5	36.1	59.9
Castor Pomace, No. 4545	45.6	89.9	60.7	75.4	38.9	64.5
Castor Pomace, No. 4546	36.8	72.6	59.3	73.6	39.3	65.1
Cotton Seed Meal	44.1	86.9	57.7	71.7	37.3	61.8
Dry Fish	35.2	69.4	54.8	68.0	42.4	70.3
Tankage	37.2	73.3	43.9	54.5	33.4	55.4
Linseed Meal	37.5	73.9	56.8	70.5	39.6	65.6
Raw Leather	1.1	2.1	1.6	1.9	1.0	1.6
Dissolved Leather	38 5	75.9	51.0	63.4	32.9	54.5
Steamed Leather	4.1	8.1	8.8	10.9	11.2	18.5
Roasted Leather	4 7	9.2	8.2	10.2	4.2	7.0

In Table IV is given the nitrogen-availability reckoned on nitrate, as found severally in the experiments of 1894, in the combined average of 1894 and of 1895, and lastly, in the average of all three years.

It is to be observed in Table IV, that while the results of 1894, in case of one-half of the fertilizers, differ by 6 to 10 per cent:

from those of 1894 and 1895 averaged together, the combined averages of 1894 and 1895 are but little altered by the results of 1896, as seen by comparing the last two columns.

Whether this increasing agreement is a consequence of the impregnation of the coal ashes and peat with microbes, or is accidental, can only be determined by further investigation.

TABLE IV.—NITROGEN-AVAILABILITY RECKONED ON NITRATE.

	Experiments of 1894.	Experiments of 1894 and 1895.	Experiments of 1894, 1895 and 1896
Nitrate of Soda	100	100	100
Collier Castor Pomace, No. **4545**	90	83	77
Cotton Seed Meal	87	79	74
Red Seal Castor Pomace, No. **4546**	73	73	70
Linseed Meal	74	72	70
Dried Blood	79	72	68
Dry Fish	69	69	69
Dissolved Leather	76	70	65
Horn and Hoof	77	67	67
Tankage	73	64	61
Steamed Leather	8	10	13
Roasted Leather	9	10	9
Raw Leather	2	2	2

The availability of the nitrogen of roasted, steamed and raw leather, while not alike in the three years, is so much lower than that of any other materials tested, as to demonstrate that the nitrogen in them is comparatively inert and of little effect unless applied in large quantities.

The experiments also demonstrate that leather may be dissolved in oil of vitriol so as to make its nitrogen nearly as available to the maize and oat crops as that of tankage. Samples of roasted leather, steamed leather and dissolved leather were prepared each year from a common stock of raw leather, and slight differences in their preparation might explain the differences of availability observed in different years.

Of the nine materials tested, other than leather, tankage certainly has the lowest nitrogen-availability, ranking 7th, 9th and 9th in the three years tests.

Regarding the nitrogen-availability of the other organic matters the experiments are not altogether conclusive.

II. A COMPARISON OF NITROGEN-AVAILABILITY DETERMINED BY VEGETATION EXPERIMENTS AND NITROGEN-SOLUBILITY IN CHEMICAL REAGENTS, 1896.

POTS 246–277.

FORMER INVESTIGATIONS.

The solubility in pepsin-hydrochloric acid [Artificial Digestion] of different forms of organic nitrogen was first proposed by Stutzer and Klinkenberg as a measure of the availability of such nitrogen to plants.—*Jour. für Landw.*, 1882, p. 363.

C. U. Shepard and P. Chazal applied artificial digestion to forms of nitrogen used in this country, and it was more fully studied by this Station. The conclusions drawn were as follows (Report 1885, p. 130):

"1. The nitrogen of dried blood, red and black (4 samples), cotton seed (4 samples), castor pomace and maize refuse (each one sample) was in every case soluble in pepsin solution, by 24 hours digestion, to the extent of 75 per cent. or more.

2. The nitrogen of fish (10 samples), dried animal matter (tankage, horse-meat, etc., 3 samples) and of bone (20 samples) was in every case soluble to the extent of over 52 per cent.

3. The nitrogen of leather, steamed or extracted by benzine, was in no case soluble to the extent of over 36 per cent. The nitrogen of horn shavings, horn dust, ground horn and hoof, bat guano, felt waste and wool waste was considerably less soluble than the nitrogen of leather.

4. This method divides all organic nitrogenous matters into two classes according to the digestibility of their nitrogen. In one class more than half of the nitrogen, in the other scarcely more than one-third is digestible. To the first class belong all whose nitrogen is known to be readily "available;" in the second class the most digestible are leathers variously manipulated which are known to be almost valueless as fertilizers. To some extent this method is, therefore, a measure of the agricultural value of nitrogen. How far it is a correct measure must be determined by vegetation experiments under accurately controlled conditions in which nitrogen is supplied in substances that have been tested by digestion experiments.

In the meantime the method has decided value because in many cases it will distinguish between available and inert nitrogen in mixed fertilizers."

At the same time the method of determining nitrogen-solubility by putrefactive fermentation as proposed by Morgen, *Landw. Versuchs.-St.* 1880, p. 50, was also examined, and the conclusion was reached that "this test of putrefaction draws the same line between the two classes that was drawn by the pepsin digestion."

In the Report of this Station for 1893, p. 218, the methods just named were further studied and compared, and the same nitrogenous matters which had been tested by these methods were also tested by vegetation experiments in which the comparative availability of their nitrogen to maize was determined by cultures in soil containing the several fertilizers.

The conclusion of this investigation was: "It is evident that the tedious vegetation-cultures are the only true test of the availability of organic nitrogen, while the pepsin-digestion may give useful indications, but cannot be depended on for decisive results."

Investigations of 1896.

This work was done in coöperation with Mr. J. P. Street, of the New Jersey Station, Reporter on Nitrogen for the Association of Official Chemists, and Mr. R. J. Davidson of the Virginia Station.

Late in April last this Station received from Mr. Street five samples of nitrogenous superphosphates for investigation as to the availability of their nitrogen.

These superphosphates had the following composition :—

Nitrogen in form of / No.	4 Blood.	5 Tankage.	6 Horn and Hoof.	7 Raw Leather.	8 Commercial Fertilizer.*
Nitrogen	2.88	2.98	2.68	2.57	2.15
Total Phosphoric Acid	10.01	9.44	10.30	6.98	11.50
Available Phosphoric Acid	8.26	7.74	8.40	5.92	8.21
Potash soluble in water	7.86	7.86	7.86	7.86	6.04

The solubility of the nitrogen of these fertilizers in pepsin-hydrochloric acid, was determined by us and also the availability of the nitrogen to the maize crop.

* Suspected of containing nitrogen in inferior form.

Solubility of Nitrogen in Pepsin Solution.

The method followed was essentially the same as that used in our experiments of previous years, and is as follows :—

Bring one gram of the material, which has been washed on a filter with cold water, into a 150^{cc} flask, and add 100^{cc} of pepsin-hydrochloric acid solution.* Place the flask, loosely corked, in a water-bath having a constant temperature of 40° C. Keep at this temperature for twenty-four hours, adding 2^{cc} of a ten-per cent. hydrochloric acid solution at the end of the 2d, 5th, 8th and 11th hours. Shake the mixture well on each addition of acid. At the end of the digestion transfer the contents of the flask to a filter, wash with 150 to 200^{cc} of cold water, and determine nitrogen in the residue by the Kjeldahl method.

The percentages of the total nitrogen of these fertilizers which dissolve by use of this method are given in the following table, together with the results obtained by Messrs. Street and Davidson, which have been kindly communicated by Mr. Street.

Percentage Solubility of Nitrogen in Pepsin-hydrochloric Acid.

Sample No. / Form of nitrogen. / Per cent. solubility determined by	4 Blood.	5 Tankage.	6 Horn and Hoof.	7 Raw Leather.	8 Unknown.
Street	94.2	77.3	56.6	18.7	51.7
Davidson	88.4	73.9	41.5†	13.8	50.5
This Station	94.8	78.5	56.3	17.5	58.1
Average	92.5	76.6	56.5	16.7	53.4

Availability of Nitrogen to the Maize Crop.

This we undertook to determine by vegetation experiments.

The pots used were of galvanized sheet iron, 7 inches in diameter and 9 inches deep. They have been described in the Report of this Station for 1893, p. 231.

The soil used in each pot was six pounds of a mixture of 97 parts by weight of air-dry anthracite coal ashes and 3 parts of air-dry peat (described in the Report for 1893, p. 231). To this were added in each case 5 grams of calcium carbonate, and

* Made by dissolving 5 grams of Parke & Davis' pulverized pepsin (guaranteed to dissolve 2,000 times its weight of coagulated egg-albumin) in 1,000^{cc} of two-tenths per cent. hydrochloric acid.

† Omitted from average.

the quantity of the fertilizer to be tested, which is given in the following table. After the whole was thoroughly mixed it was filled into the pot and gently packed.

As soon as the pots were filled they were watered, and during the whole experiment, by frequent weighing and watering, the amount of water was kept between 60 and 80 per cent. of the water-holding capacity of the soil.*

On June 2d three kernels of Longfellow maize were planted about $1\frac{1}{4}$ inches deep in each pot.

These pots stood in the vegetation house during the summer, and the crops were harvested on Sept. 1st and 2d.

No great difference in the development of the crops raised on fertilizers Nos. 4, 5, 6 or 8 was apparent during the season. Those grown with no added nitrogen, see Table V, and those grown with leather, were, of course, very small and backward in development.

The plants raised with fertilizers Nos. 4 and 5 averaged 43 and 47 inches in height respectively, flowered and bore a number of undeveloped ears at harvest time.

The plants grown with fertilizers Nos. 6 and 8 averaged 42 and 44 inches in height and were a little less fully developed than those before mentioned.

The plants grown with leather were about 26 inches high, those to which no nitrogen was given were 25 inches high. Both had some abortive tassels.

The results of this experiment appear in Table V. The eighth column of the table is "Nitrogen Increase," which is reckoned from the seventh column by subtracting from the weight of the crop-nitrogen, in each case, the nitrogen (0.059 grams) which was probably derived from soil and seed and not from the fertilizer, as is indicated in the crops from pots 273 to 276.

The last two columns show what part per hundred of the nitrogen in each fertilizer was actually taken up by the growing maize.

It appears that the per cent. availability of the five fertilizers, under the conditions of our experiment, was as follows:—

* See foot-note, page 186.

TABLE V.—VEGETATION EXPERIMENTS, 1896, WITH NITROGENOUS SUPERPHOSPHATES. AVAILABILITY OF NITROGEN TO MAIZE.

Number of Pot.	Nitrogen supplied— In form of—	Nitrogen supplied— Quantities of Nitrogen supplied (grams).	Crops harvested (exclusive of roots). Weights of air-dry Crops (grams).	Weights of Water-free Crops (grams).	Percentages of Nitrogen in air-dry Crops.	Total Nitrogen of Crop (grams).	Nitrogen increase.	Nitrogen increase expressed in percentages of Fertilizer-Nitrogen.	
251	No. 4, Blood	.5	70.8	62.16	.40	.283	.224	44.8	46.5
252	" "	.5	83.7	72.98	.36	.301,	.242	48.4	
253	" "	1.0	118.4	101.99	.43	.509	.450	45.0	
254	" "	1.0	111.6	95.34	.48	.536	.477	47.7	
255	No. 5, Tankage	.5	78.5	69.10	.35	.275	.216	43.2	44.8
256	" "	.5	93.3	80.91	.33	.308	.249	49.8	
257	" "	1.0	125.7	108.45	.43	.541	.482	48.2	
258	" "	1.0	101.7	88.94	.43	.437	.378	37.8	
259	" "	2.0	141.0	125.36	.77	1.086	1.027	51.3	
260	No. 6, Horn and Hoof	.5	76.1	66.22	.35	.266	.207	41.4	43.4
261	" " "	.5	75.0	66.03	.34	.255	.196	39.2	
262	" " "	1.0	117.8	102.18	.44	.518	.459	45.9	
263	" " "	1.0	112.7	96.74	.47	.530	.471	47.1	
264	" " "	2.0	132.1	117.93	.66	.872	.813	40.6	
265	No. 7, Leather	.5	20.8	18.07	.36	.074	.015	3.0	3.4
266	" "	.5	21.7	18.91	.34	.074	.015	3.0	
267	" "	1.0	24.3	21.51	.41	.100	.041	4.1	
268	" "	1.0	26.0	22.54	.36	.094	.035	3.5	
269	No. 8, Suspected Commer-	.5	58.2	51.59	.36	.210	.151	30.2	29.8
270	cial Fertilizer	.5	60.1	53.19	.33	.198	.139	27.8	
271	" " "	1.0	95.3	82.28	.36	.343	.284	28.4	
272	" " "	1.0	96.4	82.90	.40	.386	.327	32.7	
273	No Nitrogen added	----	16.6	14.51	.32	.053	----	----	
274	" " "	----	18.4	16.00	.34	.063	----	----	
275	" " "	----	17.2	15.00	.35	.060	----	----	
276	" " "	----	16.2	14.21	.38	.062	----	----	

	Per cent. Availability.
No. 4, Blood	46.5
No. 5, Tankage	44.8
No. 6, Horn and Hoof	43.4
No. 7, Leather	3.4
No. 8, Source of nitrogen unknown	29.8

These figures represent the comparative fertilizing value of the nitrogen in these several forms to the maize crop.

It would have been very desirable to increase the number of tests so as to duplicate the results, but the work was first proposed after other experiments had been begun that took up most of the available space in our summer vegetation house.

Comparison of Results of Maize Cultures with those of Laboratory Methods.

On page 193 have already been given the results of digestion with pepsin-hydrochloric acid.

Mr. Street has also tried the treatment with potassium permanganate, as indicated in Bull. 47, Division of Chemistry, U. S. Dept. Agriculture, p. 115.

In the following statement by Mr. S. H. T. Hayes, the results obtained by Messrs. Street, Davidson and ourselves are presented, reduced to a common basis for comparison.

The per cent. availability of nitrogen as determined by maize cultures in preparation No. 4, was in round numbers 47.

Its per cent. digestibility in pepsin-solution, as has been stated on page 193, is 93.

If now we call its per cent. digestibility 47, to agree with the per cent. availability, and reduce the other figures for pepsin digestibility in the same ratio, we have a set of numbers which show how the relative solubility and digestibility compare with relative availability, as fixed by maize cultures.

	Availability by Maize Cultures.	Digestibility in Pepsin-hydrochloric Acid.	Solubility in Potassium permanganate solution.	
			Acid.	Alkaline.
No. 4, Blood	47	47	47	47
No. 5, Tankage	45	39	45	43
No. 6, Horn and Hoof	43	28	42	52
No. 7, Leather	3	8	14	25
No. 8, Source of nitrogen unknown	30	27	34	33

In these cases the treatment with an acid solution of potassium permanganate has given the closest approximation to the results of maize cultures. The method of treatment with permanganate is thus described by Mr. Street:

Weigh one gram of material into a 500^{cc} flask and add 100^{cc} of permanganate solution. Connect with distilling apparatus and digest for one hour over a low flame without boiling and then distil for one hour. Titrate the distilled ammonia in the usual manner. The alkaline permanganate solution is made by

dissolving 16 grams of potassium permanganate and 200 grams of potassium hydrate in one liter of water. The acid solution was made by dissolving 16 grams of permanganate in one liter of ten per cent. sulphuric acid. When the acid solution is used it is necessary after the preliminary digestion to add sufficient alkali, about 50^{cc} of strong sodium hydrate, to liberate the ammonia.

We believe these chemical methods are of very great value in the examination of mixed fertilizers, as ready tests of the presence of inferior forms of nitrogen. At present, the actual agricultural value of a form of nitrogen cannot, however, be fixed without vegetation experiments.

III. On the Availability of Nitrogen in Bone of Different Degrees of Fineness. 1896.

Pots Nos. 277 to 298.

Preliminary Experiment with Oats.

Pots.

The pots used in these cultures were of stout galvanized iron, 9¾ inches in diameter and 20 inches long, open at both ends. To avoid rusting they were painted with asphalt.

These pots were sunk in the soil of a lawn to within two inches of their upper edges, and were disposed in rows 3½ feet apart, the distance between pots in the same row being 3 feet, measuring in both cases from center to center. The rows were so arranged as to form a quincunx pattern, thus:

```
o    o    o    o
   o    o    o
o    o    o    o
```

Soil and Fertilizers.

The soil was taken in October, 1895, from the Station grounds, under turf which had not been broken up for at least fourteen years, nor received either manure or chemicals for nine years.

The soil was thoroughly mixed, sifted through a screen with four meshes to the inch, and then filled into the 48 pots, which were allowed to stand over winter, uncovered, that the soil might settle naturally under the action of frost and water.

In April, 1896, the soil of each pot received 6½ grams of an acid phosphate containing 11.69 per cent. of water-soluble, 2.59 of citrate-soluble and 1.13 per cent. of acid-soluble phosphoric acid.

There were also added 10 grams of precipitated calcium carbonate and 5 grams of a mixture of sulphate of potash, double sulphate of potash and magnesia, and muriate of potash, which contained 47.38 per cent. of potash.

These fertilizers were in each case thoroughly mixed with 20 pounds of the moist soil (which represented a depth of six inches), taken from the pot for the purpose, and then carefully replaced. The soil of each pot was known to be quite deficient in available nitrogen, but was believed to contain all other ingredients of plant food in comparative abundance.

Planting and Harvesting.

Fifteen selected seed oats, germinated in the seed-testing apparatus, were placed on the surface of the soil in each pot and covered one inch deep with three pounds of the same kind of unfertilized soil which had been used in the first filling.

The planting was done on April 28th to April 30th, and plants had appeared in all the pots on May 5th.

The soil was watered from time to time during the growing season as appeared to be necessary.

The oats grew well and were harvested on July 3d, at which time the plants were ripening and the lower leaves withering, the seeds being in most cases just past the milk stage. The soil was loosened, the roots were taken up as completely as possible and the adhering soil carefully washed off. The crops, including the roots, were air-dried, weighed and their nitrogen was determined.

The oat crops were designed to deplete the soil of its available nitrogen and incidentally to show what accordance might be attained in duplicate experiments made under the conditions here existing.

The results are given in Table VI.

In 27 out of the 48 pots one or more plants remained undeveloped or died, and in only six was there any increase in the number of stalks by tillering.

In no case was the average height of the crop more than 27 inches. These facts indicate the poverty of the soil in available nitrogen.

The nitrogen determinations show that the percentage of nitrogen found in the crops was fairly uniform with exception of Nos. 313 and 324. The average percentage, excluding these, is 0.76, and the widest range is from 0.65 to 0.90 per cent.

TABLE VI. PRELIMINARY OAT CULTURES.

Number of Pot.	Development of the Oat Crops. Number of stalks.	Average height (inches).	Number of stalks headed.	Air-dry weights (grams).	Percentages of Nitrogen in air-dry Crops.	Total Nitrogen (grams).
277	15	24	15	21.6	.73	.158
278	14	22	14	18.0	.71	.128
279	15	22	15	20.0	.75	.150
280	9	21	8	18.7	.75	.140
281	11	26	8	21.8	.75	.163
282	15	24	15	23.4	.73	.171
283	14	21	14	17.9	.67	.120
284	14	23	14	22.5	.68	.153
285	15	22	14	26.7	.73	.195
286	11	20	3	19.0	.90	.171
287	12	22	9	22.2	.81	.180
288	13	23	12	22.6	.76	.172
289	14	21	14	19.2	.75	.144
290	15	21	15	19.8	.73	.145
291	13	20	10	14.9	.81	.121
292	12	21	12	15.9	.81	.129
293	13	22	13	17.5	.75	.131
294	11	23	8	17.9	.83	.149
295	15	21	15	21.7	.76	.165
296	14	22	14	18.7	.73	.137
297	15	21	15	19.9	.71	.141
298	15	20	14	20.7	.75	.155
299	10	23	10	19.5	.77	.150
300	14	21	14	21.4	.71	.152
301	15	21	15	21.4	.69	.148
302	15	24	15	26.6	.65	.173
303	15	22	14	23.4	.76	.178
304	12	26	9	28.2	.78	[.220]
305	15	19	6	21.7	.87	.189
306	14	21	13	21.7	.78	.169
307	16	21	14	24.7	.81	.200
308	15	23	15	21.9	.73	.160
309	14	21	13	20.4	.80	.163
310	12	24	6	19.1	.88	.168
311	16	23	16	25.7	.72	.185
312	14	22	14	23.1	.77	.178
313	10	18	6	11.1	1.46	[.162]
314	14	24	14	30.4	.76	[.231]
315	15	21	15	21.9	.78	.171
316	12	21	9	14.5	.85	.123
317	13	21	13	22.3	.73	.163
318	14	21	14	32.5	.71	[.231]
319	15	21	15	22.5	.78	.176
320	17	27	17	50.9	.68	[.346]
321	14	24	14	24.2	.71	.172
322	32	24	19	84.0	.74	[.621]
323	16	22	6	26.8	.77	.206
324	17	20	1	20.4	1.87	[.381]

Nos. 313 and 324 contained an excessive percentage of nitrogen, associated in 324 with high nitrogen assimilation, but in 313 with half the average yield of vegetable matter.

The yield of air-dry matter and of nitrogen in six crops, 304, 314, 318, 320, 322 and 324, is very much larger than in any others. A probable explanation of this is found in the following facts.

After planting, and before the plants appeared, it was noticed that birds sometimes perched on the edges of the pots, and their droppings were found in some cases on the soil surface within. These were removed as promptly and thoroughly as possible and close watch was kept during the day until the plants fully occupied the pots.

In the pots named, however, it is probable that droppings left on them during a shower, or when the surface soil was quite damp, were partly carried into the soil by moisture, before they were discovered and removed, thus adding materially to the available nitrogen within the soil.

Excluding the crops mentioned, the average quantity of nitrogen taken from the soil was 0.160 gram. The greatest range from this mean was 0.040 below and 0.046 above. In twenty-four crops the nitrogen was within 10 per cent. of the mean.

It would not be possible to determine any very fine differences between the availability of different forms of nitrogen, in experiments where the crop-nitrogen in duplicate tests varies as much as was here observed. But the agreement is close enough to admit of determining any considerable differences, and it may be assumed that—with the exceptions above noted—*after the oat crops were harvested*, the amounts of available nitrogen in all the pots were quite small and fairly uniform.

Maize Cultures. Availability of Bone-nitrogen.

Immediately after the oats were harvested, additional fertilizers were mixed with the soil in the way already described, and maize was planted.

From a sample of ground raw knuckle bone, such as is used for the manufacture of case-knife handles, five grades of bone were prepared.

Description of Grades of Bone used in the Experiment.

Grade		
A,	passes bolting cloth, holes $\frac{1}{150}$ in. diameter,* contains	3.38 p. ct. nitrogen.
B,	" circular holes between $\frac{1}{50}$ and $\frac{1}{150}$ in. diameter "	3.90 " "
C,	" " " " $\frac{1}{25}$ " $\frac{1}{50}$ " "	4.07 " "
D,	" " " " $\frac{1}{12}$ " $\frac{1}{25}$ " "	4.05 " "
E,	" " " " $\frac{1}{6}$ " $\frac{1}{12}$ " "	4.08 " "

* The mesh is 0.16^{mm} wide in the clear. The holes are not circular but rather octagonal in outline.

To the soil of each pot were added 16 grams of cotton hull ashes, containing 26.31 per cent. of potash and 10.47 per cent. of phosphoric acid, with the quantities of nitrate, bone or cotton seed meal given in Table VII, page 202.

Maize was planted on July 16th, 4 kernels in each pot, and was harvested late in September. At harvest time plants in all the pots bore staminate, some also pistillate flowers, but no ears had formed.

The arrangement of the experiment and the results are shown in Table VII.

In order to ascertain whether in all cases there had been surplus phosphoric acid and potash in the soil, these were determined in both the oat and maize crops from pots 288 and 314. From the data already given the quantities of soluble potash and phosphoric acid added to the soil in the fertilizers, exclusive of that contained in the nitrogenous manures, is readily determined. The results are as follows:—

Phosphoric Acid and Potash in Fertilizers and Crops.

	Oats. Added in fertilizer.	Oats. Removed in crop.	Maize. Added in fertilizer.	Maize. Removed in crop.	Left in soil from fertilizer.
Pot No. 288.					
Phosphoric Acid ----	.928	.104	1.675	.308	2.191
Potash-------------	2.369	.468	4.210	2.702	3.409
Pot No. 314.					
Phosphoric Acid ----	.928	.155	1.675	.416	2.032
Potash-------------	2.369	.547	4.210	2.500	3.532

As these crops are among the largest, it is clear that both phosphoric acid and potash were present in excess of crop requirements.

Soil-Nitrogen.

The first six maize crops (Table VII) were intended to grow without any fertilizer-nitrogen. The crop No. 324 and the corresponding oat crop were very large, probably because of accidental bird droppings whose nitrogen was not wholly exhausted by the oat crop.

Excluding No. 324, it appears that the maize crop was able to get from the soil alone on the average 0.267 gram of nitrogen (the extremes are 0.221 and 0.287) and to produce 41.4 grams of dry-matter (40.5–51.2).

TABLE VII. AVAILABILITY OF BONE-NITROGEN. MAIZE CULTURES.

No.	Nitrogen supplied— In form of—	Nitrogen supplied— Quantity of, in grams.	Crop Statistics. Average height of stalks. Inches.	Weights of air-dry Crops (grams).	Weights of Water-free Crops (grams).	Percentages of Nitrogen in air-dry Crops.	Total Nitrogen of Crops (grams).	Nitrogen Increase.	Percentage Availability of Nitrogen.	Average Availability.	Corrected Averages
277	None added	--	18	40.0	37.6	.62	.248				
285	"	--	14	37.3	35.4	.71	.265	----	----		
301	"	--	15	42.5	40.0	.52	.221	----	----		
313	"	--	19	48.6	45.5	.65	.316	----	----		
324	"	--	19	67.2	62.7	.51	[.343]	----	----		
278	"	--	24	51.2	48.3	.56	.287	----	----		
290	Nitrate of Soda	1.0	36	143.5	134.1	.56	.804	.537	53.7		
287	" "	1.0	40	151.1	142.0	.61	.922	.655	65.5		
314	" "	2.0	40	208.4	196.6	.72	1.500	1.233	[61.7]		
312	" "	2.0	48	196.8	185.7	.70	1.378	1.111	55.6	57.7	57.2
323	" "	3.0	42	176.7	167.3	1.09	1.926	1.659	55.3		
300	" "	3.0	46	173.5	163.9	1.12	1.943	1.676	55.9		
279	Cotton Seed Meal	1.0	32	120.8	113.4	.47	.568	.301	30.1		
291	" " "	1.0	23	90.3	83.9	.53	.479	.212	21.2		
303	" " "	2.0	38	153.0	146.0	.54	.826	.559	28.0		
286	" " "	2.0	46	193.4	183.8	.46	.890	.623	31.2	28.4	28.9
322	" " "	3.0	29	124.2	117.2	.84	1.043	.776	[25.9]		
288	" " "	3.0	52	237.0	223.8	.54	1.280	1.013	33.8		
280	Bone A	1.0	18	66.7	62.9	.50	.334	.067	6.7		
317	"	1.0	17	51.3	48.0	.52	.267	----	----		
304	"	2.0	23	90.8	84.9	.54	.490	.223	[11.2]		
310	"	2.0	23	77.5	72.4	.54	.419	.152	7.6	10.0	9.7
321	"	3.0	45	143.5	135.5	.66	.947	.680	22.7		
305	"	3.0	28	100.2	94.9	.61	.611	.344	11.5		
281	Bone B	1.0	22	52.1	48.9	.54	.281	.014	1.4		
293	"	1.0	15	36.7	34.4	.66	.242	.075	7.5		
299	"	2.0	16	53.0	49.9	.60	.318	.051	2.6		
309	"	2.0	18	66.0	61.8	.50	.330	.063	3.2	3.4	3.0
320	"	3.0	21	75.4	70.6	.57	.430	.163	[5.4]		
283	"	3.0	20	47.1	43.9	.58	.273	.006	.2		
282	Bone C	1.0	19	50.3	47.2	.54	.272	.005	.5		
294	"	1.0	18	42.1	39.6	.56	.236	----	----		
297	"	2.0	28	79.2	73.9	.57	.451	.184	9.2		
308	"	2.0	24	57.0	52.9	.58	.331	.064	3.2	4.2	4.2
319	"	3.0	25	81.5	77.8	.56	.456	.189	6.3		
295	"	3.0	24	67.5	63.1	.66	.446	.179	6.0		
284	Bone D	1.0	16	33.2	31.0	.63	.209	----	----		
302	"	1.0	22	50.1	47.1	.64	.321	.054	5.4		
296	"	2.0	24	58.0	54.5	.58	.336	.069	3.5		
307	"	2.0	19	52.8	49.5	.52	.275	.008	.4	2.3	1.9
318	"	3.0	25	76.2	72.8	.52	.396	.129	[4.3]		
292	"	3.0	17	46.2	43.3	.59	.273	.006	.2		
289	Bone E	1.0	17	39.3	36.4	.56	.220	----	----		
311	"	1.0	23	56.1	52.2	.60	.337	.070	7.0		
306	"	2.0	21	52.3	48.8	.53	.277	.010	.5		
315	"	2.0	25	69.3	64.6	.60	.416	.149	7.5	2.7	2.7
316	"	3.0	16	54.2	50.5	.52	.282	.015	.5		
298	"	3.0	16	50.0	47.2	.56	.280	.013	.4		

Nitrate-Nitrogen.

The next six crops received fertilizer-nitrogen in form of nitrate of soda, and in three different amounts.

The weights of crop and crop-nitrogen were excessive in No. 314; the nitrogen-yield in the corresponding oat crop was also very large. This crop is therefore omitted from the average.

In the column of "Nitrogen Increase" are given figures obtained by subtracting from the total crop-nitrogen, the average quantity of nitrogen (0.267 gram) which the unfertilized soil itself yielded, as determined by the first six crops given in Table VII.

The nitrogen-increase is what may fairly be attributed to the nitrogen of the fertilizer rather than to that of the soil and seed.

The column "Per cent. availability" expresses the percentage of the fertilizer-nitrogen which was recovered in the crop.

Next follows the average of the six separate tests, and from the last column, "Corrected Averages," are excluded crops (like 314), which were affected by some known source of error.

It appears that the average availability of the nitrogen of nitrate of soda was 57.2 per cent. (53.7–65.5). That is, of every one hundred parts applied in the fertilizer, 57.2 parts were taken by the crop. It is quite clear too that the amount of nitrogen added was not in excess of the crop requirements.

Nitrogen of Cotton Seed Meal.

Of the maize crops raised with cotton seed meal, one, No. 322, followed a very large oat crop, but was much smaller than its duplicate. Whether it is excluded from the "corrected average" or not, makes practically no difference in the result, for the "average availability" is 28.4 and the "corrected average" 28.9.

In these experiments the nitrogen-availability of cotton seed meal was about half that of nitrate of soda.

The figures given on page 190 show that the average availability of nitrogen in form of cotton seed meal in three years' experiments in coal ashes and peat, has been nearly three-quarters (74 per cent.) of that of nitrate-nitrogen.

A word as to the discrepancy between these results. The conditions which affect that decay of organic nitrogenous matters in the soil, which necessarily precedes the taking up of their nitrogen by plants (chief among which are aeration of the soil, moisture, warmth and the activity of microbe life in the soil), are not and cannot be made alike year after year. In one year they may all be very favorable, in which case the nitrogen of cotton seed meal, for example, will have a higher availability as compared with that of nitrate; in the next year the reverse may be true. Thus in 1894 the per cent. availability of nitrogen of the same cotton seed meal was 87, in 1895, 72, in 1896, 62 per cent. of that of nitrate-nitrogen.

Nitrogen of Bone.

The tests made with the finest bone, grade A, show great irregularities, which cannot be explained. Crop No. 304 followed an oat crop whose nitrogen content was excessively large. The yield of nitrogen in the maize crop is, however, about the average of the others, so that whether this result is excluded from the corrected average or not, makes no difference in the result.

The percentages representing availability of nitrogen in four of the crops are 6.7, 7.6, 11.2, and 11.5. But in another crop we have a relative availability of 22.7, and in another no more nitrogen was taken by the crop than belonged to crops which received no fertilizer-nitrogen whatever. The tests with coarser grades of bone show less wide range of results. The figures obtained are as follows:

PER CENT. AVAILABILITY OF BONE NITROGEN.

		Average per cent. availability of nitrogen.	Range of results.
Grade A.	Passed fine bolting cloth	9.7	22.7— 0
" B.	Smaller than $\frac{1}{50}$ inch	3.0	7.5—.2
" C.	$\frac{1}{50}$ to $\frac{1}{25}$ inch	4.2	9.2— 0
" D.	$\frac{1}{25}$ to $\frac{1}{12}$ "	1.9	5.4— 0
" E.	$\frac{1}{12}$ to $\frac{1}{6}$ "	2.7	7.5— 0

These experiments of a single year have shown that, under the conditions specified, fine bone flour prepared from the hardest bones (selected raw knuckle bones free from all tendon, cartilage, etc.), was about one-third as efficient a source of nitrogen to the maize crop as cotton seed meal, and that the coarser grades of bone supplied but very little nitrogen to the growing crop.

When the crops which have been described were harvested, the pots were planted with winter rye. The experiments must be continued for several years in order to arrive at safe conclusions.

ON THE USE OF COMMERCIAL FERTILIZERS FOR FORCING-HOUSE CROPS.

BY E. H. JENKINS AND W. E. BRITTON.*

I. EXPERIMENTS WITH TOMATOES, SEASON OF 1895–1896.

This work is a continuation of that begun two years since and described in the Report of this Station for 1895, pp. 75 to 98.

The experiments now to be described were planned to test further the use of a mixture of coal ashes with a few per cent. of peat for forcing crops, to determine more closely the amount of nitric nitrogen which can be economically used in such a soil for growing tomatoes, and to study the effects of larger quantities of phosphoric acid than we had previously employed.

House, Benches and Plots.

The house and the arrangement of benches in it were the same as described on pp. 77 and 78 of the Report for 1895. The bench space in the house was divided by board partitions into 30 plots. These were nearly alike in shape and had the same depth (9 inches) and the same area (13.87 square feet).

Soil and Fertilizers.

Two kinds of soil were employed. One was a compost, such as is commonly used in forcing-houses, consisting of thick turf composted with one-third its bulk of stable manure and well worked over during the preceding summer.

The other soil, for each plot, consisted of 300 pounds of coal ashes mixed with 100 grams of pure calcium carbonate, nine pounds of moss peat, such as is sold in the cities for stable bedding, or with a like amount of meadow peat from a swamp near New Haven. Both ashes and peat were sifted through a wire screen having four meshes to the linear inch.†

The fertilizer chemicals designed for a plot were sprinkled on

* The general plan of this study, the arrangement of its details and the preparation of this paper are our joint labor. The horticultural work has been done wholly by Mr. Britton. The chemical analyses have been made by Messrs. Winton, Ogdon and Mitchell.

† Note by S. W. JOHNSON—Our use of Peat as an ingredient of the "soil" employed for experimental cultures, is the result of my experience in an investigation, "On the Effect of Alkaline Bodies in developing the Fertilizing Power of

the mixture of ashes and peat, and the whole was carefully and repeatedly shovelled over to secure perfect mixture.

The soil filled each plot to a depth of about eight inches. The kinds and quantities of fertilizers applied will be seen from subsequent tables.

The First Crop.

Plants.—Seeds of the Lorillard tomato were sown July 25th, potted August 20th into $2\frac{1}{2}$ inch pots and shifted into 4 inch pots about the middle of September. Six of these plants, with the potting earth about them, were set in each of the forcing-house plots on Sept. 27th and 28th. The plants were trained to a single stem. All lateral shoots were pinched off as they appeared, dried and carefully saved for analysis, those from each plot separately.

Notes Regarding Growth.—During the period of growth, and ripening of the fruit, cloudy weather prevailed and the small yield was doubtless due to the lack of sunlight.

The plants, however, grew well from the beginning. Flowers were pollinated every second day throughout the fruiting season,

Peat," made in 1862 (briefly described in the writer's "Peat and its Uses as Fertilizer and Fuel," pp. 77–81; also in Storer's Agriculture, Vol. II, p. 19), in which it was found that maize plants rooted in peat, withstood great heat and occasional drouth without apparent injury.

A mixture of Coal Ashes and Peat was first used in our Vegetation Cultures, for studying the Availability of Nitrogen in Fertilizers, Report for 1893, p. 231. The coal ashes were either those of anthracite coal taken directly from the furnace of the large boiler that supplies steam heat to the Station buildings, or those of bituminous coal from the Whitney Lake Pumping House. These ashes contain some partially burned coal and considerable slag as well as pulverulent ash and clay.

The Peat was either a dark brown meadow "muck" from the Beaver Swamp meadow near New Haven, formed from grasses, sedges, etc., and rich in slowly available nitrogen, or the imported brown moss peat (Commercial Peat Moss) used as stable litter. The former is the cheaper and more convenient to pulverize. This Mixture is easily prepared in large quantities, is almost entirely sterile both as regards plant food and living organisms of all kinds; its texture and physical characters are more favorable to vegetation than those of quartz sand, usually employed, since it largely consists of mineral grains of very various dimensions intimately mixed together, and contains a small proportion of highly porous humus.

Its cheapness and the excellent results obtained with it, when duly enriched with plant food, have led us to employ it as a substitute for the usual compost. It is free, not only from insects and worms, but probably also from the denitrifying organisms so abundant in dung, and perhaps in composts, which dissipate the nitrogen of nitrates.

beginning on October 19th. For this purpose a spoon is held directly under each flower and the upper part of the blossom gently tapped with a pencil or small stick. Pollen is thus shaken into the spoon and at the same time the stigma is coated with it, and as flower after flower is visited on many different plants, cross-fertilization is insured.

About the middle of October a fungus (*Cladosporium fulvum*), appeared as yellowish-brown patches on the under side of the leaves of a few plants, but was quickly checked and soon eradicated by treatment with ammoniacal copper carbonate.

On November 9th, there appeared on the leaves of a few plants the injury known as "blight," "sunscald" or "burn," which very seriously damaged some of the crops and in consequence impaired the value of the experiment. A description of this trouble is given on subsequent pages.

The surface soil of all the plots was stirred every few days to check evaporation. The plants were watered whenever it was thought necessary and the atmosphere was kept moist by wetting the walks daily between nine and ten o'clock in the morning. On sunny days the wetting was repeated in the afternoon to keep the temperature from running too high.

The temperature was maintained between 65° and 70° Fahr. at night and about 10° higher during the day.

Harvesting.—Every plant was numbered and each tomato when picked was weighed and credited to the plant which bore it. It was therefore possible to judge whether the several plants in each plot were of fairly uniform vigor and bearing capacity. The first ripe fruits were harvested November 27th from plot 35 (compost), and the next were picked December 2d from plots 12, 28 and 32 (coal ashes, etc.), and from plot 20 (compost). The yield of each plot, given in Tables I and II, pages 210, 211, will be discussed later. The experiment was concluded on January 21st, 1896.

The plants, including roots, so far as it was easily practicable to gather them, and immature fruit from each plot were dried, added to the dried trimmings of the plants saved during the growing season and the whole was weighed and analyzed to determine the content of nitrogen, phosphoric acid and potash.

Average samples of fruit from both the coal ashes and the compost were analyzed and from its composition and total weight were calculated the quantities of nitrogen, phosphoric acid and potash removed by the fruit.

The Second Crop.

Immediately after the first crop was harvested and analyzed additional fertilizers were applied to some of the plots and tomato plants were set as before on all the plots.

Seed for these plants—a portion of the same stock from which the plants in the previous experiment came—was sown on December 14th; the seedlings were put in two-inch pots on December 26th and repotted to four-inch pots on January 22d.

The plants, which had been kept in a cool house and were stocky and in excellent condition, were finally set in the plots on February 14th.

Notes on the Growth.—The plants started into thrifty growth as soon as transplanted to the benches, and, by March 16th, were about two and one-half feet high. Flowers of the third clusters were then opening and most of the second clusters had set fruit. Soon after, the plants on plots 9, 10, 11 and 12 were somewhat affected by "scald;" some blossoms fell before opening and others failed to set fruit.

The first blossom appeared February 20th, and the blossoms were pollinated every day or two thereafter. The first ripe fruit was harvested April 21st from the coal ashes, plots 11, 25 and 29, and from the compost, plot 23.

The temperature, care and management of the house were essentially the same as for the first crop.

About May 1st many green tomatoes began rotting at the blossom end, being attacked by the common fungus (*Macrosporium tomato*), and ripened prematurely. The fungus was found on tomatoes grown in both coal ashes and compost, but was less prevalent on the south bench, where the flowers and fruits were nearer the glass and perhaps more fully exposed to the sun. From this time on no bottom heat could be given the plants through the night. It is quite probable that this change of condition, which noticeably checked the growth, favored the development of the fungus just referred to.

The yield, though larger than that of the first crop, on account of the increased amount of sunlight, was unquestionably lessened somewhat in every plot by the ravages of the *Macrosporium.*

The plants stood in the plots till July 8th, when they were harvested. The harvesting and subsequent work were the same as described for the first crop.

Discussion of Results.

A. *The Nitrogen and Potash Series. Plots 9–14,* Anthracite Coal Ashes and Moss Peat.*

The experiments of last year (see Report of 1895, p. 82) indicated that on plots of the size above named, 32.7 grams of nitrogen, with 8.1 grams of phosphoric acid and 29.3 grams of potash, gave a larger yield than smaller quantities of nitrogen with these amounts of phosphoric acid and potash.

We have now to inquire whether more nitrogen in the fertilizer increases the yield of the crop and whether a larger supply of phosphoric acid and potash may not render the nitrogen more effective.

As regards the question of Nitrogen Supply, Tables I, II, III and IV show the plan of experiments and their results.

The First Crop.

The largest amounts of nitrogen (32.7 grams), phosphoric acid (8.1 grams) and potash (29·3 grams), used last year, were employed this year for plot 9. While the quantities of potash and phosphoric acid in 10, 11 and 12 are alike (10 and 35 grams), the quantities of nitrogen are respectively 32.7, 40 and 47 grams.

Plot 13 had the same quantities of nitrogen and phosphoric acid as plot 11, but a larger amount of potash, to determine whether the nitrogen in plot 11 was limited in crop production, by lack of potash. Plots 14 and 12 had equal quantities of nitrogen and phosphoric acid, but the former had more potash than the latter.

* The situation of these plots in the forcing-house is shown in plate I, page 231.

TABLE I.—TOMATO CULTURES IN ANTHRACITE COAL ASHES AND MOSS PEAT, SEPT. 1895 TO FEB. 1896.

NITROGEN AND POTASH SERIES.

Fertilizers.	Plot 9	Plot 10	Plot 11	Plot 12	Plot 13	Plot 14
Nitrate of Soda, grams	204.2	204.2	249.6	295.0	249.6	295.0
Nitrogen, "	32.7	32.7	40.0	47.0	40.0	47.0
Dissolved Bone Black "	47.9	58.8	58.8	58.8	58.8	58.8
Phosphoric Acid, "	8.1	10.0	10.0	10.0	10.0	10.0
Muriate of Potash, "	58.6	70.0	70.0	70.0	80.0	90.0
Potash, "	29.3	35.0	35.0	35.0	40.0	45.0
Yield.						
Total yield of fruits, grams*	2987	3847	4425	5274	7548	8042
" " vines, "	265	281	286	312	359	383
" " roots, "	6.1	9.7	8.1	10.3	24.1	23.6
Average yield of fruits per plant, grams	498	641	738	880	1258	1340
" " " " pounds	1.1	1.4	1.6	1.9	2.7	3.0
Average number of fruits per plant	9.7	13.1	12.6	16.3	18.0	18.0
Average weight of ripe fruits, grams	57.4	55.6	70.8	64.7	84.5	84.2
Percent. of perfect shaped fruits	27.0	33.0	0	25.0	28.0	30.0
Average yield of fruits per square foot of bench area, grams	215	277	319	380	544	580
Average yield of fruits per square foot of bench area, pounds	.5	.6	.7	.8	1.2	1.3

The value of this experiment, so far as the first crop is concerned, was greatly impaired by the "burn" or "scald" already alluded to; nevertheless, it appears likely from inspection of Table I, that nitrogen was relatively deficient, on the first two plots, 9 and 10, at least. The increased yield of plot 14 over 13 may be due to the larger supply either of nitrogen or of potash.

Table III shows that from 37 to 48 per cent. of the nitrogen, from 55 to 73 per cent. of the phosphoric acid and from 59 to 84 per cent. of the potash contained in the fertilizer and ashes, were taken up by the first crop.

The Second Crop.

Before planting the second crop, nitrate of soda, dissolved bone black and muriate of potash were added to the plots of this series in such quantities as to exactly replace the nitrogen, phosphoric acid and potash removed by the first crop, including roots.

* Small unripe tomatoes remaining on the vines at time of harvest were weighed and recorded with the other fruits. The total and average yield and number of fruits per plant include these, but in computing the average weight of fruits, the number and weight of ripe fruits only were taken.

TABLE II.—TOMATO CULTURES IN ANTHRACITE COAL ASHES AND MOSS PEAT, FEBRUARY TO JULY, 1896.

NITROGEN AND POTASH SERIES.

Fertilizers.	Plot 9	Plot 10	Plot 11*	Plot 12†	Plot 13	Plot 14
Nitrate of Soda, grams	204.2	204.2	249.6	----	249.6	295.1
Cotton Seed Meal, "	----	----	----	§205.8	----	----
Nitrogen, "	32.7	32.7	40.0	47.0	40.0	47.0
Dissolved Bone Black, "	47.9	58.8	58.8	58.8	58.8	58.8
Phosphoric Acid, "	8.1	10.0	10.0	10.0	10.0	10.0
Muriate of Potash, "	58.6	70.0	70.0	70.0	80.0	90.0
Potash, "	29.3	35.0	35.0	35.0	40.0	45.0
Carbonate of Magnesia, "	24.0	----	----	----	----	----
Carbonate of Lime, "	100.0	----	----	----	----	----
Yield.						
Total yield of fruits, grams‡	7987	7682	10385	9507	10427	11467
" " vines, " } " " roots, "	477	537	532	582	637	721
Average yield of fruits per plant, grams	1331	1280	1731	1584	1738	1911
" " " " pounds	2.9	2.8	3.8	3.5	3.8	4.2
Average number of fruits per plant	10	10	18	16	15	19
Average weight of ripe fruits, grams	138	125	120	118	124	116
Percent. of perfect shaped fruits	12	35	19	28	52	49
Average yield of fruits per square foot of bench area, grams	576	554	749	686	752	827
Average yield of fruits per square foot of bench area, pounds	1.3	1.2	1.7	1.5	1.7	1.8

Turning now to Table II, giving the results of the second experiment, it is to be noted that the plants on plots 13 and 14 were healthy throughout the season, those on plot 12 were slightly affected with scald, those on 9, 10 and 11 were considerably injured, and that to 9, 11 and 12 some applications were made which render the results on those plots not strictly comparable with the others.

The much larger yield from each plot in the second experiment, Table II, in which the amount of plant food used was the same as in the first experiment, stands connected with the greater supply of sunshine.

* Also added 18 lbs. moss peat.
† Also added a handful of garden soil.
‡ See note to Table I.
§ This amount of cotton seed replaces the nitrogen removed in the first crop.

Tables III and IV.—Tomato Cultures in Anthracite Coal Ashes and Moss Peat.

Table III.—Supply and Removal of Fertilizer Elements in First Crops, Sept., 1895, to Feb., 1896.

	Plot 9	Plot 10	Plot 11	Plot 12	Plot 13	Plot 14
Nitrogen in fertilizer, grams	32.7	32.7	40	47	40	47
Nitrogen in crop, grams	12.68	13.88	14.92	17.26	19.15	21.65
Nitrogen taken by crop,* percent.	39	42	37	37	48	46
Phos. acid in fertilizer, grs.	8.1	10.0	10.0	10.0	10.0	10.0
Phos. acid in crop, grams	5.09	5.53	6.14	6.31	6.85	7.29
Phos. acid taken by crop,* percent.	63	55	61	63	69	73
Potash in fertilizer, grams	29.3	35.0	35.0	35.0	40.0	45.0
Potash in crop, grams	18.74	20.97	22.54	25.54	33.47	36.51
Potash taken by crop*, percent.	64	59	65	73	84	81

Table IV.—Supply and Removal of Fertilizer Elements in Second Crops, Feb. to July, 1896.

	Plot 9	Plot 10	Plot 11	Plot 12	Plot 13	Plot 14
Nitrogen in fertilizer, grams	32.7	32.7	40.0	47.0	40.0	47.0
Nitrogen in crop, grams	17.65	17.66	22.26	20.33	22.54	26.06
Nitrogen taken by crop,* percent.	54	54	56	43	56	55
Phos. acid in fertilizer, grs.	8.1	10.0	10.0	10.0	10.0	10.0
Phos. acid in crop, grams	6 53	6.71	9.41	7.52	7.74	7.81
Phos. acid taken by crop,* percent.	81	67	94	75	77	78
Potash in fertilizer, grams	29.3	35.0	35.0	35.0	40.0	45.0
Potash in crop, grams	35.09	35.65	42.79	38.80	42.02	46.66
Potash taken by crop,* percent.	119	102	122	111	105	104

Table IV shows that from 43 to 56 per cent. of the nitrogen, from 75 to 94 of the phosphoric acid and from 102 to 122 per cent. of the potash in the fertilizer, were taken up by the crop.

It appears probable that in every case the nitrogen was limited in its efficiency by scarcity of potash if not of phosphoric acid.

The results also show that the crop took some potash from the ashes used as soil.

On plots 13 and 14, about 72 per cent. of the nitrogen, 91 per

* i. e., parts harvested per 100 applied.

cent. of the phosphoric acid and 72 per cent. of the potash taken from the soil in the second crop, were found in the fruit. In round numbers, therefore, more than three-fourths of the plant food taken passed into the fruit; last year four-fifths was in the fruit.

The ratio of phosphoric acid to nitrogen and potash in the total crops on plots 13 and 14 is 1: 3.0: 5.3. The corresponding ratios in the fertilizers applied to these two plots are, on plot 13, 1: 4.0: 4.0 and on plot 14, 1 : 4.7 : 4.5.

It may be here remarked that the ratio of these ingredients to each other in the total crop is no sure indication of the ratio which they should bear to each other in the fertilizer.

Potash supplied by the Soil.

In two cultures carried out by way of control to ascertain to what extent potash existed in the anthracite coal ashes in available form, plot 17A received 40 grams of nitrogen and 10 grams of phosphoric acid with no potash. The yield of fruit and the quantities of fertilizer ingredients taken by the crops were:

Yield of Plot 17 A.

