SECOND ANNUAL REPORT

OF THE

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR

1889.

ITHACA, N. Y.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

SECOND ANNUAL REPORT

OF THE

Agricultural Experiment Station.

ITHACA, N. Y.,

1889.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.,
1890.

CORNELL UNIVERSITY.

Agricultural Experiment Station.

Offices of the Director and Deputy Director, 20 Morrill Hall.

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LETTER OF TRANSMITTAL.

To His Excellency,

The Governor of the State of New York:

SIR:

I have the honor herewith to transmit the Second Annual Report of the Agricultural Experiment Station of Cornell University, in accordance with the provisions and requirements of the Act of Congress, approved March 2, 1887, establishing the Station. This Report consists of the following documents:

1. The Report of the Director of the Station.
2. Acknowledgments of donations.
3. The Report of the Treasurer.
4. The Report of the Chemist.
5. The Report of the Botanist.
6. The Report of the Cryptogamic Botanist.
7. The Report of the Entomologist.
8. The Report of the Agriculturist.
9. The Report of the Horticulturist.
10. Appendix I., containing copies of the eleven Bulletins published in the course ot the year.
11. Appendix II., containing a detailed statement of the receipts and expenditures of the Station.

From the reports of the various officers of the Station it will be seen that the year has been one of productive energy. The Bulletins issued have been received with gratifying favor by the agricultural press of the country. During the year the office has received more than one hundred and sixty extracts from, or notices of, the Bulletins published by the Station, in several instances the Bulletin having been copied entire. The notices have been so highly commendatory in character that we can have no doubt as to the general favor with which the work of the Station has been received.

I have the honor to be

Your obedient servant,

[Signed] C. K. ADAMS,

President of the Cornell University.

CORNELL UNIVERSITY,

Jan. 30th, 1890.

REPORT OF THE DIRECTOR.

To the President of the Cornell University:

SIR:

I have the honor herewith to transmit the Annual Report of the Cornell University Agricultural Experiment Station, which includes the reports of the Treasurer and Deputy Director and Secretary, together with those of the divisions of Chemistry, Botany, Entomology, Agriculture, and Horticulture; also Bulletins Nos. V to XV inclusive, and a detailed statement of receipts and expenditures for the fiscal year ending June 30, 1889.

The eleven bulletins issued during the year embrace a wide field of investigation. Some of them are of a scientific character, but are none the less valuable on that account. It is impossible to make steady advancement in our investigations without the aid of the knowledge which purely scientific investigation gives.

The Tennessee Agricultural Experiment Station published in June a valuable bulletin on the potato blight. As that disease had appeared in many places in this State, it was decided to purchase three thousand copies and distribute them in the potato growing districts.

The aim has been to give immediate help to those who are seeking for it, so far as we might be able, while at the same time, doing much work in perfecting new methods, and testing and investigating the accuracy of methods now in use, in order that our results may be as perfect as human skill can make them.

There are many indications that the work done in the last year has been of marked and permanent value. The mailing list, home and foreign, has now reached upwards of seven thousand, and is increasing rapidly.

There are not less than five hundred thousand adult men in the State who are directly engaged, to a greater or less extent, in growing animals and plants, and to reach all of these with bulletins would absorb the greater share of our resources, and leave little for doing the work out of which bulletins should naturally grow.

So far this difficulty has been met by the liberal and progressive spirit of the Agricultural Press. It has uniformly shown such a broad and kindly spirit, not only towards the workers of the Station and their investigations, but to the cause of improved agriculture, thereby arousing interest and aiding the Station in getting before the public the results of its work, that I desire here, publicly, to acknowledge the great obligation to it we and our constituents are under.

The policy of aiding the reader to understand and remember the results obtained in our investigations by numerous illustrations, which was begun last year, has been enlarged upon and continued this. It was early found that untrained laborers were illy suited to perform even the most common operations of experiment work without careful and constant supervision. So, for the sake of both economy and accuracy, the common laborer has been largely dispensed with, and the work has been performed by the salaried assistants. This gives the appearance in the financial report of having spent a small amount for labor and a large amount for salaries.

In some branches of the Station work, some difficulty is found in writing the bulletins so that they will be entirely clear to the ordinary reader, because no common or popular names and terms can be found which can be used instead of those adopted by the scientists. We trust that the criticisms and difficulties will gradually disappear, as the readers become more familiar with scientific terms, and we more expert in avoiding and in coining popular substitutes or brief explanatory terms for them.

I. P. ROBERTS,
Director.

We are pleased to acknowledge the receipt of the following donations.

Retsof Mining Co., Piffard, N. Y.—1 bbl. Cattle Salt.
D. H. Burrell & Co., Little Falls, N. Y.—1 Gal. Hansen's Rennet Extract.
D. W. Beadle, St. Catherines, Ontario.—Cuttings of Russian Grape.
V. H. Hallock & Son, Queens, N. Y.—Seeds.
J. M. Thorburn & Co., New York—Seeds.
John G. Gardner, Jobstown, N. J.—Tomato Seeds.
W. O. Shallcross, Locust Grove, Md.—Apple Scions.
Ohio Experiment Station, Columbus, O.—Apple Scions.
Missouri Experiment Station, Columbia, Mo.—Apple Scions.
Edwin Allen, New Brunswick, N. J.—Apple Scions.
W. D. Barnes, Middle Hope, N. Y.—2 Paradox Grape Vines.
J. Laws, Geneva, N. Y.—1 Jennie May Grape.
Farmers' Fertilizer Co., Syracuse, N. Y.—2 sacks Fertilizers.
Per Oxide Silicates Co., New York.