	First Crop.	Second Crop.	Total.
Weight of fruit, pounds	12.00	9.10	21.10
" " grams	5436.00	4150.00	9586.00
Nitrogen in Crop, "	14.64	12.48	27.12
Phosphoric acid in Crop, "	4.38	3.00	7.38
Potash in Crop, "	20.24	19.76	40.00

The two crops were able to obtain 40 grams of potash from the coal ashes, about three-fifths as much as was taken in the two crops from plot 13, to which like amounts of nitrogen and of phosphoric acid, together with 80 grams of potash, had been added in the fertilizer.

B. The Phosphoric Acid Series, Plots 27–32, Bituminous Coal Ashes and Meadow Peat.*

The plan of experiments bearing on the phosphoric acid supply and the results are shown in Tables V, VI, VII and VIII. In this series bituminous coal ashes and peat obtained from Beaver Meadow Swamp near New Haven, were used. Moss peat contains but 0.6 per cent. of nitrogen and this is quite unavailable to the tomato plant, as was proved by our experiments last year

* See Plate I, page 231.

(Report 1895, p. 84), but the Beaver Meadow peat contains over two per cent. of nitrogen whose availability to the tomato plant we have not yet determined.

First Crop.

The six plots, 27 to 32 inclusive, were each fertilized with 40 grams of nitric nitrogen and 35 grams of potash. To plot 27 no phosphoric acid was added, but plots 28, 29, 30, 31 and 32 received 4, 8, 10, 12 and 15 grams of phosphoric acid respectively.

All the plants in plots 27 to 32 were free from disease and developed normally, except one in plot 29 which was injured and rejected.

The figures representing the yield of plot 29 have accordingly been increased by one-fifth to make them more nearly comparable with the others.

The statistics of the first crop, Tables V and VII, show that:

TABLE V.—TOMATO CULTURES IN BITUMINOUS COAL ASHES AND MEADOW PEAT. SEPT., 1895, TO FEB., 1896.

PHOSPHORIC ACID SERIES.

Fertilizers.	Plot 27	Plot 28	Plot 29†	Plot 30	Plot 31	Plot 32
Nitrate of Soda, grams	249.6	249.6	249.6	249.6	249.6	249.6
Nitrogen "	40.0	40 0	40.0	40.0	40.0	40.0
Dissolved Bone Black, "	none	23.5	47.1	58.8	70.5	88.3
Phosphoric Acid, "	"	4.0	8.0	10.0	12.0	15.0
Muriate of Potash, "	70.0	70.0	70.0	70.0	70.0	70.0
Potash, "	35.0	35.0	35.0	35.0	35.0	35.0
Yield.						
Total yield of fruits, grams*	4269	5140	4804	5795	6599	7214
" " vines, "	288	304	327	296	366	365
" " roots, "	20.7	23.8	24.0	17.5	21.0	22.5
Average yield of fruits per plant, grams	712	857	801	966	1099	1202
" " " " " pounds	1.6	1.9	1.8	2.1	2.4	2.6
" number of fruits per plant	10	12	14	13	17	18
" weight of ripe fruits, grams	79	87	65	79	70	78
Percent of perfect-shaped fruits	42	37	46	35	55	60
Average yield of fruits per square foot of bench area, grams	308	370	347	418	476	520
Average yield of fruits per square foot of bench area, pounds	.7	.8	.8	.9	1.1	1.2

* See note to Table I, page 210.

† One plant rejected. Stated yield is one-fifth greater than actual yield.

1. With 40 grams of nitrogen and 35 of potash the application of 15 grams of phosphoric acid gave a larger yield of fruit and of total crop than any smaller application, and make it probable that larger quantities of phosphoric acid would have still further increased the yield.

2. The chemical analysis of the crop on plot 27, Table VII, shows that when no phosphate was added, the crop was able to gather from the coal ashes of which the soil was largely composed, 4.28 grams of phosphoric acid; more than half as much as was assimilated by the crop on plot 32. A similar experiment on plot 17B. from which two tomato crops were harvested is described on p. 216.

3. That the yield of fruit was not larger in plots 27 to 32 than on plots 13 and 14, may be due to the fact that the former were less favorably situated as regards light and air than the plots in the nitrogen series.

4. The fact that 86 to 90 per cent. of the fertilizer-potash on plots 31 and 32 were taken up by the crop, makes it probable that the efficiency of the nitrogen and phosphoric acid supplies on these plots was limited somewhat by the supply of potash.

5. On plots 31 and 32 about 54 per cent. of the nitrogen, 61 per cent. of the phosphoric acid and 65 per cent. of the potash taken up by the crop, or in round numbers, a little less than two-thirds of the whole, was contained in the fruit.

Second Crop.

In preparation for the second crop, fertilizers were applied to each plot in amount sufficient to replace the nitrogen, phosphoric acid and potash, which were removed by the first crop, and to increase these quantities up to 55 grams in the case of nitrogen, and 50 grams in that of potash.

The quantities of phosphoric acid in each plot after the second application were as follows:

Plot 27, 15 grams.	Plot 30, 24 grams.
Plot 28, 21 grams.	Plot 31, 27 grams.
Plot 29, 21 grams.	Plot 32, 30 grams.

The smallest quantity (15 grams) of phosphoric acid is the same as the largest amount used for the first crop, Table V, and the quantity was increased in successive plots to 30 grams.

The results given in Table VI and VIII indicate that:

TABLE VI.—TOMATO CULTURES IN BITUMINOUS COAL ASHES AND MEADOW PEAT. FEBRUARY TO JULY, 1896.

PHOSPHORIC ACID SERIES.

Fertilizers.		Plot 27	Plot 28	Plot 29†	Plot 30	Plot 31	Plot 32
Nitrogen in Nitrate of Soda,	grams	55.0	55.0	55.0	55.0	55.0	55.0
Phosphoric Acid in Diss. Bone Black,	"	15.0	21.0	21.0	24.0	27.0	30.0
Potash in Muriate of Potash,	"	50.0	50.0	50.0	50.0	50.0	50.0
Yield.							
Total yield of fruits, grams*		8902	9661	9405	10135	9337	8950
" " vines, " } " " roots, " }		686	452	659	808	556	520
Average yield of fruits per plant, grams		1483	1610	1567	1689	1556	1492
" " " " " pounds		3.3	3.5	3.4	3.7	3.4	3.3
" number of fruits per plant		14	16	14	18	16	14
" weight of ripe fruits, grams		113	112	117	97	102	108
Percent. of perfect-shaped fruits		67	63	42	60	64	63
Average yield of fruits per square foot of bench area, grams		642	697	678	731	673	646
Average yield of fruits per square foot of bench area, pounds		1.4	1.5	1.5	1.6	1.5	1.4

1. With 55 grams of nitrogen and 50 of potash in the fertilizer, 24 grams of phosphoric acid, plot 30 gave the largest yield, and larger amounts of phosphoric acid, plots 31 and 32, did not increase but rather depressed the yield.

2. The per cent. of fruit of perfect shape in plots 27 to 32 was much larger than in any other plots.

3. On plot 30, which gave the largest yield, rather more potash was taken by the crop than was added in the fertilizer. It is, therefore, possible that the yield was limited by the potash supply.

4. Fifty-two per cent. of the nitrogen, 65 per cent. of the phosphoric acid and 54 per cent. of the potash taken up by the crop were found in the fruit, on plot 30.

Phosphoric Acid supplied by the Soil.

Plot 17 B, not included in Tables V–VIII, was filled with anthracite ashes and peat from Beaver Meadow, to which were added 40 grams of nitric nitrogen and 35 grams of potash, but no phosphoric acid. The quantities of nitrogen and of potash removed in the first tomato crop were added to the soil in form of nitrate of soda and muriate of potash before the second crop was planted. The object of this experiment was to determine how much phosphoric acid the two tomato crops were able to obtain from the ashes and peat.

* See note at bottom of Table 1, p. 210.

† One plant rejected.

TABLES VII AND VIII.—TOMATO CULTURES IN BITUMINOUS COAL ASHES AND MEADOW PEAT.

TABLE VII.—SUPPLY AND REMOVAL OF FERTILIZER ELEMENTS IN FIRST CROPS. SEPTEMBER, 1895, TO FEBRUARY, 1896.

		Plot 27	Plot 28	Plot 29	Plot 30	Plot 31	Plot 32
Nitrogen in fertilizer,	grams	40.0	40.0	40.0	40.0	40.0	40.0
Nitrogen in crop,	"	13.3	17.04	13.34	15.49	19.83	20.66
Nitrogen removed by crop,*	percent.	33	43	33	39	49	52
Phos. acid in fertilizer,	grams	0.0	4.0	8.0	10.0	12.0	15.0
Phos. acid in crop,	"	4.28	5.10	4.29	5.81	7.05	7.59
Phos. acid removed by crop,*	percent.	---	127.0	54	58	59	50
Potash in fertilizer,	grams	35.0	35.0	35.0	35.0	35.0	35.0
Potash in crop,	"	21.75	24.75	19.52	24.01	30.12	31.24
Potash removed by crop	percent.	62	71	56	70	86	90

TABLE VIII.—SUPPLY AND REMOVAL OF FERTILIZER ELEMENTS IN SECOND CROPS. FEBRUARY TO JULY, 1896.

		Plot 27	Plot 28	Plot 29	Plot 30	Plot 31	Plot 32
Nitrogen in fertilizer,	grams	55.0	55.0	55.0	55.0	55.0	55.0
Nitrogen in crop,	"	24.94	24.14	24.18	31.33	24.28	25.14
Nitrogen removed by crop,*	percent.	44	44	44	57	44	46
Phos. acid in fertilizer,	grams	15	21	21	24	27	30
Phos. acid in crop,	"	8.5	7.77	7.12	10.15	7.79	7.90
Phos. acid removed by crop,*	percent.	53	37	34	42	29	26
Potash in fertilizer,	grams	50	50	50	50	50	50
Potash in crop,	"	43.04	39.0	36.95	54.19	42.48	43.12
Potash removed by crop,	percent.	86	78	74	108	85	86

* i. e. parts harvested per 100 applied.

The weight of the fruit and the quantities of nitrogen, phosphoric acid and potash taken by the crops are as follows:—

YIELD OF PLOT 17 B.

		First Crop.	Second Crop.	Total.
Weight of fruits,	pounds	10.40	9.40	19.70
" "	grams	4708.00	4248.00	8956.00
Nitrogen in crop,	"	11.04	11.28	22.32
Phosphoric acid in crop,	"	2.58	2.36	4.94
Potash,	"	21.12	16.78	37.90

These figures may be compared with those for the first crop from plot 32, which received the same quantities of nitrogen and potash and in addition 15 grams of phosphoric acid.

Plot 17 B produced, in the first crop, two-thirds as much fruit as plot 32, and took from the ashes alone 2.58 grams of phosphoric acid, one-third as much as was taken by the crop on plot 32.

The second crop on plot 17 B was somewhat smaller and took somewhat less phosphoric acid from the ashes (2.36 grams).

C. Comparison between Tomatoes raised in Compost and those raised in Coal Ashes and Peat.

Statistics regarding the yield on five plots filled with Compost are given in Table IX.

These plots were in different parts of the forcing house, somewhat differently exposed to light and heat. Plot 18 was thought to be the most favorably situated, and 23 ranked next. There was no appreciable difference in the relative exposures of the other plots.

Plots 18 and 23 received no chemical fertilizers, plot 37 received 35 grams of potash and 100 grams of carbonate of lime, while plots 19 and 22 each received in September, for the first crop, 32.7 grams of nitrogen, 10 of phosphoric acid and 29.3 of potash, and for the second crop, enough of each of these to replace the amount removed by the first crop.

The plants on these five plots were perfectly healthy through the season and kept their dark green color much longer than those grown in Coal Ashes and Peat.

Addition of fertilizer chemicals to this rich Compost soil, plots 19 and 22, did not increase the yield.

TABLE IX.—TOMATO CULTURES IN COMPOST, SECOND CROP. FEB. TO JULY, 1896.

Fertilizers.	Plot 18	Plot 23	Plot 37	Plot 19	Plot 22
Nitrogen in nitrate of Soda, grams	----	----	----	32.7	32.7
Phosphoric acid in Diss. Bone Black, grams	----	----	----	10	10
Potash in Muriate, grams	----	----	35	29.3	29.3
Carbonate of Lime, grams	----	----	100	----	----
Yield.					
Total yield of fruits, grams*	10558	8523	8984	9162	8820
Total yield of vines and roots, grams	898	608	919	1146	1001
Average yield of fruits per plant, grams	1759	1420	1497	1527	1470
Average yield of fruits per plant, pounds	3.9	3.1	3.3	3.4	3.2
Average number of fruits per plant	19	14	16	17	17
Average weight per fruits, grams	104	104	101	95	89
Percent. of perfect-shaped fruits	65	44	57	75	60
Average yield of fruits per square foot of bench area, grams	761	615	648	660	636
Average yield of fruits per square foot of bench area. pounds	1.7	1.4	1.4	1.5	1.4

Comparative Yield of Fruit.—In the following table are given the average weights of fruit and of nitrogen, phosphoric acid and potash in the total crops, from the five plots of Compost just described and, for comparison, the corresponding data for the three plots of Coal Ashes and Peat, in both the nitrogen series and phosphoric acid series which had received the largest applications of fertilizer chemicals.

	Average yield of fruit. (Grams.)	Quantities taken up by the Crops (grams). Nitrogen.	Phos. Acid.	Potash.	Ratios of Phos. Acid to Nitrogen and Potash.
Compost, plots 18, 23, 37, 19, 22	9209	27.3	10.5	54.9	1 : 2.6 : 5.2
Ashes and Peat, plots 30, 31, 32	9474	26.9	8.6	46.6	1 : 3.1 : 5.4
Ashes and Peat, plots 12, 13, 14	10467	23.0	7.7	42.5	1 : 3.0 : 5.5

The small differences in the yield of fruit are in favor of the Coal Ashes and Peat.

Time of Ripening.—The rate of ripening is shown in Table X.

* See note, bottom of page 210.

TABLE X.—QUANTITIES OF TOMATOES HARVESTED IN SUCCESSIVE WEEKS FROM EQUAL AREAS OF COMPOST AND OF COAL ASHES AND PEAT.

Week ending	Compost. For the week. grams.	Compost. Total. grams.	Coal Ashes and Peat. For the week. grams.	Coal Ashes and Peat. Total. grams.
April 28	1095	1095	884	884
May 5	2052	3147	895	1779
12	1107	4254	2249	4028
19	6280	10534	12121	16149
26	4178	14712	4313	20462
June 2	3192	17904	2431	22893
9	1951	19855	2200	25093
16	1909	21764	1423	26516
June 16 to July 8	6321	28085	4726	31242
Average per plot		9362		10414

During the first two weeks the average yield of fruit from the Compost was the larger, for the next three weeks the Ashes and Peat produced the most, and thereafter the yield per week from the Compost was generally larger than from Ashes and Peat, although, as has been already noted, the total yield for the season was largest on the latter.

In this experiment fully two-fifths of the crop on Ashes und Peat ripened in a single week, while on Compost soil but one-fifth of the crop ripened in that time. This is a point of importance in forcing tomatoes for market which will receive further attention.

Root Galls.—Two plots, 20 and 21, were used to study the development of root galls in soil which had carried tomatoes the previous year and had not been frozen or removed from the forcing-house.

Plot 21 was filled with Peat and Anthracite Ashes, to which were added 32.7 grams of nitric nitrogen, 8.1 grams of soluble phosphoric acid and 29.3 grams of potash. Plot 20 contained the Compost with the same addition of chemicals.

The roots of the crop in plot 20 were well covered with nematode galls, while in plot 21 there were no galls on the roots, outside of the ball of earth which was set in with the young plant.

The results of this season's work may be summarized as follows:

1. A crop of tomatoes, started in September and beginning to bear in December, was only seven-tenths as large as one started three months later, when the amount of sunlight was daily increasing.

2. The largest quantities of nitrogen, phosphoric acid and potash taken by any one crop, [Plot 30, Feb. to July, 1896,] per 100 square feet of bench space, were as follows:

	Grams.		Pounds.	Ounces.	
Nitrogen	226	Equivalent to	3	10	Nitrate of Soda.
Phosphoric Acid	74	"		1	Dissolved Bone Black.
Potash	391	"	1	12	Muriate of Potash.

The crop on this plot amounted to 1.6 pounds of tomatoes per square foot of bench space, but other crops of 1.8 pounds took no larger quantities of fertilizer ingredients from the soil.

3. Somewhat less than two-thirds of these fertilizer ingredients were contained in the fruit.

4. To enable the plants to get these fertilizer elements as required, there should be a large excess of them in the soil.

5. With the larger amounts of fertilizer chemicals used on the plots this year, larger quantities of nitrogen, phosphoric acid and potash have gone into the fruit. Every 100 pounds of ripe tomatoes has taken:

	Ounces.		Ounces.	
Nitrogen	2.9	Equivalent to	18.2	Nitrate of Soda.
Phosphoric Acid	1.2	"	7.5	Dissolved Bone Black.
Potash	5.0	"	10.0	Muriate of Potash.

6. By the use of fertilizer chemicals, and a soil consisting of Anthracite Coal Ashes mixed with a little Peat (3 per cent.) there has been no difficulty in raising a larger crop of tomatoes than was raised in a rich Compost either with or without fertilizer chemicals.

The quantities of fertilizer chemicals which gave the maximum yield in our experiments were, per 100 square feet of bench:

Nitrate of Soda	4 lbs.	11 oz.	costing	11.8 cents.
Dissolved Bone Black		15 "	"	1.2 "
Muriate of Potash	1 "	2 "	"	2.4 "
Total				15.4

In our tests the average yield from Coal Ashes and Peat was one-tenth larger than from the Compost.

7. The plants began to bear at about the same time on both soils. During the first two weeks the yield of fruit from Compost was the larger, for the next three weeks the Ashes and Peat produced the most, and thereafter the yield per week from Compost was generally larger than from Ashes and Peat, although the total yield for the season was largest on the latter.

Two-fifths of the whole crop from the Coal Ashes and Peat was harvested within one week. Naturally this comparison is only applicable to the particular soils under experiment. That Composts may differ very greatly in their adaptability to the growth of particular crops is matter of common observation.

8. Roots growing in Coal Ashes and Peat have not been affected by nematode galls.

II. Experiments with Radishes.

The plots used in this experiment were in a row on the west bench (see H, plate I) in the new forcing-house which is described on page 231, each having an area of 14.53 square feet. Plots Nos. 67 to 71 inclusive were filled to a depth of five inches with a mixture of coal ashes, peat and carbonate of lime such as is described on page 205, to which fertilizer chemicals were added in varying amounts.

Plots 72, 73 and 74 were filled to the same depth with a compost which was made of garden surface soil mixed with one-third its bulk of stable manure and had been worked over several times during the previous summer.

First Crop.

The general plan of these experiments and the results obtained are to be seen in Table XI, p. 223.

The benches were filled on Jan. 11th and 13th, and on the 14th were sown with seed of Cardinal Globe radish from H. A. Dreer, Philadelphia, at intervals of two inches in rows 4½ inches apart, and were covered about ⅜ inch deep.

All the seed germinated. On Jan. 31, the seedlings had come up, and quite evenly, except on plot 74. The smallest plants were in plot 74, the largest in plots 72 and 73.

The temperature of the house was kept at about 65° F. during the day, and about ten degrees lower at night. The house was well ventilated, and the plants were syringed and watered as occasion required.

The radishes were pulled when ¾ inch in diameter, brushed clean and, after weighing, tied up, 10 in a bunch. The first were pulled on Feb. 15th, and all were gathered by the 24th.

Second Crop.

On Feb. 25th, all the plots were sown as before without any further addition of fertilizer chemicals. The plants came up within a few days.

On March 16, all were very even in size and color. The leaves seemed a trifle larger on No. 74 than on the other plots. This crop was harvested between March 24th and April 1st.

Table XI. Radish Cultures.

		Anthracite Coal Ashes and Peat.					Compost.		
		Plot 67	Plot 68	Plot 69	Plot 70	Plot 71	Plot 72	Plot 73	Plot 74
First Crop. Fertilizers added.									
Nitrate of Soda,	grams	162.9	203.4	242.9	203.4	203.4	----	----	162.9
Nitrogen.	"	26.1	32.5	38.9	32.5	32.5	----	----	26.1
Dissolved Bone Black	"	80.0	80.0	80.0	80.0	80.0	----	----	80.0
Phosphoric Acid,	"	13.2	13.2	13.2	13.2	13.2			13.2
Muriate of Potash,	"	88.8	88.8	88.8	73.5	117.6	----	----	88.8
Potash,	"	44.4	44.4	44.4	36.8	58.8	----	----	44.4
Number of bunches of radishes		25	22	22	20½	23	20½	23	24½
Weight of radishes,	"	1703	1735	1568	1565	1599	1553	1558	1704
Second Crop. (No fertilizers added.)									
Number of bunches of radishes		25	25	24½	23¼	23	17	16½	23
Weight of radishes,	"	1534	1439	1442	1355	1374	795	651	1344
Third Crop. Fertilizers added.*									
Nitrate of Soda,	"	47.4	46.5	44.1	42.8	43.5	----	----	41.5
Nitrogen,	"	7.6	7.4	7.1	6.8	7.0	----	----	6.6
Dissolved Bone Black,	"	50.4	50.2	49.6	49.6	49.5	----	120	53.1
Phosphoric Acid,	"	8.2	8.1	8.0	8.0	8.0	----	19.8	8.6
Muriate of Potash,	"	15.2	14.9	14.1	13.7	13.9	88.8	----	20.5
Potash,	"	7.6	7.4	7.1	6.8	7.0	44.4	----	10.2
Number of bunches of radishes		23	24	26	28	28	29½	29	30½
Weight of radishes		1545	1816	1992	2319	2248	2014	1501	2617

* Making the amounts of nitrogen, phosphoric acid and potash the same as supplied to the first crop.

Third Crop.

From the weights and chemical analyses of the first and second crops was determined how much nitrogen, phosphoric acid and potash had been removed by them from the plots. These amounts (together with 6.6 grams of phosphoric acid in form of dissolved bone black) were applied to all the plots with exception of Nos. 72 and 73, before planting a third crop.

To plot 72, 88.8 grams of muriate of potash, equivalent to 44.4 grams of potash, and to plot 73, 120 grams of dissolved bone black, equivalent to 20 grams of phosphoric acid, were added.

The seed, of the same stock as that previously used, was sown precisely as before, on April 7th. It came up very evenly, and the crop was harvested between April 29th and May 6th.

TABLE XII. ANALYSES OF RADISHES. [ENTIRE PLANTS.]

	From Compost.	From Ashes and Peat.
Eight bunches weigh,	568 grams.	574 grams.
and contain,		
Nitrogen	.222 per cent.	.235 per cent.
Phosphoric Acid	.066 "	.048 "
Potash	.342 "	.235 "

Since the number of radishes from each plot depends upon the quality of the seed used and the weight depends almost entirely upon the age of the plants, no great stress should be placed upon either the number of bunches or the weight of crop in estimating the comparative profits of the crops. The weight of the crop from each plot was taken to enable us to determine from the analyses the exact amounts of nitrogen, potash, and phosphoric acid which it contained.

To grow radishes large enough for market in the shortest possible time is the market-gardener's aim. In these cultures the period of harvest covered nearly a week, the radishes being removed when large enough for market, while a commercial grower would doubtless clear the bench at one or, at most, two gatherings. In every instance the radishes grown in coal ashes and peat with chemical fertilizers reached marketable size earlier by one to four days than those grown in compost. The quality of the radishes was considered to be alike.

The third crop was the quickest to mature, and the second required less time than the first, doubtless because of the increase of solar energy.

Results of these cultures are :—

1. Radishes can be grown in coal ashes mixed with a little peat and carbonate of lime, by the aid of fertilizer chemicals, no less well and mature a little more quickly than in compost, and are quite as smooth, tender and crisp.

2. One thousand bunches of radishes, tops included, weighed 148 pounds and took from the soil :

5.2 ounces	**Nitrogen,**	**equivalent to**	**2 lbs. 1 ounce**	**Nitrate of Soda.**
1.6 "	**Phosphoric Acid,**	**"**	**10 ounces**	**Dissolved Bone Black.**
8.1 "	**Potash,**	**"**	**16½ "**	**Muriate of Potash.**

3. To raise 1000 bunches of radishes in a single crop there were required in our experiments, on the average, 518 square feet of bench space. The largest crop required but 414 square feet per 1000 bunches.

III. CARNATION CULTURES.

The space marked I in the southwest corner of the forcing house, figured on page 231, was divided into three plots, designated as A, B, C, each having an area of 7.08 square feet, which were planted to carnations.

Plot A was filled with the compost described on page 205, to which were added 29 grams of Nitrate of Soda, 14.8 grams of Muriate of Potash and 12.25 grams of Dissolved Bone Black.

Plot B was filled with anthracite coal ashes mixed with three per cent. of moss peat and 50 grams of carbonate of lime as described on page 205. Chemical fertilizers were added as follows: Nitrate of Soda 58 grams, Muriate of Potash 29.6 grams, Dissolved Bone Black 24.5 grams, these being double the quantities added to Plot A.

Plot C was filled with compost. All the plots had a good southern exposure. Plot C, at the southwestern corner, was perhaps more favorably situated as regards light than the others.

The plants were raised from cuttings taken in January, 1895. These were duly potted, and in May set in the open ground, where they remained until September, when thrifty plants were put in 5-inch pots and set in the ground for two or three weeks, and then removed to an unheated vegetation house. December 14th the plants were transferred to the forcing-house plots. Up to this time all flower buds had been pinched off; but the plants were now allowed to make single blossoms, all lateral buds being removed.

Carnations should be set in the benches during September, but owing to delay in finishing the forcing-house the crop could not be started until very late. It will be seen that no liquid manures were given the plants, and this fact, together with the late setting, accounts for the small number of blossoms obtained.

The plants were of three varieties, Daybreak, Lizzie McGowan and Garfield. Three of each variety were placed in a plot, each plot containing nine plants.

Each plant was numbered, and the date of picking, diameter of blossom, and notes on shape, length of stem, etc., recorded up to May 1st. No observations were taken after this date, but the plants were allowed to remain in the benches, where they continued to blossom during the summer.

The table, p. 227, shows the yield of the plants up to May 1st. Had the observations extended over a longer period the yield would have been much larger, as the plants blossomed freely all through the summer.

No analyses of flowers or plants were made, so that the amounts of nitrogen, phosphoric acid and potash taken up by the plants and removed in the blossoms is not known.

A much more extensive experiment is now in progress, in the report of which these facts will be set forth.

These cultures prove that good carnations may be grown in coal ashes and peat with fertilizer chemicals, and that both the number and the average diameter of the flowers may be considerably greater than where a portion or the whole of the plant food is supplied by soil or manure. Thus, in one experiment, the number of flowers raised in coal ashes and peat, plot B, was more than three-eighths larger than that raised on compost, either alone or with fertilizer chemicals, plots A and C.

IV. Experiments with Cucumbers.

Plots Nos. 47–66 occupy the space marked O in the house figured on page 231.

In the fall of 1895, plots 47–55, on the east side of the center bench, were filled with a mixture of bituminous coal ashes and peat, and plots 57–66, on the west side, were filled with a rich compost.

All the plots containing ashes and some of those containing compost were dressed with fertilizer-chemicals and used during the winter of 1895–96 for experiments with lettuce.

The same plots were planted to cucumbers in the summer of 1896.

Table XII.—Carnation Cultures. Yield of Blossoms.

	Plot A. Compost with Chemicals.			Plot B. Coal Ashes and Peat with Chemicals.			Plot C. Compost without Chemicals.		
Variety	Garfield.	Lizzie McGowan.	Daybreak.	Garfield.	Lizzie McGowan.	Daybreak.	Garfield.	Lizzie McGowan.	Daybreak.
No. of plants	3	3	3	3	3	3	3	3	3
No. of flowers previous to May 1st	19	5	7	21	12	16	19	6	3
Average diameter of flowers (inches)	1.96	2.05	2.07	2.04	2.25	2.07	1.84	2.19	2.08
No. of perfect flowers	18	3	7	21	10	14	16	5	3

To this end the quantities of nitrogen, phosphoric acid and potash removed in the lettuce crops from the plots filled with bituminous ashes and peat were replaced so that each plot contained in the residues and newly added fertilizers, 10.3 grams of phosphoric acid and 56.2 grams of potash in form of dissolved boneblack and muriate of potash.

Five plots received quantities of nitrogen ranging from 24 to 64 grams in form of nitrate of soda, and five other plots received like quantities of nitrogen in form of cotton seed meal.

To the soil of each of the compost plots were added 32 grams of nitrogen, 10.3 grams of phosphoric acid and 56.2 grams of potash, without regard to the quantities which had been removed in the lettuce crop.

Seeds of Arlington White Spine Cucumber were sown in flats May 1st. The seedlings, first put in two and one-half inch pots, were shifted in about two weeks to four inch pots, and were set, four in each plot, on June 1st.

The vines were allowed to spread on the soil, but were confined for the most part to the plots in which they were planted.

The glass required some shading during the summer and special care was given to maintaining abundant moisture in the air as well as in the soil.

Early in July plants growing in the coal ashes and peat were decidedly larger than those growing in compost, and those supplied with nitrate-nitrogen appeared thriftier than those supplied with nitrogen in form of cotton seed meal.

The first blossoms appeared on June 20th.

Flowers were hand-pollinated every other day until Aug. 1st. Bees were then abundant in the house and further hand-pollination was found unnecessary.

The first cucumbers were picked July 14th from plots 47, 51, 52, 61, 64, and 66, and the experiment was concluded on September 16th.

Only general results are here given, as the experiment is preliminary to a fuller study of the subject.

1. From 100 square feet of bench space, filled with rich compost, 85½ pounds of cucumbers were harvested. From an equal space filled with a mixture of bituminous coal ashes and peat 99 pounds of cucumbers were harvested.

The average weight of a single cucumber was 7.2 ounces in the former case and 7.4 ounces in the latter.

2. As a source of nitrogen, nitrate of soda and cotton seed meal were about equally efficient in the coal ashes and peat—(the yield was at the rate of 100 pounds per 100 square feet of space where nitrate was used and 98.8 pounds where cotton seed meal was used)—but with compost, cotton seed meal was decidedly more efficient (94.7 pounds per 100 square feet of space, while with nitrate of soda only 76.4 pounds were produced).

3. The fresh cucumbers contained:

	Raised on Compost.	Raised on Coal Ashes and Peat.
Nitrogen	0.095 per cent.	0.083 per cent.
Phosphoric Acid	0.053 "	0.032 "
Potash	0.222 "	0.207 "

From 100 square feet of bench space, the vines and roots took the following quantities of the ingredients named:

	Compost.		Bituminous Coal Ashes and Peat.	
	Per plot. grams.	Per 100 square feet. grams.	Per plot. grams.	Per 100 square feet. grams.
Nitrogen	5.69	38.7	4.54	30.9
Phosphoric Acid	1.20	8.2	0.61	4.1
Potash	12.08	82.1	7.77	52.8
Equivalent to		Ounces.		Ounces.
Nitrate of Soda	....	8.5	....	6.8
Dissolved Bone Black	....	1.8	....	0.9
Muriate of Potash	....	5.8	....	3.7

NEW FORCING HOUSE.

By W. E. Britton.

During the fall of 1895 the facilities for experimental work were increased by the erection of a forcing-house (see F, p. 231) fifty feet long and twenty feet wide, with an attached work-room, (G) 10 feet x 25 feet. A brief description of the house is here given, as we shall have frequent occasion to refer to the arrangement of it in the account of our experiments.

The house was designed and erected by Lord, Burnham & Co., of Irvington, N. Y. Running nearly north and south, with even span, this house is connected with the tomato house (see D and E, plate I) by a passage 5 ft. wide and 4 ft. long. The superstructure stands upon cast iron posts or foot-pieces, bedded in cement thirty inches below the surface of the ground. Bolted to these foot-pieces are the wrought iron rafters, which are bent at the spring line and extend to the ridge, where they are fastened together by cast iron brackets.

Sash bars extend from the ventilating sash at the ridge to the spring line, being supported in the middle by an angle-iron purlin bolted to the rafters. The sash bars and all parts of the frame exposed to the weather are of cypress wood. Wooden cap-pieces are fitted over the iron frame so that no injury results from the contraction and expansion of the metal.

The glass used in this house is known to the trade as "second quality, double thick," and is 16x24 inches in size. The vertical walls are glazed above the benches on all sides. The ridge is 11 feet 6 inches and the spring line 4 feet 10 inches from the ground level.

Ventilation is secured by a continuous line of sash 30 inches wide on either side of the ridge and hinged to it, and a line of sash 24 inches wide extending the entire length of the west side, just above the bench.

Across the north end a lean-to (G) serves the purpose of a work-room. This is 10 feet wide and 25 feet long, and being glazed on the roof and sides, like the house itself, serves equally well as a house for growing stock plants. The floor of this lean-to is of cement, with a smooth surface, and can be used for mixing soils and fertilizers. This lean-to has a continuous ventilating sash, 30 inches wide at the upper angle of the roof, and hinged at the ridge. During the winter of 1895–96 the sections of benches indicated by the letters J, M and N, were used for growing stock plants.

This house is heated by steam brought from the central boiler which furnishes steam for all the Station buildings. The steam enters the house through an overhead pipe and returns through smaller pipes under the benches. Four pipes, divided into two coils and provided with valves, pass underneath each of the side benches. Under the center bench there are four coils of two pipes each, also furnished with suitable valves. This arrangement allows complete control of the temperature of the house.

The benches are 5¾ inches in depth and the side benches are 34 inches wide, with a space of two inches between the bench and the side of the house to permit the circulation of air. The center bench is 8 feet wide. Previous to starting any experimental work, the center and two side benches were temporarily divided into plots, having an equal area of 14.53 square feet.

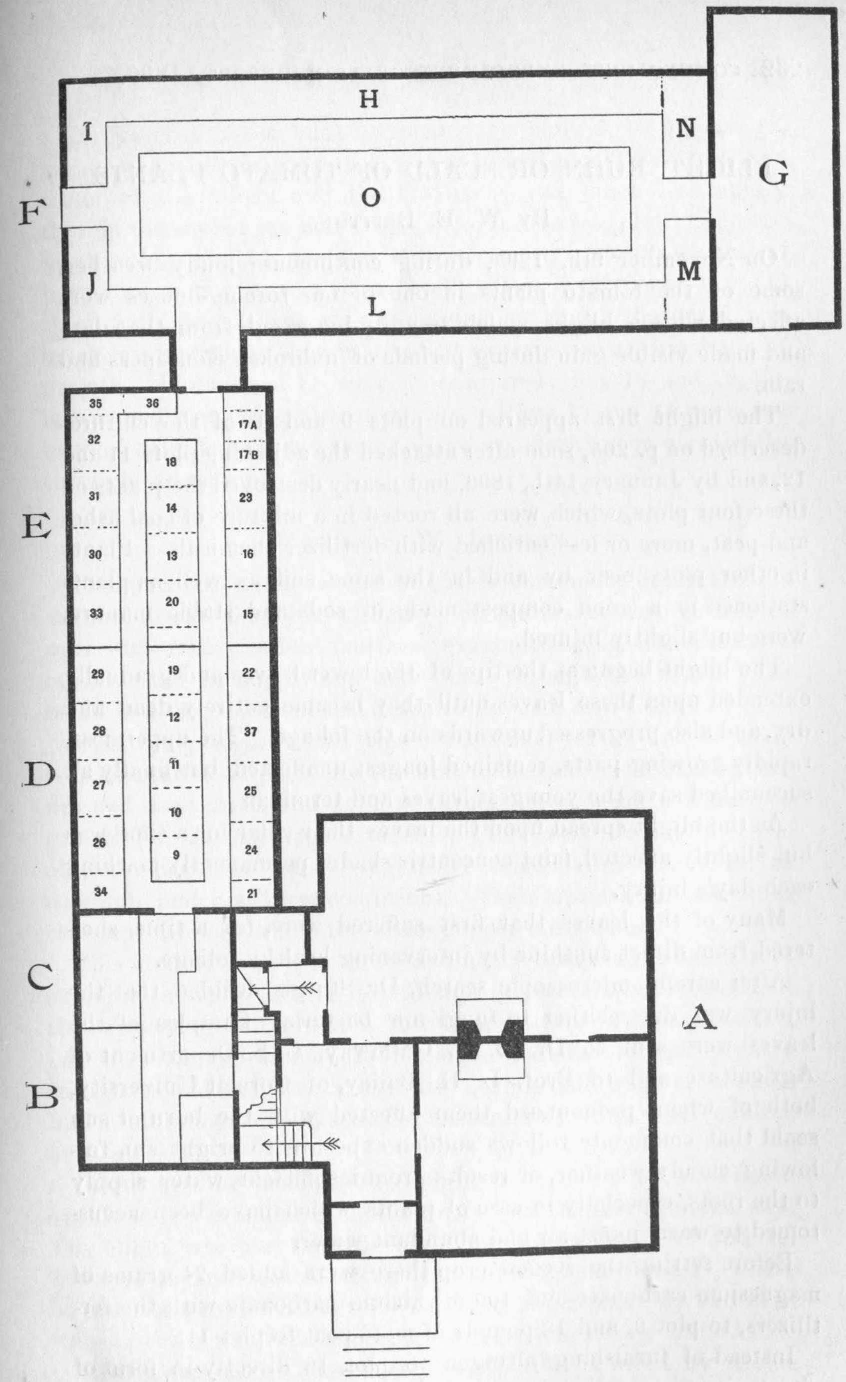


PLATE I. PLAN OF FORCING-HOUSES.

A, Botanical Laboratory; B, C, Small Plant Houses; D, E, Tomato Houses; F, New Forcing-House; G, Work-room.

BLIGHT, BURN OR SCALD OF TOMATO PLANTS.

By W. E. Britton.

On November 9th, 1895, during continuous cloudy weather, some of the tomato plants in one of our forcing-houses were affected with a blight which steadily increased from that date and made visible gain during periods of unbroken cloudiness and rain.

The blight first appeared on plots 9 and 10 of the cultures described on p. 205, soon after attacked the adjoining plots 11 and 12, and by January 14th, 1896, had nearly destroyed the plants on these four plots, which were all rooted in a mixture of coal ashes and peat, more or less enriched with fertilizer chemicals. Plants in other plots near by and in the same soil, as well as plants stationed in a good compost made of sods and stable manure, were but slightly injured.

The blight began at the tips of the lower leaves and gradually extended upon these leaves until they became entirely dead and dry, and also progressed upwards on the foliage. The uppermost, rapidly growing parts, remained longest unaffected, but finally all succumbed save the youngest leaves and terminals.

As the blight spread upon the leaves their color for a time was but slightly affected, faint concentric shades permanently marking each day's injury.

Many of the leaves that first suffered were, for a time, sheltered from direct sunshine by intervening healthy foliage.

After careful microscopic search, Dr. Sturgis decided that the injury was due neither to fungi nor bacteria. Samples of the leaves were sent to Dr. B. T. Galloway, U. S. Department of Agriculture, and to Prof. L. H. Bailey, of Cornell University, both of whom pronounced them affected with the burn or sun scald that commonly follows sudden exposure to bright sun following cloudy weather, or results from insufficient water supply to the roots, especially in case of plants which have been accustomed to warm moist air and abundant water.

Before setting the second crop there were added 24 grams of magnesium carbonate and 100 of calcium carbonate with the fertilizers, to plot 9, and 18 pounds of moss peat to plot 11.

Instead of furnishing nitrogen to plot 12 directly in form of nitrate, it was supplied by cotton seed meal mixed with a handful of garden soil to aid nitrification.

On March 6th the blight appeared on plots 9, 10, 11 and 12, and nowhere else in the house. Plot 12 had much less of it than either of the others and the trouble spread much less rapidly than in the case of the first crop. On March 24th, plot 11 showed most scald; plot 12 was almost free from it. Plot 9, which had been kept very wet, was not as badly affected as 10 and 11. On April 18th, just as fruit was beginning to ripen, the scald was much less prevalent than in the first experiment at that stage of growth. Plots 9 and 11 were more injured than 10 and 12, the last named plot being almost exempt. Plots 13 and 14 were not in the least affected, and their foliage was dark green and thrifty through the season.

Note by S. W. Johnson.

The burn or scald, as the blight is commonly designated, is without doubt simply a withering of the leaves due to loss of water by transpiration (surface evaporation), going on more rapidly than its supply can take place through the roots. The result is disorganization and death to the cells and tissues.

This injury began at the tips of the lower leaves for the same reasons that these parts are the first to become yellow or brown, dry and dead, in case of field or garden crops, when the season's growth is approaching a finish. The lower leaves are the oldest, ripest, of least vegetative vigor, and the first to succumb under adverse conditions. Their tips are furthest from the stem through which the water supply must come.

This kind of injury is most commonly observed when direct sunlight suddenly falls on the foliage of plants whose roots and the supporting soil are at a low temperature. Direct sunshine, i.e., warmed and illuminated foliage, immediately and greatly stimulates and increases transpiration, while cold roots are incapable of imbibing and cold stems of transmitting water with rapidity or at all.

In the present instance the blight is reported to have made visible progress under a continuously and densely clouded sky. The blight was also limited to the four plots, 9, 10, 11 and 12. These plots are situated at one end of the plant-house D, where its northeast corner is built into a right angle made by two high walls of the Botanical Laboratory. See Plate I, page 231.

This plant-house faces nearly south and is aired by a row of sashes hinged to the ridge over the south edge of the north bench, and operated as a single ventilator. Because of this situation and construction, south and west winds are arrested, the air is banked up against the adjacent high walls and driven down through the ventilators, falling upon the affected plots as a very noticeable cold current which may chill the benches and lower parts of the plants sufficiently to reduce "root pressure" to the point where it cannot fully supply the loss of water occasioned by transpiration from the upper foliage, the latter being maintained at a relatively high temperature.

The chilling of the benches would occur more readily in rainy or cloudy weather than in dry, with the temperature unchanged, because moist air conducts heat more rapidly than dry air.

INSECT NOTES.

By W. E. Britton.

Canker Worms (*Paleacrita vernata*, Peck, and *Anisopteryx pometaria*, Harr.).—Canker worms were extremely numerous in some parts of Connecticut during the spring and early summer of 1896, and injured fruit and shade trees more seriously than for many years.

Many of the elms of New Haven lost a part of their foliage early in the season, the canker worms having nearly finished feeding before spraying operations against the elm-leaf beetle were begun.

On the Station grounds canker worms were abundant on apple, plum, cherry and hickory foliage, and were found feeding on the chestnut and the oak. Many adults were observed about the trunks of these trees during the warm days of November and December, 1895, and most of the injury here was caused by the Fall canker worm, *A. pometaria*.

In Cheshire and elsewhere the foliage of apple orchards was completely ruined. Many farmers apparently failed to notice the presence of the caterpillars until their trees were partially defoliated, and those who then begun to spray were too late to get much benefit.

The two common kinds of canker worms closely resemble each other, but are distinguished by the time of the appearance of the adults or moths. The Fall canker worms reach the adult stage in fall or early winter. Spring canker worms mostly transform to moths in the springtime.

Their habits otherwise are identical, and they may be easily recognized by the manner in which they "spin down" from the tree when they are disturbed.

The larva of the Spring canker worm has only two pairs of abdominal pro-legs, the fifth abdominal segment being smooth. The Fall canker worm larva has three pairs of these legs, one pair being borne upon the fifth abdominal segment. This is the chief difference between the larvæ of the two species.

The females are wingless in both species, and crawl up the trunks of trees to deposit their eggs, clusters of which may be found in the crevices of the bark.

The eggs of both species hatch in spring at the time when trees are leafing out. The caterpillars are of a greenish color at first, and assume a brownish color as they increase in size. In from three to four weeks the caterpillars become full grown, and are then about an inch in length, and of a dark brown color with lines of lighter color running lengthwise, the color as a whole varying considerably. The adult males of both species are moths of an ash-gray color, with indistinct markings of black and white. The wingless females are similar in color. Both species pupate in the ground. See Plate II.

The same methods serve for combatting both species. Obstructions placed about the trunk of the tree, to prevent the wingless females from ascending to lay their eggs, are effectual preventives. Paper or cloth bands covered with tar or printers' ink are commonly used. Metal troughs filled with oil are of service if properly applied and kept clean.

The most satisfactory method of destroying the caterpillars is to spray the foliage with arsenical poison. Some orchardists have found difficulty in killing the caterpillars by spraying, but if they are attaked when young they are easily destroyed. After the tree has been nearly defoliated there is little use in applying poisons.

According to Bailey,* a mixture of 1 lb. of Paris green, 2 lbs. of lime, fresh slacked, and 200 gallons of water gives the best results. Lead arsenate (made by mixing eleven ounces of sugar of lead (lead acetate) and four ounces of arsenate of soda with 150 gallons of water) remains in suspension better than Paris green and is less liable to injure foliage.

* Cornell Experiment Station, Bulletin 101.

THE ARMY WORM (*Leucania unipuncta*, Haw.).—During the summer of 1896, the Army worm was quite abundant and the cause of much injury throughout Connecticut. A five-acre oat field upon the grounds of the School for Deaf Mutes at Hartford was attacked early in July and stripped of leaves. A portion of the oats were cut, whereupon the worms ate off the heads, leaving nothing but the straw. The writer saw the field on July 9th. The larvæ were then either nearly full grown, or had already pupated. At one place the ground was so covered that every step there would crush ten or twelve of the worms, and the noise of their movement could be distinctly heard. Kerosene oil sprinkled upon them killed the small worms. The full grown larvæ managed to crawl away, though it is doubtful if they transformed and came forth as adults. On July 10th, the writer saw a rye field at Springdale which had been devastated in a similar manner. Most of the worms here had pupated and not so many were seen, though a good illustration of their work remained. Furrows had been plowed around the infested field in order to prevent the larvæ from attacking adjacent grounds. Considerable damage was reported from the vicinity of Stamford and Norwalk.

A second brood appeared early in September. On the 5th, at the farm of Mr. George Bradley of Fair Haven, the writer found the larvæ abundant in all sizes from the newly-hatched to full grown, feeding upon a field of Hungarian grass. Nearly all of these larvæ were parasitized, by a Tachina fly, see *d*, plate III, whose eggs had been deposited just back of the head. These eggs hatch in a few hours and the young grubs make their way into the body of the Army worm, and there feed and develop. The host lives just long enough for the parasites to become full grown and then dies. That the relation proves fatal to the host, was well shown by the fact that of 17 parasitized larvæ collected on September 5th, only 7 were alive on September 9th.

The adult of this insect is a light-brown moth whose spread of wings is about one and three-fourths inches. The insect in all its stages resembles the cut worm, to which it is closely related. Usually its habits are like those of cut worms, except occasionally when it becomes so abundant as to move in armies.

The larva is about one and one-half inches long when full grown, and is without hairs. It is rather dark in color with indistinct stripes of green and white running the full length of

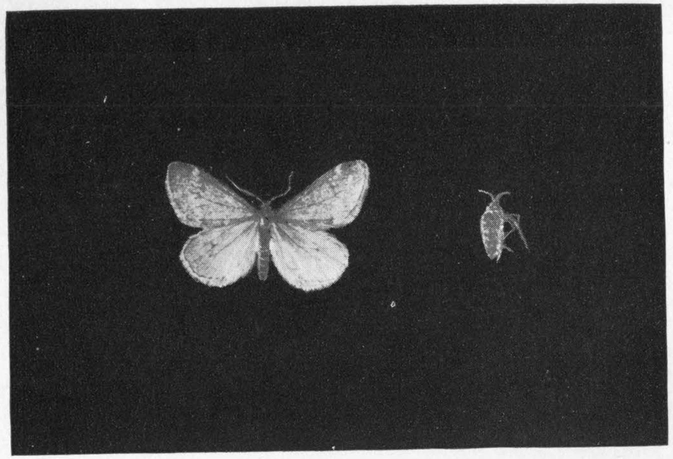


PLATE II. FALL CANKER WORM, *A. pometaria*.

Adult male and female—natural size (original).

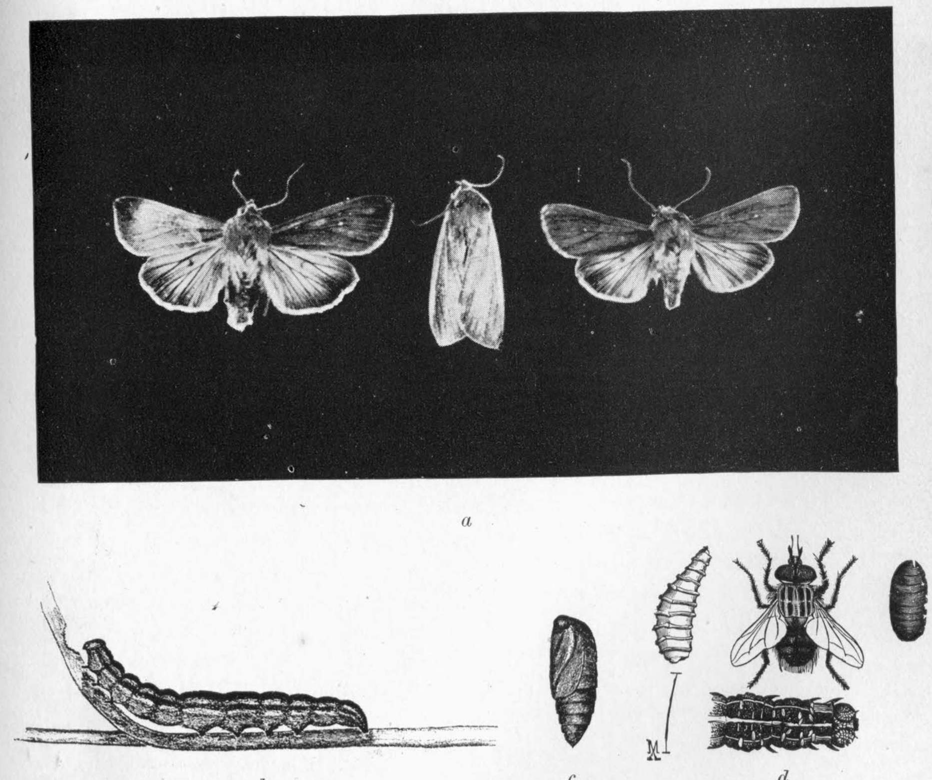


PLATE III. ARMY WORM, *L. unipuncta*.

a, Adults—from photograph; *b*, larva; *c*, pupa—from drawings. All natural size (original).

d, Parasite of Army Worm. (Riley, Circular 4, second series, Division of Entomology, United States Department of Agriculture.)

the body. This is the stage in which the insect is supposed to live through the winter; larvæ of the last brood becoming sluggish when about half grown and concealing themselves in any convenient place of shelter. In the eastern part of Massachusetts, the egg is thought to be the hibernating stage.*

Larva, pupa, and adults, are shown in Plate III.

The eggs are deposited by the adults among the leaves and stubble of grain and grass. It is said that a single female may yield from five to seven hundred eggs.† The eggs hatch in about ten days, and the larvæ feed upon plants of the grass family for about four weeks; they are then full grown and go into the ground to pupate. The pupa is dark brown in color, and about three-fourths of an inch in length. The insect remains in this stage two weeks, then the adult moth appears. There are at least two broods in Connecticut, and probably more. Weed‡ concludes that there are three broods in New Hampshire. During 1896 invasions of the Army worm were reported from Massachusetts, Pennsylvania, New York, New Hampshire, Vermont, Michigan and Iowa. The New York invasion is said to have been one of the worst in the history of that State.§

The treatment commonly recommended is to surround the infested field with a deep furrow having a perpendicular outer edge. The larvæ are unable to ascend, particularly if the surface is smooth, and will fall back into the furrow, where they may be destroyed. A convenient method is to dig holes at short intervals in the bottom of the furrow. The caterpillars in trying to get out will travel along the furrow and fall into the holes, where they may easily be crushed or destroyed with kerosene. The armies usually move in straight lines and enter fields through gate-ways instead of climbing fences. This habit should be taken advantage of in fighting them, for it is often possible to obstruct their progress while occupying only a small corner of a field, and they can then be destroyed much more easily than when scattered over a large area. Poisoning the grass directly in front of the army is also to be advised. In case of an outbreak it is necessary to act quickly, for a delay of a day or two often results in much injury.

* Mass. Hatch Exp. Station, Bulletin 28.

† Dr. C. V. Riley, Report of Entomologist, U. S. Dep't., Agr'l. Report 1881–2, p. 92.

‡ New Hampshire Agr. Exp. Station, Bulletin 39, p. 67.

§ New York Agr. Exp. Station, Bulletin 104.

It is hardly probable that an attack will occur in 1897. It is seldom that the Army worm is seriously destructive during two successive seasons. Natural enemies usually hold it in check. The great number of parasitized larvæ found in September is an indication that the parasite will be sufficiently abundant to take care of the Army worm the coming season. A dozen eggs were found upon a single larva. These were probably eggs of the Tachina fly, which is perhaps the most important parasite. There is also a bacterial disease that destroys the Army Worm in great numbers, and several species of birds prey upon the larvæ.

CURRANT STEM-GIRDLER (*Phyllœcus flaviventris*, Fitch).—In March a communication was received from Mr. George W. Peabody, of Windham, relative to an insect that injured his currants by cutting off the tips of the new growth about the middle of June. A visit to the field was made June 20th. A half acre of currant ground was infested to such an extent that from fifteen to thirty tips per plant had been cut by the insect. Some of these tips had fallen to the ground, while others still hung in a wilted or dried condition. Mr. Peabody states that his currants have been injured in this manner for four successive seasons, and that on account of the injury he has not been able to obtain good wood for propagation. Another effect is to lessen the crop of the following season by destroying a portion of the fruit-bearing canes.

The work of the insect was also observed in Berlin, Cheshire, Hamden, and New Haven, but in none of these places was the injury as great as at Windham.

The author of the injury is a slender four-winged fly. The adult deposits eggs in the soft new growth, about the middle of June. The ovipositor is thrust about half way through the stem and the egg is usually found in the heart of the tender pith. A few slanting cuts are made in the stem just above the point where the egg is placed, the tip droops and further growth ceases. As the tips become dry and brittle they break off and drop to the ground. The egg is usually found in the center of the stem about three-fourths of an inch below the cut. It is not definitely known whether the egg is deposited before the cut is made or afterwards. The young larva feeds upon the soft pith, and slowly descends inside the stem, becoming full-grown in the autumn. A thin cocoon is then formed, in which the insect passes the winter. In the spring the larva changes to a pupa

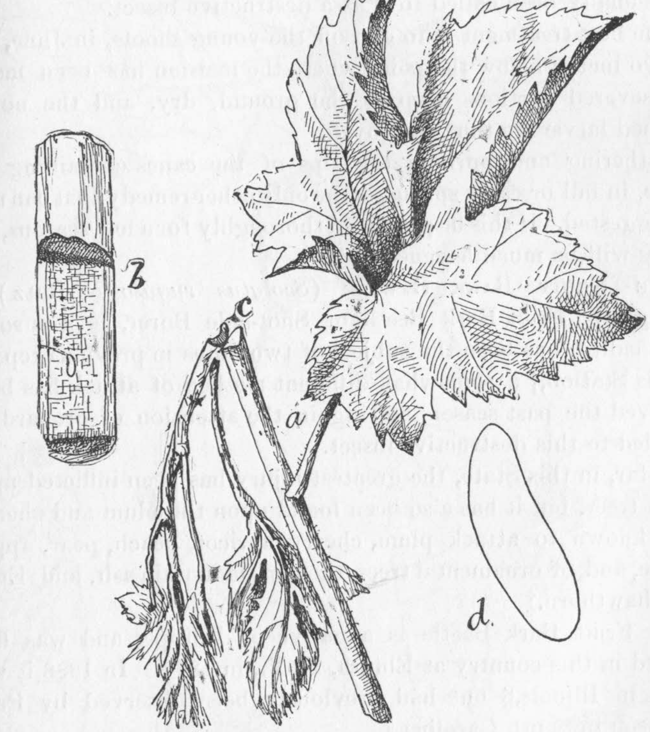


PLATE IV. CURRANT STEM-GIRDLER, *P. flaviventris*.

a, Egg puncture: *b*, section of stem, showing egg in pith; *c*, severing of terminal by female; *d*, egg—greatly enlarged. (Marlatt, Insect Life, Vol. VII, Division of Entomology, United States Department of Agriculture.)

and the adult comes forth from the middle to the last of May. The incisions are probably made with the insect's mandibles,* and are from two to three inches below the tip. See Plates IV and V.

This insect is considered to be a native of North America, where it formerly bred in wild currants. During the last four or five years it has attacked cultivated plants, and attention has occasionally been called to it as a destructive insect.

The best treatment is to clip off the young shoots, in June, one or two inches below the point where the incision has been made. The severed portions drop to the ground, dry, and the newly hatched larvæ are thus destroyed.

Gathering and burning the tips of the canes containing the larvæ, in fall or early spring, is the only other remedy that can now be suggested. If this be practiced thoroughly for a few seasons, the injury will be much lessened.

THE FRUIT BARK BEETLE (*Scolytus rugulosus*, Ratz.).—Though the Fruit Bark Beetle or Shot-hole Borer, as it is sometimes called, has been the subject of two notes in previous reports of this Station,† a somewhat different method of attack has been observed the past season, and again the attention of orchardists is called to this destructive insect.

So far, in this State, the greatest injury has been inflicted upon peach trees, but it has also been found upon the plum and cherry. It is known to attack plum, cherry, apricot, peach, pear, apple, quince, and, of ornamental trees, the elm, mountain ash, and European hawthorn.‡

The Fruit Bark Beetle is a native of Europe, and was first noticed in this country at Elmira, N. Y., in 1877. In 1888 it was found in Illinois,§ but had previously been observed by Prof. Atkinson in South Carolina.‖

On June 20th, a visit was made to the orchard of the Connecticut Valley Orchard Co., at Berlin. A few plum and cherry trees in one corner of the orchard, and somewhat removed from other trees, appeared much as if affected with the so-called "fire-blight." Young twigs were dead and the foliage had turned black. Upon examination it was found to be the work of an

* Insect Life, Vol. VII, p. 387.

† Report of Conn. Agr. Exp. Station, for 1894, p. 142, and for 1895, p. 191.

‡ Illinois Agr. Exp. Station, Bulletin 15, p. 473.

§ Ibid, p. 469.

‖ South Carolina Agr. Exp. Station, Bulletin 4.

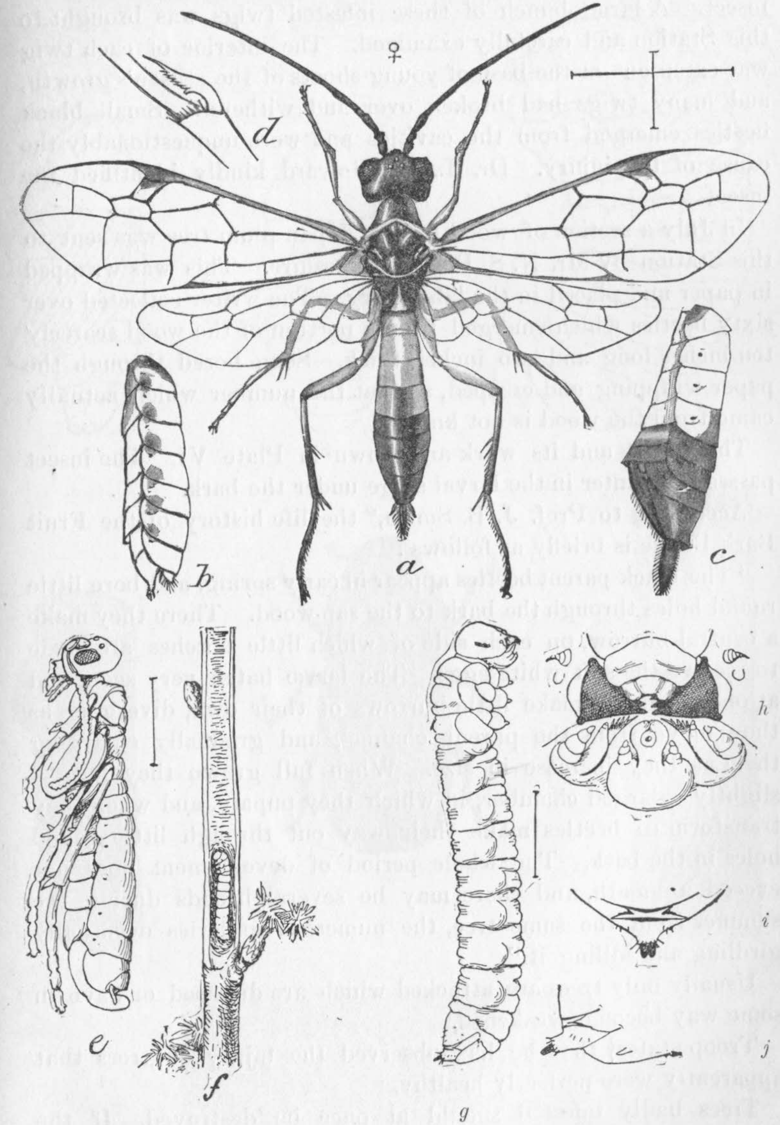


PLATE V. CURRANT STEM-GIRDLER, *P. flaviventris.*

a, Adult female; *b*, lateral view of male abdomen; *c*, do. of female; *d*, apex of anterior tibia of female; *e*, pupa; *f*, larva in twig; *g*, larva; *h*, mouth parts of larva; *i*, dorsal view of tip of abdomen; *j*, lateral view of same. (Marlatt, Insect Life, Vols. VI and VII, Division of Entomology, United States Department of Agriculture.)

insect. A large bunch of these infested twigs was brought to this Station and carefully examined. The interior of each twig was eaten out at the base of young shoots of the season's growth, and many twigs had broken over and withered. Small black beetles emerged from the cavities and were unquestionably the cause of the injury. Dr. L. O. Howard kindly identified the insect.

In July a section of wood from a Japan plum tree was sent to this Station by Mr. N. S. Platt, of Cheshire. This was wrapped in paper and placed in the laboratory. The writer collected over sixty beetles which emerged from a portion of the wood scarcely ten inches long and two inches thick. Some bored through the paper wrapping and escaped, so that the number which actually came from the wood is not known.

This insect and its work are shown in Plate VI. The insect passes the winter in the larval stage under the bark.

According to Prof. J. B. Smith,* the life history of the Fruit Bark Beetle is briefly as follows:

"The black parent beetles appear in early spring, and bore little round holes through the bark to the sap-wood. There they make a central burrow, on each side of which little notches are made to receive the soft white eggs. The larvæ hatch very soon, and at once begin to make little burrows of their own, diverging as they move from the parent channel, and gradually enlarging them as they increase in size. When full grown they form a slightly enlarged chamber, in which they pupate, and when they transform to beetles make their way out through little round holes in the bark. The whole period of development does not exceed a month, and there may be several broods during the summer from the same tree, the numerous galleries eventually girdling and killing it."

Usually only trees are attacked which are diseased or have in some way become weakened.

Troop states† that he has observed the injury on trees that apparently were perfectly healthy.

Trees badly infested should at once be destroyed. If the attack is only slight the tree can probably be saved by spraying the trunk and branches with Bordeaux mixture or whitewash to which a little Paris green has been added. This treatment has

* Economic Entomology, p. 238, 1896.

† Purdue Univ. Agr. Exp. Station, Bulletin 53, p. 128.

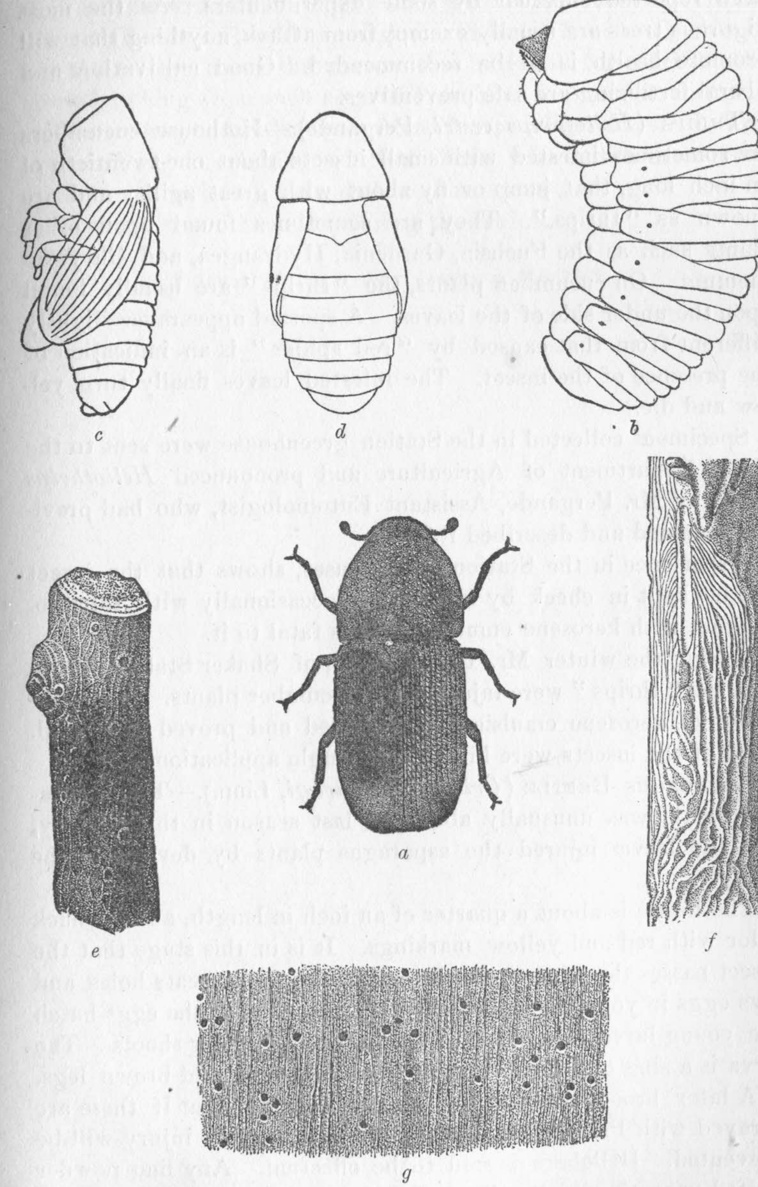


PLATE VI. FRUIT BARK BEETLE, *S. rugulosus.*

a, Adult; *b*, larva; *c*, *d*, pupæ—greatly enlarged; *e*, branch of peach, showing perforations; *f*, branch with bark removed, showing tunnels; *g*, perforations in large branch of plum. (Forbes, Bulletin 15, Illinois Agri. Exp. Station.)

been reported effectual by some experimenters. As the most vigorous trees are usually exempt from attack, anything that will promote health is to be recommended. Good cultivation and liberal fertilizing are safe preventives.

THRIPS (*Heliothrips cestri*, Pergande).—Hothouse cucumbers are sometimes infested with small insects about one-twentieth of an inch long, that jump or fly about with great agility and are known as "thrips." They are sometimes found upon other plants such as the Fuchsia, Gardenia, Hydrangea, and Chrysanthemum. On cucumber plants, the "thrips" are usually found upon the under side of the leaves. A spotted appearance slightly different from that caused by "red spider" is an indication of the presence of the insect. The infested leaves finally turn yellow and die.

Specimens collected in the Station greenhouse were sent to the U. S. Department of Agriculture and pronounced *Heliothrips cestri*, by Mr. Pergande, Assistant Entomologist, who had previously named and described it.*

Experience in the Station greenhouses, shows that the insect can be kept in check by fumigating occasionally with tobacco. Contact with kerosene emulsion proves fatal to it.

During the winter Mr. T. J. Stroud, of Shaker Station, wrote that the "thrips" were injuring his cucumber plants. An application of kerosene emulsion was advised and proved successful. Most of the insects were killed by a single application.

ASPARAGUS BEETLE (*Crioceris asparagi*, Linn.).—The asparagus beetle was unusually abundant last season in this vicinity, and the larvæ injured the asparagus plants by devouring the foliage.

The beetle is about a quarter of an inch in length, and of black color with red and yellow markings. It is in this stage that the insect passes the winter; in the spring the female eats holes and lays eggs in young asparagus shoots. As soon as the eggs hatch the young larvæ commence to feed upon the tender shoots. The larva is a slug of grayish color with black head and brown legs.

A later brood attacks the full-grown plants, but if these are sprayed with Paris green or lead arsenate, serious injury will be prevented. Hellebore is said to be effectual. Any fine powder dusted upon the plants will tend to asphyxiate the larvæ by closing their breathing pores. This treatment is good to hold the insect in check.

* Insect Life, Vol. VII, pp. 390–395.

Comstock writes*: "Where this pest occurs care should be taken to destroy all wild asparagus. This will force the beetles to lay their eggs upon the shoots that are cut for market; the larvæ hatching from such eggs will not have a chance to mature."

The asparagus beetle came from Europe about 1859. It first appeared in the vicinity of New York, where it became very troublesome and soon extended to other states.

There are several broods during the season.

* Manual for the Study of Insects, p. 576, 1895.

EXPERIMENTS ON THE PREVENTION OF POTATO-SCAB.

By Wm. C. Sturgis.

Having demonstrated by the result of the experiments of the past two years the feasibility of securing, by the use of corrosive sublimate, a practically clean crop of tubers from seed however scabby, providing only that the seed be planted on land not infested with the scab-fungus, and be fertilized with fertilizer chemicals, it seemed advisable to test the efficacy of certain other fungicides, notably sulphur, which gave good results in New Jersey, and a material known as "Lysol" and highly recommended in Europe as a germicide. As obtained from Messrs. Eimer & Amend of New York City, lysol is a heavy brownish liquid with a strong odor of creosote. It mixes readily in water, and when so mixed forms a cloudy, opalescent liquid resembling dilute soap-suds.

In France and Germany it has been recommended as a powerful antiseptic, neither corrosive nor toxic in dilute solutions, of stable composition, and superior to all others for disinfecting wounds, surgical instruments, buildings, etc.* For such purposes ½%–5% solutions are used. As long ago as 1893, French experiments proved the efficacy of 2% solutions of lysol in preventing the invasion of mushroom beds by parasitic fungi; † later it came into prominence as an insecticide, particularly in the case of plant-lice and slugs.* Solutions of ¾%–2% proved thoroughly efficacious in destroying not only soft-bodied insects such as plant-lice, but even scale-insects, and that without damage to the plant even in 2% solutions.‡ For the closing of wounds on trees, and assisting the natural healing process, lysol in a 5% solution is said to be far superior to tar or grafting-wax.‡ Finally it is stated repeatedly that ½%–1% solutions will prevent the mildew of roses and grapes as effectively and more cheaply than Bordeaux mixture, and without damage to the plants.§ As compared with Bordeaux mixture, lysol has the advantage, according to a French writer,§ of being a combined insecticide and fungicide 28% cheaper than Bordeaux mixture, and he estimates that the substitution of lysol would mean an annual gain to the vineyardists of France of 15,000,000 francs ($3,000.000).

* Revue Mycologique, XVII–68, p. 184, Oct. '95.

† Cf. Rev. Myc., XVI–62, pp. 61 & 62, Apr. '94.

‡ Zeitschrift für Pflanzenkrankheiten, V–4, pp. 252 & 253, '95.

§ Cf. Centrabl. für Bakteriologie, Parasitenkunde, u. Infektionskrankheiten, II–4, pp. 133 & 134, '96.

If these statements are trustworthy, and we have no reason to suppose the contrary, we have in lysol an agent of extreme value in the treatment of plant-diseases, one well worthy of repeated trial. The successful preparation of Bordeaux mixture assumes some skill and judgment on the part of the operator, time is unnecessarily consumed, and in inexperienced hands the application is often incomplete and unsatisfactory. Lysol, on the other hand, is a liquid; it mixes readily and immediately with water; in applying it there is none of the inconvenience caused by a clogged nozzle. The cost of lysol is a matter for serious consideration. It is retailed in New York in pint bottles at 60 cts. a pound (1 pint). This quantity is sufficient to make 25 gallons of a ½% solution. With copper sulphate at 6 cts. per lb., and lime at $1.65 per bbl. and using the 6–4–50 formula, Bordeaux mixture costs about 20 cts. for 25 gallons. Allowing for the addition of Paris green at 25 cts. per lb., in the proportion of 1 lb. to 100 gallons of the Bordeaux mixture, the latter will cost about 32 cts. for 25 gallons, as compared with 60 cts. for the same quantity of a ½% lysol solution. This can hardly be reconciled with the statement made by the French writer above referred to, regarding the relative cheapness of lysol. His figures, however, are based upon a much lower price of the pure material. Lysol is sold in cans in Paris at 2 francs per kilo (2.2 lbs.), or about 18 cts. per lb. as compared with 60 cts. per lb. in New York. At the latter figure the use of lysol as a fungicide is practically prohibited except by way of experiment. Nevertheless the statements concerning its value are so unqualified that a careful test of its properties seemed advisable.

It was decided to make the test upon potato-tubers either themselves infested with scab or planted in soil so infested. This seemed to promise the fairest basis for conclusions, since the treatment for potato-scab at present in use is antiseptic in character, and it is as an antiseptic that lysol is especially recommended. An experiment in continuation of those of previous years, to test the value of corrosive sublimate in this connection, had also been planned, and the use of the two materials side by side would, it was thought, give a fair basis of comparison. As regards the comparative cost of the two, the small amount of material used in treating seed potatoes as compared with any method involving the spraying of plants, makes a difference in the price of the crude materials hardly worth considering. As a matter of fact however, lysol is again seen to be the more expensive. Twenty-five gallons of a corrosive sublimate solution, with that chemical selling for 10 cts. per oz. and used in the proportion of $2\frac{1}{4}$ oz. to 15 gallons of water, cost about 42 cts. as compared with 60 cts. in the case of lysol.

Four sets of experiments were undertaken in different localities and under various conditions to test the value of chemicals in preventing scab. Of these experiments one had to do with ascertaining the susceptibility to scab of various root-crops and the efficacy of treating the soil in order to free it from the germs of the scab-fungus. Another had for its aim a comparison of corrosive sublimate and lysol as preventives of scab upon potatoes. The remaining two involved other questions, the comparative efficiency of lysol being merely incidental. We will therefore consider first the second of the experiments mentioned above.

Experiment I.

The Comparative Value of Corrosive Sublimate and Lysol in preventing Scab upon Potatoes.

This experiment was conducted on the Station grounds upon a piece of land which had not recently borne either potatoes or root-crops, and was therefore presumably free from the scab fungus. The seed used was completely infested with scab. It had been stored in a warm, fairly dark cellar, and by May 8th, the date of planting, all of the tubers had sprouted. The sprouts on some of the tubers were short, stocky and green; those on the remainder were from four to eight inches long, spindling and etiolated. Leaf-buds were beginning to start on some of the sprouts. The tubers were washed, divided into five lots and treated as follows:

Lot 1. Soaked in 1% Lysol solution, $1\frac{1}{2}$ hours.
Lot 2. Soaked in $\frac{1}{2}$% Lysol solution, $1\frac{1}{2}$ hours.
Lot 3. Soaked in $\frac{1}{10}$% Lysol solution, $1\frac{1}{2}$ hours.
Lot 4. Soaked in Corrosive Sublimate solution (1 oz. to 6 galls.), $1\frac{1}{2}$ hours.
Lot 5. No treatment. (Check.)

After treatment the seed potatoes were spread out to dry, the effect of the solutions, especially on the sprouts, was noted, and the tubers were then cut and planted as usual.

The external effect of the lysol was very marked. In the case of the two stronger solutions the etiolated sprouts were colored pale brownish-red or pink, especially where bruised or cut, and the same color was observable in the liquid after the tubers were removed. The green, stocky sprouts were uninjured except that the young leaf-buds were blackened. The surface of the tubers themselves showed no sign of injury. With the $\frac{1}{10}$% solution, although it showed a discoloration similar to that observed in the other two after contact with the tubers, the latter were uninjured even when the sprouts were long and etiolated and showed green leaf-buds. With the corrosive sublimate, as was expected from the results of the experiment of last year, no injury was observable on the sprouts.

Observations made on the growth of the plants showed no very marked irregularities, except in the case of the seed treated with 1% lysol. The plants in this row were three or four days later in appearing above ground than any of the others, a few hills failed entirely, and the crop was light and composed of very small tubers. The 1% solution of lysol had evidently done serious injury to the seed. It is possible that the result would have been different had the seed-tubers not been sprouted.

Potato-bugs began work early and in great numbers, thus giving abundant opportunity for testing the insecticidal qualities of lysol. Each of the three rows in which the seed had been treated with lysol were sprayed twice with lysol of the same strength as that used on the seed. The spray was applied in sufficient quantity to drench the plants but produced no perceptible diminution in the number of bugs. Colonies of young, soft-bodied bugs were soaked with the 1% solution without apparent injury, and the lysol was therefore discontinued after the second spraying, and a dry Bordeaux mixture prepared by Messrs. Hotchkiss Bros. of Wallingford and mixed with Paris green, was substituted. This checked the bugs in a measure, but the vines had been injured beyond recovery and died three weeks before those on the two adjoining rows. Of these two, the row which had been reserved as a check was dusted twice with the dry Bordeaux mixture mentioned above, mixed with Paris green. By this means the plants were kept comparatively free from bugs, but early in August the "early blight" appeared, and though a spray of the Bordeaux mixture was at once substituted for the dry form, the blight spread slowly and eventually destroyed the vines. On the remaining row treated with corrosive sublimate, Bordeaux mixture made according to the usual formula was used from the beginning. Three applications were made, the vines remained free from bugs throughout the season, and showed only a few traces of blight.

The potatoes were all dug Aug. 28th. The general lack of vigor on the part of the plants, shown by their short period of growth and poor returns, was doubtless due in large measure to the character of the seed which, besides being covered with scab, had given up much of its remaining vitality to the sprouts; while the latter, grown largely in the dark, were unfit to produce plants of much vigor. After being dug, the potatoes from each row were separated into three grades depending upon the amount of scab present upon them. The results are shown in the following table:

TABLE I. COMPARATIVE EFFICIENCY OF LYSOL AND CORROSIVE SUBLIMATE AS PREVENTIVES OF POTATO-SCAB.

	Treatment.	First Quality.	Second Quality.	Third Quality.	Total Yield.
Row 1	Not treated, Check	7 lbs. 5 oz.=32%	11 lbs. 4 oz.=49%	4 lbs. 8 oz.=19%	23 lbs. 1 oz.
Row 2	Lysol, $\frac{1}{10}$%	10 lbs. 14½ oz.=40%	11 lbs. 14½ oz.=44%	4 lbs. 7½ oz.=16%	27 lbs. 4½ oz.
Row 3	Lysol, ½%	9 lbs. 3 oz.=55%	6 lbs. 3½ oz.=38%	1 lb. 3 oz =7%	16 lbs. 9½ oz.
Row 4	Lysol, 1%	13 lbs. 10 oz.=78%	3 lbs. 14½ oz.=22%	0	17 lbs. 8½ oz.
Row 5	Corrosive Sublimate, ½ oz. to 3 galls.	25 lbs. 12½ oz.=89%	3 lbs. 5½ oz.=11%	0	29 lbs. 2 oz.

The advantage attending the use of corrosive sublimate under the conditions outlined above, viz.: when the seed itself presents the only source of contagion, is seen at a glance. Notwithstanding the fact that Row 5 was only 39 ft. long as compared with 54 ft. in the case of the other rows, it shows the highest total yield. This is to be attributed rather to the preservation of the vines by means of Bordeaux mixture than to the treatment of the seed, but it is of interest in that connection. As to the

immediate effect of the treatment of the seed, the only row which shows an approach to the good results obtained from the use of corrosive sublimate, is that treated with 1% lysol solution. Neither row shows any very scabby tubers in the crop and the lysol produced only 11% less tubers of first quality and 11% more tubers of second quality than did the corrosive sublimate. But we have already seen indications that lysol of a concentration stronger than $\frac{1}{10}$% injures seed-potatoes, those at least which have sprouted before treatment. These indications are borne out by the results, the crop resulting from the use of $\frac{1}{10}$% lysol being much greater than that obtained with the stronger solutions, and only slightly less than that secured with corrosive sublimate. As to the quality of the crop it will be seen that the percentage of first-quality tubers increases, and the percentage of second and third-quality tubers decreases, with the increased strength of the lysol solution; and this ratio holds good throughout the series, the check row showing returns of the poorest quality, the corrosive sublimate row showing the best, and the lysol increasing in efficacy with the strength of the solution.

From the results thus obtained we may summarize our conclusions as follows:

(1) Corrosive sublimate continues to hold its own as a preventive of potato-scab in cases where the seed is the only source of contagion.

(The results obtained in this instance are very remarkable considering the fact that the seed used was so completely infested with scab that not a single tuber showed a square inch of clean surface.)

(2) As a preventive of potato-scab lysol is distinctly inferior to corrosive sublimate. A solution of $\frac{1}{10}$% is not sufficient to secure disinfection of the seed, while solutions of ½% and 1% injure the seed, at least when the latter is sprouted, and therefore lessen the crop very materially.

(3) As an insecticide, in the case of potato-bugs, lysol possesses little value as compared with Paris green, and is besides much more expensive.

(4) As a fungicide lysol fails to check the early blight of potatoes.

(5) Dry Bordeaux mixture mixed with Paris green and dusted on potato plants, is inferior both as a fungicide and an insecticide, to Bordeaux mixture used as a liquid spray.

EXPERIMENT II.

The Comparative Value of Corrosive Sublimate, Lysol, and Sulphur in preventing Scab upon infested Land.

This experiment was conducted at South Manchester on land occupied for the past two years by potatoes. The piece of land selected was a portion of Plot B of last year's experiment. This plot produced a crop of which 75% was scabby; the soil was therefore presumed to be thoroughly infested with the fungus. It was divided into two equal parts, on one of which scabby seed was used and on the other clean seed. A blank space, ten feet wide, separated the two portions. The potatoes were planted in twelve rows each 20 feet long, and before being cut and planted received the following treatment:

Row 1. Washed in water. Check.
Row 2. Soaked $1\frac{1}{2}$ hours in Lysol solution, $\frac{1}{10}$%.
Row 3. Soaked $1\frac{1}{2}$ hours in Lysol solution, $\frac{1}{2}$%.
Row 4. Soaked $1\frac{1}{2}$ hours in Lysol solution, 1%.
Row 5. Washed. Rolled in Sulphur. Sulphur sown in each hill.
Row 6. Soaked $1\frac{1}{2}$ hours in Corrosive Sublimate solution, $\frac{1}{2}$ oz. to $2\frac{1}{2}$ galls.
Rows 7–12 inclusive received the same treatment respectively, but reversed in order of planting.

Rows 1–6 were planted with seed free from scab; rows 7–12 with scabby seed.

The experiment was expected to give additional information on the following points:

1. The effect of planting clean seed and scabby seed, not treated, on scabby land. (Rows 1 and 12.)
2. The effect of treating clean seed and scabby seed with lysol solutions of different concentrations. (Rows 2–4 and 9–11.)
3. The same, sulphur being used as the disinfecting agent.
4. The same, corrosive sublimate in solution being used.

The clean potatoes were treated, cut and planted on May 15th, the scabby potatoes on May 18th. No visible injury resulted from any of the lysol solutions. On June 5th the plants in the two check-rows, the rows treated with sulphur and those treated with the two weaker solutions of lysol, were appearing above ground. The remaining rows started two days later, but all grew rapidly and at the close of the season showed no perceptible difference in vigor. Paris green served to check the potato-bugs, and though the early blight appeared, the attack was not sufficiently severe to impair the results. On September 14th one-half of each row was dug; the rest remained untouched until October 20th in order to test the possible advantage of early digging in cases where scab had already attacked the crop.

The results obtained September 14th are given in the following table:

TABLE II. CORROSIVE SUBLIMATE, LYSOL, AND SULPHUR AS PREVENTIVES OF POTATO-SCAB ON INFESTED LAND. SEPT. 14TH.

	Treatment.	1st Quality.	2d Quality.	3d Quality.	Total Yield.	
Row 1	No treatment Check	8 lbs.=44%	7 lbs.=39%	3 lbs.=17%	18 lbs.	Clean Seed.
Row 2	Lysol, $\frac{1}{10}$%	5 lbs.=50%	3.5 lbs.=35%	1.5 lbs.=15%	10 lbs.	
Row 3	Lysol, $\frac{1}{2}$%	7 lbs.=52%	4.5 lbs.=33%	2 lbs.=15%	13.5 lbs.	
Row 4	Lysol, 1%	6 lbs.=75%	2 lbs.=25%	0	8 lbs.	
Row 5	Seed rolled in Sulphur Sulphur in hills	10 lbs.=65%	5.5 lbs.=35%	0	15.5 lbs.	
Row 6	Corrosive Sublimate, $\frac{1}{2}$ oz. to 3 galls.	14 lbs.=85%	2.5 lbs.=15%	0	16.5 lbs.	
Row 7	Corrosive Sublimate, $\frac{1}{2}$ oz. to 3 galls.	8 lbs.=70%	3.5 lbs.=30%	0	11.5 lbs.	Scabby Seed.
Row 8	Seed rolled in Sulphur Sulphur in hills	8 lbs.=64%	3.5 lbs.=28%	1 lb.= 8%	12.5 lbs.	
Row 9	Lysol, 1%	2.5 lbs.=31%	4 lbs.=50%	1.5 lbs.=19%	8 lbs.	
Row 10	Lysol, $\frac{1}{2}$%	4.5 lbs.=50%	3 lbs.=33%	1.5 lbs.=17%	9 lbs.	
Row 11	Lysol, $\frac{1}{10}$%	6 lbs.=46%	5 lbs.=39%	2 lbs.=15%	13 lbs.	
Row 12	No treatment Check	3 lbs.=26%	6.5 lbs.=57%	2 lbs.=17%	11.5 lbs.	

Comparing the general results as obtained from the scabby and from the clean seed, it is seen that the scabby seed produced decidedly the smaller crop, the difference between the total yields being 16 pounds. This difference can only be explained on the supposition that seed-potatoes infested with scab not only endanger the crop as regards quality, but are less vigorous and consequently less productive than clean seed. A comparison between Rows 1 and 12 illustrates these facts regarding the inferior quantity and quality of tubers produced from scabby seed.

As regards the effect of the lysol solutions little need be added to the comments in this connection on experiment No. 1. Essentially the same facts are revealed in both experiments. The 1% solution (Rows 4 & 9) has unmistakably diminished the yield, while the weaker solutions, though far better than nothing, are decidedly inferior in efficiency to corrosive sublimate (compare Rows 2 & 3 with Row 6, and Rows 10 & 11 with Row 7). It is quite possible however, that another factor in the use of lysol, disregarded in both of these experiments, may prove an important one. The duration of the treatment was the same in all cases 1½ hours, and it is quite possible that the 1% solution allowed to act for a shorter period might prove as effective in sterilizing the seed without at the same time diminishing its vitality. In view of the non-poisonous character of lysol and the convenience attending its use, it certainly seems worthy of further trial.

The use of sulphur as a preventive of potato-scab was recommended by Halsted.* According to one experiment conducted by him in 1895 on the College Farm, sulphur used at the rate of 300 pounds per acre (the seed being rolled in the sulphur and the remainder sprinkled in the rows) "kept off the scab almost completely, where the standard remedy, namely, corrosive sublimate, tested in four strengths, all failed absolutely to show any less scab than the check-belts" (almost 100%). The land used in this experiment is stated to have been in cabbages the year before, but no information is given as to the character of the soil with regard to the scab fungus. In another experiment, planned by Prof. Halsted, the land used was known to be thoroughly infested with scab, yet in this case the highest percentage of scab obtained in connection with corrosive sublimate (applied to the land at the rate of 120 pounds per acre) was only 5%, and this was reduced to 1% where the usual method of soaking the seed in a solution of the poison had been followed. On the other hand, with sulphur used upon the seed before planting, the crop showed 5% of scabby tubers, and this was reduced to 1% when the sulphur was applied to the land at the rate of 300 pounds and 150 pounds per acre. In this second experiment the stand was very seriously reduced where the corrosive sublimate was applied to the land, while sulphur applied in the same way at the rates above-mentioned gave a full stand. Inasmuch however, as corrosive sublimate applied in the usual way to the seed

* N. J. Agric. Exper. Sta., Rep. for 1895, pp. 270–275.

gave a full crop, the results would seem merely to indicate that soil applications of the sublimate are not to be recommended, but that when applied to the seed it is quite as efficient as sulphur applied to the land and more efficient than sulphur applied to the seed. Moreover it would be manifestly impracticable to use corrosive sublimate costing 10 cents per ounce, at the rate of even 30 pounds to the acre, when better results can be secured for the same area by the use of a few ounces dissolved in water. Sulphur is of course much cheaper, costing, by the barrel of 150 pounds, 2 cents per pound, or $3.00 per barrel, but even this is more expensive per acre than the corrosive sublimate solution as commonly used.

With the view of testing this matter sulphur was used in two rows of Experiment No. 2 at South Manchester, and the results compared with those obtained with corrosive sublimate. The seed for each row, after being washed, was rolled in one pound of sulphur (730 lbs. per acre), dropped in the row, and then the remainder of the sulphur was scattered in the open row. As already noted, the seed started quickly and grew well. The yield was practically the same as that from the check rows and from the rows treated with sublimate. Reference to the table on page 253 shows that for both the clean and the scabby seed the sublimate has the advantage of the sulphur as regards the quality of the crop, in the first case by 20%, and in the second by 6%. (Rows 5 & 6, 7 & 8.) Again the corrosive sublimate treatment proves superior, as a preventive of potato-scab, to any other material used. In the case of clean seed it reduced the amount of scab on the crop by 41%, in the case of scabby seed by 44%, and that, without any material diminution in the quantity of the crop. Considering both quantity and quality of the yield, it is superior to sulphur, its nearest rival, and is moreover cheaper on a large scale. The results obtained from that portion of the crop which was allowed to remain in the ground until Oct. 20th, and a comparison between those results and the condition of the crop a month earlier, are given in the following tables.

TABLE III. CORROSIVE SUBLIMATE, LYSOL, AND SULPHUR AS PREVENTIVES OF POTATO-SCAB ON INFESTED LAND. OCT. 20TH.

	Treatment.	1st Quality.	2d Quality.	3d Quality.	Total Yield.	
Row 1	0	7.5 lbs.=68%	3 lbs.=28%	0.5 lb.=4%	11 lbs.	Clean Seed.
Row 2	Lysol $\frac{1}{10}$%	8 lbs.=59%	4 lbs.=30%	1.5 lbs.=11%	13.5 lbs.	
Row 3	Lysol ½%	7.5 lbs.=71%	3 lbs.=29%	0	10.5 lbs.	
Row 4	Lysol 1%	7.5 lbs.=79%	2 lbs.=21%	0	9.5 lbs.	
Row 5	Sulphur	10.5 lbs.=75%	3.5 lbs.=25%	0	14 lbs.	
Row 6	Corrosive Sublimate	11.5 lbs.=78%	3 lbs.=20%	0.25 lb.=2%	14.75 lbs.	
Row 7	Corrosive Sublimate	10.5 lbs.=78%	3 lbs.=22%	0	13.5 lbs.	Scabby Seed.
Row 8	Sulphur	6 lbs.=55%	5 lbs.=45%	0	11 lbs.	
Row 9	Lysol 1%	5 lbs.=53%	4 lbs.=42%	0.5 lb.=5%	9.5 lbs.	
Row 10	Lysol ½%	6 lbs.=52%	5 lbs.=44%	0.5 lb.=4%	11.5 lbs.	
Row 11	Lysol $\frac{1}{10}$%	5 lbs.=40%	5 lbs.=40%	2.5 lbs.=20%	12.5 lbs.	
Row 12	0	4.5 lbs.=46%	5 lbs=51%	0.25 lb.=3%	9.75 lbs.	

TABLE IV. COMPARATIVE RESULT OF LATE AND EARLY DIGGING ON THE QUALITY OF POTATOES EXPOSED TO SCAB.

Row.	Sept. 14. Total Scabby.	Oct. 20. Total Scabby.	Difference.
1	56%	32%	−24%
2	50%	41%	9%
3	48%	29%	−19%
4	25%	21%	− 4%
5	35%	25%	−10%
6	15%	22%	+ 7%
7	30%	22%	− 8%
8	36%	45%	+ 9%
9	69%	47%	−22%
10	50%	48%	− 2%
11	54%	60%	+ 6%
12	74%	54%	−02%

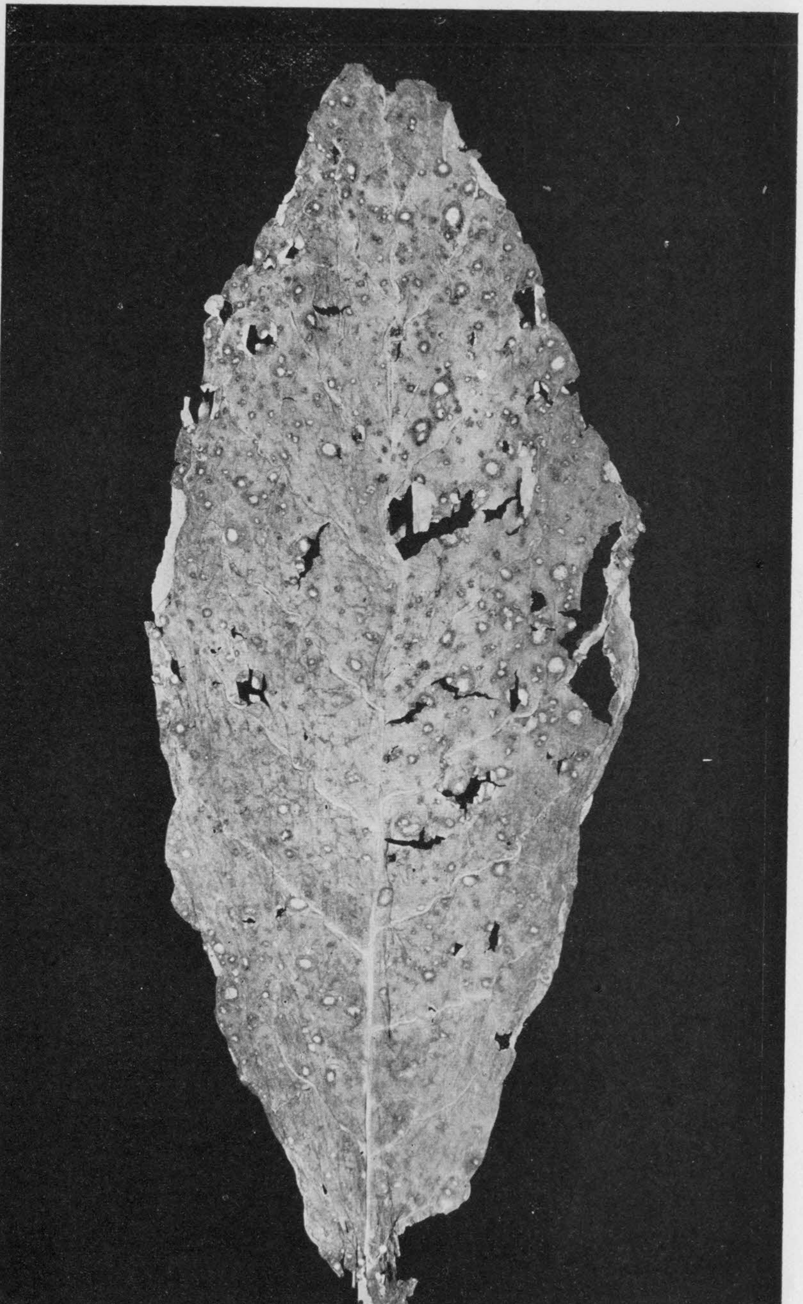


PLATE VII. LEAF-SPOT OF TOBACCO.

ON A DESTRUCTIVE FUNGOUS DISEASE OF TOBACCO IN SOUTH CAROLINA.

Plate VII, and Plate VIII figs. 1–3.

BY WM. C. STURGIS.

On Aug. 7th, I received through the kindness of Prof. Halsted of the N. J. Agricultural Experiment Station a sample of tobacco leaf showing a remarkably diseased appearance, and it seems advisable to call the attention of tobacco-growers to the matter, because the disease is evidently capable of doing great damage to standing tobacco, and because its immediate cause is a fungus belonging to a very large genus having an almost unlimited range and liable therefore to occur north of the locality from which it is at present reported.

The diseased leaves were sent to Prof. Halsted from South Carolina, and when received at this Station early in August, were comparatively fresh and of a yellow color similar in tone to that of half-cured wrapper tobacco. The disease appeared as brown circular spots from the size of a pin-head up to half an inch or more in diameter, scattered thickly over the upper surface of the leaves. These brown spots are sometimes marked with whitish centers bordered by a darker, slightly raised line; and sometimes, especially towards the tips and edges of the leaves, they coalesce to form large brown blotches and areas of irregular outline. The leaf does not decay as a result of the spotting, but the whole leaf turns yellow prematurely and dies from the tip downwards, while the tissues immediately occupied by the fungus dry up and show a tendency to fall away, leaving irregular holes in the leaf (Plate VII). Microscopic examination of the diseased spots showed that they were uniformly invaded by a species of fungus belonging to the genus *Cercospora*, members of which cause leaf-diseases of the peach, violet, beet, celery and many other plants. The particular species under consideration was named by Messrs. Ellis & Everhart, *Cercospora Nicotianæ*, from the scientific name of the plant which it affects. The original description of the fungus is as follows.*

* Proc. Acad. Nat. Sci. of Phil., 1893, p. 170.

DESCRIPTION OF PLATE VIII.

Cercospora Nicotianæ, Ell. & Ev.

FIG. 1.—Cross-section of upper surface of tobacco-leaf showing the fungous threads bursting through in three places and producing spores on their tips. Magnified 95 diameters.

FIG. 2.—Portion of the same. Magnified 196 diameters.

FIG. 3.—Spores germinating after remaining thirty hours on the surface of a leaf floated in water. The germ-tubes are seen penetrating through two stomata, which alone are represented in the drawing. Magnified 375 diameters.

Puccinia Asparagi, DC.

FIG. 4.—Two sori of summer-spores occupying the external tissues of an asparagus-stem. Magnified 50 diameters.

FIG. 5.—Portion of the same. Magnified 196 diameters.

FIG. 6.—Portion of a sorus of winter-spores. Magnified 196 diameters.

FIG. 7.—A sorus of winter-spores. Magnified 50 diameters.

These results are wholly unexpected and can not at present be explained. In only three cases do the figures show an increase of scab as a result of allowing the tubers to remain in the ground, and the increase is comparatively slight. On the other hand, the decrease in the amount of scab is very marked, especially in Rows 1 and 12, where the tubers were not protected by any fungicide whatever. Such facts could be explained only upon the supposition that the amount of scab-fungus in the soil, or its virulence, experienced a remarkable decrease and permitted the effects of earlier attacks to become in a measure obliterated. But such a supposition seems contrary to both reason and experience. Leaving then this question unsettled to await further elucidation, we may summarize the results of Experiment II as follows:

(1) Where the soil is infested with scab-fungus the crop of tubers will be seriously diseased if no preventive treatment is applied. The disease will be further aggravated under such conditions by the use of scabby seed. The use of infested land for potatoes should therefore be discountenanced.

(2) Lysol used in 1% solution injures the seed when the latter is allowed to remain one and a half hours in contact with it. Weaker solutions are almost inoperative when used upon either clean or scabby seed planted on infested land.

(3) Sulphur is an unsatisfactory preventive of potato-scab, no matter what the quality of the seed, when the soil is infested. It further tends to roughen the surface of tubers growing in contact with it.

(4) Of the three fungicides used, corrosive sublimate is the only one which can be recommended as a preventive of potato-scab. Its efficiency is diminished by the presence of the fungus in the soil.

(5) Infested land is to be avoided in planting potatoes. If its use is unavoidable, the selection of clean seed and treatment of the same with corrosive sublimate will enhance the value of the crop.

EXPERIMENT III.

The comparative effect of Fresh and Composted Manure in favoring the development of potato-scab, and the comparative value of Corrosive Sublimate, Lysol and Sulphur in preventing scab upon clean land.

This experiment was conducted at South Manchester upon a piece of land which had not recently borne potatoes and was presumably free from infection. In testing the effect of manure, clean seed was used without previous treatment in order to have only the one source of contagion. In testing the fungicides, scabby seed was used in connection with commercial fertilizers, the contagion being thereby introduced on the tubers only.

The rows were arranged as follows, each row being 63 feet long:

Rows 1 and 2. Clean seed, fertilized with fresh barnyard manure.
Rows 3 and 4. Clean seed, fertilized with composted barnyard manure.
Row 5. Scabby seed, soaked for $1\frac{1}{2}$ hours in $\frac{1}{10}$% lysol solution.
Row 6. Scabby seed, soaked for $1\frac{1}{2}$ hours in $\frac{1}{2}$% lysol solution.
Row 7. Scabby seed, soaked for $1\frac{1}{2}$ hours in 1% lysol solution.
Row 8. Scabby seed, soaked for $1\frac{1}{2}$ hours in corrosive sublimate solution ($\frac{1}{2}$ oz. to 3 galls.).
Row 9. Scabby seed, rolled in 1 lb. sulphur (230 lbs. per acre), remainder sprinkled in row.
Row 10. Scabby seed, no treatment. Check.

The manure was used liberally; one-half of it was first scattered in the open rows, the seed was then dropped upon it and pressed down, the rest of the manure was then scattered and the earth drawn over it. By this means direct contact was secured between the seed and the manure both above and beneath.

As in Experiment II, one-half of each row was dug Sept. 14th and the remainder Oct. 20th. The results of the first digging are presented in the following table:

TABLE V. EFFECT OF MANURE AND OF FUNGICIDES UPON THE PREVALENCE OF POTATO-SCAB ON CLEAN LAND. SEPT. 14TH.

Row.	Treatment.	1st Quality.	2d Quality.	3d Quality.	Total Yield.	
1 and 2	Fresh Manure No treatment	7 lbs.=27%	11 lbs.=42%	8 lbs.=31%	26 lbs.	Clean seed
3 and 4	Composted Manure No treatment	14.5 lbs.=40%	14 lbs.=38%	8 lbs.=22%	36.5 lbs.	
5	Lysol, $\frac{1}{10}$%	8.5 lbs.=68%	3.5 lbs.=28%	0.5 lb.=4%	12.5 lbs.	Scabby seed
6	Lysol, $\frac{1}{2}$%	9 lbs.=68%	4 lbs.=30%	0.25 lb.=2%	13.25 lbs.	
7	Lysol, 1%	6 lbs.=72%	2 lbs =25%	0.25 lb.=3%	8.25 lbs	
8	Corrosive Sublimate	13 lbs.=88%	1.5 lbs.=10%	0.25 lb.=2%	14.75 lbs.	
9	Sulphur	13 lbs.=81%	3 lbs.=19%	0	16 lbs.	
10	0 Check	7 lbs.=50%	5 lbs.=36%	2 lbs.=14%	14 lbs.	

Referring to this table, we will consider first the effect of the barn-yard manure. The results obtained in a similar experiment

last year showed that the use of composted manure, as compared with fresh manure, increased the amount of scabby potatoes by over 25 per cent. At the same time it was seen that the compost produced the larger yield. The former result was unexpected and the present experiment was therefore undertaken.

Comparing the results obtained from Rows 1 & 2 with those from Rows 3 & 4, we see at once that not only has the composted manure produced the larger yield, but the quality of the tubers grown on it is decidedly superior to that of the potatoes grown on the fresh manure. This seem to indicate that if barn-yard manure is to be used in connection with potatoes, it should be composted and thoroughly rotted before it is used. But that manure in any form does tend to induce scab upon potatoes, is abundantly proved by this experiment, the percentage of scabby potatoes from the manured rows being in excess of that obtained from the check row, even though the manured rows were planted with clean seed and the check row with scabby seed; nor is the yield much larger with the manure than with the fertilizer-chemical. We may conclude then, that it is inadvisable to use stable or yard-manure in any form for potatoes, even though neither the seed nor the soil present any source of contagion. This conclusion is based upon results uniformly obtained during three successive years and under many varying conditions.

The lysol treatment is again open to the same objections which we have considered in the other experiments. The weaker solutions are certainly better than nothing, as may be seen by comparing Rows 5 & 6 with Row 10, but the quality of the crop from both rows shows conclusively that the seed-potatoes, which were the only source of contagion, were not sterilized by the treatment. The 1% solution gives better results as regards the prevention of scab, but the yield has been very seriously diminished from its effects. The sulphur again proves superior to the lysol, and indeed shows a good record, (compare Rows 9 & 10.) But corrosive sublimate still heads the list as the best preventive of scab, all things considered. Its value is most decidedly marked when the seed offers the only source of contagion; and it is fortunate that such is the case, for the use of barn-yard manure is seldom unavoidable, and clean land can generally be substituted for land which has become infested with the scab-fungus; but it is frequently impossible to secure clean seed for planting, and under such circumstances the corrosive sublimate treatment presents a cheap and expeditious method of securing at least an almost clean crop.

It only remains to consider again the effect, as regards the increase of scab, of leaving the potatoes in the ground.

The following tables show the results of the second digging, Oct. 20th, and a comparison between those results and the character of the crop a month earlier.

TABLE VI. EFFECT OF MANURE AND OF FUNGICIDES UPON THE PREVALENCE OF POTATO-SCAB ON CLEAN LAND. OCT. 20TH.

Row.	Treatment.	1st Quality.	2d Quality.	3d Quality.	Total Yield.	
1 and 2	Fresh Manure.	9.5 lbs.=26%	13 lbs.=36%	14 lbs.=38%	36.5 lbs.	Clean seed.
3 and 4	Composted Manure	15 lbs.=32%	18 lbs.=38%	14 lbs =30%	47 lbs.	Clean seed.
5	Lysol, $\frac{1}{10}$%	12.5 lbs.=73%	4.5 lbs.=26%	0.25 lb.=1%+	17.25 lbs.	Scabby seed.
6	Lysol, $\frac{1}{2}$%	13 lbs.=70%	5 lbs.=27%	0.5 lb.=3%—	18.5 lbs.	Scabby seed.
7	Lysol, 1%	13.5 lbs.=68%	6 lbs.=30%	0.5 lb.=2%+	20 lbs.	Scabby seed.
8	Corrosive Sublimate	14 lbs.=78%	4 lbs.=22%	0	18 lbs.	Scabby seed.
9	Sulphur	16 lbs.=77%	4.5 lbs.=22%	0.25 lb.=1%	20.75 lbs.	Scabby seed.
10	0	10.5 lbs.=60%	6.5 lbs.=37%	0.5 lb.=3%—	17.5 lbs.	Scabby seed.

TABLE VII. COMPARATIVE EFFECT OF LATE AND EARLY DIGGING ON THE QUALITY OF POTATOES EXPOSED TO SCAB.

Row.	Sept. 14. Total Scabby.	Oct. 20. Total Scabby.	Difference.
1 and 2	73%	74%	+ 1%
3 and 4	60%	68%	+ 8%
5	32%	27%	— 5%
6	32%	30%	— 2%
7	28%	32%	+ 4%
8	12%	22%	+10%
9	19%	23%	+ 4%
10	50%	40%	—10%

No satisfactory conclusions can be reached from these figures regarding the advisability or otherwise of leaving in the ground potatoes which are exposed to the attacks of the scab fungus. The manured rows dug Oct. 20th show an increase in the percentage of scab over those dug Sept. 14th, but the same is true of the rows which received the most effective treatment, while the row which had no treatment at all shows a decided decrease. These results do not even agree with those obtained in Experiment II, except as regards the decreased percentage of scab in the untreated rows.

Leaving this matter without further comment, we may summarize the results of Experiment III, as follows:

(1) Barn-yard manure as a fertilizer for potatoes, even when both soil and seed are free from the scab-fungus, will induce scab upon the crop and produce very serious injury. The use of manure should therefore be avoided.

(2) Lysol in a solution of 1% tends to reduce the yield, though it is fairly effective as a preventive of scab. The efficiency of weaker solutions of lysol is not such as to warrant their recommendation unless they are allowed to act for two hours at least.

(3) Sulphur as a preventive of potato-scab is second only to corrosive sublimate in efficiency. It costs more however, and is not so conveniently applied.

[One of the principal advantages claimed for sulphur in this connection is that when scattered in the hill or row it permeates the soil and serves to destroy the scab-fungus in the soil as well as upon the tubers, and can therefore be used to great advantage on scabby land. This cannot be properly claimed in the case of corrosive sublimate. If true, this character would add largely to the value of sulphur. Our experiments, however, fail to substantiate this claim conclusively, the percentage of scabby tubers upon infested soil being quite as much larger proportionately than that upon clean soil as in the case of corrosive sublimate. (Compare the results of Experiment II and Experiment III as regards the percentage of scabby tubers accompanying the use of sulphur and sublimate respectively.)]

General Summary.

A careful consideration of the results of the three experiments described in the preceding pages of this Report and of those described in the Reports of this Station for the past two years, warrants the following conclusions, regarding the treatment of potato-scab:

(1) Regarding the Soil. The surest means of infecting potatoes with scab is planting them upon land infested with the scab-fungus. No treatment as yet known will be of much avail against this source of contagion. In planting potatoes, beets or turnips therefore, select land which has not recently borne any one of these crops.

(2) Regarding the Fertilizer. Barn-yard manure is a fertile source of contagion against which no treatment is thoroughly effective. Avoid manure as a fertilizer for potatoes, beets or turnips, if possible.

(3) Regarding the Seed. Seed-potatoes carrying the living germs of the scab-fungus will produce a scabby crop, and, other things being equal, the amount of scab on the crop will be directly proportionate to the amount of scab on the seed. Select therefore, clean, smooth potatoes for planting, if possible. In case scab-spots are visible upon any of the seed-potatoes treat them all, before planting, with some well recognized fungicide.

(4) Regarding Preventive Treatment. (a) The cheapest and most effective method of preventing potato-scab consists in soaking the seed for one and one-half hours, before cutting or planting, in a solution of corrosive sublimate made in the proportion of $2\frac{1}{4}$ ounces to 15 gallons of water. This treatment reaches its highest efficiency in cases where the seed-potatoes constitute the only source of infection. It is efficient, though in a much lesser degree, in case barn-yard manure is used as a fertilizer, and is least effective in case the soil is infested.

(b) In certain cases flowers of sulphur applied to the seed before cutting and to the soil before planting reduces very materially the amount of scab upon the crop, but the expense and inconvenience of this treatment as compared with the more effective corrosive sublimate treatment, renders its adoption generally impracticable.

(c) Lysol can not as yet be recommended as a practicable preventive of potato-scab. It is possible that a $\frac{1}{2}\%$ solution, allowed to act upon the seed for a period not less than two hours, would give satisfactory results. The non-poisonous character of lysol, the convenience attending its use, and its possible value as a fungicide render further experiments with it highly advisable.

(5) Use clean land and avoid manure. Plant only smooth seed, if possible. If there is a suspicion of scab in the soil or on the seed treat the latter thoroughly with corrosive sublimate solution.

(6) Lysol applied as a spray failed to give satisfaction as an insecticide or fungicide.

(7) The commercial article known as "Dry Bordeaux Mixture" proved distinctly inferior as a fungicide to Bordeaux mixture prepared in liquid form according to the recognized formula and applied as a spray.

ON THE SUSCEPTIBILITY OF VARIOUS ROOT-CROPS TO POTATO-SCAB AND THE POSSIBILITY OF PREVENTIVE TREATMENT.

By Wm. C. Sturgis.

It is already a well-known fact that beets and turnips planted on land infested with scab-fungus, from whatever source, are liable to the attacks of the fungus equally with potatoes. In order to carry this question further a preliminary investigation was undertaken this year at South Manchester, its object being to ascertain which of our common root-crops, besides beets and turnips, were susceptible to potato-scab, and if the attack of the fungus could be prevented or its virulence diminished by treatment of the soil with fungicides previous to sowing the seed. The land selected was a portion of the potato-field used last year, and was known to be thoroughly infested. The plants selected for the experiment were radishes (Long scarlet) parsnips, salsify, carrots (Long orange), turnips (Ruta-baga), turnips (White egg), beets (Mangels), and beets (Red Egyptian). The plot was carefully prepared and laid out in thirty-two rows (four to each variety of seed), each twenty feet long. Each set of four rows received the same treatment respectively, viz:

Row 1. Water, 2 gallons.
Row 2. $\frac{1}{2}\%$ Lysol solution, 2 gallons.
Row 3. 1% Lysol solution, 2 gallons.
Row 4. Corrosive sublimate solution (1 ounce to 6 gallons), 2 gallons.

The rows were furrowed out, the solutions applied as evenly as possible from a watering-pot, and the seed sown. It was hoped that by this means the chemicals held in solution would permeate the soil about the seed, be washed down deeper by rains, and thus, in a measure at least, sterilize the soil occupied by the descending roots.

The planting was done May 15th and a careful record was kept during the early summer to ascertain the effect of the chemicals upon the germination of the seed and the growth of the plants. During this period the plants were thinned out twice. Later, as the roots matured, ten or more were pulled from different parts of each of the rows which showed a sufficiently good stand. This was repeated at intervals of about three weeks until October 20th, the roots pulled being washed at once and carefully examined for traces of scab.

The germination of the seed and the growth of the plants was extremely irregular, owing to the effects of the chemicals. The check rows, which had been treated with water only, showed a good growth on June 5th, and gave a perfect stand in every instance. On the same date the rows treated with ½% lysol showed the seedlings above ground, with the exception of the mangels, carrots and parsnips, but the growth was scattered and uneven. Of the rows treated with 1% lysol, the beets and the salsify alone showed a few scattered seedlings; with corrosive sublimate the turnips of both kinds and the radishes had made a good start; the other rows so treated were still blank. It was evident therefore, that both of the chemicals used had injured the seedlings more or less; the injury was most apparent from the 1% lysol, less so from the sublimate, and least of all from the ½% lysol. None however, showed a satisfactory stand as compared with the check rows on June 5th.

On July 31st there were still many blank rows. With 1% lysol the beets and radishes showed a very incomplete stand, the carrots and salsify showed two or three plants each, the other seeds had failed altogether. With corrosive sublimate the radishes and both kinds of turnips showed a fair stand, but the plants were very backward, the beets showed a few scattered plants, the salsify showed two plants only, and the mangels, carrots and parsnips were a complete failure. With ½% lysol the parsnips and carrots alone failed completely, the beets and turnips showed a fair but much belated stand, the mangels, salsify and radishes showed only four or five plants each. We must conclude therefore, that lysol in a solution of ½% or more, and corrosive sublimate in the strength commonly used for disinfecting seed-potatoes, injure the seeds of our common root-crops so seriously when applied to the adjacent soil that their effectiveness in preventing scab upon the roots is a matter of no importance, except as a guide to future work upon the subject.

The susceptibility of the root-crops to scab was ascertained by successive examinations of a few roots pulled from each of the check-rows. The first examination was made July 31st. At this time the beets, turnips and radishes alone were large enough to show tangible results. The radishes showed no sign whatever of scab; 28% of the turnips showed what might have been incipient scab-spots, but they were not sufficiently advanced to permit of accurate diagnosis; the beets were seriously diseased, 55% of the roots showing well-developed scab-spots over the greater part of their surface.

On August 18th samples were taken from the check-rows of the radishes, ruta-bagas, turnips, mangels and beets. The radishes again showed no scab and the experiment in their case was considered as closed. The ruta-bagas showed no scab, the turnips showed 17% of the roots slightly scabby, the mangels 40% and the beets showed no roots free from scab. On September 10th the beets showed 33% of scab, the turnips none, the ruta-bagas 43%, the carrots none and the parsnips none. The mangels were not examined on this date. On October 20th the parsnips showed 10% of the roots doubtfully scabby, the salsify showed all clean roots. No examination of the other root-crops was made on this date. This closed the experiment so far as the susceptibility to scab of the various root-crops was concerned.

It will be seen that of the eight varieties tested, the radishes and carrots alone remained unquestionably free from scab. The salsify showed very little if any scab, the parsnips gave similar results, the ruta-bagas gave an average of 21% of scab, the turnips 15%, the mangels 40% and the beets 63%.

Although, from the fact that the stand was so seriously affected by the chemicals used as preventives of scab, the results regarding their efficiency in this respect are of little practical value, it may be well to consider them briefly. The radishes, carrots, salsify and parsnips may be left out of the question since even when not treated they proved to be very slightly, if at all, susceptible to scab, and we need examine only the results obtained in the case of the beets, mangels, turnips and ruta-bagas.

On July 31st the turnips and the beets were examined, and on Aug. 18th and Sept. 10th all of the rows were examined with the exception of those in which the lack of plants, owing to the diminished stand, prevented further investigation. The following table represents the results obtained both as regards the stand on July 31st and the amount of scab present.

TABLE VIII. EFFECT OF FUNGICIDES APPLIED TO INFESTED SOIL IN PREVENTING POTATO-SCAB UPON ROOT CROPS.

			June 5.	July 31.		Aug. 18.	Sept. 10.	
	Row.	Treatment.	Stand.	Stand.	Scabby.	Scabby.	Scabby.	Average.
Beets	32	0	Good	Good	55%	100%	33%	63%
	31	Lysol $\frac{1}{2}$%	Poor	Fair	40%	28%?	14%?	27%
	30	Lysol 1%	Very poor	Poor	25%	17%?	----	21%
	29	Cor. sub.	------	Very poor	Clean	----	25%	13%
Mangels	28	Cor. sub.	------	------	----	----	----	----
	27	Lysol 1%	------	------	----	----	----	----
	26	Lysol $\frac{1}{2}$%	------	Very poor	----	----	17%	17%
	25	0	Good	Good	----	40%	----	40%
Turnips	24	0	Good	Good	28%?	17%	Clean	15%
	23	Lysol $\frac{1}{2}$%	Poor	Fair	11%	----	Clean	6%
	22	Lysol 1%	------	------	----	----	----	----
	21	Cor. sub.	Fair	Fair	33%	----	Clean	16%
Ruta-bagas	20	Cor. sub.	Fair	Fair	----	----	17%	17%
	19	Lysol 1%	------	------	----	----	----	----
	18	Lysol $\frac{1}{2}$%	Poor	Fair	----	----	40%	40%
	17	0	Good	Good	----	Clean	43%	21%

It is unnecessary to comment further upon these results; they may be summarized as follows:

(1) Beets, mangels, turnips and ruta-bagas are susceptible to potato-scab in a marked degree if planted in soil infested with the fungus causing that disease. None of these root-crops therefore, should occupy land which has recently borne scabby potatoes.

(2) Radishes, parsnips, salsify and carrots show little if any susceptibility to potato-scab when exposed to it in the soil.

(3) Corrosive sublimate in a solution of the strength commonly employed as a disinfectant for potatoes infested with scab, tends to diminish the yield from root-crops so seriously when applied to the adjacent soil, that its use in this way can not be recommended. The same is true regarding solutions of lysol of a concentration of $\frac{1}{2}$% or more. The results of the experiment above tabulated seem to indicate that solutions of either corrosive sublimate or lysol, applied before seeding, to soil infested with potato-scab, will lessen very decidedly the amount of scab upon root-crops subject to this disease. It is questionable if these solutions, made of sufficient strength to insure partial immunity to the crop, will not so far decrease the yield as to render their use impracticable. The results indicate that further experiments in this direction are advisable.

ON A LEAF-BLIGHT OF MELONS.

BY WM. C. STURGIS.

Attention was called in our last Report, p. 186, to a serious disease of melons caused apparently by a fungus of the genus *Alternaria*. The disease attacked and practically ruined three large fields of melons owned by the Messrs. Meeker of Saugatuck. This year the owners were advised to make thorough applications of Bordeaux mixture, beginning just before the first flowers opened, and repeating the treatment three or four times at intervals of ten days. The melons were planted upon land which had not before been used for this purpose, and it was therefore hoped that the vines would be fully protected by the treatment. But late in July word was received from the Messrs. Meeker that the leaves of many of the vines were beginning to wilt and show other evidences of blight. Inspection of the vines showed a serious condition, but one differing decidedly in general appearance from that caused last year by the *Alternaria*. The spraying had been faithfully done and the vines were still covered with the mixture applied a few days previously for the third time, but the leaves were wilting and the edges turning yellowish in color. As the trouble advanced the portions first affected became brown and crisp, and sometimes the whole leaf was involved. The injury was further increased by the presence of great numbers of plant-lice which infested the lower side of the leaves and caused them to curl up, thereby preventing the thorough application of the Bordeaux mixture. Careful examination of the affected leaves showed only occasional indications of fungous-attack on the dead tissues. The portions of the leaves first affected were uniformly free from fungi, but it was observed that the texture of such leaves was abnormally thick and leathery, as though the tissues were surcharged with water. The weather had been such as to render this view highly probable. The wilting and yellowing of the leaves was first noticed as serious on July 23d. The weather for eight days previous to that date was characterized by long periods of cloudiness or haze sometimes followed by rain, alternating with short periods of clear, extremely hot sunshine. This condition was especially marked on July 18th and 19th. The melons occupied fairly level land having a southern exposure, so that during rainy weather the soil retained a great deal of water and was supposably reduced in temperature. Moreover, when the sun shone the vines were exposed to its full force. It was further observed that the wilted and blighted leaves of water-melons showed numerous corky blisters upon the yellow areas, apparently caused by the rupture and subsequent healing-over of cells turgid with water. That under such meteorological conditions the leaves of certain plants will suffer serious injury is attested by many observers. A trouble almost identical with this melon-blight did great damage to tomato-plants grown under glass at this Station, and is commonly associated with a burning sun immediately following a prolonged period of cloudy weather. Lodeman (Cornell Agr. Exp. Sta., Bull. 76, p. 429) calls attention to a similar trouble affecting grapevines, and agrees in attributing it to "a disturbance of the equilibrium existing between the absorption of water by the roots and its evaporation from the leaves." Bailey and Galloway recognize the same cause and effect in the case of blighted tomatoes. It is unnecessary here to discuss the scientific explanation of this phenomenon. It is sufficient to note that in the case of the melons there is no other sufficient cause to which the trouble can be attributed. The two species of fungi found occasionally upon the dead leaf-tissue are, it is true, the agents of a distinct disease, but in this case no trace of them was found in the early stages of the blight, and very few traces at any time; the plant-lice undoubtedly worked much injury, but the majority of the leaves upon which they were most abundant were not blighted, while the blighted leaves harbored few lice; the meteorological conditions, on the other hand, were such as to cause injuries identical with those observed.

It is difficult to offer any suggestions as to the prevention of such injury; it would seem however, that by providing for thorough drainage during rainy weather and for screening the vines in case of a sudden access of sunshine, it might be in a measure avoided.

N. B. For a further discussion of the cause of this trouble as seen in the case of tomato-plants, see p. 232 of this Report.

ON THE PROBABLE WINTER-CONDITION OF THE FUNGUS OF PEACH-SCAB.

(*Cladosporium carpophilum.*)

By Wm. C. Sturgis.

Early in March I received some specimens of peach-twigs which showed evidences of a diseased condition. They were abundantly marked with more or less circular blotches of a yellowish-brown color with a dark gray or black border, somewhat resembling in appearance the familiar "bird's-eye rot" of grapes (*Sphaceloma ampelinum*, de Bary). Frequently these spots or blotches became confluent and invested the twigs so completely as to mask the normal pinkish-brown color of the young bark. Investigation showed that this trouble was widely spread. The original specimens were received from Milford, later it was found on peach-trees at Cheshire and on the Experiment Station grounds, and in the neighborhood of Bridgeport it occurred abundantly on peach, almond and apricot. Upon the apricot trees examined the blotches were of a pale gray color, and the growth of the fungus beneath the cuticle had ruptured the latter so that the surface of the blotches appeared marked with fine longitudinal cracks. In some cases a black fungous growth occupying the margin of the blotch, was observable with a hand-lens.

Microscopic examination of thin sections of both diseased and normal bark showed the same conditions prevailing as a result of the fungous growth upon all the host-plants above mentioned.

A section of a normal twig shows first the comparatively thick *cuticle* composed of a single layer of brownish cells, the superficial walls of which are much thickened and hyaline. Beneath this layer are four or five layers of very much flattened cells constituting, together with the cuticle, the *epidermis* or bark. In the peach the sub-cuticular layers of cells are much less developed than in the apricot and are sometimes wholly wanting. The *cambium* or delicate growing tissue immediately below the bark, is composed in both cases of large, thin-walled cells, the contents of which are colored pink in the more superficial layers (thus giving the characteristic color to the young twigs), and are abundantly provided with chlorophyl in the deeper layers. The cambium may measure 0.2^{mm} or more in thickness; in its deeper layers are numbers of "cystoliths"—crystalline aggregations occupying intercellular cavities,—and beneath it are seen the groups of thick-walled wood-cells. So much for the microscopic structure of a normal twig of peach.

Sections through a diseased spot show a number of pathological changes. The cuticle has been partially broken down and separated from the layers of cells beneath; the latter have been increased in number by the transformation of the subjacent cambium cells into layers of flattened, corky cells, and the pink color of the upper layers of cambium cells has disappeared. By this transformation of the cambium cells the function of this layer is impaired, and if the injury becomes very deeply seated the cambium may become practically obliterated; this involves the death of the twig at that point. Occupying the spaces formed by the partial separation of the cuticle, is seen the *mycelium* or vegetative portion of a fungus, collected into aggregations of dark-brown spherical cells—a resting condition characteristic of the mycelium of many superficial or semi-superficial fungi. In many cases this mycelium has reached the surface through the cracks in the ruptured cuticle, and there are still to be seen the short, erect, brown *hyphae* upon which the spores of the former season were borne. What appear to be the spores themselves are occasionally seen, not attached to the *hyphae* or *sporophores*, but mingled with the fungous crust upon the surface of the bark. These spores are dark-brown, two-celled, and measure $15\mu - 21\mu \times 5\mu - 9\mu$, thus agreeing with those of the "peach-scab" fungus, *Cladosporium carpophilum*, Thüm.

At the time of this first examination the most careful search failed to show a single spore in direct connection with the mycelium; but on July 8th, twigs of peach showing the characteristic spots were collected at Milford, and the connection between the spores and the mycelium was evident. The edges of the spots were beset with a dense growth of erect fungous threads each bearing upon its tip a brown, two-celled spore identical with those seen earlier in the season.

Peach-scab is too well known to require any extended description. It attacks a number of stone-fruits such as the peach, nectarine, apricot, plum and cherry, producing small, round greenish-brown spots upon the fruit when not more than half grown. If the attack is severe the spots coalesce, the cells injured by the fungus repair the injury by the formation of cork, a hardening of

the tissues at that point results, they cease to expand and, as the surrounding portion of the fruit grows, the injured part cracks open, or the whole fruit becomes dwarfed and misshapen. The fungus causing this trouble has, until recently, been supposed to occur exclusively upon the fruit; Halsted however, has noted its occurrence on the leaves of the peach, where it produces a "shot-hole" injury.* He writes as follows: "The fungus prefers the portions of the leaf lying midway between the main veins, and as these portions become infested by the fungus the tissue dries up and finally falls away, leaving holes that are often circular in shape. The fungus upon the leaf agrees very closely with that upon the fruit, the chief difference, perhaps, being in the size of the spores, which are somewhat narrower as a rule than those upon the fruit."

We have therefore conclusive evidence that the fungus causing the scab of peaches and other stone-fruits, rendering them unsightly and diminishing their market-value, may do additional injury by attacking the leaves, and that it passes the winter in a sterile, resting condition on the twigs of the previous season's growth. With the advent of warm weather the fungus becomes active, and spores are produced abundantly which are carried by the wind or other agencies to the leaves and young fruit. Thus far the winter-condition has not been observed on other than peach, apricot and almond trees. The fact of its occurrence on the twigs suggests the advisability, in severe cases, of cutting away and burning the new wood in winter while the fungus upon it is dormant. In cases calling for less drastic treatment, great benefit would doubtless result from two thorough sprayings with a solution of 1 pound of copper sulphate in 25 gallons of water, applied early in the spring before the buds swell. If the previous crop of leaves or fruit has shown much scab, all the refuse should be gathered and burned before the copper sulphate solution is used. It can not be too strongly stated that when once the dormant stage of a parasitic fungus is known and located, preventive treatment is an easy matter as compared with the laborious operations necessary later, when the fungus is producing its myriads of spores, each a possible center of infection.

*N. J. Agr'l Exp't. Sta., Rep. for 1894, p. 329.

"*Cercospora Nicotianæ, E. & E. On leaves of tobacco, Raleigh, N. C. Oct., 1891. Spots amphigenous, pale, becoming white,* 2–5^{mm} *diam., with a narrow, inconspicuous, reddish, slightly raised border, often concave below. Hyphae tufted, amphigenous,* 75–100×4–5μ, 2–3-*times geniculate above and sometimes with a short lateral branch, brown, septate. Conidia slender,* 40–75×3–3½μ, *hyaline, slightly curved, multiseptate (mostly about* 6-*septate).*"

The general appearance of the specimens examined by me and the slightly larger size of the spores indicate that the fungus was more luxuriant and more perfectly developed than in the case of the specimens which served as a basis for the original description; otherwise the agreement is exact. The fruiting threads of the fungus are found usually near the centers of the diseased spots on both surfaces of the leaf. They arise from the delicate vegetative threads which permeate the leaf-tissues in all directions, and as a rule they issue in tufts through the "breathing-pores" or *stomata* of the leaf, each thread or *sporophore* bearing upon its tip a long, tapering spore divided by cross-partitions into a number of cells. (Plate VIII, figs. 1 and 2.) The spores germinate readily, and when bits of the infested leaves are floated upon water in a watch-glass for 24–48 hours the microscope shows the spores producing germ-tubes which grow over the surface of the leaf, gain entrance through the *stomata*, and spread rapidly within the tissues of the leaf. (Plate VIII, fig. 3.)

The trouble seemed to be so serious that, at Prof. Halsted's suggestion, I entered into correspondence with Mr. J. R. Barron, of Workman, S. C., from whom the diseased leaves came. This correspondence elicited the following facts regarding the prevalence and the serious character of the disease in the South. Mr. Barron states that, while it is new in his immediate neighborhood, it has long been known in North Carolina. The present season seems to have been peculiarly favorable to its spread; it caused a loss of $1,000 on Mr. Barron's crop, in fact the crop throughout his section of the country was practically ruined by it and at last accounts it was spreading. It attacks at least four different varieties of tobacco grown on various soils, loamy, clayey and upland. There seems to be no definite period at which the plant first becomes subject to the disease, the latter sometimes appearing by the time the young plants show six leaves, sometimes not until later, but the period of worst attack seems to be just as the tobacco is ripening. Mr. Barron writes that the weather in his neighborhood was very dry up to June 20th, but moderately damp from that time until harvest, a fact which, taken in connection with the late appearance of the trouble, would indicate that the latter thrives best in damp weather. In the localities where the disease occurs, it is commonly known as "frog-eye," but this term seems to include at least two distinct conditions of the tobacco-leaf. In the Tenth Census of the United States (1880), Vol. III, p. 856, occurs the following note upon "Frog-eye" or "White-speck:" "This disease, if it is such, is of rare occurrence, and is little understood. In Florida, white specks are a sure indication of fine texture in the leaf, and this 'frog-eye' appearance was at one time much esteemed. This particular marking seems to result from conditions of soil or climate, or from both, and some varieties are more frequently affected than others." This seems to be a different thing from the trouble caused by the Cercospora, though known by the same name. Under the name of "small-pox" (*Pockenkrankheit*), several European observers describe a disease of tobacco common abroad and evidently very similar in appearance to our "frog-eye," but all agree in attributing it to a deficient supply of water occasioned either by an imperfect development of the root-system or by a lack of moisture in the soil.

A third disease, somewhat similar in character, is known among tobacco-growers in Virginia as "spot" or "firing," and is attributed to sudden changes from very wet to very dry weather, or *vice versa*. This trouble, however, seems to be sufficiently distinct from the "frog-eye" to be disregarded in this connection.

Finally, Ellis & Everhart described in 1892 a fungus occurring upon tobacco in North Carolina, which they named *Macrosporium tabacinum*. After describing it they say, "This is the 'White-speck' of the North Carolina planters." The fungus *Macrosporium* is certainly as distinct as possible from *Cercospora*, and upon the very many leaves which I examined, and which were abundantly spotted with the latter fungus, I found no trace of the former.

We have, therefore, (1) the "frog-eye" or "white-speck" of the Census Report; (2) the "small-pox" of European observers; (3) the "white-speck" of the North Carolina planters, due to a *Macrosporium*; and (4) the "frog-eye" of North and South Carolina, uniformly associated with a species of *Cercospora*. It seems probable that the primary cause of the trouble mentioned

in the Census Report was overlooked, and that the "frog-eye" and the "white-speck" of the southern States are very similar diseases caused by two distinct species of fungi, but often confounded by the casual observer. The European trouble is probably different, as it seems impossible that a fungus so apparent as either of those above mentioned could have been overlooked by careful observers.

The problem of finding a preventive for a fungous disease which attacks the leaves of tobacco in the field is an extremely difficult one. Bordeaux mixture would doubtless check the "frog-eye," but its use would be very questionable, owing to the gummy texture of the tobacco-leaf and the use to which the leaf is put. Possibly by beginning the treatment soon after the plants are set and discontinuing it at least a month before cutting, the disease would be prevented and at the same time the ripening leaves be freed by subsequent rains from all traces of the fungicide. This result would be more certainly attained by the use of the ammonia solution of copper-carbonate, a powerful fungicide which the texture of the leaf would cause to adhere sufficiently well, but which would wash off more readily and completely than Bordeaux mixture.

A third fungicide of possible value in this connection is flowers of sulphur dusted upon the leaves. This would undoubtedly adhere well, and would be much more convenient to apply than any liquid fungicide inasmuch as, in the case of tobacco, any fungicide would have to be applied by hand. Used liberally in clear, sunny weather, sulphur has a very marked fungicidal value.

Finally, it is quite possible that judicious fertilizing might so far increase the vigor of the plants as to render them less subject to, if not exempt from fungous disease.

There is good evidence to show that, in the case of peach trees, the application of a soluble nitrogenous plant-food, such as nitrate of soda, serves to increase the general vigor of the trees and thus prevent the attacks of the shot-hole fungus (*Cercospora Persica*), a disease very similar to the "frog-eye" of tobacco. With this idea in mind, a sample of the fertilizer chemical used by Mr. Barron was secured and was submitted to Mr. Winton, of this Station, for analysis, with the following result:

Total Nitrogen	2.16%
Total Phosphoric Acid	12.32%
Total Potash (as Muriate)	1.09%
Chlorine	1.05%

These figures indicate a rather low-grade quality of fertilizer with a marked deficiency of potash, but whether this fact is sufficient in itself to account for the susceptibility of the tobacco to fungous attack remains to be proved. Mr. Barron was advised to experiment in this direction by increasing the percentage of potash, using for this purpose either the sulphate, or else cotton-hull ashes, and to compare the results so obtained with those obtained on an adjoining plot fertilized with the low-grade fertilizer analyzed by us. Until more definite information is obtained on this point some advantage would doubtless result from careful attention to drainage, in case the soil is inclined to be soggy, and the burning of all refuse from a diseased crop.

Meanwhile, it would be well for Connecticut tobacco-growers to be on the watch for this leaf-disease and to report it immediately upon its appearance, in order that preventive measures may be instituted without delay.

NOTES ON THE SO-CALLED "SHELLING" OF GRAPES.

By Wm. C. Sturgis.

Although the condition of grapes known as "shelling" has been carefully investigated and its probable cause assigned,* the trouble has been reported once in this State and it therefore seems advisable to comment briefly upon its character, cause and possible prevention.

The single case reported occurred during the past summer at Cheshire on a row of Niagara grapes, and was first noticed about Aug. 20th. The characteristics of the disease are very evident in the fruit. Shelling grapes, at least in the case of green varieties, show a peculiar though indistinct mottling of the surface; the skin is abnormally thick and the whole berry therefore feels harder than healthy berries at the same stage of development; a section of a diseased berry shows a narrow brown zone just beneath the skin; the taste of shelling grapes is noticeably insipid as compared with the tart, astringent flavor of the unripe but healthy fruit; finally, the woody tissues of the stem which enter the fruit and, in the case of sound berries, remain attached to the stem when the berry is pulled off, are so far weakened in

* Lodeman in Cornell Univ. Agr. Exp. Sta., Bull. 76, pp. 413–440, Nov., 1894.

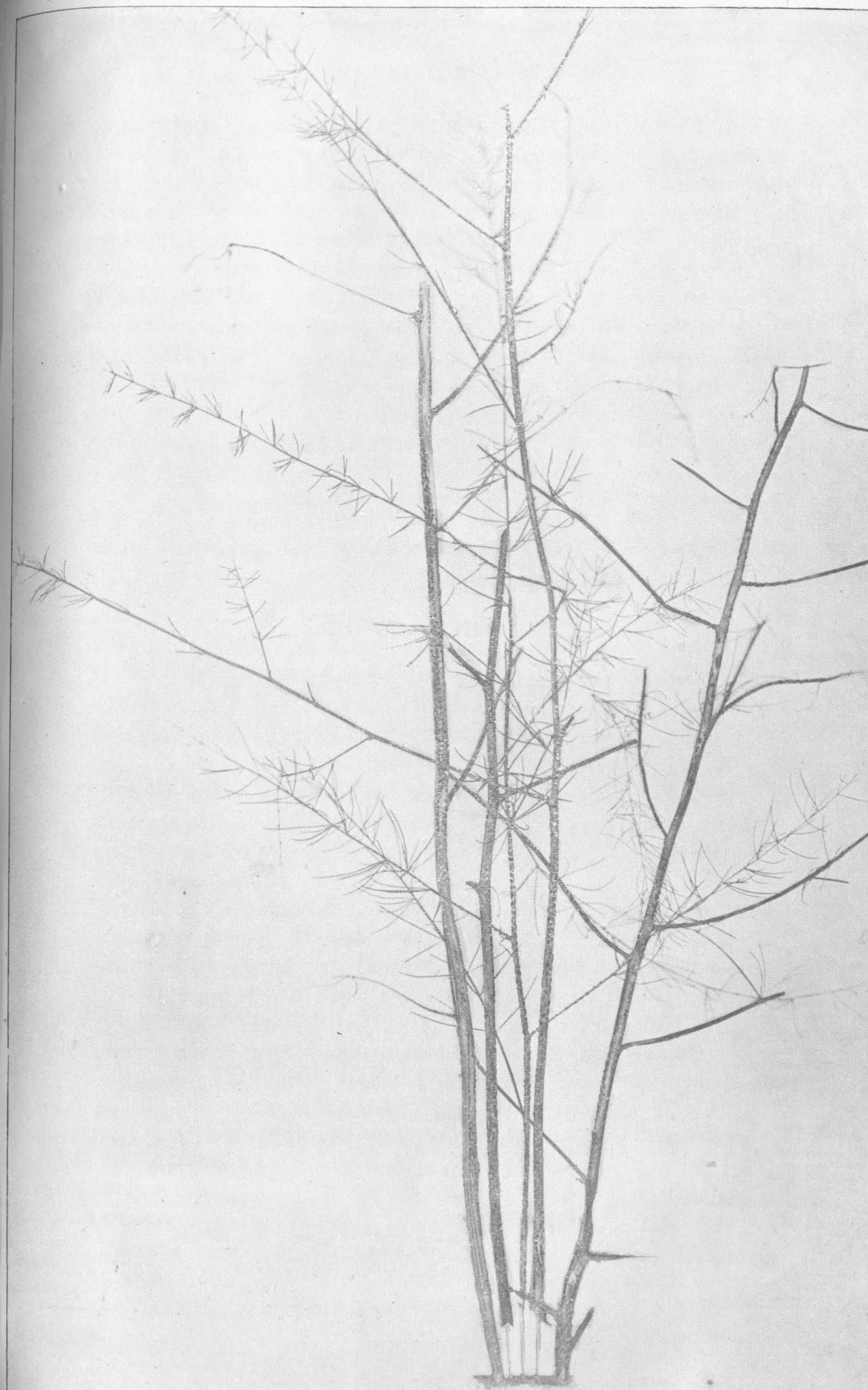
the case of shelling grapes that the weight of the berry is sufficient to cause them to separate from the stem, and the berries fall to the ground, leaving the end of the stem perfectly even, "as if cut with a knife." This dropping of the fruit from two to three weeks before maturing is a characteristic symptom of shelling, and may result in very serious loss, a loss emphasized by the fact that the trouble does not confine itself to certain bunches on a vine leaving others unaffected, but affects portions, generally the end, of every bunch.

After a most exhaustive consideration of all the possible causes of shelling, Lodeman concludes (l. c., p. 452) that neither insects nor fungi are to be considered as a primary cause of the trouble; that the condition of the soil, apart from the supply of available plant-food, does not exercise any marked influence on the degree of shelling; that meteorological conditions are not primarily responsible for it; and that it is not due to a lack of phosphoric acid. Among the agencies which may increase or favor the diseased condition, Lodeman mentions parasitic fungi, which weaken the function of the leaves; a weakening of the plant due to over-bearing; the drawing of nourishment from the fruit by the over-production of wood; an excessive supply of nitrogen emphasized by too much tillage; prolonged drought or excessive rains following drought; and a poorly developed root-system resulting in a general weakening of the plant. The condition of the food-supply as regards potash seems to be the only remaining factor to be considered, and Lodeman is inclined to attribute the primary cause of shelling to a lack of that element. This view is in a measure substantiated by observation and experiment.

The conditions under which shelling occurred at Cheshire are in line with Lodeman's conclusions. The vines have occupied for nine years a piece of land formerly used for a nursery; the soil is light, well-drained and naturally dry; the only fertilizer which has been applied has been occasional odds and ends, such as waste mortar, cellar sweepings, etc. Under these conditions one would suspect a lack of potash in the soil. The general condition of the vines was poor. The leafage was not over-abundant and was badly affected with downy mildew; the crop was fair, apart from the shelling, but fully half the fruit had dropped from the latter cause. There had been abundance of rain throughout the season, a horse-cultivator had been used two or three times, but no work had been done with the hoe and the ground was decidedly weedy.

DESCRIPTION OF PLATE IX.

Stems of Asparagus affected with "Rust," caused by the fungus *Puccinia Asparagi*, DC. The black sori are seen occupying lines and patches on the stems. Slightly reduced.



The fungus is easily recognized upon close inspection. It presents the appearance of small rust-colored or black pustules, technically called *sori*, arranged in lines or scattered groups upon the stem and branches of the affected plant. (Plate IX.) Microscopic examination shows that these *sori* have their origin within the tissues of the plant, and later rupture the epidermis, producing innumerable spores freely exposed to the air (Plate VIII, figs. 4–7). These spores are of two kinds, first, a form, almost spherical and one-celled, which may be called the summer-spores; these appear first and impart their color to the pale or rusty-brown *sori* (Plate VIII, figs. 4 & 5). The second form appears later; they are almost black in color, borne on long stalks, provided with thick walls, and divided in the middle by a cross-partition. (Plate VIII, figs. 6 & 7.) These we may call the winter-spores, since it is they which live through the winter upon the refuse of the diseased bushes and serve to propagate the disease with the return of warm weather in the spring. There can be no question but that this fungus bids fair to become a serious pest, and the only practical method of keeping it in check at present consists in burning every vestige of the diseased bushes. It is barely possible that some fungicidal treatment may prove available, but the rust-fungi are usually very resistant to fungicides, and thorough burning in the autumn or late summer will be more than likely to make unnecessary a resort to fungicides the following season.

The Spread of the San José Scale in Connecticut.—In the Report of this Station for 1895, p. 192, attention was called to the recent appearance of this dreaded scale-insect in the neighborhood of New London, Hartford and Bridgeport. At that time we sent out circulars to ninety-two fruit growers, all of whom had purchased trees from a New Jersey nursery known to have been infested with the scale. We have received forty-three replies to these circulars, of which thirteen report the presence of the scale, twenty-eight are negative and two doubtful. The centers of infection at present are along the coast at Darien, Bridgeport, New Haven, New London, Groton and Mystic; and in Hartford County at Hartford, Farmington, New Britain and Plantsville. Taking the forty-three replies received to our circular as a basis for estimate, it seems fair to conclude that the scale is very widely spread throughout the fruit-growing portions of the State. With regard to remedial measures nothing can be

added at present to the recommendations published in Bulletin 121 of this Station and included in our Annual Report for 1895, pp. 194–202.

A word of warning, however, should be said regarding the use of a substance known as "Dendrolene." This material was originally prepared in New Brunswick, N. J., and was highly recommended as a means of preventing the attacks of borers, canker-worms, plant-lice, the pear psylla, codling moths and scales, with no injury to the trees, except when applied to young twigs or in such a manner as to cover the buds. Later we received from the Bowker Fertilizer Co., of Boston, a can of dendrolene, with the request that we give it a trial. At this time we were preparing to treat the orchard of Mr. J. L. Raub, of New London, which was completely infested with the San José scale, as well as with the bark-beetle, *Scolytus rugulosus*. Early in April the trees infested with scale were treated with a solution of whale-oil soap in the proportion of 1 lb. to 5 galls. No injury resulted from this treatment, and specimens of bark sent us by Mr. Raub on April 16th showed only about 20 per cent. of living scales. On April 23rd the dendrolene was sent to Mr. Raub with directions as to its use. It was to be applied in a thin coating with a paint-brush to the trunk and limbs of two infested peach trees; two neighboring trees, equally infested, were to receive a coat of whitewash; two others a solution of caustic potash, and the remainder of the infested trees were to be treated with kerosene emulsion. All of the peach trees infested with the bark-beetle were to be treated with dendrolene. Through a misunderstanding the dendrolene was used much more generally throughout the orchard than we had intended, but the quantity originally sent was small, so that each tree received only a thin coating upon the trunk and the base of the branches. Under date of June 4th word was received from Mr. Raub that all of the trees treated with dendrolene were dying. I at once visited the orchard and examined the trees. I found the bark beneath the dendrolene in bad condition, but at the time I attributed that condition to the effect of the scale, and expected, now that the latter were dead, that the bark would recover. It seemed best, however, to advise a cessation of further treatment. Early in November Mr. Raub wrote that the trees had not recovered, and the cause of death was evident upon examination of specimens of bark sent at the same time. The dendrolene upon them was still slightly sticky; it had penetrated the outer bark and had reduced the cambium to a brown, damp powder. It seems advisable to record the disastrous effect following the use of dendrolene in this instance, since the article has been widely advertised on the basis of a most careful and, on the whole, successful trial in New Jersey, but has since been found by Profs. Troop, of the Indiana Experiment Station, and Goff, of the Wisconsin Station, to produce results identical with those above reported.

The only plausible explanation of these facts is, that the substance at present sold as dendrolene is of a different composition from that originally made and named by Prof. Nason, of New Brunswick, N. J. This explanation is borne out by the fact that the successful experiments in New Jersey upon which the value of dendrolene is based were all made with the article as prepared by Professor Nason, while the complaints regarding it have all emanated from those who have used the article as prepared and sold by the Bowker Fertilizer Co. Fruit-growers are therefore warned that the use of dendrolene, as at present prepared, is attended with great danger to the trees to which it is applied, and that, at best, it is unsafe to make free use of dendrolene until some means is found of lessening its penetrating power.

EXPERIMENTS IN GROWING TOBACCO WITH DIFFERENT FERTILIZERS.

FINAL REPORT ON THE FERMENTED CROPS OF 1895.

By E. H. Jenkins.

The object of these experiments is to study the effects on the quality of wrapper-leaf tobacco of certain fertilizers commonly used by our Connecticut growers. Each plot under experiment receives the same fertilizers for a term of years in order to test these fertilizers under the varying climatic conditions which a succession of years affords, and final judgment on the quality of the crops is made after they have been fermented in the case and are ready for manufacture.

The work was begun in 1892 and has been carried on each year since then by this Station, in connection with the Connecticut Tobacco Experiment Company.

A full description of this experiment will be found in former reports of this Station, viz.: 1892, pp. 1–24; 1893, pp. 112–144; 1894, pp. 254–284; 1895, pp. 128–156.

An account of the growing, harvesting and curing of the crop of 1895 is printed on pages 146 to 156 of the 19th Annual Report of this Station for 1895.

Samples of the long and short wrappers from each plot, with top leaves and seconds sufficient to fill the case, were cased down for fermentation at the warehouse of Mr. L. B. Haas in Hartford, on Dec. 14th, 1895. The case lay undisturbed till Nov. 23d, 1896, when it was opened and the samples examined.

Shrinkage during Fermentation.

The tobacco weighed 337 pounds when it was cased. After fermentation it weighed 301 pounds, having lost in the intervening time 36 pounds, or 10.7 per cent.

This loss is less than has been previously observed in our experiments. The percentage losses each year have been, crop of 1892, 13.8 per cent.; of 1893, 14.0; of 1894, 11.1, and of 1895, 10.7 per cent.

The fermented crop of 1893 was judged by the expert to be "unsweated," while the others were called "well sweated," and particularly this crop of 1895, which had lost less weight by fermentation than any of the others.

It is the *nature* of the change during fermentation—about which almost nothing is known at present—and not the total loss by fermentation, which determines the effect of the process on the quality of the leaf.

Judgment of the Expert.

Each lot of tobacco was marked with a number, different from the one used in the previous year, and which gave no indication of the plot from which the tobacco came.

The lots were examined and graded by Mr. Benjamin L. Haas of Hartford, who has done the same work each year since beginning the experiment. Mr. Haas devoted two days to the work, and there has thus been secured a perfectly unbiased and intelligent judgment by an expert fully acquainted with the present requirements of the trade.

A strict judgment has been given, noting all defects in the leaf.

The crops on the experiment field were in general of quite as good quality as those grown elsewhere in the neighborhood.

General Remarks.—All the samples of tobacco from the experiment field were ripe and sound.

In general all the samples show a great improvement in burn over those of previous crops. The short, light wrappers on all the plots are nearer what the trade wants in tobacco than anything we have produced hitherto, not excepting the crop of 1892.

There are few lots of really poor tobacco, and some of the lots have been graded down simply on account of their color. While most of the tobacco crops of 1895, examined by Mr. Haas, have showed some white vein after fermentation, the tobacco from the experiment field has scarcely a trace of it.

Some of the lots have a white deposit on the stem and veins, extending occasionally to other parts of the leaf surface.

This is usually called in the trade "white mold," a name which covers two very distinct things. One is a fungus, firmly attached to the tissues, the other is a crystalline salt of magnesia, probably the malate, which is easily brushed off from the affected leaves. Both damage the leaf for sale, though the latter disappears entirely in the process of manufacture and does not damage either the taste or burning quality of the leaf. The former is not

so readily gotten rid of and may possibly be the cause of the mustiness which develops during fermentation and ruins the quality of the leaf.

The lots of tobacco which showed any traces of those two kinds of "white mold" were lots H, K, M, O, AA, on which there was a very small amount of the genuine mold, and lots E, G, H, K, M, N, O, R, S, X, Z, on which there was the white crystalline salt.

In every case the amount found was very small, not enough to seriously damage the selling quality.

Following are the details of the expert's judgment of the separate crops:

Lot A.

Fertilizers: 1579 lbs. cottonseed meal and 1297 lbs. cotton hull ashes per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $46.55 per ton.

Yield: 830 lbs. long wrappers per acre.
220 " short " " "
Total 1050 "

Quality:—*Burn*, holds fire well, coals very slightly. *Ash*, clear gray, hard. *Colors*, medium mottled. *Texture*, well sweated, open grain, fair finish. *Yield*, fairly profitable. *Size*, undesirable. *Vein*, fine. *Stem*, small. *Relative rank*, 14th.

Lot B.

Fertilizers: 1669 lbs linseed meal and 1324 lbs. cotton hull ashes per acre, containing 105 lbs. nitrogen, 152 lbs. phosphoric acid and 340 lbs. potash. Cost, $52.32.

Yield: 780 lbs. long wrappers per acre.
240 " short " " "
Total 1020 "

Quality: *Burn*, holds fire well, coals very slightly. *Ash*, clear gray, hard. *Colors*, dark mottled. *Texture*, well sweated, open grain, dull finish. *Yield*, fairly profitable. *Size*, very desirable. *Vein*, light. *Stem*, medium. *Relative rank*, 10th.

Lot C.

Fertilizers: 2631 lbs. cottonseed meal and 1221 lbs. cotton hull ashes per acre, containing 175 lbs. nitrogen, 177 lbs. phosphoric acid and 340 lbs. potash. Cost, $56.41 per acre.

Yield: 950 lbs. long wrappers per acre.
330 " short " " "
Total 1280 "

Quality:—*Burn*, good, holds fire fairly. *Ash*, clear white, hard. *Colors*, dark. *Texture*, well sweated, open grain, dull finish. *Yield*, unprofitable. *Size*, undesirable. *Vein*, prominent. *Stem*, medium. *Relative rank*, 25th.

LOT D.

Fertilizers: 3158 lbs cottonseed meal and 1184 lbs. cotton hull ashes per acre, containing 210 lbs. nitrogen, 186 lbs. phosphoric acid and 340 lbs. potash. Cost, $61.38 per acre.

Yield: 1170 lbs. long wrappers per acre.
300 " short " " "

Total 1470 "

Quality:—*Burn*, holds fire well. *Ash*, mixed gray, hard, *Colors*, dark. *Texture*, good open grain, well sweated, dull finish. *Yield*, fairly profitable. *Size*, medium to large. *Vein*, fine. *Stem*, light. *Relative rank*, 9th.

LOT E.

Fertilizers: 2083 lbs. castor pomace, 1254 lbs. cotton hull ashes per acre, containing 105 lbs nitrogen, 205 lbs. phosphoric acid and 340 lbs. of potash. Cost, $43.83 per acre.

Yield: 1010 lbs. long wrappers per acre.
300 " short " " "

Total 1310 "

Quality:—*Burn*, holds fire. *Ash*, mixed gray, hard. *Colors*, medium mottled, dark. *Texture*, well sweated, open grain, dull finish. *Yield*, unprofitable. *Size*, undesirable. *Vein*, curly. *Stem*, heavy. *Relative rank*, 22d.

LOT F.

Fertilizers: 1669 lbs. linseed meal, 536 lbs. cotton hull ashes and 277 lbs. Cooper's bone per acre, containing 105 lbs. nitrogen, 152 lbs. phosphoric acid and 150 lbs. of potash. Cost, $38.47 per acre.

Yield: 640 lbs. long wrappers per acre.
220 " short " " "

Total 860 "

Quality: *Burn*, holds fire well, coals very slightly. *Ash*, clear gray, hard. *Colors*, dark mottled. *Texture*, well sweated, medium open grain, dull finish. *Yield*, fairly profitable. *Size*, medium to large. *Vein*, light. *Stem*, medium. *Relative rank*, 16th.

LOT G.

Fertilizers: 3472 lbs. castor pomace and 1149 lbs. cotton hull ashes per acre, containing 175 lbs. nitrogen, 253 lbs. phosphoric acid and 340 lbs. of potash per acre. Cost, $51.87 per acre.

Yield: 850 lbs. long wrappers per acre.
290 " short " " "

Total 1140 "

Quality:—*Burn*, coals slightly, holds fire. *Ash*, clear gray, inclined to flake. *Colors*, medium to dark. *Texture*, well sweated, open grain, dull finish. *Yield*, unprofitable. *Size*, medium to large. *Vein*, medium to large. *Stem*, medium. *Relative rank*, 28th.

LOT H.

Fertilizers: 4166 lbs. castor pomace and 1097 lbs. of cotton hull ashes per acre, containing 210 lbs. nitrogen, 277 lbs. phosphoric acid and 340 lbs. of potash per acre. Cost, $55.93 per acre.

Yield: 1190 lbs. long wrappers per acre.
260 " short " " "

Total, 1450 "

Quality:—*Burn*, holds fire fairly, coals slightly. *Ash*, mixed gray, hard. *Colors*, dark mottled. *Texture*, well sweated, medium close grain, dull finish. *Yield*, fairly profitable. *Size*, medium to large. *Vein*, small. *Stem*, medium. *Relative rank*, 18th.

LOT I.

Fertilizers: 2083 lbs. castor pomace, 1254 lbs. cotton hull ashes, 640 lbs. nitrate of soda per acre (the latter in two applications after planting), containing 210 lbs. nitrogen, 205 lbs. phosphoric acid and 340 lbs. of potash. Cost, $59.84 per acre.

Yield: 1310 lbs. long wrappers per acre.
260 " short " " "

Total, 1570 "

Quality:—*Burn*, holds fire well. *Ash*, clear gray, hard. *Colors*, medium, mottled. *Texture*, well sweated, open grain, dull finish. *Yield*, fairly profitable. *Size*, undesirable. *Vein*, fine. *Stem*, medium. *Relative rank*, 15th.

LOT J.

Fertilizers: 2083 lbs. castor pomace, 1254 lbs. cotton hull ashes, and 640 lbs. of nitrate of soda per acre (the latter applied at time of first cultivation), containing 210 lbs. nitrogen, 205 lbs. phosphoric acid and 340 lbs. of potash. Cost, $59.84 per acre.

Yield: 1270 lbs. long wrappers per acre.
320 " short " " "

Total, 1590 "

Quality:—*Burn*, holds fire well. *Ash*, clear gray, hard. *Colors*, clear, dark. *Texture*, well sweated, open grain, fair finish. *Yield*, profitable. *Size*, medium to large. *Vein*, fine. *Stem*, light. *Relative rank*, 5th.

LOT K.

Fertilizers: 1579 lbs. cottonseed meal, 1102 lbs. double sulphate of potash and magnesia, and 457 lbs. Cooper's bone, per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $40.29 per acre.

Yield: 830 lbs. long wrappers per acre.
270 " short " " "

Total, 1100 "

Quality: *Burn*, holds fire fairly. *Ash*, clear white, hard. *Colors*, medium to light. *Texture*, well sweated, open grain, dull finish. *Yield*, fairly profitable. *Size*, medium to large. *Vein*, medium to small. *Stem*, medium. *Relative rank*, 12th.

LOT L.

Fertilizers: 1579 lbs. cottonseed meal, 1102 lbs. double sulphate of potash and magnesia, 457 lbs. Cooper's bone, and 300 lbs. of lime per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. of potash. Cost, $42.27 per acre.

Yield: 640 lbs. long wrappers per acre.
250 " short " " "

Total, 890 "

Quality: *Burn*, holds fire fairly. *Ash*, clear, white. *Colors*, medium to dark. *Texture*, open grain, well sweated, dull finish. *Yield*, unprofitable. *Size*, undesirable. *Vein*, prominent. *Stem*, prominent. *Relative rank*, 23d.

LOT M.

Fertilizers: 1579 lbs. cottonseed meal, 621 lbs. high grade sulphate of potash and 457 lbs. Cooper's bone, per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $39.28 per acre.

Yield: 640 lbs. long wrappers per acre.
250 " short " " "

Total, 890 "

Quality: *Burn*, coals but holds fire fairly. *Ash*, clear gray, hard. *Colors*, light, clear. *Texture*, close grain, fairly sweated, good finish. *Yield*, fairly profitable. *Size*, medium. *Vein*, fine. *Stem*, light. *Relative rank*, 21st.

LOT N.

Fertilizers: 1579 lbs. cottonseed meal, 621 lbs. high grade sulphate of potash, 457 lbs. Cooper's bone and 300 lbs. of lime per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs of potash. Cost, $41.26 per acre.

Yield: 840 lbs. long wrappers per acre.
310 " short " " "

Total, 1150 "

Quality:—*Burn*, coals slightly, holds fire fairly. *Ash*, clear gray, inclined to flake. *Colors*, medium to dark. *Texture*, well sweated, inclined to close grain, dull finish. *Yield*, unprofitable. *Size*, medium to large. *Vein*, prominent. *Stem*, medium. *Relative rank*, 26th.

LOT O.

Fertilizers: 1579 lbs. cottonseed meal, 578 lbs. carbonate of potash and 457 lbs. Cooper's bone, per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $72.90 per acre.

Yield: 840 lbs. long wrappers per acre.
310 " short " " "

Total, 1150 "

Quality:—*Burn*, coals slightly, holds fire well. *Ash*, mixed gray, hard. *Colors*, medium to dark, bright. *Texture*, well sweated, open grain, fine finish. *Yield*, very profitable. *Size*, very desirable. *Vein*, fine. *Stem*, light. *Relative rank*, 4th.

LOT P.

Fertilizers: 1579 lbs. cottonseed meal, 1728 lbs. double carbonate of potash and magnesia and 457 lbs. of Cooper's bone, per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $57.64 per acre.

Yield: 740 lbs. long wrappers per acre.
330 " short " " "

Total, 1070 "

Quality:—*Burn*, perfect, holds fire well. *Ash*, clear white, hard. *Colors*, medium to dark. *Texture*, good open grain, well sweated, fine finish. *Yield*, very profitable. *Size*, desirable. *Vein*, fine. *Stem*, light. *Relative rank*, 1st.

LOT Q.

Fertilizers: 2000 lbs. H. J. Baker's A. A. Ammoniated Superphosphate and 4000 Baker's Tobacco Manure per acre, containing 240 lbs. nitrogen, 453 lbs. phosphoric acid and 434 lbs. potash per acre.

Yield: 900 lbs. long wrappers per acre.
200 " short " " "

Total, 1100 "

Quality:—*Burn*, coals slightly, does not hold fire. *Ash*, mixed gray, hard. *Colors*, medium to dark. *Texture*, open grain, well sweated, dull finish. *Yield*, unprofitable. *Size*, medium to large. *Vein*, fine. *Stem*, medium. *Relative rank*, 24th.

LOT R.

Fertilizers: 2000 lbs. Stockbridge Tobacco Manure and 500 lbs. of the same used as a starter, per acre, containing 154 lbs. nitrogen, 307 lbs. phosphoric acid and 278 lbs. potash, per acre.

Yield: 810 lbs. long wrappers per acre.
240 " short " " "

Total, 1050 "

Quality:—*Burn*, holds fire well, coals slightly. *Ash*, clear gray, hard. *Colors*, clear, light. *Texture*, open grain, well sweated, fine finish. *Yield*, profitable. *Size*, medium to large. *Vein*, curly. *Stem*, medium. *Relative rank*, 7th.

LOT S.

Fertilizers: 3000 lbs. Stockbridge Tobacco Manure and 500 lbs. of the same used as a starter, per acre, containing 215 lbs. nitrogen, 430 lbs. phosphoric acid and 389 lbs. of potash per acre.

Yield: 1110 lbs. long wrappers per acre.
230 " short " " "

Total, 1340 "

Quality:—*Burn*, holds fire well, coals. *Ash*, mixed gray, hard. *Colors*, clear, light. *Texture*, well sweated, fairly open grain, fine finish. *Yield*, profitable. *Size*, medium. *Vein*, fine. *Stem*, medium. *Relative rank*, 8th.

LOT T.

Fertilizers: 945 pounds dry fish scrap, 547 lbs. nitrate of soda, 300 lbs. of lime per acre, containing 175 lbs. nitrogen, 70 lbs. phosphoric acid and no potash. Cost, $32.19 per acre.

Yield: 580 lbs. long wrappers per acre.
140 " short " " "

Total, 720 "

Quality:—*Burn*, does not hold fire, coals. *Ash*, white, flakes. *Colors*, dark, mottled. *Texture*, not well sweated, close grain, no finish. *Yield*, unprofitable. *Size*, undesirable. *Vein*, heavy, curly. *Stem*, coarse. *Relative rank*, 29th.

LOT U.

Fertilizers: 2200 lbs. Mapes' Tobacco Manure, wrapper brand, and 600 lbs. Mapes' Tobacco Starter. per acre, containing 138 lbs. nitrogen, 232 lbs. phosphoric acid and 291 lbs. potash per acre.

Yield: 970 lbs. long wrappers per acre.
210 " short " " "

Total, 1180 "

Quality:—*Burn*, holds fire well, coals very slightly. *Ash*, mixed gray, hard. *Colors*, clear light. *Texture*, well sweated, open grain, fine finish. *Yield*, profitable. *Size*, medium to large. *Vein*, curly. *Stem*, medium to large. *Relative rank*, 13th.

LOT V.

Fertilizers: 2400 lbs. Mapes' Tobacco Manure, wrapper brand, 400 lbs. Mapes' Tobacco Starter, per acre, containing 143 lbs. nitrogen, 219 lbs. phosphoric acid, 309 lbs. potash.

Yield: 790 lbs. long wrappers per acre.
210 " short " " "

Total, 1000 "

Quality:—*Burn*, holds fire fairly well, coals very slightly. *Ash*, mixed gray. *Colors*, clear, light. *Texture*, well sweated, open grain, fine finish. *Yield*, very profitable. *Size*, medium to large. *Vein*, fine. *Stem*, light. *Relative rank*, 3d.

LOT W.

Fertilizers: 2400 Mapes' Tobacco Manure, wrapper brand, per acre, containing 130 lbs. nitrogen, 165 lbs. phosphoric acid, 296 lbs. potash per acre.

Yield: 850 lbs. long wrappers per acre.
210 " short " " "

Total, 1060 "

Quality:—*Burn*, holds fire fairly well. *Ash*, clear gray. *Colors*, clear, light. *Texture*, well sweated, open grain, fine finish. *Yield*, very profitable. *Size*, medium to large. *Vein*, fine. *Stem*, light. *Relative rank*, 2d.

LOT X.

Fertilizers: 2000 lbs. Sanderson's Tobacco Formula per acre, containing 99 lbs. nitrogen, 156 lbs. phosphoric acid and 122 lbs. potash per acre.

Yield: 1000 lbs. long wrappers per acre.
210 " short " " "

Total, 1210 "

Quality:—*Burn*, does not hold fire, coals. *Ash*, mixed gray, hard. *Colors*, dark. *Texture*, medium close grain, well sweated, dull finish. *Yield*, unprofitable. *Size*, undesirable. *Vein*, medium. *Stem*, medium. *Relative rank*, 27th.

LOT Y.

Fertilizers: 1579 lbs. cottonseed meal and 7290 lbs. wood ashes per acre, containing 105 lbs. nitrogen, 214 lbs. phosphoric acid and 340 lbs. potash. Cost, $55.27 per acre.

Yield: 690 lbs. long wrappers, per acre.
270 " short " " "

Total, 960 "

Quality:—*Burn*, holds fire well. *Ash*, clear gray. *Colors*, medium to dark. *Texture*, well sweated, close grain. *Yield*, fairly profitable. *Size*, desirable. *Vein*, fine. *Stem*, light. *Relative rank*, 6th.

LOT Z.

Fertilizers: 1134 lbs. dry ground fish, 1197 lbs. double sulphate of potash and magnesia, 283 lbs. Cooper's bone, per acre, containing 105 lbs. nitrogen, 159 lbs. phosphoric acid and 340 lbs. potash. Cost, $41.74 per acre.

Yield: 710 lbs. long wrappers per acre.
260 " short " " "

Total, 970 "

Quality:—*Burn*, holds fire well. *Ash*, clear, white, hard. *Colors*, dark, mottled. *Texture*, well sweated, medium open grain, dull finish. *Yield*, unprofitable. *Size*, medium to large. *Vein*, curly. *Stem*, medium. *Relative rank*, 11th.

LOT AA.

Fertilizer: 10 to 12 cords of stable manure per acre, containing 111 lbs. nitrogen, 71 pounds phosphoric acid, 149 lbs. potash per acre.

Yield: 580 lbs. long wrappers per acre.
250 " short " " "

Total, 830 "

Quality:—*Burn*, holds fire fairly. *Ash*, clear white, hard. *Colors*, medium to light. *Texture*, well sweated, open grain, dull finish. *Yield*, fairly profitable. *Size*, medium to large. *Vein*, medium to small. *Stem*, medium. *Relative rank*, 17th.

LOT BB.

Fertilizers: 6000 lbs. tobacco stems and 2894 lbs. castor pomace per acre, containing 239 lbs. nitrogen, 74 lbs. phosphoric acid and 517 lbs. potash. Cost, $63.71 per acre.

Yield: 1250 lbs. long wrappers per acre.
270 " short " " "

Total, 1520 "

Quality:—*Burn*, coals, holds fire fairly. *Ash*, mixed gray. *Colors*, medium to dark. *Texture*, well sweated, medium close grain. *Yield*, unprofitable. *Size*, medium to large. *Vein*, small. *Stem*, medium. *Relative rank*, 19th.

LOT CC.

Fertilizers: 3000 lbs. Pinney's Formula Fertilizer per acre, containing 131 lbs. nitrogen, 196 lbs. phosphoric acid and 305 lbs. potash per acre.

Yield: 740 lbs. long wrappers per acre.
230 " short " " "

Total, 970 "

Quality:—*Burn*, holds fire fairly, coals slightly. *Ash*, mixed gray, hard. *Colors*, dark, mottled. *Texture*, fairly sweated, medium close grain, dull finish. *Yield*, unprofitable. *Size*, medium to large. *Vein*, medium. *Stem*, medium. *Relative rank*, 20th.

The lots in order of their value as wrappers, taking all points into consideration, are graded as follows:

P (best),	W,	V,	O,	J,	Y,	R,	S,	D,	B,	Z,	K,
1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.
U,	A,	I,	F,	AA,	H,	BB,	CC,	M,	E,	L,	
13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st.	22d.	23d.	
Q,	C,	N,	X,	G,	T (poorest).						
24th.	25th.	26th.	27th.	28th.	29th.						

The first five in the above list differ *very* little in quality.

From 25 to 35 leaves were weighed on a balance sensitive to $\frac{1}{30}$ of an ounce, and from these weights the results in the table are computed.

NUMBER OF FERMENTED LEAVES TO THE POUND. CROP OF 1895.

Plot.	Long Wrappers.	Short Wrappers.	Plot.	Long Wrappers.	Short Wrappers.
A	54	84	P	80	94
B	66	95	Q	60	83
C	57	84	R	56	89
D	70	73	S	56	92
E	63	84	T	52	86
F	70	84	U	56	83
G	52	73	V	51	83
H	58	89	W	67	103
I	47	80	X	56	80
J	54	92	Y	69	89
K	55	89	Z	71	88
L	54	78	AA	63	79
M	58	73	BB	56	54
N	56	86	CC	61	103
O	60	86			

The average number of leaves per pound, before and after fermenting, are as follows:

CROP OF 1895. NUMBER OF LEAVES TO THE POUND.

	Pole-cured.	Fermented.
Short wrappers	79	85
Long wrappers	55	60

EFFECTS OF DIFFERENT FORMS OF NITROGEN.

Cottonseed Meal and Castor Pomace.

Plots A, C and D received 105, 175 and 210 pounds of nitrogen respectively, per acre, in form of cottonseed meal, together with about 150 pounds of phosphoric acid and 340 pounds of potash in form of cotton hull ashes.

Plots E, G and H each received the same quantities of cotton hull ashes and 105, 175 and 210 pounds of nitrogen respectively, per acre, but the latter in form of castor pomace.

The largest amount of fertilizer-nitrogen yielded in each case the largest crop.

The yield of wrapper leaf grown on these two fertilizers was practically the same, there being an average difference of only 35 pounds to the acre in favor of the castor pomace, which yielded 1,300 pounds of wrapper leaf per acre. The per cent. of wrapper leaves in the crops and the number of wrapper leaves per pound was also practically the same.

The lots A, C, D (cottonseed meal) were graded 14th, 25th and 9th. The lots E, G, H (castor pomace) were graded 22d, 28th and 18th.

The average quality of the leaf raised on cottonseed meal was therefore rather better than that raised on castor pomace.

Linseed Meal.

Plot B was dressed with 105 pounds of nitrogen per acre in form of linseed meal and with the same amount of cotton hull ashes as A and E, which received their nitrogen in form of cottonseed meal and castor pomace.

Plot B yielded nearly as much wrapper leaf as Plot A (cottonseed meal), a larger proportion being short wrappers. The number of leaves to the pound was larger and in other respects the quality was somewhat better, being graded 10th. Plot F, with the same amount of linseed meal and phosphoric acid but half the quantity of potash that was put on B, yielded considerably less tobacco and was graded 16th.

Fish.

Plot L was dressed with dry ground fish, which supplied 105 pounds of nitrogen per acre, and with 1,260 pounds of double sulphate of potash and magnesia. This plot yielded 80 pounds less of wrappers per acre than A (cottonseed meal) and 340 pounds less than E (castor pomace). The quality of leaf was quite as good as either and was graded 11th.

Plot T, which received 175 pounds of nitrogen per acre in form of fish and nitrate of soda, *with no potash*, produced but a small quantity of wrappers of very inferior quality;—the only lot of really bad tobacco in the whole experiment field.

Nitrate of Soda, at First and Second Cultivation.

This experiment is to ascertain the effect on the crop of supplying one-third of the nitrogen of a heavy application (210 pounds per acre) as a top dressing in the form of nitrate of soda, either in one application at the time of first cultivation (Plot I), or in two applications at the time of the first and second cultivation (Plot J).

In this year the effect has been to increase the yield of wrapper leaf over that of plot H, which was dressed with the same amount of nitrogen all in the form of castor pomace, and the quality of the leaf is also somewhat better, lots I and J being graded 15th and 5th respectively, H being 18th. Different results have been obtained in previous crops, and on the whole this method of fractional fertilization has not been successful.

Stable Manure.

Plot AA was dressed in 1895 with from 10 to 12 cords of stable manure, but no "starter" or other commercial fertilizer was added, as it was thought the land was now rich enough in plant food to dispense with anything more than the manure itself supplied.

The yield of wrappers was the smallest on the whole field excepting plot T, and the quality of the crop was not more than average, and was graded 17th. In 1894, this plot was dressed with Swift-Sure Superphosphate in addition to the stable manure, and the crop, though quite small (560 pounds of wrappers per acre) was of better quality than any other in the field.

Tobacco Stems.

Plot BB, dressed with 3 tons of tobacco stems to the acre and nearly 3,000 pounds of castor pomace, yielded one of the largest crops of wrappers (1,520 pounds per acre), of rather less than average quality, graded 19th.

EFFECT OF DIFFERENT FORMS OF POTASH.

Plots A, K, L, M, N, O, P and Y were dressed with like quantities of nitrogen (in form of cottonseed meal), phosphoric acid and potash; but the potash was supplied in different forms.

The results of the experiments are summarized in the following table:

Plot,	Source of Potash.	Weight of wrappers. Long.	Short.	No. of wrapper leaves in a pound. Long.	Short.	No. of seconds during which leaf holds fire.	Relative rank.
P	Double carbonate potash and magnesia	740	330	80	94	52	1st
O	Carbonate of potash	840	310	60	86	38	4th
Y	Wood ashes	690	270	69	89	56	6th
A	Cotton hull ashes	830	220	54	84	33	14th
K	Double sulphate potash and magnesia	830	270	55	89	31	12th
L	Double sulphate potash and magnesia with lime	640	250	54	78	40	23d
M	High grade sulphate of potash and magnesia	640	250	58	73	32	21st
N	High grade sulphate of potash and magnesia with lime	840	310	56	86	40	26th

The results of these experiments agree in the main with the corresponding ones made in the three previous years. The various forms of carbonate of potash have yielded on the whole better tobacco than the sulphates, and the low grade sulphate has produced better tobacco than the high grade. Tobacco raised on high grade sulphate has each year shown a tendency to "coal" on the cigar even when it was free-burning.

The above summary presents briefly the results of the experiments of 1895. The experiments of 1896 close the series. The crop of 1896 is now in the case for fermentation and will be examined by the expert in the fall of 1897. A complete review of the whole five years' work can then be given.

EXPERIMENTS IN GROWING TOBACCO WITH DIFFERENT FERTILIZERS. SEASON OF 1896.

BY E. H. JENKINS.

These experiments are in continuation of those begun in 1892 in coöperation 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 Reports of this Station for 1892, pages 1 to 24; for 1893, pages 112 to 144; for 1894, pages 254 to 284; for 1895, pages 128 to 156.

FERTILIZERS.

The fertilizers used in 1896 were sampled and analyzed by Messrs. Winton, Ogden and Mitchell with the following results:

COMPOSITION AND COST OF FERTILIZERS USED.

	Cost Per Ton.	Percentage Composition. Nitrogen.	Phosphoric Acid.	Potash.
Nitrate of Soda	$45.00	16.00	----	----
Cotton Seed Meal	23.50	7.38	3.28	1.93
Castor Pomace	20.00	4.72	1.89	1.06
Linseed Meal	18.00	6.72	1.89	1.30
Tobacco Stems	12.00	1.90*	.60*	8.10*
Cooper's Bone	28.00	2.33	27.89	
Cotton Hull Ashes	45.00	----	8.99	25.48
Wood Ashes	15.00	----	----	4.58
High Grade Sulphate of Potash	50.00	----	---	48.98
Carbonate of Potash	170.00†	----	----	54.10
Double Carbonate Potash and Magnesia	39.00‡	----	----	18.10
Double Sulphate Potash and Magnesia	30.00	----	----	26.44
Fish	35.00	8.33	6.84	----

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.

* Estimated. † By single pound; ton rates would be much lower.
‡ Total cost of importing a one ton lot from Stassfurt.

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.

FERTILIZERS APPLIED, SEASON OF 1896.

Name of Plot.	FERTILIZERS APPLIED. Pounds per Acre.	Cost per Acre.	Fertilizer contains pounds. Nitrogen.	Phosphoric Acid.	Potash.
A	1423 Cotton Seed Meal 1227 Cotton Hull Ashes	$44.50	105	157	340
B	1562 Linseed Meal 1254 Cotton Hull Ashes	42.28	105	143	340
C	2371 Cotton Seed Meal 1156 Cotton Hull Ashes	53.99	175	182	340
D	2845 Cotton Seed Meal 1121 Cotton Hull Ashes	59.58	210	195	340
E	2225 Castor Pomace 2141 Cotton Hull Ashes	50.17	105	152	340
F	1562 Linseed Meal 509 Cotton Hull Ashes 242 Cooper's Bone	28.90	105	143	150
G	3707 Castor Pomace 1180 Cotton Hull Ashes	63.62	175	177	340
H	4450 Castor Pomace 1150 Cotton Hull Ashes	70.37	210	188	340
I	2225 Castor Pomace 1241 Cotton Hull Ashes 328 Nitrate of Soda* 326 Nitrate of Soda†	64.93	210	152	340
J	2225 Castor Pomace 1241 Cotton Hull Ashes 656 Nitrate of Soda	64.93	210	152	340
K	1423 Cotton Seed Meal 1182 Double Sulphate of Potash and Magnesia 396 Cooper's Bone	40.06	105	157	340
L	1423 Cotton Seed Meal 1182 Double Sulphate of Potash and Magnesia 396 Cooper's Bone 300 Lime	42.04	105	157	340
M	1423 Cotton Seed Meal 638 High Grade Sulphate of Potash 396 Cooper's Bone	38.28	105	157	340

* Applied between the rows July 7. †Applied between the rows July 20.

Fertilizers Applied, Season of 1896.

Name of Plot.	FERTILIZERS APPLIED. Pounds per Acre.	Cost per Acre.	Fertilizer contains pounds.		
			Nitrogen.	Phosphoric Acid.	Potash.
N	1423 Cotton Seed Meal 638 High Grade Sulphate of Potash 396 Cooper's Bone 300 Lime	40.26	105	157	340
O	1423 Cotton Seed Meal 578 Carbonate of Potash 396 Cooper's Bone	$71.46	105	157	340
P	1423 Cotton Seed Meal 1724 Double Carbonate Potash and Magnesia 396 Cooper's Bone	55.94	105	157	340
Q	2000 Baker's A. A. Superphosphate 4000 Baker's Tobacco Manure	----	238	452	522
R	2000 Stockbridge Tobacco Manure	----	116	227	202
S	3000 Stockbridge Tobacco Manure	----	174	340	303
T	1050 Dry Ground Fish 550 Nitrate of Soda 300 Lime	32.83	142	71	----
U	2000 Mapes' Tobacco Manure, Wrapper Brand	----	120	114	212
V	2400 Mapes' Tobacco Manure, Wrapper Brand 400 Mapes' Starter	----	157	190	268
W	2400 Mapes' Tobacco Manure, Wrapper Brand	----	145	136	254
X	2000 Sanderson's Formula for Tobacco	----	88	241	172
Y	1423 Cotton Seed Meal 6825 Wood Ashes	66.79	105	150	340
Z	1260 Dry Ground Fish 1211 Double Sulphate of Potash and Magnesia 256 Cooper's Bone	43.79	104	86	340
AA	Stable Manure 10–12 cords*	----	111	71	149
BB	3091 Tobacco Stems	36.00	111	36	486
CC	3000 Pinney's Formula Fertilizer	----	131	196	305

* Estimated to contain 111 lbs. nitrogen, 71 lbs. phosphoric acid and 119 lbs. potash.

Plowing, Planting and Care During Growth.

On April 7th and again on April 14th, the field was harrowed.

The fertilizers were evenly broadcast on the several plots, May 11th, and plowed in. The field was again harrowed on the 12th.

A few weeks before the plants were set, the field was found to be infested with cut-worms which fed upon the young weeds as they came up.

To rid the land of cut-worms, small handfuls of an even mixture of 500 pounds of damp wheat bran and 5 pounds of Paris green were dropped, about 2 paces apart, on the rows where tobacco plants were to be set. Multitudes of the worms were found, poisoned by this mixture.

The tobacco plants were set with the Bemis planter, on May 25th, 12 days after the application of Paris green. In former years a good many plants have been eaten by cut-worms the night after planting; this year not a single plant was found to be injured.

On May 30 about 100 plants in all had been destroyed by cut-worms or wire worms, and were replaced. On June 6th about 50 more were replaced. No further damage was done by worms. In each of the four previous years the cut-worms have killed large numbers of plants and in consequence the stand of tobacco has been uneven.

July 14th the first topping of the tobacco was done, about half the plants requiring it. The others were topped on the 18th. The crop was harvested on Aug. 11th and 12th.

Copious rains fell after the tobacco was set, but the crop did not start as promptly nor grow as vigorously through the season as the year before. It is probable that a part of the fertilizer was either carried out of reach of the young plants by the rains, immediately after planting, or that the roots were slow to reach it.

In 1892 excellent results followed from harrowing in the fertilizer lightly; (abundant rain followed planting).

In 1893, the fertilizer was harrowed in, but the plants were somewhat "burned" by the fertilizer; (little rain followed planting).

In 1895, excellent results followed from plowing in the fertilizer; (rather dry weather followed planting).

In 1896, the fertilizer was plowed in as in 1895, but the crop was slow in starting and backward in development till near harvest time; (abundant rains followed planting).

It is likely that soluble plant food moves easily in the very light sandy soils on which tobacco is grown, following the movement of water in the soil.

If the land is dressed with large amounts of fertilizer chemicals which are only harrowed in, and if very dry weather follows planting the tender plants may be burned, but if the fertilizer is plowed in, it is distributed in moister soil, where the roots strike down for water.

If, on the other hand, copious rain immediately follows planting, the fertilizer which has been lightly harrowed in may be carried down no further than the roots easily reach, while, if plowed in, it may be carried by the rains below this point and so be in part at least lost to the crop.

At planting time, therefore, it is not possible to determine which way of putting in fertilizer will give the better results.

RAINFALL.

The rainfall during the growing season, measured in a standard rain-gauge by Mr. Adelbert DuBon, was as follows:

Date.	Inches of rainfall.	Date.	Inches of rainfall.
May 28	1.00	July 7	0.19
" 31	0.60	" 9	0.20
June 9	0.33	" 16	0.26
" 10	1.63	" 21	0.25
" 14	1.75	" 24	0.65
" 16	0.82	" 27	0.23
" 21	0.09	Aug. 2	0.73
July 4	0.63	" 9	0.12
" 5	0.32	" 14	1.24

Total, 11.04 inches.

The tobacco crop, from setting time to harvest, was in the field 79 days. On 18 or more of those days rain fell, and the longest period during which there was no rain was 13 days.

Observations of soil temperature and moisture were not made in 1896.

HARVESTING, CURING, STRIPPING AND SORTING.

The crop was harvested on Aug. 12th.

The weather was generally favorable during the period of curing, and the pole-cured crop showed neither pole-burn nor white vein.

It was taken down from the poles, cured, on Oct. 6th, and was stripped and bundled on the 7th. The sorting was begun on Oct. 26th and was finished on the 31st.

At each handling of the crop a representative of the Station was present; all weights were made and recorded, and samples drawn by him.

As the crops were sorted, samples were carefully drawn from each lot of long and short wrappers and labeled 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 ("sand leaves"), 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 much used for cigar binders. The "top leaves" are often as large as the long wrappers, but heavier, darker in color and unripe.

WEIGHTS, IN POUNDS, OF THE BARN-CURED LEAVES FROM $\frac{1}{20}$ ACRE.
CROP OF 1896.

Plot.	Long Wrappers.	Short Wrappers.	Top Leaves.	Seconds.	Total.
A	41¾	13¼	16¾	9¼	81
B	30	12¾	17½	12	72¼
C	40¾	14¼	14½	8¼	77¾
D	47¼	13¾	17¼	8¼	86½
E	42¾	13¼	18¾	10¾	85½
F	20	10¾	17¾	12	60½
G	40¾	13½	16¾	9¾	80¾
H	47	13¾	15½	12½	88¾
I	45¼	14	18¼	9	86½
J	43¼	14¼	17¾	9¾	85
K	45¼	14¼	16¼	8¼	84
L	32¼	11¼	18¼	14	75¾
M	32¾	12½	20¾	11	77
N	40¾	14½	18¼	8¼	81¾
O	34	14½	15	8½	72
P	26¼	13¼	12¾	10½	62¾
Q	26¾	11	17¾	14½	70
R	32¼	11¼	19¼	12½	75¼
S	36	12¾	18½	9¼	76½
T	--	--	--	--	69*
U	42⅜	12⅜	18	10⅞	83⅝
V	37⅛	11⅝	19½	9	77¼
W	27⅜	10½	16⅞	9⅜	64⅛
X	30	11¼	16¼	11¼	68¾
Y	31¾	10	16¼	11½	69½
Z	37½	12½	16¼	10	76¼
AA	32½	8	18	10¼	68¾
BB	41½	14¾	15	8	79¼
CC	27	12¼	17	9¼	65½

* Crop very poor in quality. Not sorted.

Per Cent. of the Four Different Grades.

Pole-cured Crop of 1896.

Plot.	Long Wrappers.	Short Wrappers.	Total per cent. of Wrappers.	Top Leaves.	Seconds
A	52	16	68	21	11
B	42	18	60	24	16
C	52	18	70	19	11
D	55	16	71	20	9
E	50	16	66	22	12
F	33	17	50	29	21
G	50	17	67	21	12
H	53	16	69	17	14
I	52	16	68	21	11
J	51	17	68	20	12
K	54	17	71	19	10
L	43	15	58	24	18
M	42	16	58	27	15
N	49	18	67	22	11
O	47	20	67	21	12
P	42	21	63	20	17
Q	38	16	54	25	21
R	43	15	58	25	17
S	47	17	64	24	12
T	--	--	--	--	--
U	50	15	65	21	14
V	48	15	63	25	12
W	42	16	58	26	16
X	44	16	60	24	16
Y	46	14	60	23	17
Z	49	16	66	21	13
AA	47	12	59	26	15
BB	52	19	71	19	10
CC	41	19	60	26	14

Comparative Fire-holding Capacity.

Pole-cured Crop, 1896.

The method of determining the fire-holding capacity is described in the Station Report for 1892, page 17, and the meaning of the figures in the following table is described on page 296 of the present report.

Plot.	Long Wrappers.	Short Wrappers.	Calculated from the average of both.	Plot.	Long Wrappers.	Short Wrappers.	Calculated from the average of both.
A	330	259	290	P	214	159	183
B	274	237	253	Q	100	100	100
C	306	236	267	R	183	144	161
D	223	165	190	S	157	137	146
E	188	158	171	T	---	---	---
F	185	218	205	U	165	132	147
G	208	157	177	V	146	220	190
H	151	143	147	W	206	167	184
I	229	211	220	X	131	109	119
J	201	249	231	Y	288	239	262
K	137	109	121	Z	129	149	141
L	171	117	140	AA	163	134	148
M	121	119	121	BB	241	158	194
N	135	113	123	CC	126	114	119
O	187	169	177				

Number of Pole-cured Leaves to the Pound.

Crop of 1896.

Plot.	Long Wrappers.	Short Wrappers.	Plot.	Long Wrappers.	Short Wrappers.
A	60	85	P	63	81
B	63	87	Q	58	75
C	56	82	R	54	91
D	57	68	S	64	92
E	51	83	T	--	--
F	76	102	U	63	72
G	65	78	V	61	86
H	51	79	W	62	97
I	59	83	X	61	91
J	64	83	Y	89	106
K	56	86	Z	60	88
L	54	88	AA	62	92
M	61	95	BB	59	92
N	60	84	CC	72	98
O	70	72			

The average number of short wrapper leaves to the pound was 86; of the long wrapper leaves 62.

SOME RESULTS OF THE EXPERIMENTS WITH TOBACCO FERTILIZERS FOR THE FIVE YEARS, 1892–1896.

By E. H. Jenkins.

These experiments, begun in 1892, with the co-operation of the Connecticut Tobacco Experiment Co., have been made for five consecutive years. The crop of 1896, described in the preceding paper, completes the series. Samples of this crop are now cased down for fermentation and cannot be graded as to their quality until October or November, 1897.

Final discussion of the quality of the tobacco from the several plots must, of course, be reserved till that time.

We may, however, compare the average yields of these plots for the five-year period and examine those qualities of the crop which have been determined in the unfermented leaves.

1. Effect of the Quantity of Fertilizer-nitrogen on the Amount and Quality of the Crop.

Plots A, C, D, E, G and H have received annually, for five years, 340 pounds of potash and from 140 to 190 pounds of phosphoric acid per acre, chiefly in form of cotton hull ashes.*

Plots A, C and D have also received annually cottonseed meal, and plots E, G and H, castor pomace, in such quantities that plots A and E had annually 105 pounds of nitrogen per acre, plots C and G 175 pounds and plots D and H 210 pounds of fertilizer-nitrogen. Table I shows the statistics of the crops.

* The only other source of potash and phosphoric acid has been the nitrogenous matter (cottonseed meal or castor pomace), which supplied a comparatively small amount. This large quantity of potash was used because experienced growers suggested it and it agrees with a common practice. We believe the amount is much larger than is generally required. The amount of phosphoric acid, too, is probably largely in excess of the crop requirements, but as it came from the ashes used, the quantity could not be made less without lessening the potash supplied.

Table I.—Tobacco Experiment, 1892–1896. Effect of Different Amounts of Nitrogen. Yearly Averages.

Plot.	Fertilizer-nitrogen. Source of Nitrogen.	Fertilizer-nitrogen. Pounds per acre.	Tobacco Crop, pounds per acre. Total.	Tobacco Crop. Long Wrap.	Tobacco Crop. Short Wrap.	Percentage of Wrap.	No. of pole-cured Leaves to pound. Long Wrap.	No. of pole-cured Leaves to pound. Short Wrap.	No. of seconds holds fire. Long Wrap.	No. of seconds holds fire. Short Wrap.
A	Cotton Seed Meal	105	1615	740	245	61	66	89	14	15
E	Castor Pomace ..	105	1760	803	203	60	59	84	10	15
	Average		**1688**	**772**	**224**	**61**	**63**	**87**	**12**	**15**
C	Cotton Seed Meal	175	1673	795	276	64	61	85	12	14
G	Castor Pomace ..	175	1700	769	267	61	62	81	10	13
	Average		**1687**	**782**	**272**	**63**	**62**	**83**	**11**	**14**
D	Cotton Seed Meal	210	1839	957	268	67	60	85	10	15
H	Castor Pomace ..	210	1863	996	271	68	60	84	10	12
	Average		**1851**	**977**	**269**	**68**	**60**	**85**	**10**	**14**

Table I shows that

1. 210 pounds of fertilizer-nitrogen per acre, either in form of castor pomace or cottonseed meal, have given a larger crop of tobacco annually for five years than either 105 or 175 pounds of fertilizer-nitrogen.

This gain has been in wrapper-leaf altogether; the more valuable part of the crop. The percentage of wrapper-leaf in the crop was 68 when 210 pounds of fertilizer-nitrogen were used, 63 and 61 when smaller quantities of fertilizer-nitrogen were applied.

Where 210 pounds of fertilizer-nitrogen were used, the pole-cured wrapper-leaves were very slightly heavier (60 long wrapper-leaves, 85 short wrapper-leaves to the pound) than those raised with smaller amounts of fertilizer-nitrogen (63 long wrappers, 87 short wrappers per pound). The difference in fire-holding capacity was too slight to have significance.

2. The plot having 210 pounds of nitrogen in form of cottonseed meal produced 224 pounds more of crop than the one having 105 pounds of nitrogen. At 12½ cents per pound this gain amounts to $28.06 per acre. The increased amount of fertilizer, 1500 pounds, at $25.00 per ton, costs $18.75, so that it has paid to use the larger quantity of fertilizer—provided the quality of the leaf was not damaged by it.

The quality of the 1896 crop cannot be determined till the fall of 1897, but the tobacco from plots having the largest quantity of fertilizer-nitrogen, whether cottonseed meal or castor pomace, has, on the average of four years' crops, been of better quality than that from plots with smaller amounts of fertilizer-nitrogen.

Can Part of a Heavy Dressing of Nitrogen be Advantageously Applied in Form of Nitrate of Soda, During the Growing Season?

(Plots I and J compared with H.)

The same quantities of cotton hull ashes were put on plots H, I and J for five years. The same quantities of nitrogen (210 pounds) were also put on these three plots.

But while the nitrogen applied to plot H was all in form of castor pomace, plots I and J received only 105 pounds of nitrogen per acre, in form of castor pomace, and the other 70 pounds in form of nitrate of soda, either in one application, plot J, or in two, plot I.

Following are the results:

Table II.—Effect of Nitrate of Soda Added During the Growing Season. Yearly Averages.

Source of Nitrogen.	Plot H. Castor Pomace.	Plot I. Castor Pomace and Nitrate of Soda.	Plot J. Castor Pomace and Nitrate of Soda.
Amount of Fertilizer-Nitrogen, pounds per acre	210	210	210
Yield of leaf tobacco in pounds,			
Total	1863	1860	1932
Long wrappers	996	973	1040
Short "	271	273	293
Per cent. of wrappers in Crop	68	67	69
No of pole-cured leaves in 1 pound			
long wrappers	60	63	65
short "	84	83	80
No. of seconds holds fire, long wrappers	10	9	10
Short wrappers	12	15	16

The average yield of tobacco as well as the yield of wrapper leaves was decidedly larger on plot J, which received part of its nitrogen in a single application of nitrate of soda after the crop was nearly half grown, than on either of the other plots; the individual leaves were no heavier, nor was there any perceptible difference in fire-holding capacity. The quality of the wrapper leaf must determine whether the practice is a profitable one. The indications are that the quality of the crops, where nitrate of soda was applied after the plants were partly grown, was inferior to that of plot H, to which no nitrate was added.

Comparison of Cotton Seed Meal and Castor Pomace as Tobacco Fertilizers.

Table I, page 311, gives the data necessary for this comparison.

The crops fertilized with castor pomace have been uniformly larger than those fertilized with cottonseed meal, the average yearly difference for five years being 111 pounds per acre, and the difference in wrapper leaf being 25 pounds annually, in favor of castor pomace. There has been no significant difference in the weight of 100 wrapper leaves or in the fire-holding capacity.

At $12\frac{1}{2}$ cents per pound, 111 pounds of tobacco would bring $13.87. As the average cost of nitrogen in castor pomace has been four cents more per pound than in cottonseed meal during the five years of this experiment, 210 pounds of fertilizer-nitrogen from castor pomace have cost $8.40 more than the same quantity of nitrogen from cotton seed. So that the net annual profit from the use of castor pomace instead of cottonseed meal is not more than $5 47 per acre, *provided the quality of the crop is the same.*

For four years the relative rank of the tobaccos grown on the several plots named in the table above has been—

Table III. — Quality of the Tobacco from Plots Named, Expressed by the Relative Rank.

	105 lbs. Nitrogen. Plot A. Cotton Seed Meal.	105 lbs. Nitrogen. Plot E. Castor Pomace.	175 lbs. Nitrogen. Plot C. Cotton Seed Meal.	175 lbs. Nitrogen. Plot G. Castor Pomace.	210 lbs. Nitrogen. Plot D. Cotton Seed Meal.	210 lbs. Nitrogen. Plot H. Castor Pomace.
1892	10th	16th	2d	4th	3d	5th
1893	23	29	5	22	8	9
1894	5	28	11	15	16	14
1895	14	22	25	28	9	18
Average	**13th**	**24th**	**11th**	**17th**	**9th**	**11th**

The relative quality of tobacco from plots A, C, D, dressed with different amounts of cottonseed meal, has been 13th, 11th, 9th. The relative quality of the corresponding plots dressed with castor pomace has been 24th, 17th, 11th.

It is therefore quite clear that the average quality of the tobacco raised with cottonseed meal has been somewhat better than that of tobacco raised with castor pomace.

Comparison of Linseed Meal with Cotton Seed Meal and Castor Pomace.

(Plot B compared with plots A and E.)

This test was begun in 1893 and has therefore been carried on for only four years.

Plot B was annually dressed with the same quantity of cotton hull ashes as plots A and E, but was dressed with 105 pounds of nitrogen per acre, in form of linseed meal, while A and E received like amounts of nitrogen in form of cottonseed meal and castor pomace, respectively.

The data for the comparison are as follows:

TABLE IV. — COMPARISON OF LINSEED MEAL WITH COTTON SEED MEAL AND CASTOR POMACE.

Source of Nitrogen.	Plot B.* Linseed Meal.	Plot A.* Cotton Seed Meal.	Plot E.* Castor Pomace.
Amount of Nitrogen per acre, pounds	105	105	105
Average annual yield in pounds, Total	1501	1585	1740
Long wrappers	664	732	820
Short wrappers	222	219	223
Per cent. of Wrappers in Crop	59	60	60
No. of pole-cured leaves in 1 pound long wrappers	61	63	57
Short wrappers	85	85	81
No. of seconds holds fire, long wrappers	12	14	10
short "	15	15	15

These data show that the average total yield of tobacco from linseed meal, in the four years of the test has been somewhat less than from cottonseed meal and considerably less than from castor pomace. There is a corresponding difference in the weight of the wrapper leaves.

Three of the four crops have been examined and graded as to quality. The relative ranks of those crops raised on linseed meal, plot B, were 1st, 6th, 10th, while those raised on cottonseed meal were, in the same years, 23d, 5th, 14th, and on castor pomace 29th, 28th and 22d.

In the three years of which we have complete data less tobacco was raised on linseed meal than on equivalent quantities of either castor pomace or cottonseed meal, but the quality of leaf raised on linseed meal was better than that from the other forms of nitrogen.

COMPARISON OF FISH WITH COTTON SEED MEAL AS A FERTILIZER FOR TOBACCO.

(Plot Z compared with plot K.)

Plots Z and K in 1893 and the following years were dressed with like quantities of bone and double sulphate of potash and magnesia. Each plot also received annually 105 pounds of nitrogen, plot Z in form of dry ground fish, plot K in form of cotton seed meal. The data regarding the crops are given below:

* For the years 1893–1896 only.

TABLE V.—COMPARISON OF FISH WITH COTTON SEED MEAL AS A TOBACCO FERTILIZER.

Source of Nitrogen.	Plot Z.* Dry Fish.	Plot K.* Cotton Seed Meal.
Amount of Nitrogen per acre, pounds	105	105
Average annual yield of tobacco in pounds, total	1496	1740
Long wrappers	611	879
Short "	228	217
Per cent. of wrappers in Crop	56	63
No. of pole-cured leaves in 1 pound long wrappers	62	58
short "	82	87
No. of seconds holds fire, long wrappers	7.6	7.6
short wrappers	11.1	9.7

The average annual yield per acre from dry fish has been much less than from cottonseed meal, by about 250 pounds, and the per cent. of wrappers in the crop has been considerably smaller (56 per cent. from dry fish, 63 per cent. from cottonseed meal). The crop from dry fish in 1893 was very small, one-half what it was in the next three years, and each successive crop has been larger than the one next preceding it, indicating perhaps that the nitrogen of fish is more slowly available, and that its effects are in consequence more lasting. The tobacco of the three crops on plot K (cottonseed meal), ranked 15th, 17th and 12th. The three corresponding crops on Z (fish), have ranked 12th, 3d and 11th. Hence for three successive years quite as good tobacco, though not as many pounds per acre, has been raised with dry fish and potash salts as with an equivalent quantity of cottonseed meal and potash salts.

STABLE MANURE AND TOBACCO STEMS.

Plots AA and BB were introduced into the experiment in 1893. In 1892 when the other plots were under tillage, these plots were uncultivated and were covered with a sparse growth of poverty grass and blackberry vines. Hence a *strict* comparison of these with the other plots cannot be made.

Plot AA has been dressed annually for four years with mixed yard manure at the rate of 10–12 cords per acre, estimated to supply about 111 pounds of nitrogen, 71 pounds of phosphoric acid and 149 pounds of potash. In 1893 and 1894 it also received 500 pounds per acre of Swift-Sure Superphosphate, containing 15 pounds of nitrogen, 72 pounds of phosphoric acid and 23 pounds of potash.

Plot BB has received in each of the four years 6000 pounds of tobacco stems, containing 111 pounds of nitrogen, 36 pounds of

* Four years, 1893–1896.

phosphoric acid and 486 pounds of potash. In 1893 and 1894 it likewise received 500 pounds of Swift-Sure Superphosphate.

The average results for the four years are given in Table VI, and for comparison the corresponding figures for plot A (average of the same four years).

TABLE VI.—STABLE MANURE COMPARED WITH COTTON SEED MEAL AND TOBACCO STEMS.

Fertilizer.	Plot A.* Cotton Seed Meal and Cotton Hull Ashes.	Plot AA.* Stable Manure.	Plot BB.* Tobacco Stems.
Average yearly yield of leaf-tobacco, pounds per acre	1585	1390	1654
Average yearly yield of long wrappers, pounds per acre	733	470	745
Average yearly yield of short wrappers, pounds per acre	219	211	231
Per cent of wrappers in crop	60	49	59
No. of pole-cured leaves in 1 pound of long wrappers	63	64	67
No. of pole-cured leaves in 1 pound of short wrappers	85	74	85
No. of seconds holds fire, long wrappers	14	10	10
No. of seconds holds fire, short wrappers	15	12	12

The much smaller crops raised on stable manure are explained in part by the fact that the nitrogen of stable manure is far less readily available than that of either stems or cottonseed meal.

The views of growers in the Connecticut and Housatonic valleys regarding the value of stable manure are widely divergent. Some affirm that they would use nothing else if they could get enough stable manure; others would not use manure at all for this crop. It is certainly true that some of the finest broadleaf is grown on land dressed for the most part at least with manure. Many growers also give their lands a light dressing of yard manure every few years.

When no other fertilizers are used in connection with it the crop is rather light, at least for the first few years, till the land is well filled with the manure. The leaf is said to "lack finish" when pole-cured, *but after fermentation* it is said to have a "finish" superior to that raised on chemicals alone. We believe that an annual

* Average of *four* years.

dressing of manure will often pay well, supplementing it with a supply of more quickly available plant food in the form of fertilizer chemicals.

The successive crops from the plot AA, dressed with manure, ranked 13th, 17th and 1st.

Those from the plot BB (tobacco stems) ranked 16th, 21st, 19th, while the three corresponding crops on cottonseed meal ranked 23d, 5th and 14th.

COMPARISON OF THE EFFECTS OF VARIOUS FORMS OF POTASH ON THE QUALITY OF THE CROP.

(Plots A, K, L, M, N, O, P,* Y.*)

All of the plots in this series were dressed each year with 105 pounds of nitrogen per acre, in form of cotton seed meal (about 1500 pounds per acre).

All were likewise dressed annually with 340 pounds per acre of potash, *but in different forms.* Thus A received cotton hull ashes; K, double sulphate of potash and magnesia; L, double sulphate of potash and magnesia, *with lime* at the rate of 300 pounds per acre; M, high grade sulphate of potash; N, high grade sulphate of potash and magnesia, *with lime* at the rate of 300 pounds per acre; O, carbonate of potash; P, double carbonate of potash and magnesia; and Y, wood ashes.

Plots A and Y received about 150 pounds of phosphoric acid annually per acre, chiefly in the ashes. The like quantity was supplied to the other plots in form of Cooper's bone.

The averages of the five years' course of experiments are given in Table VII. (See following page.)

The largest average yield of leaf tobacco (1771 pounds per acre) and of wrapper leaf (1151 pounds per acre), and the highest per cent. of wrapper leaf (65) in the crop, was taken from plot K, dressed with double sulphate of potash and magnesia as a source of potash.

The leaves were heavier (60 and 82 long and short wrapper leaves to the pound) than those from the other plots named, and their fire-holding capacity was less than that from any except those dressed with high grade sulphate of potash.

The quality of the wrappers, judged from the four crops already examined by the expert, was about the same as that of wrappers from plot A, where cotton hull ashes were used.

The addition of lime had little effect on the quality of leaf.

* Four years only.

TABLE VII.—COMPARISON OF THE EFFECTS OF VARIOUS FORMS OF POTASH AS TOBACCO FERTILIZERS.

Source of Potash.	Plot A. Cotton Hull Ashes.	Plot K. Double Sulphate of Potash and Magnesia.	Plot L. Double Sulphate of Potash and Magnesia with Lime.	Plot M. High Grade Sulphate of Potash.	Plot N. High Grade Sulphate of Potash with Lime.	Plot O. Carbonate of Potash.	Plot P.* Double Carbonate of Potash and Magnesia.	Plot Y.* Wood Ashes.
Yield of Tobacco per acre	1615	1776	1664	1709	1690	1549	1416	1482
Long Wrappers	740	874	705	653	742	672	601	631
Short Wrappers	241	277	277	253	272	257	263	199
Per cent. of wrappers in crop	61	65	59	53	60	60	61	56
No. of pole-cured leaves in 1 lb. long wrappers	66	60	63	67	64	70	66	69
No. of pole-cured leaves in 1 lb. short wrappers	89	82	87	86	85	89	87	91
No. seconds holds fire, long wrappers	14	8	8	7	8	10	13	12
short wrappers	15	10	10	10	11	14	119	17
Relative rank	10–23–5–14	6–15–17–12	9–25–7–23	23–28–26–21	7–19–25–26	1–24–13–4	14–2–1	10–12–6

* Four years.

The plots dressed with high grade sulphate of potash with and without lime, M and N, bore a larger average crop than any except K, and rather more wrappers than most of the others. But the leaves held fire for a shorter time than those from the other plots, and the quality of the four crops already examined was poorer than that of any others in the series.

Plots O, P, Y, having as their source of potash, carbonate of potash, double carbonate of potash and magnesia and wood ashes respectively, bore lighter crops than the others in this series, but the average quality, judged from the four crops from O and three crops from P and Y, already examined, was the best in the whole experiment field.

EFFECTS OF SMALLER QUANTITIES OF POTASH IN THE FERTILIZER.

Plots B and F in 1892 received a dressing of cotton hull ashes containing 340 pounds of potash per acre. B also received 140 pounds per acre of nitrogen in cottonseed meal; F received the same quantity of nitrogen in form of castor pomace.

For the next four years both plots received yearly like quantities of nitrogen and phosphoric acid, but plot F received only 150 pounds of actual potash per acre, while B received 340 pounds,—both in forms of cotton hull ashes.

The following table shows the average results of four years' test.

TABLE VIII.—EFFECTS OF DIFFERENT QUANTITIES OF POTASH.

Source of Fertilizer-Potash.	Plot B. Cotton Hull Ashes.	Plot F. Cotton Hull Ashes.
Amount of Fertilizer-Potash per acre, pounds	340	150
Average yearly yield of leaf tobacco, pounds per acre	1501	1600
" " " long wrappers, " "	664	669
" " " short " "	222	260
Per cent. of wrappers in crop	59	58
No. of pole-cured leaves in 1 pound of long wrappers	68	66
" " " 1 " short "	89	91
No. of seconds holds fire, long wrappers	12	9
" " " short "	17	14

The results of four years' tests show a somewhat larger average crop on plot F, which received annually 150 pounds of potash, and over 40 pounds more annually of wrapper leaves. The number of pole-cured leaves to the pound was about the same on both plots, those from plot B holding fire a little longer.

There was little difference in the quality of the three crops which have been fermented.

In this experiment, therefore, about 900 pounds of cotton hull ashes per acre, or 190 pounds of potash, were annually put on the land in excess of the crop requirements.

As has been shown in previous reports, an average tobacco crop of 1800 pounds per acre, takes from the land not more than 150 pounds of potash in stalks and leaves. When land has been well fertilized for some years, it is probable that 150 pounds of water-soluble potash annually applied is enough to secure a full crop of tobacco.

An excess of potash, however, tends to neutralize the otherwise injurious effects of an excess of chlorides in the soil.

Tobacco Raised on Mixed Fertilizers supplied by Manufacturers.

Plot Q received per acre annually for five years, 2000 pounds of AA Superphosphate and 4000 pounds of Baker's Tobacco Manure, made and supplied by H. J. Baker & Bro. of New York. The two supplied 238 pounds of nitrogen, 452 pounds of phosphoric acid and 522 pounds of potash.

Plot R received per acre annually 2000 pounds of Stockbridge Tobacco Manure and 500 pounds of the same, used as a starter. The two supplied 154 pounds of nitrogen, 307 pounds of phosphoric acid and 278 pounds of potash.

Plot S received in 1892, 4000 pounds per acre of Bowker's Tobacco Manure. In 1893 and each succeeding year, 3000 pounds of Stockbridge Tobacco Manure and 500 pounds of Stockbridge Tobacco Starter were used, the two containing 209 pounds of nitrogen, 393 pounds of phosphoric acid and 396 pounds of potash.

The fertilizers for plots R and S were made and supplied by the Bowker Fertilizer Co. of Boston and New York.

Plot U received in 1892, per acre, 500 pounds lime, 500 pounds of Mapes' Tobacco Starter and 2600 pounds of Mapes' Wrapper Brand Tobacco Manure. In 1893 and the following years it received 600 pounds per acre of Mapes' Tobacco Starter and 2200 pounds of Mapes' Wrapper Brand Tobacco Manure, the two containing 158 pounds of nitrogen, 211 pounds of phosphoric acid and 278 pounds of potash.

Plot V received per acre in 1892, 500 pounds of lime, 500 pounds of Mapes' Tobacco Starter and 2600 pounds of Special Tobacco Manure. In 1893 it received 800 pounds of Starter and 2000 pounds of Mapes' Wrapper Brand Tobacco Manure. In 1894 and the following years it received 400 pounds of Starter and 2400 pounds of Wrapper Tobacco Manure. These supplied 163 pounds of nitrogen, 196 pounds of phosphoric acid and 294 pounds of potash.

Plot W received per acre in 1892, 500 pounds of lime, 500 pounds of Tobacco Starter and 2600 pounds of Special Tobacco Manure. In 1893 it received 1000 pounds of Starter and 1800 pounds of Wrapper Tobacco Manure. In 1894 and the following years it received 2400 pounds of Wrapper Tobacco Manure, supplying 151 pounds of nitrogen, 143 pounds of phosphoric acid and 280 pounds of potash.

The fertilizers for plots U, V and W were made and supplied by the Mapes' Formula and Peruvian Guano Co. of New York City.

Plot X received per acre in 1892, 6000 pounds of Sanderson's Tobacco Manure, and in 1893 and each of the following years it received 2000 pounds of the same brand of fertilizer, supplying 103 pounds of nitrogen, 281 pounds of phosphoric acid and 105 pounds of potash.

The fertilizers for this plot were made and supplied by L. Sanderson, New Haven.

The results of this series are given in the following table, and are submitted without further comment.

Table IX.—Effects of Fertilizers made and supplied by the Firms named.

Name of Manufacturer. Plot.	Baker. Q.	Bowker. R.	Bowker. S.	Mapes. U.	Mapes. V.	Mapes. W.	Sanderson X.
Pole-cured Crop.							
Total crop, pounds per acre	1892	1614	1770	1991	1624	1600	1605
Long wrappers, " "	896	673	893	1039	796	764	755
Short " " "	252	247	273	256	226	228	240
Per cent. of wrappers	61	57	66	65	63	62	62
No. of long wrapper leaves per pound	58	64	61	59	61	63	61
No. of short wrapper leaves per pound	80	73	86	77	86	94	86
Holds fire, seconds, long wrappers	6.0	9.0	8.0	7.0	8.0	10.0	6.0
Holds fire, seconds, short wrappers	7.0	11.0	12.0	10.0	12.0	12.0	7.0

The relative rank of the tobacco from these plots, during the past four years, has been :—

Q	Baker's	15th,	20th,	29th,	24th
R	Bowker's	13th,	17th,	23d,	7th
S	"	11th,	7th,	22d,	8th
U	Mapes'	20th,	4th,	18th,	13th
V	"	24th,	11th,	24th,	3d
W	"	18th,	2d,	8th,	2d
X	Sanderson	21st,	27th,	9th,	27th

THE EFFECTS OF FERTILIZERS ON THE COMPOSITION OF WRAPPER LEAF TOBACCO.*

The analyses of leaf tobacco given in this paper were made on samples carefully drawn from the crops of plots each of which had an area of $\frac{1}{20}$ acre.

For at least four years, and in most cases, for five years, each of these plots had been dressed with fixed amounts of nitrogen, phosphoric acid and potash, which were the same each year and were derived from the same materials annually. The comparative quality of the crops from each plot has been determined annually after fermentation, by an expert.

The crops harvested in the last year of the experiment should show more clearly than those of a test made in a single year, the special effects which the several fertilizers have had on the chemical composition of the wrapper leaf as well as on its quality.†

The samples analyzed were taken from the following plots, and each will be referred to hereafter by the letter designating the plot on which it grew.

TABLE I.—DESCRIPTION OF PLOTS. CROP OF 1896.

Plot.	Fertilizers annually applied.	Quantity of Fertilizer Ingredients applied, lbs. per acre. Nitrogen.	Phos. Acid.	Potash.	Yield of Tobacco in 1896, lbs. per acre. Total.	Long Wraps.	Short Wraps.
P	Cotton seed meal, double carbonate potash and magnesia, bone	105	157	340	1255	525	265
D	Cotton seed meal, cotton hull ashes	210	195	340	1730	945	275
F	Linseed meal, cotton hull ashes, bone	105	143	150	1210	400	215
Y	Cotton seed meal, wood ashes	105	150	340	1390	635	200
AA	Horse manure	111	71	149	1375	650	160
O	Cotton seed meal, carbonate of potash, bone	105	157	340	1440	680	290
H	Castor pomace, cotton hull ashes	210	188	340	1775	940	275
L	Cotton seed meal, double sulphate potash and magnesia, bone	105	157	340	1515	645	225
BB	Tobacco stems	111	36	486	1585	830	295
M	Cotton seed meal, high grade sulphate of potash, bone	105	157	340	1540	645	250

* All the analyses given below were made by Messrs. Winton, Ogden and Mitchell. The results have been prepared for publication by the Vice-Director.

† The quality of the leaf is the sum of all those factors which the dealer and the cigar manufacturer regard in making their selection for purchase. Color,

The quality of the tobacco from these several plots cannot be learned till the autumn of 1897, after it has finished fermentation in the case. Lot P has ranked highest, on the average, for the previous years. D, F, Y, and AA have ranked next, all of them nearly alike, then follow O, H and L in the order given, then BB, while M has been decidedly the poorest of all. It is, however, quite possible that the comparative quality of the crops of 1896, from which these samples were taken, will differ from this average of the previous years.

The relative ranks of the pole-cured long and short wrappers of 1896, *as regards fire-holding capacity alone*, are as follows:

	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.
Long wrappers,	Y	BB	D	P	O	F	L	AA	H	M
Short wrappers,	Y	F	O	D	P	BB	H	AA	M	L

Preparation of the Samples.

Each sample consisted of twelve hands, about fifteen wrappers to the hand, which were carefully drawn for the purpose, when the tobacco was sorted. These samples were dried for a short time at a low heat, not over 24° C., pulverized and kept in well-stoppered bottles for analysis.

Methods of Analysis.

Water, fiber, and ether extract were determined as recommended by the Association of Official Chemists.

Protein was calculated by subtracting from the total nitrogen those portions which were in form of nicotine and nitric acid, and multiplying the remainder by the factor 6.25.

Nicotine was determined by the method of Kissling, Fres. Zeitschr., XXI, p. 64.

Nitric Acid was extracted with 85 per cent. alcohol and determined by the method of Schulze-Tiemann, from the volume of nitric oxide gas evolved.

size, "grain," "finish," burn, size and kind of vein and stem, all go to make up the "quality" of which the dealer and cigar maker are the sole judges.

While it is true that good burning quality is essential to wrapper leaf tobacco, it is also true that to meet the present requirements of the market, other things are also essential which cannot be measured—like the burn—by any laboratory tests and can only be properly judged by one who is in touch with the trade in leaf tobacco.

Ash was determined in 100 grams of the dry tobacco by careful incineration of a weighed quantity of the tobacco in a platinum dish at a heat below redness. Owing partly to the presence of nitrates, as well as to the large amounts of lime and magnesia present, it is particularly easy to nearly free the ash of tobacco from coal at a low heat.

Nitrogen-free extract was determined as usual by difference.

The Tables of Analyses.

Tables II and III, given on page 325, show the composition of the air-dry leaves. The percentage of water ranges from 7.24 to 9.95. With this amount of water the leaves are very brittle and can be easily pulverized.

Considerably more sand adheres to the short than to the long wrappers because the former are nearer the base of the stalk. The average per cent. of adhering sand in the short wrappers is 6.52, and in the long wrappers 2.31 per cent.

Neither the moisture nor adhering sand are of any significance in studying the effects of the fertilizers, and the foregoing analyses have therefore been recalculated to a water-free and sand-free basis, as shown in Tables IV and V, page 326.

Tables VI and VII give the analyses of the crude ash of the several lots of tobacco, containing small quantities of hygroscopic water and of coal from imperfectly burned organic matters, and very considerable quantities of sand which adheres to the surface of the leaves, even after curing.

The crude ash also contains a comparatively large amount of carbonic acid, which is not found in the unburned leaf, but results from the destruction of the organic matter of the plant.

In Tables VIII and IX, these things, water, sand and carbonic acid, have been omitted and the analyses recalculated to "Pure Ash."

Analyses of Air-dry Leaf Tobacco.

Table II.—Long Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Water	9.76	9.25	9.95	8.53	9.01	8.23	9.30	9.01	7.75	8.16
Sand	2.34	2.72	1.75	2.53	1.98	2.44	2.45	2.35	1.56	3.05
Pure ash*	13.92	15.88	13.78	15.43	16.25	14.38	15.45	16.25	15.33	16.28
Ether extract	4.64	4.10	4.75	4.05	5.15	4.73	4.28	4.34	4.77	4.35
Fiber	12.16	11.21	12.29	11.83	13.15	12.28	11.38	12.24	12.35	12.55
Nicotine	3.22	2.75	2.96	2.64	2.38	2.85	2.90	2.56	3.32	2.50
Nitric acid	1.30	3.66	.54	1.27	.89	1.62	3.31	1.27	3.12	.54
Proteids, etc.†	17.13	16.25	15.75	15.69	15.19	17.00	16.69	16.06	17.19	16.06
Nitrogen-free extract	35.53	34.18	38.23	38.03	36.00	36.47	34.24	35.92	34.61	36.51
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Crude ash	20.76	24.09	20.24	23.73	22.15	22.91	23.05	23.52	23.10	25.26
Nitrogen as nicotine	.56	.48	.51	.46	.41	.49	.50	.44	.57	.43
Nitrogen as nitric acid	.34	.95	.14	.33	.23	.42	.86	.33	.81	.14
Nitrogen as proteids, etc.	2.74	2.60	2.52	2.51	2.43	2.72	2.67	2.57	2.75	2.57
Total nitrogen	3.64	4.03	3.17	3.30	3.07	3.63	4.03	3.34	4.13	3.14

* Free from sand, water, carbonic acid and charcoal.

† Total nitrogen, less nitrogen as nicotine and nitric acid, × 6.25.

Table III.—Short Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Water	9.65	8.35	9.41	9.22	9.11	7.24	8.19	8.14	8.33	7.58
Sand	6.72	7.57	4.71	5.04	6.22	6.94	7.96	6.97	5.01	8.04
Pure ash*	14.61	16.71	15.28	16.62	17.45	15.62	16.91	17.94	17.45	17.90
Ether extract	4.85	4.45	5.27	4.53	5.09	4.85	4.35	4.33	5.04	4.61
Fiber	10.69	10.12	12.37	11.27	11.98	11.00	10.20	10.68	11.21	10.95
Nicotine	2.93	2.26	2.33	1.98	1.99	2.40	2.16	2.15	2.18	1.89
Nitric acid	.56	2.08	.23	.60	.35	.71	2.91	.46	2.93	.27
Proteids, etc.†	10.87	11.50	11.31	11.25	11.00	11.62	12.44	10.87	12.37	11.62
Nitrogen-free extract	39.12	36.96	39.09	39.49	36.81	39.62	34.88	38.46	35.48	37.14
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Crude ash	26.47	30.85	25.29	28.67	28.51	30.11	30.63	30.58	29.77	32.95
Nitrogen as nicotine	.51	.39	.40	.34	.37	.41	.37	.37	.38	.33
Nitrogen as nitric acid	.15	.54	.06	.16	.09	.19	.76	.12	.76	.07
Nitrogen as proteids, etc.	1.74	1.84	1.81	1.80	1.76	1.86	1.99	1.74	1.98	1.86
Total nitrogen	2.40	2.77	2.27	2.30	2.19	2.46	3.12	2.23	3.12	2.26

* Free from sand, water, carbonic acid and charcoal.

† Total nitrogen, less nitrogen as nicotine and nitric acid, × 6.25.

Analyses of Leaf-Tobacco free from Water and Sand. (Calculated from Tables II and III.)

Table IV.—Long Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Pure ash*	15.84	18.04	15.60	17.35	18.26	16.10	17.51	18.33	16.90	18.34
Ether extract	5.28	4.66	5.38	4.55	5.78	5.29	4.85	4.90	5.26	4.90
Fiber	13.84	12.73	13.91	13.30	14.77	13.75	12.90	13.81	13.62	14.13
Nicotine	3.66	3.12	3.35	2.97	2.67	3.19	3.29	2.89	3.66	2.81
Nitric acid	1.48	4.16	.62	1.43	1.00	1.81	3.76	1.43	3.44	0.61
Proteids, etc.†	19.49	18.46	17.84	17.64	17.07	19.03	18.91	18.12	18.96	18.09
Nitrogen-free extract	40.41	38.83	43.30	42.76	40.45	40.83	38.78	40.52	38.16	41.12
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen as nicotine	.64	.55	.58	.52	.46	.55	.57	.50	.63	.48
Nitrogen as nitric acid	.39	1.08	.16	.37	.26	.47	.97	.37	.89	.16
Nitrogen as proteids, etc.	3.11	2.95	2.85	2.82	2.73	3 04	3.03	2.90	3.03	2.89
Total nitrogen	4.14	4.58	3.59	3.71	3.45	4.06	4.57	3.77	4.55	3.53

* Free from sand, water, carbonic acid and charcoal.
† Total nitrogen, less nitrogen as nicotine and nitric acid, × 6.25.

Table V.—Short Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Pure ash*	17.47	19.88	17.80	19.38	20.61	18.20	20.16	21.13	20.13	21.21
Ether extract	5.80	5.29	6.13	5.28	6.01	5.65	5.19	5.10	5.82	5.46
Fiber	12.78	12.03	14.40	13.14	14.15	12.82	12.16	12.58	12.93	12.98
Nicotine	3.50	2.69	2.71	2.31	2.36	2.80	2.58	2.53	2.52	2.24
Nitric acid	.67	2.47	.27	.70	.41	.83	3.47	.54	3.38	.32
Proteids, etc.†	13.00	13.67	13.16	13.12	12.99	13.54	14.84	12.80	14.27	13.77
Nitrogen-free extract	46.78	43.97	45.53	46.07	43.47	46.16	41.60	45.32	40.95	44.02
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen as nicotine	.61	.46	.47	.40	.40	.48	.44	.44	.44	.39
Nitrogen as nitric acid	.18	.64	.07	.18	.11	.22	.90	.14	.87	.08
Nitrogen as proteids, etc.	2.08	2.19	2.10	2.10	2.08	2.16	2.38	2.04	2.29	2.21
Total nitrogen	2.87	3.29	2.64	2.68	2.59	2.86	3.72	2.62	3.60	2.68

* Free from sand, water, carbonic acid and charcoal.
† Total nitrogen, less nitrogen as nicotine and nitric acid, × 6.25.

Analyses of the Crude Ash of Leaf-Tobacco.

Table VI.—Long Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Water	1.18	.36	.37	.29	.59	.49	.51	.24	.96	.25
Carbonic acid	21.13	22.85	23.06	24.00	17.18	25.69	22.03	19.99	25.75	22.86
Charcoal	.35	.35	.34	.44	.56	.70	.46	.35	.45	.73
Sand	11.27	11.31	8.63	10.66	8.95	10.66	10.64	10.02	6.77	12.09
Silica	1.10	1.10	1.00	.76	.76	.90	1.02	.89	.72	.85
Potash	30.53	29.26	28.50	27.40	35.15	29.22	29.80	26.68	35.67	24.88
Soda	.72	.48	.58	.44	.29	.37	.54	.34	.32	.46
Lime	16.03	20.10	21.06	22.60	14.53	22.50	18.90	22.23	18.15	25.11
Magnesia	11.02	8.03	8.65	6.14	8.92	3.21	8 80	6.13	4.54	2.25
Oxide of iron and alumina	1.38	1.34	1.00	1.12	.84	1.26	1.23	1.23	.82	1.34
Phosphoric acid	2.55	2.23	2.30	2.12	2.50	2.24	2.28	2.73	1.98	3.07
Sulphuric acid	3.30	2.90	4.63	3.46	3.97	2.50	3.59	7.68	3.04	6.00
Chlorine	.56	.60	.44	1.27	8.26	.59	1.24	1.52	1.42	.62
	101.12	100.91	100.56	100.70	102.50	100.43	101.04	100.03	100.59	100.51
Oxygen equivalent to chlorine	.13	.13	.10	.28	1.86	.13	.38	.33	.31	.14
	100.99	100.78	100.46	100.42	100.64	100.30	100.66	99.70	100.28	100.37

Table VII.—Short Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Water	2.00	.45	.60	.45	.53	.58	.82	.41	.62	.42
Carbonic acid	17.27	19.59	20.18	22.84	15.31	21.88	17.61	17.96	23.14	19.40
Charcoal	1.23	1.18	.93	1.26	1.56	1.87	.67	.59	.86	1.16
Sand	25.40	24.53	18.62	17.57	21.83	23.05	25.99	22.79	16.82	24.43
Silica	1.33	1.50	1.46	.99	1.10	1.40	1.79	1.11	1.15	1.28
Potash	25.57	21.82	24.09	24.02	26.14	23.31	24.56	21.01	30.13	19.89
Soda	.42	.64	.81	.72	.40	.40	.57	.42	.64	.49
Lime	10.35	18.45	18.75	21.10	14.35	19.78	14.13	19.75	17.52	21.95
Magnesia	12.34	6.81	8.72	5.33	8.37	2.68	8.90	5.87	4.10	2.56
Oxide of iron and alumina	1.42	1.38	1.34	1.38	1.71	1.38	1.14	1.60	1.36	1.14
Phosphoric acid	1.57	1.57	1.64	1.41	1.82	1.36	1.44	1.76	1.12	2.05
Sulphuric acid	1.97	1.77	3.40	2.59	2.76	1.36	2.24	6.59	2.02	4.74
Chlorine	.27	.26	.25	.58	5.88	.29	.57	.69	.73	.28
	101.14	99.95	100.79	100.24	101.76	99.34	100.43	100.55	100.21	99.79
Oxygen equivalent to chlorine	.06	.05	.05	.13	1.32	.06	.12	.15	.16	.06
	101.08	99.90	100.74	100.11	100.44	99.28	100.31	100.40	100.05	99.73

Analyses of the Pure Ash of Leaf-Tobacco.

Table VIII.—Long Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Silica	1.64	1.67	1.47	1.17	1.04	1.43	1.52	1.29	1.09	1.32
Potash	45.54	44.40	41.88	42.14	47.91	46.56	44.46	38.62	53.76	38.61
Soda	1.07	.73	.85	.68	.40	.59	.81	.49	.48	.71
Lime	23.89	30.50	30.95	34.76	19.80	35.85	28.20	32.17	27.35	38.98
Magnesia	16.43	12.18	12.70	9.44	12.16	5.12	13.13	8.87	6.84	3.49
Oxide of iron and alumina	2.06	2.03	1.47	1.72	1.14	2.01	1.84	1.78	1.24	2.08
Phosphoric acid	3.80	3.38	3.38	3.26	3.41	3.57	3.40	3.95	2.98	4.76
Sulphuric acid	4.92	4.40	6.80	5.32	5.41	4.14	5.35	11.11	4.58	9.31
Chlorine	.84	.91	.65	1.95	11.26	.94	1.85	2.20	2.14	.96
	100.19	100.20	100.15	100.44	102.53	100.21	100.56	100.48	100.46	100.22
Oxygen equivalent to chlorine	.19	.20	.15	.44	2.53	.21	.56	.48	.46	.22
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table IX.—Short Wrappers. Unfermented Crops of 1896.

Plot.	P.	D.	F.	Y.	AA.	O.	H.	L.	BB.	M.
Silica	2.41	2.77	2.41	1.70	1.80	2.69	3.24	1.89	1.95	2.36
Potash	46.34	40.29	39.88	41.43	42.70	44.92	44.48	35.82	51.41	36.62
Soda	.76	1.18	1.34	1.24	.65	.77	1.03	.72	1.09	.90
Lime	18.76	34.07	31.04	36.39	23.45	38.11	25.59	33.68	29.90	40.41
Magnesia	22.37	12.58	14.44	9.19	13.68	5.16	16.12	10.00	6.99	4.71
Oxide of iron and alumina	2.57	2.55	2.22	2.37	2.79	2.66	2.06	2.73	2.32	2.10
Phosphoric acid	2.84	2.90	2.71	2.43	2.97	2.62	2.61	3.00	1.91	3.77
Sulphuric acid	3.57	3.27	5.63	4.47	4.51	2.62	4.06	11.23	3.45	8.72
Chlorine	.49	.48	.41	1.00	9.61	.56	1.03	1.18	1.25	.52
	100.11	100.09	100.08	100.22	102.16	100.11	100.22	100.25	100.27	100.11
Oxygen equivalent to chlorine	.11	.09	.08	.22	2.16	.11	.22	.25	.27	.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Discussion of the Tables of Analyses.

We are here concerned chiefly with the effects of fertilizers on the chemical composition of the crops. The relation between the chemical composition and the quality of the wrapper leaf of 1896, cannot be fully considered until the samples have been fermented and graded according to their quality. Tables IV and V show that the short wrappers have about two per cent. more of ash or mineral matter than the long wrappers, half a per cent. more of ether extract (fat, wax, chlorophyl, etc.), and about four per cent. more of "nitrogen-free extract" (sugar, starch, gum, etc.).

On the other hand they have less fiber by about 0.7 per cent., less nicotine by 0.5 per cent., less nitric acid by .67 per cent., and less protein by 3.85 per cent.

The explanation of these differences is in the facts that the short wrappers are rather more mature at harvest than the long wrappers, they are smaller and have perhaps already returned to the stalk and to the upper leaves a portion of their substance, particularly nitrogenous matter, which is always most abundant, proportionally, in rapidly growing parts,—and in the seed.

There appear to be no differences in the percentages of ether extract, fiber and nitrogen-free extract which can be connected with differences in the fertilizers used.

There is a range of 3.7 per cent. in the amount of pure ash of the short wrappers and of 2.7 per cent. in the ash of the long wrappers.

The wrappers from M, fertilized with high grade sulphate of potash, Cooper's bone and cottonseed meal, and which were decidedly inferior to the other lots in quality in the three years previous, have the largest per cent. of ash.

Most striking are the percentages of nitric acid. A small amount of nitrate is almost always found in wrapper-leaf tobacco. The wrappers from plots D and H, which were annually dressed with twice as much fertilizer-nitrogen as the others, and also those from plot BB, which was dressed with 111 pounds of fertilizer-nitrogen in form of tobacco stems, contained very much more nitrate than any other of the tobaccos.

The long wrappers from the three plots named contained 4.16, 3.76 and 3.44 per cent. respectively, while the highest per cent. in any other lot examined was 1.81. The short wrappers from the same plots contained 2.47, 3.47 and 3.38 per cent., while the highest per cent. in any other lot was .83.

Where available nitrogen is present in considerable excess of the crop requirements, as it undoubtedly was on plots D and H, it is to be expected that more nitrogen may pass into the plant than is needed for its development and may be deposited in the tissues as nitrate of potash.

The high percentage of nitrates in BB cannot be thus explained. When the normal development of the plant is hindered by drought or other unfavorable influence, nitrogen may be taken up from the soil as nitrates which the plant is unable to utilize for the production of proteids or other nitrogenous organic matters. There is, however, no other indication that the tobacco grown on this plot suffered from any unfavorable influences other than affected all the rest of the field.

The percentage of protein in the long wrappers ranges from 17.1 to 19.5. The three plots, D, H and BB, which had the highest per cent. of nitrates, are surpassed by only two lots, O and P, in percentage of protein.

The percentage of protein in the short wrappers ranges from 10.09 to 12.4, and here, too, the three lots, D, H and BB, show a higher percentage of protein than most of the others.

The highest percentage of nicotine is found in both long and short wrappers from plot P, dressed with double carbonate of potash and magnesia, cotton seed meal and bone. Tobacco from this plot has been of better average quality, in the three years 1893, '94 and '95, than that from any other of those represented in this table.

The effect of fertilizers on the composition of the ash, as shown in Tables VIII and IX, is very marked.

There are no striking differences in the composition of the ash of the long and short wrappers. The ash of the short wrappers contains a somewhat larger percentage of silica, soda, lime, magnesia, and oxide of iron than the long wrappers, while the latter contain correspondingly more potash, phosphoric acid, sulphuric acid and chlorine than the short wrappers.

These differences are fully explained by the fact that the short wrappers were more mature than the long wrappers when harvested.

In the following paragraphs reference is made to the long wrappers only, except where the short wrappers are specially mentioned.

1. Potash ranges from 53.76 to 38.61 per cent. The per cent.

is highest on tobacco from plot BB, which received annually most fertilizer-potash (in form of tobacco stems). It is least in tobacco from plots L and M, both of which received 340 pounds of fertilizer-potash annually in form of sulphate, M as high grade sulphate, L as low grade sulphate. The per cent. of potash in lots L and M is even less than in lots AA and F, which received only 150 pounds of fertilizer-potash yearly, but in form of manure or of cotton hull ashes.

It appears, therefore, that from equal quantities of fertilizer-potash, added presumably quite in excess of crop requirements, the tobacco crop took up much less from forms containing sulphate than from those containing potash as carbonate, plots O, P, D, F and Y.

The tobacco which held fire longest was lot Y, in which the per cent. of potash was less than the average. The per cent. of lime and magnesia taken together is, however, larger than in any other lot.

Next in fire-holding capacity among the long wrappers is BB, which contains more potash than any others, while the per cent. of lime and magnesia is smaller than any others. Lot D comes next, in which the per cent. of potash is about the average, while the sum of the per cents. of lime and magnesia is higher than any except Y and F.

Lot M had the poorest fire-holding capacity. It contained less potash than any other lot, more lime and magnesia than most, more phosphoric acid than any and more sulphuric acid than any except L.

In general the same things hold true of the short wrappers. The relative fire-holding capacity of the short wrappers is, however, not the same. Lot Y held fire longest, followed by F, O and D in the order named. Lot L had the least fire-holding capacity and M next.

2. The percentage of lime in the long wrappers ranges from 19.80 to 38.98. It is least in lot AA (stable manure), next in lot P (bone, carbonate of potash and magnesia and cotton seed meal), next in BB (stems).

Lot M, which received high grade sulphate of potash with lime and cotton seed meal, contained most lime, and lot O came next in this respect.

Lots M and O, which have most lime, have least magnesia, while those lots having least lime have relatively the most magnesia. The percentage of lime in the pure ash of the long wrappers ranges from 19.8 to 38.98 per cent., and magnesia from 3.49 to 16.43 per cent. But the percentages of lime and magnesia, *taken together*, show a much narrower range, viz. from 31.9 to 43.65.

Plot P received annually a dressing of magnesia amounting to 300 pounds or more, plot Y received annually over 200 pounds, plot L 170 pounds, plots H and D about 120 pounds and plot F one-half that amount.

The effects of these applications appear in the ash analyses. Lot P contains most magnesia, lots H, F and D rank next in this regard, followed by Y.

Lots P, Y, F and D, which contained comparatively large percentage amounts of magnesia in the ash, have been among the best tobaccos, as regards quality, in the previous years.

These statements regarding the long wrappers are substantially correct, also, for the short wrappers.

It is noteworthy that the short wrappers of lot P, which in previous years have been of better quality than any other of the lots here discussed, contained more magnesia than lime in the ash.

3. The percentage amounts of sulphuric acid in the ash of lots L and M, from the plots dressed with sulphates of potash, are very much larger than any others, as was to be expected.

4. Lot AA, from the plot dressed with stable manure, contains a very high percentage of chlorine, 11.26, five times as much as any other lot in the series. Of the other lots, L, BB, Y and H contain over one per cent.

Double sulphate of potash and magnesia (L), tobacco stems (BB), and wood ashes (Y), all contain small amounts of chlorine, which, in addition to what chlorine is always in the soil and the rain, explains the percentages found, none of which are of special significance as regards their effect on the quality of the tobacco, except that in AA.

The observations here made are summarized as follows:—

1. The analyses represent the cumulative effects on the composition of the tobacco leaf of fertilizers applied for four and five years in succession.

2. The short wrappers have a somewhat larger percentage of ash, ether-extract and nitrogen-free extract than the long wrappers and correspondingly less fiber, nicotine, nitric acid and protein.

Of ash ingredients the short wrappers contain a somewhat larger percentage of silica, soda, lime, magnesia and oxide of iron, and a correspondingly smaller percentage of potash, phosphoric acid, sulphuric acid and chlorine.

3. There are no differences in the percentages of ether-extract, fiber and nitrogen-free extract traceable to the different fertilizers used.

Where fertilizer-nitrogen was applied in large excess of the probable crop requirements, a much larger percentage of nitrates was found in the leaf, amounting in one case to 3.78 per cent. of nitric acid (N_2O_5), than where smaller quantities of fertilizer-nitrogen were applied.

The percentages of protein and of nicotine were also above the average in tobacco to which the larger quantities of fertilizer-nitrogen had been applied.

4. The fertilizers used have had striking effects on the composition of the ash.

a. The largest percentage of potash was in tobacco to which most fertilizer-potash had been applied.

The percentage of potash is least in the ash of tobacco from the plots dressed with potash in form of sulphate. The percentage of potash in the ash of the tobacco from those plots is also less than it is in the ash of tobacco from plots which were dressed with the same, or even half the same quantity of fertilizer-potash in form of carbonate.

b. The tobacco dressed with high-grade sulphate of potash and the ash of which contained a smaller per cent. of potash than any other lot, contains on the other hand the highest per cent. of lime, and the tobacco dressed with the double sulphate of potash and magnesia also contains a relatively high per cent. of lime.

c. In general the tobaccos which have most lime have least magnesia, and vice versa. Comparatively large percentages of magnesia are found in the lots of tobacco which were raised on plots dressed with fertilizers containing much magnesia. In the short wrappers of a single plot, P, the percentage of magnesia was larger than that of lime.

The quality of the leaf has not been damaged in previous years by these large quantities of magnesia. Lots P, Y, F and D, which have large percentage amounts of magnesia, have heretofore been among the best tobaccos as regards quality of leaf.

d. The percentage of sulphuric acid in the leaf is very much larger when sulphates are used in the fertilizer.

It is believed that these large amounts of sulphuric acid impair the burning quality of the leaf, and in this experiment the "burn" of tobacco from the plot which was dressed with high-grade sulphate, has been very unsatisfactory.

e. The ash of tobacco from the plot dressed with stable manure contains five times as much chlorine as the ash from any other lot in the series.

AMOUNT OF NITROGEN, PHOSPHORIC ACID AND POTASH IN PEAS AND BEANS.

Samples of Peas of a wrinkled variety and of field Beans were sent to the Station by E. E. Burwell, New Haven, with a statement of the yield per acre, and an inquiry as to how much plant food each crop took from an acre in the seed alone.

The analyses were as follows:

	Peas. 5237	Beans. 5235
Nitrogen	4.27 per cent.	3.75 per cent.
Phosphoric acid	1.07 "	.90 "
Potash	1.13 "	1.47 "
Yield per acre	20 bushels.	25 bushels.
Equivalent to	1,120 pounds.	1,500 pounds.
Containing per acre—Nitrogen	47.8 pounds.	56.2 pounds.
Phosphoric acid	13.1 "	13.5 "
Potash	12.7 "	22.0 "

The crop of beans took from an acre about the same amount of phosphoric acid as the peas, but 9 pounds more each of nitrogen and of potash.

OBSERVATIONS ON THE GROWTH OF MAIZE CONTINUOUSLY ON THE SAME LAND FOR NINE YEARS.*

The plan of this experiment and the results obtained in previous years are given in detail in the Nineteenth Report of this Station, for 1895, pp. 216–225.

The results of the experiment in 1896 are here placed on record without discussion, which is reserved.

Gross Yield of the Plots in 1896.

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 too high and that of the cobs slightly too low. But the error is small.

Table I.—Gross Yield of the Plots in Pounds per Acre. 1896.

	Plot A. Cow Manure.	Plot B. Hog Manure.	Plot C. Chemicals.	Plot D. No Fertilizer.
Kernels	5478.5	5975.5	4210.0	672.0
Cobs	664.0	737.0	530.0	78.0
Stover	11,557.5	10,957.5	6750.0	3900.0
Total	17,700.0	17,670.0	11,490.0	4650.0

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.

This appears in Table II.

Table II.—Dry Matter of the Crops, Pounds per Acre. 1896.

	In Kernels.	In Cobs.	In Stover.	Total.
Plot A, cow manure	3338.2	593.0	6484.6	10,415.8
Plot B, hog manure	3652.3	658.1	5260.3	9570.7
Plot C, fertilizer-chemicals	2372.4	473.3	3516.6	6362.3
Plot D, no fertilizer	342.1	69.7	1670.9	2082.7

The percentage of water-free kernels, cobs and stover on the several plots, appears in the following table:

* The analyses given in this paper have been made by Messrs. Winton, Ogden and Mitchell, chemists of this Station. This paper has been prepared for publication by the Vice-Director.

TABLE IIA.—PERCENTAGE OF WATER-FREE KERNELS, COBS AND STOVER, IN THE CROPS. AVERAGE OF SEVEN YEARS.

	Plot A.	Plot B.	Plot C.	Plot D.
Kernels	38.1	41.3	41.4	29.5
Cobs	6.7	7.4	8.2	5.5
Stover	55.2	51.3	50.4	65.0
	100.00	100.00	100.0	100.0

The relative yields of dry matter from these plots for the last seven 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 SEVEN 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
1895	100	108.2	72.6	38.4
1896	100	91.9	61.1	20.0
Average	100	100.4	81.8	51.0

If the yield from each plot in 1890 is called 100, the comparative yields for the following years will be as represented in Table IIIA.

TABLE IIIA.—RELATIVE YIELD OF DRY MATTER IN THE SEVEN YEARS, 1890 TO 1896.

	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
1895	82	85	67	43
1896	116	101	79	31

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 1896.

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.

TABLE IV.—YIELD OF FOOD INGREDIENTS IN POUNDS PER ACRE, 1896.

	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	2138.8	71.0	5072.6	7282.4	2324.5	78.9	5696.8	8100.2	1838.1	56.7	3233.3	5128.1	329.9	8.3	2229.3	2567.5
Ash	31.2	9.3	404.5	445.0	37.0	10.3	303.5	350.8	12.2	7.4	188.3	207.9	2.0	1.1	84.6	87.7
Albuminoids	347.3	15.9	399.9	763.1	411.0	17.7	356.1	784.8	244.6	12.7	247.7	505.0	31.0	1.9	99.8	132.7
Fiber	45.5	199.9	2260.6	2506.0	55.0	221.8	1775.1	2051.9	34.1	159.5	1184.0	1377.6	4.9	23.5	496.9	525.3
Nitrogen-free extract	2740.4	364.6	3341.3	6446.3	2955.0	404.6	2765.7	6125.3	1961.9	291.0	1854.2	4107.1	287.5	42.8	966.4	1296.7
Fat	175.3	3.3	78.6	257.2	193.0	3.7	60.3	257.0	119.1	2.7	42.5	164.3	16.7	.4	23.0	40.1
	5478.5	664.0	11,557.5	17,700.0	5975.5	737.0	10,957.5	17,670.0	4210.0	530.0	6750.0	11,490.0	672.0	78.0	3900.0	4650.0

Table V shows the composition of the crops on the four plots, A, B, C and D, for the year 1896.

Table VI exhibits the striking differences in the percentage composition of the crops on the four plots calculated from the average of six years.

The crops, both of kernels and stalks, on A and B, which have been very heavily dressed each year, the one with cow manure, the other with hog manure, are practically identical as regards chemical composition.

The kernels of the crop on C, which receives each year a liberal dressing of fertilizer chemicals, 1500 pounds to the acre, contains in the kernels somewhat less ash or mineral matter and fat, and half a per cent. less of proteids, etc., than the crops on A and B, with correspondingly more nitrogen-free extract. Similar differences are found in the composition of the stalks.

The kernels in the crop on D, to which no fertilizer or manure has been applied since 1889, have 2.0 per cent. less proteids than that of plots A and B, somewhat less ash and fat, but more fiber and nitrogen-free extract.

TABLE V.—COMPOSITION, PER CENT., OF FIELD-CURED MAIZE, KERNELS AND STOVER FROM PLOTS A, B, C, D. 1896.

	Analyses of Field-cured Maize.						Calculated Water-free.				
	Water.	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
KERNELS.											
Plot A	39.04	.57	6.34	.83	50.02	3.20	.93	10.38	1.35	82.07	5.27
Plot B	38.90	.62	6.88	.92	49.45	3.23	1.04	11.26	1.50	80.91	5.29
Plot C	43.66	.29	5.81	.81	46.60	2.83	.52	10.32	1.44	82.69	5.03
Plot D	49.09	.30	4.61	.73	42.79	2.48	.59	9.05	1.44	84.05	4.87
STOVER.											
Plot A	43.89	3.50	3.46	19.56	28.91	.68	6.25	6.16	34.87	51.51	1.21
Plot B	51.99	2.77	3.25	16.20	25.24	.55	5.78	6.76	33.75	52.57	1.14
Plot C	47.90	2.79	3.67	17.54	27.47	.63	5.36	7.04	33.67	52.72	1.21
Plot D	57.16	2.17	2.56	12.74	24.78	.59	5.07	5.97	29.74	57 83	1.39

TABLE VI.—AVERAGE COMPOSITION OF THE DRY MATTER OF KERNELS AND STOVER OF CROPS OF 1890, 1891, 1892, 1893, 1894, 1895 AND 1896.

	Ash.	Albuminoids.	Fiber.	Nitrogen-free Extract.	Fat.
KERNELS.					
Plot A	1.29	11.34	1.68	80.44	5.25
" B	1.42	11.56	1.62	80.13	5.27
" C	1.17	10.97	1.76	81.02	5.08
" D	1.17	9.33	1.82	82.83	4.85
STOVER.					
Plot A	6.54	6.65	33.40	52.01	1.40
" B	6.66	6.65	33.68	51.60	1.41
" C	5.80	6.41	34.13	52.30	1.36
" D	5.19	5.43	32.96	54.99	1.43

To complete the data regarding this experiment two other tables are presented.

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 1896.

It also gives the amounts of those fertilizing materials which have been added to the soil capital (+) or withdrawn (—) in the eight 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. The "bushels of shelled corn" given in this table have been calculated by adding 20 per cent. to the weight of the water-free kernels and dividing the sum by 50.

TABLE VII.—ENRICHMENT OR IMPOVERISHMENT OF SOIL BY NINE YEARS' MANURING AND CROPPING WITH INDIAN CORN. 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 seven years' cropping	+1117.9	+788.1	+799.1	+1879.8	+3446.0	+63.9	+520.2	+971.6	+177.4	−316.6	+53.8	−66.0
Applied in 1896	286.3	136.4	204.5	419.9	586.5	72.4	172.0	162.0	69.0	00.0	00.00	00.0
Taken off in Crop of 1896	122.1	31.7	147.8	125.6	45.5	143.1	80.8	22.2	75.6	21.2	7.4	6.6
Excess (+) or Deficiency (—) after nine years' cropping	+1282.1	+892.8	+155.8	+2174.1	+3987.0	−6 8	+611.4	+1111.4	+170.8	−337.8	+46.4	−72.6

TABLE VIII.—YIELD OF DRY MATTER AND "SHELLED CORN" PER ACRE FOR NINE YEARS AND COMPOSITION OF DRY MATTER.

	Year.	Distance of Planting.	Pounds of Dry Matter per Acre.	Bushels of Shelled Corn.	Ash.	Proteids, etc.	Fiber.	Nitrogen-free Extract.	Fat.
					Percentage Composition of Dry Matter				
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	189·B	" 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
Cow Manure	1895A	" 12 " "	7408	75	3.8	8.7	20.0	64.6	2.9
Hog Manure	1895B	" 12 " "	8013	80	4.4	8.7	20.7	63.2	3.0
Fertilizer Chemicals	1895C	" 12 " "	5375	58	3.1	8.2	20.1	65.6	3.0
No Manure or Fertilizer	1895D	" 12 " "	2842	28	2.9	6.4	20.7	67.3	2.7
Cow Manure	1896A	" 12 " "	10416	80	4.3	7.3	24.7	61.2	2.5
Hog Manure	1896B	" 12 " "	9571	88	3.7	8.2	21.4	64.0	2.7
Fertilizer Chemicals	1896C	" 12 " "	6362	57	3.3	7.9	21.6	64.6	2,6
No Manure or Fertilizer	1896D	" 12 " "	2083	8	4.2	6.4	25.2	62.3	1.9

THE PROTEIDS OF LUPIN SEEDS.

BY THOMAS B. OSBORNE AND GEORGE F. CAMPBELL.

The lupin is a leguminous plant little known in this country except as a garden ornament. The yellow lupin (*Lupinus luteus*) and the blue lupin (*Lupinus angustifolius*), both native to Mediterranean regions, have long been cultivated in Europe because of their ability to grow luxuriantly on sandy or gravelly soils, and by their help large areas of poor, "worn out" land have been reclaimed and made agriculturally profitable, as these plants furnish abundant fodder and by the decay of their deeply penetrating roots, and especially when plowed under green, they rapidly impregnate the soil with humus and render it productive for other crops.

Ritthausen (Jour. f. Prakt. Chem., **103**, 78; the same, New Series, **24**, 222, and **26**, 422, and Die Eiweisskörper, etc., Bonn, 1872), first studied and described under the name *conglutin* the characteristic proteid of the lupin seed. He found that the yellow and blue lupin both yielded conglutin scarcely distinguishable in properties and only differing in composition as respects sulphur, of which his preparations from the yellow lupin contained 1 per cent. and those from the blue lupin but 0.5 per cent. Ritthausen also analyzed preparations which, from their composition, he concluded to be legumin. He stated that both legumin and conglutin are extracted from lupin seeds by salt solutions as well as by dilute alkali, and that the two proteids can be separated from each other by dissolving in alkali, then precipitating with an acid and finally treating with salt solution. On neutralizing these alkali solutions conglutin retains while legumin loses its solubility in saline solutions.

By extracting with five per cent. sodium chloride brine Ritthausen obtained two preparations from yellow lupin having the composition given under **1** and **2**; by dissolving **2** in potash water and reprecipitating, **3** was prepared; the blue lupin by extracting with salt solution yielded **4**.

CONGLUTIN, RITTHAUSEN.

	Yellow Lupin.			Blue Lupin.
	1	2	3	4
Carbon	50.40	50.58	50.26	50.39
Hydrogen	7.00	7.06	6.89	6.94
Nitrogen	18.34	18.04	18.28	18.22
Sulphur }	24.26	24.32	1.01	0.49
Oxygen }			23.56	23.96
	100.00	100.00	100.00	100.00

The proteid rendered insoluble in salt solution by previous precipitation from an alkaline liquid, by acetic acid, he found to have the following composition, these figures being the average of five quite closely agreeing analyses:

LEGUMIN, RITTHAUSEN.

Carbon	51.36
Hydrogen	6.97
Nitrogen	17.50
Sulphur	0.59
Oxygen	23.58
	100.00

Palladin (Zeit. f. Biol., **31**, 191) has recently described the properties of "vitellin" contained in seeds of the yellow lupin. In many details the results of his work do not agree with ours, but as he admits that the "vitellin" which he examined was always somewhat impure, it is unnecessary to review his statements here.

YELLOW LUPIN.

We find that seeds of the yellow lupin contain a small quantity of proteid that is soluble in pure water, a large quantity soluble in salt solutions, a small amount soluble in potash-water, and a little nitrogenous matter, presumably proteid, which cannot be extracted by these solvents.

To determine the proportions of these proteids, very finely ground yellow lupin meal was first completely extracted with warm alcohol of .868 sp. gr. in order to remove as far as possible the amides and alkaloids which occur in considerable quantities in this seed. The air dry meal before exhaustion with alcohol contained 8.16 per cent. of nitrogen. Alcohol removed 11.0 per cent. of the meal and gave a residue containing 8.49 per cent. of nitrogen, showing that 0.60 per cent. of nitrogen calculated on the original meal had been removed. The original meal accordingly contained 7.56 per cent. of nitrogen in the form of compounds insoluble in alcohol. As the seed reacted strongly acid towards litmus it is possible that a considerable quantity of alkaloids was not removed by the alcohol, but it was not desirable to add any alkali in this extraction for fear of affecting the proteids.

One thousand grams of the alcohol-exhausted and thoroughly air-dried meal were treated with successive quantities of ten per cent.

sodium chloride solution until saturation of the filtered extract with ammonium sulphate showed that no more proteid was removed. The united extracts were filtered clear, saturated with ammonium sulphate, the precipitated proteids were dissolved in brine, the solution was filtered and dialyzed for several days. The abundant precipitate thus produced was filtered out, washed by decantation with water and with alcohol and dried over sulphuric acid. The substance thus obtained weighed 279.0 grams.

The solution filtered from this globulin was saturated with ammonium sulphate, the precipitate produced was dissolved in water, the solution filtered and dialyzed until no more globulin separated. By this second dialysis 15.2 grams of globulin were secured. The solution filtered from this second portion of globulin was concentrated by dialysing in alcohol and the proteid completely thrown down by adding absolute alcohol. The precipitate which resulted was then dehydrated with absolute alcohol and dried over sulphuric acid. Only 4.20 grams of substance were thus obtained, indicating the presence of very little proteid soluble in water.

The residue of meal was washed with water, which took up no proteid, and exhausted by successive applications of 2-10 per cent. potash water. The alkaline extracts were filtered clear and treated with dilute acetic acid. No precipitate resulted until a decided excess of acid had been added. The proteid thus separated was washed with water and with alcohol, dried over sulphuric acid and weighed 60.53 grams.

The meal residue was next washed with water and with alcohol, dehydrated with absolute alcohol and thoroughly air dried. It weighed 192.0 grams, showing the lupin seed to contain over 80 per cent. of substance soluble in salt solution and very dilute alkali, an amount not approached by any other seed which we have examined.

The nitrogen was determined in the various products and the results are summarized in the following table:

AMOUNT OF PROTEID EXTRACTED FROM YELLOW LUPIN BY VARIOUS SOLVENTS.

Extracted residue contained 1.51 per cent. N. or		2.90 grams.
Proteid extracted by alkali,	60.53 grams, contained 16.43 per cent. N. or	9.95 "
Proteid extracted by salt solution	279.0 grams, contained 17.86 per cent. N. or	49.83 "
	15.2 grams, contained 18.09 per cent. N. or	2.75 "
Proteid extracted by water,	4.2 grams, contained 16.55 per cent. N. or	0.69 "
	Total proteid, 358.93 grams.	
Total nitrogen accounted for		66.12 "
1,000 grams of meal contained 8.49 per cent. N. or		84.90 "

We thus have 77.88 per cent. of the nitrogen accounted for.

We will next consider in order:

I. Proteids soluble in pure water.

II. Proteids insoluble in water, but soluble in sodium chloride solution.

III. Proteids insoluble in water and in salt solution, but soluble in dilute potash-water.

I. PROTEIDS SOLUBLE IN PURE WATER.

As just indicated, water-soluble proteids occur in yellow lupin seeds in very small amount. Much the largest quantity obtained in any of the numerous extractions made was that already described, which formed 0.42 per cent. of the alcohol-extracted meal or 0.37 per cent. of the original meal. On treating this substance with water, a very considerable part was found to be coagulated. Since proteoses are not supposed to be rendered insoluble by prolonged treatment with alcohol, this insoluble matter was probably coagulated albumin or globulin, or possibly a mixture of both. The aqueous solution filtered from this insoluble proteid yielded a very small flocculent coagulum at 59°. The solution filtered after heating to 65°, became turbid at 67°, and flocks in minute amount appeared at 69°, which steadily increased until at 85° a very considerable coagulum had formed.

In another extraction by means of water, prolonged dialysis caused the separation of a small quantity of globulin which, when dissolved in salt solution, yielded a flocculent coagulum at 59° and but traces above 65°.

The solution from which most of this globulin had been removed by dialysis, gave a slight coagulum at 59°, and after heating to 65° the filtrate became turbid at 66°, and at 84° again yielded a small flocculent coagulum.

It is probable, therefore, that the substance coagulating at 59° is a globulin soluble in extremely dilute salt solutions which it is impossible to separate completely by dialysis and that the proteid coagulating at the higher temperature is an albumin.

Owing to the exceedingly small quantity of these proteids nothing further was learned respecting them.

The solution from which the coagulated proteid had been removed by heating gave a strong rose-red reaction with the biuret test, but no precipitate in the cold with nitric acid even after adding salt.

The yellow lupin seed accordingly contains a very small amount of albumin and a small quantity of proteose.

Neumeister (Zeitschrift für Biologie n. f.—**12,** 461) states that he found peptone in lupin seeds in large amount.

In order to test the seeds of the yellow lupin for peptones, 1,000 grams of freshly ground meal were treated with three liters of distilled water, and after agitating therewith for an hour the extract was strained through fine bolting cloth and the residue pressed out in a powerful screw press. Two liters of extract rich in dissolved substances was obtained, which was immediately saturated with ammonium sulphate and filtered. Lest peptones might be formed during the operation of extraction, the process up to this point was carried forward as rapidly as possible so that not over three hours elapsed before the solution, saturated with ammonium sulphate, was filtered. In order to be sure that the solution had been thoroughly saturated, a quantity of crystals of this salt were suspended in it over night, but no more proteid separated. Neumeister has stated that saturating seed extracts while hot and when made alternately acid and alkaline in reaction, is unnecessary. We, however, heated the solution to boiling, added ammonium sulphate as long as it dissolved, concentrated somewhat and allowed to cool. Much ammonium sulphate separated, but no noticeable quantity of proteose. After filtering off the separated sulphate, the solution was heated to boiling and concentrated until sulphate began again to crystallize out. Ammonia was next added to distinct alkaline reaction, and after heating a short time the solution was again cooled, filtered from deposited

sulphate and the filtrate concentrated until more sulphate separated. Acetic acid was added to acid reaction, the heating continued for a time, and the whole again cooled. After filtering out the separated crystals the solution measured 350 c. c. The solution was then nearly neutralized with ammonia, leaving its reaction slightly acid, and after adding an equal volume of water a freshly prepared solution of tannic acid was gradually added so long as a precipitate was produced in a small portion of the filtered liquid. A bulky reddish precipitate formed which, after standing 24 hours, was removed from the filter and treated with a slight excess of hot concentrated solution of baryta. After standing a short time the warm solution was filtered, and as it was very strongly alkaline from free ammonia, one-half was neutralized with sulphuric acid, thereby removing the excess of baryta. Neutral lead acetate was then added and the solution filtered. The most carefully applied biuret test did not show the least trace of peptone in this solution. The remainder was then evaporated nearly to dryness and about two cubic centimeters of syrup obtained which, if it had all been peptone, would hardly be considered a large amount. No peptone reaction whatever could be obtained with this syrup.

The other half of the solution was treated exactly as Neumeister directed—that is, neutral lead acetate was added without neutralizing the ammonia, and, after filtering, the biuret reaction was applied, but with no indication of peptone.

Since writing the above, S. Frankfurt (Landw. Ver.-Stat. **47,** 454) has stated that no peptone is present in seeds of the lupin, and attributes Neumeister's results to his long treatment of the seeds with water. In a letter to Frankfurt, Neumeister stated that after swelling the seeds in water they were rubbed up and digested with water for 24 hours, and that the vessels containing the extracting seeds were exposed to the direct action of sunlight in summer. It is thus evident that the peptone found by Neumeister was formed during the extraction and was not an original constituent of the seed.

II. *Proteids soluble in saline solutions.*

As just mentioned, a very small quantity of a globulin soluble in extremely dilute salt solutions, yielding a flocculent coagulum when its solution in ten per cent. sodium chloride is heated to 59°, was found in extracts of the yellow lupin seed. As but little of this proteid is present in this seed, no attempt was made to do more than note its presence. Owing to its ready solubility in very dilute salt solutions, this proteid dissolves when lupin meal is treated with water. Besides this little if any other globulin substance is extracted from lupin seeds by the dilute saline solution which results when the meal is treated with water. Large quantities of globulin are, however, obtained by extraction with stronger salt solutions.

One hundred grams of meal yielded directly with salt solution an extract which was filtered clear, saturated with ammonium sulphate, the precipitate produced filtered out, dissolved in brine and the solution filtered clear and dialyzed for eighteen hours. The globulin thus precipitated was filtered out, washed with water, alcohol and ether, dried over sulphuric acid and found to weigh 12 grams. The filtrate by further dialysis similarly yielded 4.7 grams of globulin. These preparations, **1** and **2**, were analyzed with the results given below. The residue, remaining after exhausting 100 grams of meal with water, on treating with salt solution gave an extract which, when filtered clear and dialyzed four days, yielded 20.36 grams of globulin, preparation **3**, having the composition given in the following table. A large quantity of the globulin was prepared by extracting one kilogram of finely ground lupin meal with six liters of brine, filtering the resulting solution, saturating with ammonium sulphate, filtering out the precipitate produced, dissolving this in dilute salt solution, again precipitating by saturating with ammonium sulphate, re-dissolving the precipitate, filtering the solution so obtained and dialyzing for forty hours. The very large precipitate which separated was washed thoroughly by decantation with water, dilute alcohol, absolute alcohol and ether and then dried over sulphuric acid. In this way 112 grams of preparation **4** were secured having the composition given in the subjoined table. The filtrate from **4**, after three days further dialysis, gave a second precipitate of globulin which was decidedly more viscid than **4.** This by the usual treatment yielded 30 grams of preparation **5** with the composition given below.

Another portion of meal weighing one kilogram was several times extracted with water and the residue treated with successive applications of 10 per cent. salt solution. The extract was filtered clear and dialyzed for forty hours. The globulin so precipitated was thoroughly washed with water by decantation, then with dilute alcohol and finally with absolute alcohol until no more color was removed, and finally with ether and then dried over sulphuric acid ; 120 grams of preparation **6** were thus obtained, giving on analysis the figures stated below. The solution from which **6** had separated was saturated with ammonium sulphate, the precipitate dissolved in brine and the solution returned to the dialyzer. After some days the small precipitate which had separated was filtered out, washed and dried in the usual manner and gave 5.0 grams of preparation **7** having the composition given below.

In order to avoid as far as possible any contamination of the proteid with nitrogenous or other substances soluble in alcohol, a quantity of very fine ground lupin meal was exhausted in a Squibbs percolator with a large quantity of strong alcohol, the process being continued until only a trace of solid matter remained after evaporating a considerable quantity of the alcoholic extract.

Two kilograms of this meal were then extracted as thoroughly as possible with brine, the solution filtered clear and saturated with ammonium sulphate. The proteids thus precipitated were dissolved in brine, the solution filtered perfectly clear and the globulin thrown down by dialyzing three days was filtered off, washed and dried in the manner already described. There was thus obtained 506 grams of globulin, preparation **8**.

The solution filtered from **8** by longer dialysis yielded 45 grams of preparation **9.** These preparations had the composition given below.

Lupin Globulin.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Carbon	50.62	50.68	50.63	50.49	50.29	50.41	49.81	50.20	49.47
Hydrogen	6.94	6.95	7.00	6.77	6.89	6.85	6.79	6.75	6.77
Nitrogen	17.45	17.89	18.05	17.90	17.88	18.01	17.79	17.86	18.07
Sulphur	0.77	0.80	0.88	0.88	1.25	0.87	1.48	0.98	1.49
Oxygen	24.22	23.68	23.44	23.96	23.69	23.86	24.13	24.21	24.20
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ash	0.51	0.27	0.74	0.26	0.30	0.99	0.83	0.38	0.23

These figures agree quite closely except those for **5, 7** and **9** in which carbon is less and sulphur decidedly more than in the others. The fact that these three preparations separated on prolonged dialysis of the solutions which had yielded **4, 6** and **8** indicates the presence of two globulins, of different composition.

It was therefore necessary to submit this substance to very thorough fractional precipitation in order to determine definitely its true composition. Accordingly one hundred grams of preparation **6** were dissolved in 800^{cc} of five per cent. salt solution, filtered from a very small quantity of insoluble matter and the perfectly clear solution was mixed with 800^{cc} of water and cooled to 0°. A very large proportion of the dissolved proteid separated as a solid, coherent mass on the bottom of the beaker from which the clear solution was completely decanted. This precipitate was marked A, the solution B. The precipitate A was dissolved in 100^{cc} of ten per cent. brine, yielding readily a perfectly clear solution. This was mixed with 100^{cc} of water at 20° but no precipitate resulted. Water was then added gradually until an abundant precipitate formed and the total volume equalled 500^{cc}. After settling, the clear solution was poured off from the precipitate and the latter washed thoroughly with water and alcohol and dried over sulphuric acid. In this way 46.0 grams of preparation **10** were obtained, having the following composition.

LUPIN GLOBULIN, **10**.

Carbon	50.49
Hydrogen	6.77
Nitrogen	17.89
Sulphur	0.66
Oxygen	24.19
	100.00
Ash	0.51

The solution decanted from **10** was mixed with 600^{cc} more water, which gave another precipitate that, after washing and drying, weighed 10.5 grams and had the composition given below.

LUPIN GLOBULIN, **11**.

Carbon	50.18
Hydrogen	6.94
Nitrogen	17.93
Sulphur	0.82
Oxygen	24.13
	100.00
Ash	0.77

The solution B decanted from the first precipitate A as described above was diluted with an equal volume of water, cooled

to 0° and allowed to deposit the resulting precipitate. After washing and drying, preparation **12**, weighing 8.0 grams, was obtained, which gave the following results on analysis.

LUPIN GLOBULIN, **12**.

Carbon	50.08
Hydrogen	6.82
Nitrogen	18.26
Sulphur	1.30
Oxygen	23.54
	100.00
Ash	0.74

The solution from which **12** separated was saturated with ammonium sulphate, the proteid thereby precipitated was dissolved in water and the clear solution dialyzed. A small precipitate resulted which when washed and dried weighed 1.40 grams and had the following composition.

LUPIN GLOBULIN, **13**.

Carbon	49.54
Hydrogen	6.91
Nitrogen	18.24
Sulphur } Oxygen }	25.31
	100.00
Ash	0.49

These fractional precipitations show a regular decrease in their content of carbon and an increase in both nitrogen and sulphur, that of the latter being especially marked. It is to be noted that the total weight of the foregoing fractions formed only 65.9 per cent. of the proteid taken, suggesting that the globulin was undergoing a change while in solution; but as no especial care was exercised to obtain all the proteid from the solutions, this process was repeated, not only with a view to settling this point, but to obtain larger quantities of the extreme fractions for further examination.

One hundred grams of preparation **8** were dissolved in 800^{cc} of five per cent. brine and the solution, after filtering perfectly clear, was mixed with 800^{cc} of water and cooled to 10°. The abundant precipitate which resulted was allowed to settle, and the solution decanted. The precipitate was marked C, the solution D. Precipitate C was next dissolved in 100^{cc} of ten per cent. brine and

300^{cc} of water at 20° added to the resulting solution. After standing some time the clear solution was decanted from the large deposit of proteid and the latter washed and dried. Thus were obtained 50.0 grams of preparation **14**, which analysis showed to have the following composition.

LUPIN GLOBULIN, 14.

Carbon	50.71
Hydrogen	7.00
Nitrogen	17.86
Sulphur	0.67
Oxygen	23.76
	100.00
Ash	0.39

The filtrate from **14** was mixed with 400^{cc} of the first washings of **14** and cooled to 7°–8°. On standing, a part of the proteid deposited and the clear solution was then decanted. The precipitate, preparation **15**, after washing and drying weighed 8.46 grams, and according to analysis contained:

LUPIN GLOBULIN, 15.

Carbon	50.14
Hydrogen	6.94
Nitrogen	17.83
Sulphur	0.86
Oxygen	24.23
	100.00
Ash	0.81

The solution from which **15** had separated was dialyzed but only a very small quantity of globulin could be obtained, preparation **16**, which weighed 0.7 gram and without correction for ash contained 18.22 per cent. of nitrogen. Solution D decanted from precipitate C as already described was cooled to 3°, that is 7° lower than before. This caused a further quantity of globulin to separate, which gave preparation **17**, weighing 21.14 grams.

LUPIN GLOBULIN, 17.

Carbon	50.13
Hydrogen	6.88
Nitrogen	17.72
Sulphur	0.80
Oxygen	24.41
	100.00
Ash	0.59

The solution from which **17** separated was dialyzed free from chlorides and 13.7 grams of preparation **18** obtained having the following composition:

LUPIN GLOBULIN, 18.

Carbon	50.04
Hydrogen	6.79
Nitrogen	18.43
Sulphur	1.48
Oxygen	23.26
	100.00
Ash	0.25

The filtrate from **18** contained but a very little proteid precipitable with ammonium sulphate. The total weight of these fractions was 94.0 grams; the 6 grams unaccounted for may be fairly attributed to mechanical loss and therefore a change of proteid to non-proteid substances is improbable.

These fractions, like those of the preceding series, show a decrease in carbon and an increase in nitrogen and sulphur as we pass from the least to the most soluble.

Another series of separations was next made by fractional solution.

One hundred grams of preparation **8** were dissolved in 800^{cc} of five per cent. brine, diluted with 800^{cc} of water at 20° and the solution cooled to 5°. The clear solution was then decanted from the separated proteid and dialyzed till free from chlorine. The globulin thus separated after washing and drying weighed 24.03 grams and had the following composition:

LUPIN GLOBULIN, 19.

Carbon	50.11
Hydrogen	6.84
Nitrogen	18.46
Sulphur	1.28
Oxygen	23.31
	100.00
Ash	0.17

The proteid deposited by cooling as just described was dissolved in 700^{cc} of five per cent. brine and cooled at 5°. The clear solution was decanted and dialyzed, yielding 18.60 grams of preparation **20**, which contained:

LUPIN GLOBULIN, 20.

Carbon	50.27
Hydrogen	6.78
Nitrogen	18.43
Sulphur	1.15
Oxygen	23.37
	100.00
Ash	0.10

The substance precipitating on cooling as just described was dissolved in 600[cc] of five per cent. salt solution, mixed with an equal volume of water and cooled to 2°. The clear solution was dialyzed and 5.6 grams of preparation **21** were obtained, which gave the following results on analysis:

LUPIN GLOBULIN, 21.

Carbon	50.03
Hydrogen	6.86
Nitrogen	18.47
Sulphur	1.49
Oxygen	23.15
	100.00
Ash	0.22

The precipitate that separated on cooling the solution from which **21** was obtained, was dissolved in 500[cc] of five per cent. brine, diluted with an equal volume of water and cooled to 7°. The solution was decanted from the precipitate and dialyzed. Thus was obtained 4.31 grams of preparation **22**, which contained:

LUPIN GLOBULIN, 22.

Carbon	50.44
Hydrogen	6.92
Nitrogen	18.23
Sulphur	1.14
Oxygen	23.27
	100.00
Ash	0.11

The substance deposited by cooling, as last described, was dissolved in 300[cc] of five per cent. salt solution, filtered clear and dialyzed till free from chlorides. The deposited globulin, after washing and drying, weighed 33.88 grams and contained:

LUPIN GLOBULIN, 23.

Carbon	51.13
Hydrogen	6.86
Nitrogen	18.03
Sulphur	0.49
Oxygen	23.49
	100.00
Ash	0.52

Like the preceding, this series of fractional separations shows a decrease in carbon and an increase in nitrogen and sulphur with increased solubility. The total weight of the fractions obtained was 86.42 grams, the loss being no greater than was to be expected.

Thirty-five grams of preparation **10** and the same quantity of preparation **14**, representing the least soluble portions obtained in the two first series of fractions, were next dissolved in 600[cc] of five per cent. brine, diluted with an equal volume of water and cooled to 6°. The solution was decanted from the precipitate which resulted, filtered clear and dialyzed. The globulin thus precipitated after washing and drying weighed 12.43 grams and contained:

LUPIN GLOBULIN, 24.

Carbon	50.10
Hydrogen	6.94
Nitrogen	18.12
Sulphur	0.94
Oxygen	23.90
	100.00
Ash	0.23

The precipitate produced by cooling the solution, as just described, was dissolved in 500[cc] of salt solution, diluted with 500[cc] of water and cooled to 6°. The deposited proteid after the usual treatment weighed 7.80 grams and had the following composition:

LUPIN GLOBULIN, 25.

Carbon	50.32
Hydrogen	6.90
Nitrogen	18.06
Sulphur	0.81
Oxygen	23.91
	100.00
Ash	0.27

The substance separated by cooling as just described was dissolved in 1000^{cc} of two and one-half per cent. sodium chloride solution and cooled to 7°. The clear fluid, decanted from the thus precipitated proteid, was dialyzed and yielded 5.51 grams of globulin, giving on analysis the following results:

LUPIN GLOBULIN, 26.

Carbon	50.80
Hydrogen	6.91
Nitrogen	18.01
Sulphur	0.64
Oxygen	23.64
	100.00
Ash	0.23

The proteid separated by cooling the solution from which 26 had been obtained was dissolved in 500^{cc} of five per cent. salt solution, diluted with an equal volume of water and cooled to 14°. The clear solution was decanted and dialyzed and gave 4.9 grams of preparation 27, which analysis showed to have the composition here given:

LUPIN GLOBULIN, 27.

Carbon	50.90
Hydrogen	6.85
Nitrogen	17.88
Sulphur	0.55
Oxygen	23.82
	100.00
Ash	0.27

The substance deposited at 14° as noted above was dissolved in 500^{cc} of five per cent brine, diluted to 1000^{cc} and allowed to settle at the temperature of the room (about 22°). The fluid was then decanted, dialyzed and further treated in the usual manner. There was thus obtained 5.45 grams of preparation 28, which contained:

LUPIN GLOBULIN, 28.

Carbon	50.93
Hydrogen	6.94
Nitrogen	17.83
Sulphur	0.48
Oxygen	23.82
	100.00
Ash	0.23

The substance separated by diluting the solution from which 28 resulted was washed with water and alcohol, dried and found to weigh 20.6 grams. Its composition was:

LUPIN GLOBULIN, 29.

Carbon	50.80
Hydrogen	6.83
Nitrogen	17.88
Sulphur	0.46
Oxygen	24.03
	100.00
Ash	0.70

This like the other series of fractional separations shows an increase in carbon and decrease in sulphur and nitrogen content accompanying a decrease in solubility. If the final fractions, which have been most thoroughly purified, are arranged as in the table below, it will be seen that a nearly constant composition has been reached, so that the average of these analyses may be taken as closely representing the composition of the least soluble and most abundant globulin of the yellow lupin.

YELLOW LUPIN GLOBULIN, CONGLUTIN.

	23	26	27	28	29	Average.
Carbon	51.13	50.80	50.90	50.93	50.80	50.91
Hydrogen	6.86	6.91	6.85	6.94	6.83	6.88
Nitrogen	18.03	18.01	17.88	17.83	17.88	17.93
Sulphur	0.49	0.64	0.55	0.48	0.46	0.52
Oxygen	23.49	23.64	23.82	23.82	24.03	23.76
	100.00	100.00	100.00	100.00	100.00	100.00

This is the globulin discovered by Ritthausen, and described by him under the name conglutin.

A careful examination of preparation 29 showed this globulin to have the following reactions:

In very dilute acids and alkalies it is completely soluble, yielding perfectly clear solutions of a light yellow color.

Dissolved in very dilute acetic acid, the proteid is precipitated by neutralizing the solution with sodium carbonate. On adding sodium chloride brine to the solution containing the precipitate in suspension, the latter is completely dissolved.

In ten per cent. sodium chloride brine it dissolves readily, giving a very slightly turbid solution of a pale yellow color, which turns litmus paper red, lackmoid paper blue, and has no effect on tropæoline when evaporated to dryness with it.

A solution containing ten per cent. of the globulin dissolved in ten per cent. sodium chloride brine behaved as follows:

Dilution with twice its volume of water produced a considerable precipitate.

Addition of one drop of acetic acid, sp. gr. 1.035, or one drop of hydrochloric acid (1 part concentrated acid and 3 parts of water) to 5^{cc} of this solution gave a heavy precipitate.

Addition of mercuric chloride* dissolved in ten per cent. brine gave no precipitate.

Tannin as well as picric acid gave a heavy precipitate.

Diluted with an equal volume of ten per cent. brine, the solution, containing five per cent. of globulin, reacted as follows:

No precipitate was produced by saturation with sodium chloride, magnesium sulphate or sodium sulphate at 20°, but at 34° saturation with the last-named salt precipitated all but a minute trace of the globulin.

When the solution in ten per cent. sodium chloride brine, containing five per cent. of proteid, was heated gradually in a water bath, no change appeared even after heating some time at 100°. After more prolonged heating a thick transparent skin formed on the surface. On cooling and standing several hours, the solution set to a solid jelly and became somewhat turbid.

Addition of nitric acid to the solution in brine gave a precipitate not soluble in an excess of this acid. On heating, the usual xanthoproteic reaction occurred, which was preceded by the development of a slight pink color quickly changing to yellow, doubtless due to a trace of coloring matter still adhering to the proteid. When the globulin in the dry state was treated with very dilute nitric acid a clear solution resulted which gave a heavy precipitate on adding an excess of acid, that behaved on heating as just described. The usual proteid reactions were obtained with Millon's, Adamkiewics' and the biuret tests.

In order to determine the composition of the more soluble fractions, the greater parts of **18**, **19** and **20** were united, giving forty grams of substance which was dissolved in 400^{cc} of five per

* Palladin (Zeitschrift f. Biol. **31**, 195) states that 10 per cent. sodium chloride solutions are not precipitated by mercuric chloride, but that diluted solutions give precipitates soluble in salt solution. The precipitate which he thus obtained was of course caused by the water added with the mercuric chloride. If he had dissolved the mercury salt in brine, no precipitate would have resulted.

cent. brine, the solution was filtered perfectly clear, the filter washed with 100^{cc} of the same salt solution, and the filtrate and washings were mixed with an equal volume of water. After cooling to 8°, and standing some time a part of the globulin separated. From this the solution was decanted. The proteid was deposited as a viscid transparent fluid, which became opaque on treating with distilled water and finally solid. It was dehydrated with absolute alcohol and dried over sulphuric acid giving 19.2 grams of preparation **30**, having the following composition:—

LUPIN GLOBULIN, **30**.

Carbon	49.64
Hydrogen	6.87
Nitrogen	18.21
Sulphur	1.20
Oxygen	24.08
	100.00
Ash	0.32

The solution decanted from preparation **30** was mixed with 500^{cc} of water and cooled to 7°. The resulting precipitate, when treated in the same way as **30** had been, gave 9.25 grams of preparation **31**, containing:—

LUPIN GLOBULIN, **31**.

Carbon	49.62
Hydrogen	6.72
Nitrogen	18.22
Sulphur	1.36
Oxygen	24.08
	100.00
Ash	0.43

The solution from which **31** had separated was dialyzed free from chlorides, and yielded 7.4 grams of preparation **32**:

LUPIN GLOBULIN, **32**.

Carbon	49.59
Hydrogen	6.75
Nitrogen	18.43
Sulphur	1.62
Oxygen	23.61
	100.00
Ash	0.17

These three fractions have very nearly the same composition, which is in close agreement with that of the other most soluble fractions already described, as may be seen from the following table:

LUPIN GLOBULIN.

	13.	18.	9.	30.	31.	32.	Average.
Carbon	49.54	49.63	49.47	49.64	49.62	49.59	49.58
Hydrogen	6.91	6.78	6.77	6.87	6.72	6.73	6.80
Nitrogen	18.24	18.43	18.08	18.21	18.22	18.43	18.27
Sulphur }	25.31	1.48	1.49	1.20	1.36	1.56	1.42
Oxygen }		23.68	24.20	24.08	24.08	23.67	23.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

A series of tests of preparation **30**, conducted at the same time and under identical conditions with those described for preparation **29**, revealed the following differences. In ten per cent. sodium chloride brine, **30** dissolved to a perfectly clear solution more colored than that yielded by **29**.

Preparation **30**, dissolved in brine to a solution containing ten per cent. both of salt and proteid, was not even rendered turbid by dilution with two volumes of water, but with three volumes a slight precipitate was given. A similar solution of **29**, with two volumes of water, gave a considerable precipitate, and with three volumes a very heavy precipitate.

5^{cc} of the ten per cent. solution of **30** required eight drops of acetic acid, sp. gr. 1.035, to produce a slight precipitate, while one drop under the same conditions gave a heavy precipitate in a similar solution of **29**.

With one drop of hydrochloric acid (one part concentrated HCl and three parts H_2O) only a turbidity was produced in the case of **30**, while under like conditions **29** yielded a heavy precipitate.

Saturation with sodium sulphate of the solution containing five per cent. of **30** gave only a partial precipitation, **29** being wholly precipitated under like conditions.

When this five per cent. solution in ten per cent. brine was heated in a water bath a turbidity formed at 94°, increasing as the temperature was raised, becoming dense at 99° and after long heating a gelatinous flocculent precipitate separated which was unchanged on cooling and standing; when heated with nitric acid the pink color which preceded the yellow of the xanthoproteic reaction was more pronounced than that yielded by **29**.

In all other respects no difference could be detected between the reactions of **30** and **29**. The most noticeable property in which both differ from nearly all other vegetable globulins is that neither yields insoluble products (the so-called "albuminates") when separated from solution. The only evidence of such a tendency noticed in the very large number of preparations made, was in some cases shown by the presence of a slight turbidity when precipitates were re-dissolved.

Both give solutions which react strongly acid with litmus. Titrated with standard ammonia, two grams of each of these globulins required the addition of ten milligrams of ammonia to cause an alkaline reaction with litmus.

Although the analyses of the final fractions of the more soluble globulin agree closely and their properties and reactions are quite alike, it seems to us doubtful if they represent a definite chemical species. The close physical and chemical resemblance between the least soluble substance and the most soluble, suggests that they are closely related. The distinct difference in some properties observed between the extreme products of fractional precipitation make it probable that a combination of some sort has taken place between the conglutin and other constituents of the seed.

As the lupin seed is unusually rich in soluble constituents, it would not be surprising if the proteid on precipitation carried down with it more or less of these substances which could be with difficulty separated afterwards. From the globulin of the blue lupin by fractional precipitation readily soluble products were obtained which however were wholly different in composition and quite distinct in reaction from the more soluble fractions of the yellow lupin globulin. The soluble fractions are possibly conglutin combined either chemically or mechanically with other constituents of the seed, which in the two varieties of lupin are apparently present in different proportions.

C. *Proteid insoluble in water and saline solution but soluble in dilute alkalies.*

As previously described on page 344, after exhausting one kilogram of yellow lupin meal with ten per cent. sodium chloride solution and washing the residue with water, by continued extraction with two-tenths per cent. potash water a solution was obtained which after filtering clear and adding acetic acid to dis-

These three fractions have very nearly the same composition, which is in close agreement with that of the other most soluble fractions already described, as may be seen from the following table:

LUPIN GLOBULIN.

	13.	18.	9.	30.	31.	32.	Average.
Carbon	49.54	49.63	49.47	49.64	49.62	49.59	49.58
Hydrogen	6.91	6.78	6.77	6.87	6.72	6.73	6.80
Nitrogen	18.24	18.43	18.08	18.21	18.22	18.43	18.27
Sulphur } Oxygen }	25.31	1.48	1.49	1.20	1.36	1.56	1.42
		23.68	24.20	24.08	24.08	23.67	23.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

A series of tests of preparation **30**, conducted at the same time and under identical conditions with those described for preparation **29**, revealed the following differences. In ten per cent. sodium chloride brine, **30** dissolved to a perfectly clear solution more colored than that yielded by **29**.

Preparation **30**, dissolved in brine to a solution containing ten per cent. both of salt and proteid, was not even rendered turbid by dilution with two volumes of water, but with three volumes a slight precipitate was given. A similar solution of **29**, with two volumes of water, gave a considerable precipitate, and with three volumes a very heavy precipitate.

5^{cc} of the ten per cent. solution of **30** required eight drops of acetic acid, sp. gr. 1.035, to produce a slight precipitate, while one drop under the same conditions gave a heavy precipitate in a similar solution of **29**.

With one drop of hydrochloric acid (one part concentrated HCl and three parts H_2O) only a turbidity was produced in the case of **30**, while under like conditions **29** yielded a heavy precipitate.

Saturation with sodium sulphate of the solution containing five per cent. of **30** gave only a partial precipitation, **29** being wholly precipitated under like conditions.

When this five per cent. solution in ten per cent. brine was heated in a water bath a turbidity formed at 94°, increasing as the temperature was raised, becoming dense at 99° and after long heating a gelatinous flocculent precipitate separated which was unchanged on cooling and standing; when heated with nitric acid the pink color which preceded the yellow of the xanthoproteic reaction was more pronounced than that yielded by **29**.

In all other respects no difference could be detected between the reactions of **30** and **29**. The most noticeable property in which both differ from nearly all other vegetable globulins is that neither yields insoluble products (the so-called "albuminates") when separated from solution. The only evidence of such a tendency noticed in the very large number of preparations made, was in some cases shown by the presence of a slight turbidity when precipitates were re-dissolved.

Both give solutions which react strongly acid with litmus. Titrated with standard ammonia, two grams of each of these globulins required the addition of ten milligrams of ammonia to cause an alkaline reaction with litmus.

Although the analyses of the final fractions of the more soluble globulin agree closely and their properties and reactions are quite alike, it seems to us doubtful if they represent a definite chemical species. The close physical and chemical resemblance between the least soluble substance and the most soluble, suggests that they are closely related. The distinct difference in some properties observed between the extreme products of fractional precipitation make it probable that a combination of some sort has taken place between the conglutin and other constituents of the seed.

As the lupin seed is unusually rich in soluble constituents, it would not be surprising if the proteid on precipitation carried down with it more or less of these substances which could be with difficulty separated afterwards. From the globulin of the blue lupin by fractional precipitation readily soluble products were obtained which however were wholly different in composition and quite distinct in reaction from the more soluble fractions of the yellow lupin globulin. The soluble fractions are possibly conglutin combined either chemically or mechanically with other constituents of the seed, which in the two varieties of lupin are apparently present in different proportions.

C. *Proteid insoluble in water and saline solution but soluble in dilute alkalies.*

As previously described on page 344, after exhausting one kilogram of yellow lupin meal with ten per cent. sodium chloride solution and washing the residue with water, by continued extraction with two-tenths per cent. potash water a solution was obtained which after filtering clear and adding acetic acid to distinct acid reaction yielded a precipitate which after washing with water and alcohol and drying over sulphuric acid weighed 60.53 grams. This was re-dissolved in two-tenths per cent. potash water, the solution again filtered clear and carbonic acid passed through it. The proteid partly separated, but could not be filtered, so a little ammonium chloride was added to convert the potassium carbonate into chloride, but even after passing carbonic acid through the solution for some time and allowing it to stand over night in an ice box, only a partial separation resulted. Acetic acid was then added in slight excess and the precipitate filtered off and washed thoroughly with water and with alcohol. Dried at 110° this preparation, **33**, gave the following results on analysis:

LUPIN PROTEID, **33**.

Carbon	51.40
Hydrogen	6.79
Nitrogen	16.43
Sulphur	1.03
Oxygen	24.35
	100.00
Ash	1.57

BLUE LUPIN.

One kilogram of fine ground meal of the seeds of the blue lupin was extracted with a large quantity of distilled water applied in successive portions and the residual meal thrown on fine bolting cloth after each application. The extract thus obtained was allowed to stand over night. The partly clarified liquid was syphoned off, saturated with ammonium sulphate, the precipitate dissolved in brine and the solution filtered clear and dialyzed for 48 hours. A precipitate resulted which was filtered off, washed with water and with alcohol and dried over sulphuric acid, giving preparation **34**, weighing 8.46 grams. The filtrate was dialyzed for ten days longer in a stream of water, but no more proteid separated. The solution was then concentrated by dialysis in alcohol and absolute alcohol added until all the proteid contained in it was precipitated. The substance thus obtained weighed when dry only 1.42 grams and was not examined further than to find that it was nearly all insoluble in water, having been coagulated by the prolonged treatment with alcohol. This insolubility of the greater part of this substance shows that very little proteose is present.

Like the yellow lupin, this seed contains but little proteid matter soluble in water, and that is mostly globulin dissolved by aid of the salts extracted from the seed.

The meal residue which had been exhausted with water was treated with ten per cent. sodium chloride solution and the extract, after filtering perfectly clear, was dialyzed for 40 hours. The globulin, which separated in a coherent mass on the bottom of the dialyzer, was washed thoroughly by decantation with water and with alcohol and dried over sulphuric acid. This gave 115.0 grams of preparation **35**.

Another preparation of this globulin was made by treating one kilogram of the meal directly with ten per cent. brine, filtering the extract perfectly clear and dialyzing for 40 hours. The globulin thus precipitated, after washing and drying, formed preparation **36** and weighed 112 grams. These three preparations were dried at 110° and analyzed with the following results.

	BLUE LUPIN GLOBULIN.			CONGLUTIN.
	34	**35**	**36**	Yellow lupin.
Carbon	50.58	50.82	50.85	50.91
Hydrogen	6.58	6.87	6.78	6.88
Nitrogen	17.82	18.04	18.04	17.93
Sulphur	0.72	0.40	0.50	0.52
Oxygen	24.30	23.87	23.83	23.76
	100.00	100.00	100.00	100.00
Ash	0.64	1.22	1.11	

The agreement between **35** and **36** and the purified conglutin of the yellow lupin is very close indeed, but in order to be sure that this was not accidental these two preparations were subjected to the following treatment.

One hundred grams of **35** were dissolved in 500^{cc} of five per cent. sodium chloride brine and 500^{cc} of water added to the solution. A large rapidly settling precipitate resulted which formed a semi-fluid mass on the bottom of the beaker, from which the very nearly clear solution A was poured after a short time. The precipitate B was dissolved in 280^{cc} of 6.5 per cent. brine and the resulting solution, which measured 380^{cc}, was diluted with an equal volume of water and cooled to 5°. The solution was then decanted from the precipitate, which was washed and dried as usual and found to weigh 39.2 grams, preparation **37**. The solution decanted from **37** was dialyzed until free from salt, whereby a precipitate resulted which when washed and dried weighed 4.2 grams and formed preparation **38**. The solution A, decanted from precipitate B as above described, was cooled to 5° and the solution C decanted from the precipitate D. This precipitate was again dissolved in 300^{cc} of five per cent. brine, 300^{cc} of water added and the whole cooled to 5°. The precipitate thus produced when dried weighed 19.5 grams, preparation **39**. The solution from which **39** had separated was dialyzed and yielded preparation **40**, weighing 5.4 grams.

The solution C decanted from precipitate D was dialyzed free from chlorides and thereby 13.0 grams of preparation **41** was separated. These preparations were dried at 110° and analyzed with the following results. In the table they are arranged according to their solubility in dilute salt solutions.

	37	39	38	40	41	
Carbon	51.25	51.04	50.82	50.98	50.79	
Hydrogen	6.96	6.75	6.66	6.83	6.79	
Nitrogen	18.11	18.15	17.69	17.66	17.64	
Sulphur	0.32	0.24	0.49	0.38	0.39	
Oxygen	23.36	23.82	24.34	24.15	24.39	
	100.00	100.00	100.00	100.00	100.00	
Ash	0.95	0.71	0.61	0.52	0.75	
Amount	39.2	19.5	4.2	5.4	13.0	grams.

From these figures it would seem that preparation **35** contained some impurities, which accumulated in the three most soluble fractions in which the nitrogen is a little lower and the sulphur slightly higher than in the less soluble fractions. Preparation **36** was next fractionally precipitated in the following manner.

One hundred grams were dissolved in 700^{cc} of five per cent. sodium chloride brine, filtered perfectly clear and the solution diluted with an equal volume of distilled water. The proteid separated as a viscid liquid from which the solution E was decanted. The precipitate, F, was dissolved in 100^{cc} of five per cent. brine and the resulting solution, which measured 175^{cc}, was cooled in a freezing mixture to —4°, and then allowed to stand until it had warmed to 20°. The precipitate thus produced formed a perfectly transparent syrupy liquid which measured 61^{cc}. The solution from which this had separated was decanted and the fluid precipitate was washed by stirring up with water,

whereby it was rendered opaque and pasty. On washing with fresh quantities of water the substance became denser and granular. It was finally washed with alcohol and dried over sulphuric acid, giving 25 grams of preparation **42**.

The washings of **42** were cooled to 0° and 0.4 gram preparation **43** obtained. The solution from which this separated contained very little proteid, which was not saved. The solution E, decanted from precipitate F, was cooled to 8°, and the solution G was decanted from the proteid H, thus separated.

This precipitate was treated with 77^{cc} of five per cent. sodium chloride brine giving a solution measuring 126^{cc}, which was cooled to —10° and then allowed to stand until warmed to 20°, when 49^{cc} of a clear viscid liquid separated. This was washed with water in the same manner as **42** had been and then with alcohol, dried over sulphuric acid, and 18.5 grams of preparation **44** obtained. From the washings of **44** by cooling to 0° 2.62 grams of preparation **45** were separated. The solution G, decanted from precipitate H, was cooled in a freezing mixture until partly frozen, when it was allowed to melt and deposit the separated proteid. The latter, J, after decanting the solution I, was dissolved in 50^{cc} of five per cent. sodium chloride brine and the 75^{cc} of solution which resulted was cooled to —2°, but only a turbidity resulted. The solution was therefore diluted with an equal volume of water, again cooled to —2°, and slowly warmed to 20°. The proteid separated as a viscid liquid measuring 24^{cc} and when washed with water and alcohol gave 10.0 grams of preparation **46**. From the washings of **46** by cooling to 0° there separated 0.56 gram of preparation **47**. The solution I, decanted from precipitate J, was diluted with an equal volume of water and cooled to 0°. The substance which separated was washed with water and alcohol and when dried weighed 9.15 grams and formed preparation **48**. The solution from which **48** had separated contained too little proteid to save.

Dried at 110° these preparations gave the following results on analysis, which are arranged in the table in the order of their solubility.

	42	44	43	45	46	47	48
Carbon	51.09	51.14		50.86	50.94		50.65
Hydrogen	6.83	6.89		6.89	6.89		6.84
Nitrogen	18.08	18.10	17.82+	17.95	17.79	17.77	17.56
Sulphur	0.38	0.33		0.46	0.27		0.44
Oxygen	23.62	23.54		23.84	24.11		24.51
	100.00	100.00		100.00	100.00		100.00
Ash	0.59	0.47	?	0.69	0.51	0.54	8.86
Amount	25.00	18.50	0.40	2.62	10.00	0.56	9.15 grams.

If the analyses of preparations **37, 39, 42** and **44**, which constitute the greater part of the proteid substance of **35** and **36**, are compared, it will be seen that they are in very close agreement and it is fair to presume that they represent very nearly the true composition of this the principal proteid of the blue lupin. If these analyses are also compared with those of conglutin from the yellow lupin, it will be evident that the two varieties of lupin contain one and the same globulin, especially since a rigid comparison of the reactions of purified preparations from the two seeds failed to reveal the slightest difference. The following table will facilitate a comparison of the above mentioned figures.

	Conglutin.					
	Blue Lupin.					Yellow Lupin.
	37	39	42	44	Average.	Average.
Carbon	51.25	51.04	51.09	51.14	51.13	50.91
Hydrogen	6.96	6.75	6.83	6.89	6.86	6.88
Nitrogen	18.11	18.15	18.08	18.10	18.11	17.93
Sulphur	0.32	0.24	0.38	0.33	0.32	0.52
Oxygen	23.36	23.82	23.62	23.54	23.58	23.76
	100.00	100.00	100.00	100.00	100.00	100.00

If now we compare the analyses of the more soluble fractions as shown in the following table, they will be seen to be quite similar to each other but decidedly different from the more soluble globulin of the yellow lupin.

	38	40	41	46	47	48	Average.	Soluble globulin yellow lupin.
Carbon	50.82	50.98	50.79	50.94		50.65	50.84	49.58
Hydrogen	6.66	6.83	6.79	6.89		6.84	6.80	6.80
Nitrogen	17.69	17.66	17.64	17.79	17.77	17.56	17.69	18.27
Sulphur	0.49	0.38	0.39	0.27		0.44	0.39	1.42
Oxygen	24.34	24.15	24.39	24.11		24.51	24.28	23.93
	100.00	100.00	100.00	100.00		100.00	100.00	100.00

A comparison of the reactions of **41** with those of **37** showed that much less difference existed between the extreme fractions from the blue lupin than between those from the yellow. A ten per cent. solution of **37** in ten per cent. brine gave a considerable precipitate when diluted with twice its volume of water, while three times its volume were required to produce a slight precipitate in similar solutions of **41**. Solutions of both were precipitated with equal quantities of acid, **41** not needing the large excess of acid to cause precipitation which the soluble product from the yellow lupin required.

A solution of five per cent. of **37**, in ten per cent. brine, even after prolonged heating at 99°–100°, appeared wholly unaffected until the solution was subsequently cooled, when it solidified. A similar solution of **41** began to yield a flocculent coagulum at 75°, which at 80° was voluminous. After heating in a boiling water bath for some time nearly all the proteid was coagulated. As to the relations of these two substances, what was said on page 361, in our opinion, applies equally in this case.

Conclusion.

Both yellow and blue lupin seeds contain very little proteid matter soluble in water. The total quantity of proteid soluble in pure water obtained from the yellow lupin amounted to only 0.37 per cent. Of this a part consists of proteose. Whether the remainder is albumin, or a globulin soluble in extremely dilute salt solutions, which therefore could not be completely separated by dialysis, was not determined. Peptone is not contained in the freshly ground seed but is formed in small quantity after prolonged contact with water.

The greater part of the proteid matter contained in these seeds is soluble in saline solutions, the yellow lupin yielding 26.2 per cent. This is the body known as conglutin, but as heretofore described and as usually obtained it is contaminated with other substances present in the seed. Preparations from the blue lupin are usually much purer than those from the yellow, for the latter contain a considerable quantity of some sulphur containing substance from which conglutin can be separated by fractional precipitation out of dilute salt solutions. This explains why Ritthausen's conglutin from the yellow lupin contained twice as much sulphur as that from the blue lupin.

When purified no difference in properties and reactions can be detected between preparations from the two seeds.

The composition of conglutin as obtained by us is shown by the following figures.

CONGLUTIN.

	Yellow Lupin.	Blue Lupin.
Carbon	50.91	51.13
Hydrogen	6.88	6.86
Nitrogen	17.93	18.11
Sulphur	0.52	0.32
Oxygen	23.76	23.58
	100.00	100.00

Conglutin is readily soluble in sodium chloride solutions containing upwards of five per cent. of the salt. By sufficient dilution it is precipitated, a syrupy liquid separating which is rendered opaque and solid by treatment with water. Dissolved in salt solution, it is apparently unaffected by prolonged heating in a boiling water bath, but solutions thus heated on standing and cooling form a solid opalescent jelly which becomes clear and fluid on again heating. Unlike other globulins conglutin does not yield insoluble (coagulated) products by washing with alcohol or drying.

After exhausting lupin meal with salt solution, a small quantity of proteid can be extracted by two-tenths per cent. potash water, from which it is precipitated by adding acetic acid in slight excess but not by making the solution neutral to litmus. Only one preparation of this substance was made, which gave the following results on analysis.

Carbon	51.40
Hydrogen	6.79
Nitrogen	16.43
Sulphur	1.03
Oxygen	24.35
	100.00

Owing to the insolubility of this substance in any but alkaline fluids and the difficulty of making preparations of known purity nothing further was learned respecting it.

EFFECT OF MINUTE QUANTITIES OF ACID ON THE SOLUBILITY OF GLOBULIN IN SALT SOLUTIONS.

BY THOMAS B. OSBORNE AND GEO. F. CAMPBELL.

In a paper on crystallized vegetable proteids by one of us (Osborne, Am. Chem. Jour., XIV, 671) it was shown that the principal globulin of the seed of the castor bean is partly insoluble in a saturated solution of sodium chloride, and partly soluble therein, and that these two parts are alike in composition and but slightly different in reactions. Having found a proteid of similar composition and properties in the sunflower seed, we have again turned our attention to the globulin of the castor bean, with the hope that we might discover the cause of this partial precipitation by saturating its solutions with salt.

A considerable quantity of this globulin was prepared by extracting castor pomace with three per cent. brine at 60° and allowing the filtered extract to cool to the temperature of the room. The proteid thus separated was washed with water and alcohol, and dried over sulphuric acid. It formed a slightly colored dense powder consisting of a mixture of spheroids and octahedral crystals.

Seventy-five grams of this preparation were treated with 750^{cc} of ten per cent salt solution and, after agitating for some time, filtered from a large insoluble residue. This latter was washed thoroughly with ten per cent. brine and the filtrate and washings were united. In this way the substance was separated into two parts, one soluble and one insoluble, in cold salt solution. This solution was then saturated with sodium chloride and the large precipitate produced was filtered off, dissolved in ten per cent. brine and this process twice repeated. The saturated sodium chloride solutions filtered from these precipitations were united and dialyzed free from salt, the proteid thus precipitated was washed with water and alcohol, and dried over sulphuric acid. Thus 12.39 grams of preparation **A** were obtained, representing the fraction of this globulin soluble in cold ten per cent. brine and *not* precipitated by saturation with sodium chloride. The proteid which had been several times precipitated from solution by saturation with salt, as just described, was dissolved in ten per cent. brine, and the solution filtered perfectly clear and dialyzed. By the usual treatment 18.52 grams of preparation **B** were obtained, representing the part of this globulin soluble in cold ten per cent. brine, but insoluble in saturated brine.

The part of the globulin which failed to dissolve in cold ten per cent. sodium chloride solution was next treated with salt solution of this strength, heated to 60° and allowed to cool to 14°. The greater part of the proteid was dissolved by this treatment, and after decanting the solution the undissolved residue was treated three successive times in the same way. The solutions obtained by this process were filtered clear from a slight quantity of suspended matters and saturated with sodium chloride, which precipitated all but an insignificant quantity of the dissolved proteid.

This precipitate was dissolved in ten per cent. brine filtered clear and dialyzed. The precipitated globulin, after filtering off, washing and drying, weighed 12.37 grams, and formed preparation **C.**

The part of the original globulin which failed to remain in solution after the above treatment with hot salt solution was dissolved in brine at 60°, filtered clear and allowed to cool over night. Very nearly all the proteid precipitated on cooling, and was washed and dried, giving preparation **D,** weighing 1.66 grams.

These four preparations were analyzed with very great care with the following results:

	A.	B.	C.	D.
Carbon	50.99	51.10	51.12	51.25
Hydrogen	6.92	6.87	6.95	6.97
Nitrogen	18.95	18.67	18.83	18.74
Sulphur } Oxygen }	23.14	23.36	23.10	23.04
	100.00	100.00	100.00	100.00
Ash	0.19	0.14	0.14	0.41

The difference between these results barely exceed the usual errors of analysis, although several determinations of each element in the different fractions indicate that these differences are not due to analytical errors. It would not be safe, however, to take such slight variations into account, especially when we consider the great difficulty in making perfectly pure preparations of proteids as well as exact combustions. We must, therefore, conclude that no difference in composition is proved to exist between these four preparations which present such marked differences in solubility. A comparative examination of these substances was made with the following results:

In ten per cent. brine at 20° A dissolved completely, B with the exception of a small residue, C partly, much being insoluble, while D did not dissolve at all. B and C dissolved nearly completely when warmed to 45°.

Five grams of each of A, B and C were dissolved in 50^{cc} of ten per cent. sodium chloride solution by heating to 50°. On cooling to 20° B and C deposited a very slight amount of proteid, but on cooling to 12° A gave a clear solution, while B deposited a not inconsiderable quantity of substance and C decidedly more. To 5^{cc} of each of these solutions at 20° were added 5^{cc} of water. A remained clear, B gave a slight precipitate, and from C practically all the dissolved globulin was thrown down, since further dilution of the solution filtered from this precipitate gave only a turbidity. With 5^{cc} more water added to A a turbidity resulted, while the same amount added to B gave a heavy precipitate. The dilution of A and B was continued until the strength of the salt solution was 1.66 per cent., when B yielded no more by further dilution, and A still contained dissolved globulin.

Five per cent. solutions of each of these proteids, in ten per cent. brine, when heated became turbid, A and B at 88°, C at 87° and flocculent coagula formed in A and C at 90° and in B at 91°, thus showing no difference in relation to heat.

Saturation with sodium chloride of the ten per cent. solution of this globulin gave a small precipitate in A, but completely precipitated B and C.

This partial precipitation of A shows that the substance precipitated by saturating with salt is a derivative of the body originally soluble in saturated brine.

In order to find the effect of minute quantities of acid added to these several fractions, two grams of each were treated with 20^{cc} of 0.05 per cent. acetic acid, or five milligrams of acid for each gram of proteid, which caused no noticeable solution. Two grams of salt were added to each whereby A was largely, B partly, and C but slightly dissolved. Heated to 50°, A gave a clear solution, B a nearly clear solution, while C dissolved only partly and precipitated on cooling to 20°.

The acid added to these solutions could not be detected by very delicate litmus paper, the reaction being perfectly neutral.

A solution of A was prepared in exactly the same manner, omitting the acetic acid, and the two solutions compared.

Diluted with an equal volume of water, no precipitate formed in either solution, but with two volumes an abundant precipitate fell in that containing the acid, while only a very slight precipitate formed in the other.

Saturated with sodium chloride, the solution with acid gave a large precipitate, that without acid only a small one.

It is thus clear that a quantity of acid too small to be detected with litmus or by analysis causes changes in the fraction soluble in saturated salt solution, whereby products result having the same general properties as those exhibited by the fractions B and C.

In order to obtain more evidence on this point, these experiments were repeated and extended, using crystallized edestin from hemp seed.

Five grams of edestin were suspended in 50^{cc} of 0.05 per cent. acetic acid, 5 grams of salt were added and the solution was warmed to 50° to dissolve the insoluble "albuminate" present.

Another solution was then prepared in exactly the same manner without using acetic acid. Both solutions reacted perfectly neutral to litmus paper.

Equal volumes at the same temperature, and in test tubes of the same size were immersed in the same bath of cold water. The solution containing acid precipitated first and in far greater amount than the other.

Five cubic centimeters of each were diluted with an equal volume of water at 20°. The solution with acid gave a much greater precipitate than the other. After allowing these to stand and cool to 10° the precipitates were filtered off and one drop of strong acetic acid was added to each filtrate. The solution which had been made with acid gave only a turbidity, while a considerable precipitate formed in the other, showing that dilution precipitates the solution to which acid had been added far more readily than the solution without the acid.

Equal volumes of these solutions were saturated with salt, the precipitates filtered off, and one drop of acetic acid was added to each filtrate.

That from the solution made with acid gave only a turbidity while the other gave a very heavy precipitate.

Here again we see that the addition of a quantity of acid, too small to detect after the solution has been made, brings about changes similar to those naturally occurring in the seeds and extracts of the castor bean and sunflower and to those following

the addition of acid to that part of the globulin of the castor bean which is soluble in saturated salt solutions.

Whether such changes occur only through the influence of acids is a question not settled, and regarding which some doubt is raised by the fact that preparations of crystallized edestin which were originally soluble in ten per cent. sodium chloride solution, with the exception of a small quantity of "albuminate" and yielded solutions which gave only traces of precipitates on saturating with sodium chloride, were found, after keeping dry and in cork-stopped bottles two and four years, to have become largely insoluble in cold salt solution and to yield solutions which were nearly completely precipitated by saturating with salt. The insoluble portion dissolved nearly completely in ten per cent. brine at 60° to a solution precipitated somewhat by cooling to 20° and abundantly at lower temperatures, copiously precipitated by dilution with an equal volume of water, and almost completely precipitated by saturating with sodium chloride. It is not at all impossible that this change, too, may have been caused by acid, for these preparations stood during several years in the laboratory, the air of which at times contained some acid vapors. We thus see the same changes taking place in the dry proteid on long keeping as those definitely caused by minute quantities of acid.

That this change to a condition in which the globulin is precipitated by salt is an intermediate step towards the formation of the insoluble form, the so-called "albuminate" of Weyl, is evident from what has been already stated, especially the fact that by treatment with warm salt solution this insoluble matter can be changed into the form soluble in cold salt solution and precipitable by saturation with salt.

In this connection it is interesting to note that the only animal globulin obtained from an acid tissue is myosin, and that this myosin not only is readily precipitated by saturating with salt, but quickly and spontaneously changes to the insoluble form known as syntonin. In the dead muscle the amount of acid greatly exceeds that used in our experiments, for its presence is plainly shown by the strong acid reaction of the muscle serum. In alkaline muscle plasma myosin is not found, but myosinogen, paramyosinogen and myoglobulin. The last three are described as precipitated by saturation with sodium chloride, but it may be that when tested in this respect the formation of acid had already begun and had reached a point where it caused precipitation with salt but could not be detected by the usual tests.

THE PROTEIDS OF THE SUNFLOWER SEED.

BY THOMAS B. OSBORNE AND GEORGE F. CAMPBELL.

The only published observations on the proteid of the sunflower seed which we have found were made by Ritthausen (Pflüger's Archiv XXI. 89, 1880) and by Vines (Jour of Physiology III. 93). By extracting with very dilute alkali Ritthausen obtained from finely ground oil-free meal 44.71 per cent. of proteid, having the composition given under **1.** By treating with sodium chloride brine, diluting the extract with five volumes of water and passing carbonic acid through the solution, he got 25.3 per cent. with the composition given under **2,** and by exhausting a preparation obtained in the same manner as **1** with brine, and proceeding as with **2,** he got a preparation whose analysis is given under **3.**

SUNFLOWER PROTEID. RITTHAUSEN.

	1	2	3
Carbon	51.88	51.51	51.18
Hydrogen	6.66	6.76	6.82
Nitrogen	17.99	18.21	18.06
Sulphur	0.71	0.61	23.94
Oxygen	22.76	22.91	
	100.00	100.00	100.00

Vines states that if a section of sunflower seed be treated with ether to remove oil it will be found that the aleurone grains, though readily soluble in 10 per cent. sodium chloride solution, will not dissolve in saturated solution; if, however, they be treated with alcohol instead of ether, the globulin of which these grains consist behaves like vitellin, that is, it dissolves in a saturated solution of sodium chloride.

Vines further states that "it is of interest to note the fact that most of the substances which I found in the grains recur in the crystalloids, more especially vitellin and its derivatives; thus the peculiar globulin which forms the crystalloids of Ricinus appears to be in the grains of Helianthus."

Ritthausen's results indicate that by far the greater part of the proteid matter of the sunflower-seed has a uniform composition, and that a large part of this proteid is insoluble in salt solution, but soluble in dilute alkali. The composition which he found for this proteid resembles that of the globulin edestin, which we have found in many seeds, the only difference being a slightly lower

content of nitrogen. On this account it seemed to us desirable to examine this proteid and determine its relation to edestin. This was the more important, because Vines' statement of its behavior when treated with ether and with alcohol showed it to possess the same peculiar relations to salt solutions observed by one of us (Osborne, Report Conn. Expt. Station, 1892, p. 138, and Am. Chem. Jour. **14,** 671) in studying the globulin of the castor bean, *Ricinus communis.* As the deportment of globulins to saturated sodium chloride solutions has been made the basis of a division of these bodies into two main classes, it is important for us to know whether this is founded on fundamental differences in the proteids, or is simply due to the unlike conditions under which the proteids are found.

Sunflower seeds were crushed and a large part of the woody shells removed. The meal was then ground under benzine and, after freeing from oil, air dried. This meal when treated with ten per cent. sodium chloride brine yielded an extract of a strong blackish green color, from which a considerable quantity of proteid could be separated by dilution, by dialysis or by saturation with sodium chloride.

When heated, this extract becomes turbid at 48° and flocks separated at 62°. The solution heated to 75° and filtered from this slight coagulum yields a large precipitate when saturated with salt, thus showing that most of the substance thus precipitated is not, as *myosin* is said to be, coagulated below 75°.

The unheated extract saturated with sodium chloride gives a precipitate which when dissolved in ten per cent. brine coagulates at the same temperature as the original extract, but the amount of this coagulum is but a small fraction of the substance precipitated by saturation with salt.

The following preparations were made, but as subsequently pointed out were found to be more or less impure, so that these results have value only as affording evidence of the uniform composition of the globulin extracted by salt solution from the sunflower seed.

	1	2	3	4	5	6	7	8	9
C.	51.57	51.77	51.65	51.69	51.85	----	----	----	----
H.	6.81	6.83	6.72	6.80	6.84	----	----	----	----
N.	18.16	18.20	18.17	18.24	18.00	18.20	18.23	18.09	18.07
S.	23.46	23.20	23.46	0.78	23.31	----	----	----	----
O.				22.49					
	100.00	100.00	100.00	100.00	100.00				

Of these, **1** is the total globulin extracted by brine from one portion of oil-free meal; **2, 3, 4** and **5** are fractional precipitates from another similar extraction; **6,** substance precipitated by saturating the salt extract with sodium chloride; **7** and **8,** substance soluble in saturated sodium chloride solution, and **9,** that precipitated by cooling an extract made with a one and a half per cent. salt solution heated to 60°.

These results show that the most abundant proteid of the sunflower seed consists of a single globulin, and that the proteid precipitated by saturating with sodium chloride contains the same amount of nitrogen as the proteid soluble in a saturated solution of this salt. As Vines stated that the substance of the aleurone grains was soluble in a saturated salt solution after treatment with alcohol, while after treatment with ether it was insoluble therein, although soluble in ten per cent. salt solution, we thought that possibly by treating our meal with alcohol we might remove some substance, perhaps an acid soluble in alcohol but insoluble in ether, which might be the cause of this peculiar behavior of the proteid. We accordingly extracted a quantity of sunflower meal with alcohol of 0.820 sp. gr. and in order to determine whether acid had been removed we attempted to titrate a portion of the extract with a one per cent. solution of potash. On adding the alkali a colored precipitate resulted which rendered the indicator (*phenolphthalein*) useless. The attempt was then repeated, omitting the indicator. When the potash solution was added a bright chrome yellow color resulted, which gradually increased with the formation of a precipitate as the quantity of potash was increased. With a larger excess of potash the precipitate redissolved. This reaction we found to be due to helianthotannic acid (Ludwig and Kromayer, N. Br. **99,** 1 and 285). The results of our investigation of this acid will be given in another paper.

Having now found a very delicate test for this acid, we applied it to our preparations of globulin and obtained a strong reaction in every case. It was therefore necessary to remove this acid from the meal before attempting to obtain the proteid and accordingly the extraction of the meal with alcohol was continued. It was, however, practically impossible to remove the acid so completely as to obtain no yellow reaction when the extract was treated with potash.

The meal which had been nearly freed from this acid was

washed with ether and air dried. 100 grams were extracted with ten per cent. sodium chloride brine and the filtered extract saturated with salt. An abundant precipitate separated, just as with meal which had not been treated with alcohol. This was filtered off, dissolved in ten per cent. brine and again precipitated by saturation with salt. This precipitate was again dissolved in salt solution, filtered perfectly clear and dialyzed. The globulin which was thus precipitated was filtered out, washed with water and alcohol and dried over sulphuric acid. This preparation, **10,** weighed 7.4 grams and had the following composition:

SUNFLOWER GLOBULIN, *Preparation* **10.**

Carbon	51.27
Hydrogen	6.55
Nitrogen	18.21
Sulphur	0.78
Oxygen	23.25
	100.00
Ash	0.31

The saturated sodium chloride solutions filtered from the two precipitations of **10,** were united and dialyzed until free from chloride, the resulting precipitate was filtered out and treated as **10** had been. Preparation **12** was thus obtained, which on analysis gave the following results:

SUNFLOWER GLOBULIN, *Preparation* **12.**

Carbon	51.58
Hydrogen	6.55
Nitrogen	18.29
Sulphur	0.97
Oxygen	22.61
	100.00
Ash	0.29

As both the preceding preparations were found to contain detectable quantities of helianthotannic acid another attempt was made to prepare some meal which should be practically free from this acid.

One hundred grams of meal were therefore extracted in a Squibbs percolator with alcohol of 0.820 sp. gr., the whole being kept at 65° C. until 1500^{cc} of extract were obtained.

The temperature was then raised to 75° and the extraction continued, about seven liters of alcohol being passed through the meal. The last two liters were evaporated and left a residue weighing only 0.28 grams.

The meal residue was air dried and extracted with ten per cent. sodium chloride solution. The extract was then filtered clear and saturated with ammonium sulphate, the precipitated proteid filtered out, dissolved in brine, the solution filtered perfectly clear and dialyzed.

The proteid was thus precipitated in large spheroids and was filtered out, washed with water and alcohol, dried over sulphuric acid and found to weigh 15.5 grams, preparation **13.** This substance was freer from coloring matter than any before made, and had the following composition:

SUNFLOWER GLOBULIN, *Preparation* **13.**

Carbon	51.54
Hydrogen	6.99
Nitrogen	18.58
Sulphur	1.00
Oxygen	21.71
	100.00
Ash	0.47

This preparation, which was very nearly white in color, dissolved after drying almost wholly in ten per cent. sodium chloride brine at 20°, giving a solution slightly tinged with greenish brown, which on dilution yielded an abundant precipitate that on warming, while suspended in the diluted solution, redissolved completely and again separated on cooling in spheroids, and on settling united to a coherent layer.

Solutions in ten per cent. sodium chloride brine behaved as follows:

When saturated with magnesium sulphate at 20° or sodium sulphate at 34°, the proteid was completely thrown out of the solution. When saturated with sodium chloride it was partly precipitated.

With mercuric chloride, picric acid or tannic acid a heavy precipitate was produced.

With minute quantities of nitric, sulphuric, hydrochloric or acetic acid the globulin was precipitated.

In pure water this preparation formed a plastic mass, but none dissolved.

In water containing a minute quantity of acid it dissolved readily and completely.

With the xanthoproteic, Millon's, biuret and Adamkiewics' tests the usual proteid reactions were obtained.

When dissolved in ten per cent. sodium chloride solution and tested for heat coagulation point in the usual manner a turbidity formed at 90°, and a flocculent coagulum began to separate at 93°, increasing as the temperature was raised toward 100°. After heating some time in a boiling water bath a considerable coagulum formed, yet a large proportion of the substance still remained in solution, as shown by the voluminous precipitate produced on adding acetic acid to the solution filtered from the coagulum.

In composition and reaction this preparation agrees with the globulin edestin except that a part is precipitated by saturating its solutions in brine with sodium chloride. In composition the part precipitated by saturating with salt and that remaining in solution are alike. We have in another paper (this Report, p. 369) pointed out that the globulin of the castor bean shows a similar behavior, and that the part precipitated by saturating with salt is a derivative of the part soluble in saturated salt solutions. We have further shown that the addition to a solution of edestin of a quantity of acetic acid too small to detect after mixing with the proteid, causes a precipitation of the edestin on saturating its solution with brine, and that under these conditions, the proteid otherwise behaves like the globulin from the castor bean and sunflower seed.

As helianthotannic acid contains about 53.0 per cent. of carbon the presence of two per cent. of this acid in our preparation would but slightly raise the figures obtained for carbon and reduce those for nitrogen by about 0.35 per cent. The composition of the purer preparations which we have obtained differ from edestin to about this extent.

It is therefore our opinion that the sunflower seed contains as its principal proteid the globulin edestin, but that as obtained by extraction from the seed, this is mixed with helianthotannic acid, from which we have not succeeded in separating it completely.

Having thus found that a large part of this globulin is insoluble in saturated salt solutions under all the conditions of our tests, we were led to repeat Vines' experiments, but have been unable to confirm his observations, the aleurone grains appearing to be wholly unaffected by saturated salt solution after treatment of the seed with alcohol.

THE PROTEIDS OF THE COW PEA, (*Vigna Catjang.*)

BY THOMAS B. OSBORNE AND GEORGE F. CAMPBELL.

The proteids of this plant have never been, to our knowledge, the subject of study. Because of its great and increasing agricultural importance, and as a plant differing botanically from those included in our investigation of "legumin," the proteids of its seeds have much interest. The material examined was prepared by coarsely grinding the peas, separating the black seed-coats by a current of air, and then grinding the coarse meal to a fine flour. Two kilograms of this flour were treated with a quantity of ten per cent. sodium chloride solution, the extract was strained through fine bolting cloth and allowed for three hours to deposit the greater part of the suspended starch. The extract was then run through a DeLaval centrifugal separator, whereby most of the remaining suspended starch and fiber was removed, and lastly was filtered perfectly clear by passing through a thick layer of filter paper pulp. The extract was saturated with ammonium sulphate, the precipitated proteids were collected on a filter, and dissolved in brine. The solution was filtered perfectly clear and dialyzed for four days.

The proteid, thus separated, in the form of spheroids, was designated **A**, and the solution filtered therefrom was marked **B**. **A** was collected on several paper filters. One portion was washed very thoroughly with water and with alcohol and, dried over sulphuric acid, gave preparation **1**, which weighed 29.7 grams. The rest of **A** was dissolved in one liter of five per cent. sodium chloride brine, and the solution filtered perfectly clear. On adding one liter of distilled water a large precipitate, **D**, separated, which was allowed to settle over night. The fluid, **C**, was then decanted from the proteid, **D**, which had formed a coherent deposit. **D** was dissolved in 150^{cc} of ten per cent. sodium chloride brine with which it readily yielded a clear solution, and water was added to make the volume one liter. A rapidly settling precipitate appeared that soon united to a coherent layer, from which the nearly clear liquid was decanted. After thoroughly washing this precipitate with water and with alcohol and drying it over sulphuric acid there resulted 50.9 grams of preparation **2**. The solution decanted from **2** was treated with 200^{cc} of water, causing a precipitate which, washed and dried as before, gave 12.83 grams of preparation **3**. Similarly the solution

decanted from **3**, when mixed with 200^{cc} more water, gave 6.2 grams of preparation **4**.

The solution decanted from **4** was dialyzed until chlorides were removed, which treatment precipitated all but a trace of the dissolved proteids. In this way 4.4 grams of preparation **5** were obtained.

The solution **C**, decanted from the precipitate **D**, as described on page 380, was diluted with 500^{cc} of water. The proteid thus thrown down, after washing and drying, formed preparation **6**, which weighed 16.9 grams. The filtrate from **6** was dialyzed for two days, and a deposit obtained weighing when dry 10.5 grams, **7**. The filtrate from **7** was nearly free from proteid matter.

These preparations were analyzed, after drying at 110°, with the following results:

	1	2	3	4	5	6	7
Carbon	52.45	52.69	52.63	52.56	52.52	52.59	52.27
Hydrogen	6.92	6.77	6.90	6.98	7.04	7.08	6.97
Nitrogen	17.16	17.18	17.50	17.18	17.27	17.24	16.99
Sulphur	0.40	0.57	0.52	0.62	0.53	0.56	0.50
Oxygen	23.07	22.77	22.45	22.66	22.64	22.53	23.57
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ash	0.32	0.64	0.47	0.50	0.42	0.45	0.16

It will be noticed that the first six preparations are nearly identical in composition. Of these, **1** represents the globulin precipitated by dialyzing the solution of the ammonium sulphatep recipitate (which contained all the proteid matter extracted from the seed). **2, 3, 4** and **5** are four fractions of that portion of the substance (of which **1** was a part) that is most readily precipitated by dilution. **6**, which also agrees with the foregoing, is that part of the remainder thrown down by further diluting the solution filtered from the precipitate, yielding **2, 3, 4** and **5**, while **7, 8, 9** and **10** are portions more soluble in very dilute salt solution. In composition, **7** differs from **1–6**. Although the figures obtained for **1** closely agree with those for **2, 3, 4** and **5**, the former has been shown to contain about ten per cent. of the globulin, **7**, whose presence in this proportion affects but slightly the percentage composition of **1**. It will be noticed that **8** and **9** contain more carbon and sulphur than the other preparations. If these analyses are compared with those of similarly obtained preparations from the pea and vetch, it will be seen that they are

THE PROTEIDS OF THE COW PEA, (*Vigna Catjang.*)

By Thomas B. Osborne and George F. Campbell.

The proteids of this plant have never been, to our knowledge, the subject of study. Because of its great and increasing agricultural importance, and as a plant differing botanically from those included in our investigation of "legumin," the proteids of its seeds have much interest. The material examined was prepared by coarsely grinding the peas, separating the black seed-coats by a current of air, and then grinding the coarse meal to a fine flour. Two kilograms of this flour were treated with a quantity of ten per cent. sodium chloride solution, the extract was strained through fine bolting cloth and allowed for three hours to deposit the greater part of the suspended starch. The extract was then run through a DeLaval centrifugal separator, whereby most of the remaining suspended starch and fiber was removed, and lastly was filtered perfectly clear by passing through a thick layer of filter paper pulp. The extract was saturated with ammonium sulphate, the precipitated proteids were collected on a filter, and dissolved in brine. The solution was filtered perfectly clear and dialyzed for four days.

The proteid, thus separated, in the form of spheroids, was designated **A**, and the solution filtered therefrom was marked **B**. **A** was collected on several paper filters. One portion was washed very thoroughly with water and with alcohol and, dried over sulphuric acid, gave preparation **1**, which weighed 29.7 grams. The rest of **A** was dissolved in one liter of five per cent. sodium chloride brine, and the solution filtered perfectly clear. On adding one liter of distilled water a large precipitate, **D**, separated, which was allowed to settle over night. The fluid, **C**, was then decanted from the proteid, **D**, which had formed a coherent deposit. **D** was dissolved in 150^{cc} of ten per cent. sodium chloride brine with which it readily yielded a clear solution, and water was added to make the volume one liter. A rapidly settling precipitate appeared that soon united to a coherent layer, from which the nearly clear liquid was decanted. After thoroughly washing this precipitate with water and with alcohol and drying it over sulphuric acid there resulted 50.9 grams of preparation **2**. The solution decanted from **2** was treated with 200^{cc} of water, causing a precipitate which, washed and dried as before, gave 12.83 grams of preparation **3**. Similarly the solution decanted from **3**, when mixed with 200^{cc} more water, gave 6.2 grams of preparation **4**.

The solution decanted from **4** was dialyzed until chlorides were removed, which treatment precipitated all but a trace of the dissolved proteids. In this way 4.4 grams of preparation **5** were obtained.

The solution **C**, decanted from the precipitate **D**, as described on page 380, was diluted with 500^{cc} of water. The proteid thus thrown down, after washing and drying, formed preparation **6**, which weighed 16.9 grams. The filtrate from **6** was dialyzed for two days, and a deposit obtained weighing when dry 10.5 grams, **7**. The filtrate from **7** was nearly free from proteid matter.

These preparations were analyzed, after drying at 110°, with the following results:

	1	2	3	4	5	6	7
Carbon	52.45	52.69	52.63	52.56	52.52	52.59	52.27
Hydrogen	6.92	6.77	6.90	6.98	7.04	7.08	6.97
Nitrogen	17.16	17.18	17.50	17.18	17.27	17.24	16.99
Sulphur	0.40	0.57	0.52	0.62	0.53	0.56	0.50
Oxygen	23.07	22.77	22.45	22.66	22.64	22.53	23.57
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ash	0.32	0.64	0.47	0.50	0.42	0.45	0.16

It will be noticed that the first six preparations are nearly identical in composition. Of these, **1** represents the globulin precipitated by dialyzing the solution of the ammonium sulphatep recipitate (which contained all the proteid matter extracted from the seed). **2, 3, 4** and **5** are four fractions of that portion of the substance (of which **1** was a part) that is most readily precipitated by dilution. **6**, which also agrees with the foregoing, is that part of the remainder thrown down by further diluting the solution filtered from the precipitate, yielding **2, 3, 4** and **5**, while **7, 8, 9** and **10** are portions more soluble in very dilute salt solution. In composition, **7** differs from **1–6**. Although the figures obtained for **1** closely agree with those for **2, 3, 4** and **5**, the former has been shown to contain about ten per cent. of the globulin, **7**, whose presence in this proportion affects but slightly the percentage composition of **1**. It will be noticed that **8** and **9** contain more carbon and sulphur than the other preparations. If these analyses are compared with those of similarly obtained preparations from the pea and vetch, it will be seen that they are

By diluting the salt solutions of vignin it is apparently more readily precipitated than legumin, and far more readily than phaseolin.

Saturation of solutions of vignin with sodium chloride or magnesium sulphate gives no precipitate, but saturation with sodium sulphate at 34° causes nearly complete precipitation of the proteid.

Mercuric chloride gives no precipitate; tannic acid and picric acid make heavy precipitates in its solutions.

With Adamkiewics', Millon's, the biuret and xanthoproteic tests the usual proteid reactions are obtained.

Strong solutions of this globulin dissolved in ten per cent. sodium chloride become turbid when heated to 98°, and after continued heating set to a jelly.

Besides vignin the cow pea contains a small quantity of proteid matter represented by preparation **7**, which in composition, as well as reactions, agrees very closely with phaseolin. Phaseolin differs from all other plant globulins, which we have thus far observed, in not being precipitated from its solution in ten per cent. sodium chloride brine by a large quantity of acetic acid. In this respect **7** behaves like phaseolin.

The composition of phaseolin as obtained from different seeds is shown by the following statement:

PHASEOLIN.

	Cow pea.	Kidney bean.	Adzuki bean.
Carbon	52.27	52.58	52.56
Hydrogen	6.97	6.84	6.97
Nitrogen	16.69	16.47	16.45
Sulphur	0.50	0.56	0.57
Oxygen	23.57	23.55	23.45
	100.00	100.00	100.00

The solution **B**, filtered from **A**, as described on page 380, was saturated with ammonium sulphate and the small precipitate produced was dissolved in a little dilute salt solution, filtered perfectly clear and dialyzed for two weeks. A precipitate resulted which was filtered out, washed with water and alcohol and dried over sulphuric acid. This preparation, **8**, weighed 3.2 grams. The filtrate from **8** was dialyzed ten days longer, but as nothing separated, the solution was dialyzed against alcohol. A small precipitate, **9**, appeared, which weighed 3.75 grams.

These preparations after drying at 110° were analyzed with the following results:

	8	9
Carbon	53.13	53.36
Hydrogen	7.09	7.05
Nitrogen	16.51	16.21
Sulphur	1.09	1.13
Oxygen	22.18	22.25
	100.00	100.00
Ash	0.65	0.81

It will be noticed that these two preparations agree quite closely in composition. Although **8** was precipitated by dialysis in water and is unquestionably a globulin, while **9** could not be precipitated by even prolonged dialysis, nevertheless it is our opinion that these are one and the same proteid. In a subsequent paper we hope to point out the relations of this globulin to the proteids obtained similarly from other leguminous seeds.

Conclusion.

1. The chief proteid of the cow pea is a globulin, much resembling the legumin of the pea and vetch, but essentially different in composition and properties, for which we propose the name *vignin*. Its composition, as found by the average of closely agreeing analyses of nine fractional precipitates, is as follows:

VIGNIN.

Carbon	52.64
Hydrogen	6.95
Nitrogen	17.25
Sulphur	0.50
Oxygen	22.66
	100.00

2. Besides vignin, the cow pea contains a globulin which has the composition and, so far as could be determined, the properties of phaseolin, which we have found in the kidney bean (*Phaseolus vulgaris*), and the adzuki bean (*Phaseolus radiatus*).

3. The cow pea contains a third globulin, extremely soluble in very dilute salt solutions, which could be precipitated but partially by dialysis in water and completely only in the coagulated

form by dialysis in alcohol. This substance closely resembles in properties and composition bodies obtained from several other leguminous seeds. Its composition, as found by analysis of two precipitates, one obtained by dialysis in water and the other by further dialysis in alcohol, is as follows:

Carbon	53.25
Hydrogen	7.07
Nitrogen	16 36
Sulphur	1.11
Oxygen	22.21
	100.00

PROTEID OF THE WHITE PODDED ADZUKI BEAN (*Phaseolus radiatus*).

BY THOMAS B. OSBORNE AND GEORGE F. CAMPBELL.

This is a small red bean cultivated in Japan. The seeds used in this investigation were grown in Kansas and sent to us by Prof. C. C. Georgeson.

As our object was to discover the nature of the globulin forming the chief proteid constituent of various leguminous seeds, no attempt was made to determine the total amount of proteid contained in this seed, nor to study the other proteid substances occurring in small quantity.

It was impossible, by any means at our command, to remove the closely adhering red seed-coat, but as it was found that this yielded but little coloring matter to salt solutions the entire seed was ground until all passed a sieve of fine bolting cloth.

Two kilograms of this meal were treated with eight liters of ten per cent. sodium chloride solution, and after stirring some time the mixture was strained on fine bolting cloth.

After standing long enough to deposit most of the suspended starch the extract was filtered quite clear and saturated with ammonium sulphate. The precipitate so produced was filtered out, suspended in water and, in order to remove the adherent ammonium sulphate, which prevented solution of the proteid in a sufficiently small volume of water, the mixture was dialyzed over night. The proteid was thus completely dissolved. The solution was filtered perfectly clear and again dialyzed four days. A large precipitate of globulin resulted, which was filtered out and a portion collected on a separate paper and washed thoroughly with water and alcohol and dried over sulphuric acid. This was found to weigh 13.21 grams and formed preparation **1.**

The remainder of the globulin was suspended in 850^{cc} of water and 150^{cc} of ten per cent. salt solution added, which yielded a nearly clear solution, showing the globulin to be readily soluble in one and a half per cent. brine. The solution was filtered clear and the filter washed with 100^{cc} of 1.5 per cent. salt solution. The filtered liquid, measuring 1100^{cc}, was treated with 500^{cc} of water, thereby throwing down a large, rapidly settling precipitate which, after decanting the fluid, was dissolved in ten per cent. salt solution, filtered perfectly clear and dialyzed for three days. The globulin was thus nearly completely precipitated, for further dialysis of the filtered solution caused separation of very little more. Under the microscope the globulin appeared as well developed spheroids. After filtering, this precipitate was washed with water and with alcohol and dried over sulphuric acid. This formed preparation **2**, weighing 41.5 grams.

The solution decanted from the first precipitation of **2**, caused by the addition of 500^{cc} of water as described above, was further diluted with 500^{cc} of water, which caused an abundant separation of proteid. After settling over night the clear solution was decanted from the precipitate and the latter washed thoroughly with water and with alcohol and dried over sulphuric acid, giving preparation **3**, weighing 31.34 grams.

The solution decanted from **3** was cooled over night in an ice chest to 9°, which caused a further separation of proteid in large spheroids. This was filtered off, washed with water and alcohol, dried over sulphuric acid and found to weigh 6.18 grams, preparation **4.**

The filtrate from **4** was dialyzed for 24 hours and filtered from an abundant precipitate. The latter was washed with water and alcohol, and after drying weighed 12.0 grams, preparation **5.** The filtrate from **5** gave only a trace of precipitate on further dialysis.

The preparations were dried to constant weight at 110° and analyzed. The following figures show that fractional precipitation had caused no separation and that the globulin is identical in composition with phaseolin as obtained from the white bean, *Phaseolus vulgaris*.*

PHASEOLIN.

Adzuki bean.

	1	2	3	4	5
Carbon	52.31	52.56	52.74	52.74	52.44
Hydrogen	7.03	6.98	6.94	6.97	6.91
Nitrogen	16.43	16.41	16.34	16.62	16.47
Sulphur	0.57	0.62	0.56	0.49	0.61
Oxygen	23.66	23.43	23.42	23.18	23.57
	100.00	100.00	100.00	100.00	100.00
Ash	0.16	0.73	0.32	0.90	0.05

* Report of this Station for 1893, page 186.

Average. Adzuki bean.	Average. White bean.
52.56	52.58
6.97	6.84
16.45	16.47
0.57	0.56
23.45	23.55
100.00	100.00

The reactions of phaseolin, whether obtained from the common white bean or the adzuki, are as follows:

In cold and warm water it is entirely insoluble.

In sodium chloride solutions it is readily soluble, one per cent. brine dissolving large quantities of phaseolin.

In dilute acids and alkalies it is readily soluble; the solutions are precipitated by neutralization.

Solutions in dilute nitric or acetic acid are not precipitated even by large excess of acid.

Dissolved in ¼ per cent. sodium carbonate solution, phaseolin is precipitated by neutralization, the precipitate being wholly dissolved on adding sodium chloride.

Phaseolin dissolved in ten per cent. sodium chloride brine reacts as follows: It is *not* precipitated even by large excess of hydrochloric, nitric, sulphuric or acetic acids. By a large quantity of trichloracetic acid a precipitate is produced. By dilution with a sufficient quantity of water a precipitate results. Saturation with sodium chloride or magnesium sulphate does not precipitate the phaseolin, but saturation with ammonium sulphate completely throws it out of solution, while saturation with sodium sulphate at 34° precipitates it mostly but not entirely. Potassium ferrocyanide together with a large excess of acetic acid gives a precipitate.

With mercuric chloride dissolved in ten per cent. salt solution, no precipitate is produced. With tannin large precipitates result. With picric acid dissolved in ten per cent. salt solution, no precipitate forms until a considerable quantity of the acid is added, the precipitate thus produced dissolves on adding salt solution.

Phaseolin gives with the biuret, Adamkiewics', Millon's and xanthoproteic tests, the usual proteid reactions.

When solutions in ten per cent. sodium chloride brine are heated, turbidity occurs between 90° and 95° and a small flocculent coagulum separates at 97° to 98°; even prolonged heating in the boiling water bath coagulates but a small part of this globulin.

The solution filtered from the globulin which had separated on dialyzing the solution of the proteids precipitated by saturating the seed extract with ammonium sulphate was again saturated with this salt and the precipitate thereby produced was dissolved in a small volume of water and, after filtering clear, the solution was dialyzed for six days. Three grams of a dark-colored globulin separated which seemed much contaminated with coloring matter. This was filtered out and the clear filtrate dialyzed five days longer, but no precipitate was obtained. The solution was then dialyzed into alcohol and the precipitate which resulted after drying weighed 8.5 grams. The filtrate contained but a trace of proteid. This substance was ground to a powder, thoroughly exhausted with water, washed with alcohol, dried and found to weigh 7.05 grams. Dried at 110° this preparation, **6**, had the following composition, which it will be noticed is similar to that of preparations obtained in a like manner from the pea, vetch and cow pea.

Adzuki bean.	Pea.		Vetch.	Cow pea.	
6	**5**	**8**	**20**	**8**	**9**
53.97	53.33	53.54	53.55	53.13	53.36
7.01	6.98	6.99	6.70	7.09	7.05
16.31	16.14	16.69	16.46	16.51	16.21
0.88	1.00	1.01	1.02	1.09	1.13
21.83	22.55	21.77	22.27	22.18	22.25
100.00	100.00	100.00	100.00	100.00	100.00

Preparation **8**, from the cow pea, was obtained by prolonged dialysis in water, and accordingly must be regarded as a very soluble globulin. Since preparations agreeing well in composition and general properties with it have been similarly obtained from other leguminous seeds by dialysis, it is our opinion that the above analyses represent a distinct globulin which can be only in part removed from its solutions by dialysis in water but is wholly separated, in a coagulated form, by dialysis in alcohol. This globulin is at present being further investigated and it is our intention to offer more respecting its properties in a subsequent paper.

THE AMOUNT AND PROPERTIES OF THE PROTEIDS OF THE MAIZE KERNEL.

By Thomas B. Osborne.

Some time since Prof. R. H. Chittenden and the writer published the results of an extended investigation of the proteids of this seed. (Amer. Chem. Jour., Vol. xiii, pp. 453, 529, and Vol. xiv, p. 20. Abstract in Report of this Station for 1891, p. 136.) In that paper no definite statements were made respecting the quantities of the various proteids found, nor were the properties of some of them as fully described as is now possible. For these reasons the results of some additional researches are here put on record.

The proteids of the maize kernel may be distinguished according to their solubilities as follows:

a. Proteid, soluble in pure water, having some of the properties of proteose.

b. Globulins, insoluble in pure water, but soluble in salt solutions.

c. Proteid, insoluble in water and salt solutions, but soluble in alcohol of 60 to 99 per cent.

d. Proteid matter, insoluble in water, salt solutions and alcohol, but soluble in dilute alkalies and acids.

a. Proteid soluble in Water.

If the substance precipitated from an aqueous extract of yellow corn meal by saturating with ammonium sulphate, is dissolved in water and the resulting solution dialyzed, the globulins extracted from the meal by aid of the soluble mineral constituents of the seed are *largely* precipitated. If these globulins are next *completely* removed by heating the solution to 80° and the filtrate therefrom be precipitated by an excess of alcohol, a small quantity of proteid is obtained having many of the reactions characteristic of proteose. A recent determination showed the presence of only 0.06 per cent. of this body. The quantity found was too small for a satisfactory study of the properties of the substance, but the following observations were made. Dissolved in a little water, only a very small quantity of undissolved substance remained, showing the nearly complete removal of proteid coagulable by alcohol.

The clear filtrate from this insoluble matter when diluted with an equal volume of distilled *water* gave a considerable coagulum on boiling, but when diluted with the same quantity of *ten per cent. salt solution* only an opalescence resulted on boiling. Nitric acid added to the aqueous solution gave a heavy precipitate which nearly all dissolved on warming, with the production of a strong yellow color, and reappeared on cooling. Saturation of its solution with sodium chloride gave a precipitate much increased by the addition of acetic acid, the filtrate from which was not further precipitated on adding nitric acid. The biuret reaction was violet, not rose red, as is usually given by proteoses. This color reaction, however, was probably modified by the color substance associated with the proteid. Sulphate of copper gave with solutions of this proteose only a turbidity. These reactions do not altogether agree with those given by the proteoses which result from the action of enzymes on native proteids. It is possible that future investigation will show that the so-called proteoses found in seeds belong to a different order of proteids from those usually formed by proteolysis.

In the paper already referred to, a substance is described as albumin which was obtained from solutions that were supposed to have been freed from globulin by prolonged dialysis, by adding thereto ten per cent. of sodium chloride and precipitating with very dilute hydrochloric acid. My recent experience in investigating plant proteids has shown that it is extremely difficult and in many cases impossible to completely precipitate all of the very soluble globulins by dialysis, and since the composition of the so-called albumin thus obtained agreed quite closely with that of a very soluble globulin separated from these solutions by prolonged dialysis, and also since the globulin and the so-called albumin coagulated at about the same temperature, I now feel convinced that the two substances are identical, the latter being a part of the globulin which was not precipitated by dialysis. In the former paper attention was called to the fact that this body, in some respects, resembled a globulin more closely than an albumin.

In the former paper were also described, as albumin, coagula obtained by concentrating solutions supposed to have been freed from globulin by dialysis and heating to 100°. It was there suggested that these coagula were probably alteration products of the proteids in solution. Since then "proteoses" from many different seeds have been found to yield coagula under similar conditions. It seems therefore quite certain that no true albumin exists in the maize kernel.

b. Proteids soluble in Saline Solutions.

If an aqueous extract of yellow corn meal is dialyzed for some time, a proteid, having the properties of a globulin, is precipitated which was found to have the following composition:

MAYSIN.

Carbon	52.68
Hydrogen	7.02
Nitrogen	16.76
Sulphur	1.30
Oxygen	22.24
	100.00

In our paper on the proteids of this seed, Prof. Chittenden and myself designated this globulin "maize myosin." Further study of plant proteids has shown that no sharp distinction can be drawn between plant myosin and plant vitellin, and I now propose to call this proteid *maysin*, in reference to the specific botanical name *mays*. This globulin readily loses its solubility in saline solutions after precipitation, and therefore the amount present in the seed was underestimated in our former paper. A recent determination in yellow corn meal gave 0.25 per cent.

This proteid is readily soluble in very dilute saline solutions so that it is completely extracted from corn meal by water. Dissolved in ten per cent. sodium chloride brine it is coagulated by heating to 70°.

After separating maysin from the extract of corn meal by dialysis, further prolonged dialysis throws down a small quantity of another globulin having the following composition:

MAIZE GLOBULIN.

Carbon	52.38
Hydrogen	6.82
Nitrogen	15.25
Sulphur	1.26
Oxygen	24.29
	100.00

This is the globulin which I now think to be identical with the "albumin" which was formerly obtained by precipitation with salt and acid. This proteid was found in very small amount, 25 kilos of fine meal yielding only 4.1 grams by dialysis and 3.4 grams by precipitation with salt and acid, that is 7.5 grams in all or 0.03 per cent. of the meal. This figure cannot be taken as representing quite accurately the total quantity present, for doubtless some was lost in consequence of the globulin becoming insoluble and some also through incomplete extraction. The total quantity, however, is exceedingly small, probably not more than 0.04 per cent.

Dissolved in ten per cent. sodium chloride solution, this globulin coagulates on heating to 62°.

If yellow corn meal, after thorough extraction with water, is treated with ten per cent. salt solution, a further quantity of globulin is extracted, which is readily precipitated by dialysis in well developed spheroids.

This globulin, formerly designated maize vitellin, agrees in composition and reactions and is, doubtless, identical with edestin which I have found in various seeds.

A recent determination of edestin in the seed of yellow corn showed the presence of but 0.06 per cent. The quantities obtained in the former investigation were 0.06, 0.10 and 0.10 per cent. The composition of this globulin is as follows:

MAIZE EDESTIN.

Carbon	51.43
Hydrogen	6.86
Nitrogen	18.06
Sulphur	0.86
Oxygen	22.79
	100.00

Edestin is much less soluble in saline solutions than the two globulins previously described, and for this reason is readily precipitated by dialysis or dilution. In warm dilute salt solutions it dissolves freely, but on cooling separates more or less completely, according to the temperature and the strength of the salt solution. Dissolved in ten per cent. sodium chloride brine, it is partly coagulated by heating above 90°, but even on boiling the coagulation is far from complete.

c. *Proteid soluble in Dilute Alcohol.*

Finely ground maize meal when extracted by hot alcohol loses 0.8 per cent. of nitrogen, equivalent to 5 per cent. of the characteristic proteid called maize-fibrin by Ritthausen, but first described by Prof. Gorham of Harvard University, in 1821, and named by him zein. The composition of zein, as shown by the average of nine closely agreeing analyses of as many preparations, is the following:

ZEIN.

Carbon	55.23
Hydrogen	7.26
Nitrogen	16.13
Sulphur	0.60
Oxygen	20.78
	100.00

Zein is in many ways a remarkable proteid. It dissolves abundantly in ethyl alcohol of 0.820 specific gravity, forming solutions which on evaporation in thin layers leave a perfectly transparent sheet of the proteid.

In *absolute* alcohol, as also in water, zein is wholly insoluble, but in mixtures of water and alcohol it dissolves to a greater or less extent, according to the proportions of the two liquids. It is most soluble in alcohol of from 85 to 95 per cent., and dissolves but little in alcohol of less than 50 per cent. Solutions of zein in diluted alcohol deposit the proteid on evaporation as the proportion of water in the solution increases. Strong alcoholic solutions of zein gradually coagulate to transparent jellies, which on long standing become hard and solid. In 95 per cent. methyl alcohol and in commercial propyl alcohol hydrate, zein dissolves readily.

In concentrated glycerin zein is freely soluble on heating to about 150° C., to solutions, which, when much is dissolved, solidify on cooling to 20°. In such solutions zein can be heated to 200° C. without undergoing any apparent change, for, on pouring them into water, the zein separates as a pulverulent precipitate readily and completely soluble in dilute alcohol.

In crystallized phenol, zein is readily soluble on warming, yielding solutions which leave on evaporation clear films of unchanged zein. In glacial acetic acid, zein dissolves in large proportion and is left, by evaporating the acid on a boiling water bath, in transparent films of apparently unchanged proteid, which readily dissolve in alcohol.

Strong solutions of zein in glacial acetic acid when poured rapidly into water give large coherent precipitates which retain all the original properties of the proteid; if the solution is dilute the zein is to a greater or less extent dissolved by the aqueous acetic acid.

In one-half per cent. sodium carbonate solution and in two-tenths per cent. hydrochloric acid, zein is wholly insoluble even when warmed for 24 hours at 40°.

In $\frac{1}{10}$ to 2.0 per cent. caustic potash solution, zein is very readily dissolved and even by heating to 40° for 24 hours in such solutions is not converted into "alkali-albumin," for the precipitate obtained by neutralizing solutions so treated is completely soluble in alcohol.

Alcoholic solutions of zein are not precipitated by tannin, picric acid, trichloracetic acid, lead acetate, silver nitrate, mercuric chloride, ferric chloride or potassio-mercuric iodide. Clear solutions mixed with silver nitrate dissolved in alcohol leave clear films when evaporated on glass, which gradually turn deep red on exposure to sunlight. When hydrochloric acid in considerable quantity is added to a solution of zein in ethyl alcohol containing much silver nitrate, no precipitate is produced until the mixture has stood for some time, when a turbidity gradually develops which is affected but slowly by light. If the mixture of acid, zein and silver nitrate is boiled it becomes turbid at once.

Zein treated with an alcoholic solution of ferric chloride shows no visible change, but if tested with potassium ferricyanide a deep blue solution is formed, showing that the ferric chloride is reduced at once.

Potassium ferricyanide added to the zein solution is not reduced even after standing some hours.

On digestion with pepsin in hydrochloric acid, zein is converted into proteoses and peptones.*

According to J. G. C. T. Kjeldahl (Bied. Centr. 1896, xxv, 197, from Forhandl. Skand. Naturfors 1892, 385–390) zein dissolved in 75 per cent. alcohol has a specific rotation of $(\alpha)_D - 35°$ and in glacial acetic acid $(\alpha)_D - 28°$.

d. Proteid matter soluble in Alkalies.

This was estimated as follows. One hundred grams of very finely ground maize meal which contained 1.54 grams of nitrogen were successively exhausted with two-tenths per cent. potash water and with alcohol. The dried residue weighed 77 grams

* Chittenden, Medical Record, xlv, 487.

and contained 0.1645 grams of nitrogen. Accordingly 1.3755 grams of nitrogen, including that of all the soluble proteids, had been extracted. This amount multiplied by the factor 6.25 gives the total quantity of soluble proteids, viz., 8.5969 grams. Subtracting therefrom the sum of the several proteids previously determined, viz., zein 5 grams, globulins 0.39 grams and proteose 0.06 grams, there remains 3.1469 grams of proteid insoluble in salt solutions and alcohol, but soluble in dilute potash water.

The alkaline extract obtained in estimating the quantity of this proteid was filtered perfectly clear, neutralized with acetic acid, the precipitate filtered out, washed thoroughly with water and extracted with hot alcohol to remove zein.

The proteid residue was then redissolved in dilute potash water, filtered clear and again precipitated by neutralization with acetic acid and thoroughly washed with water, with hot alcohol and finally with ether. After drying at 110° the preparation was analyzed with the following results:

Carbon	51.26
Hydrogen	6.72
Nitrogen	15.82
Sulphur	0.90
Oxygen	25.30
	100.00
Ash	2.38

The results of this analysis do not indicate that this substance has any relation to the other proteids already described. Owing to its insolubility in neutral fluids no characteristic reactions could be obtained, and accordingly nothing more was learned respecting it.

The foregoing statements show that 100 grams of the yellow corn meal contained approximately:

Proteid soluble in $\frac{2}{10}$ per cent. potash	3.15 grams	containing	15.82	per cent.	N.	=	0.4983	grams.
Zein	5.00	"	"	16.13	"	"	"	= 0.8065	"
Very soluble globulin	0.04	"	"	15.25	"	"	"	= 0.0061	"
Edestin	0.10	"	"	18.10	"	"	"	= 0.0181	"
Maysin	0.25	"	"	16.70	"	"	"	= 0.0417	"
Proteose	0.06	"	"	17.00	"	"	"	= 0.0102	"
								1.3809	"
Nitrogen undissolved by dilute potash water								0.1645	"
Total								1.5454	
Nitrogen in meal by analysis								1.5400	
Mean percentage of nitrogen in Maize Proteids								16.057	

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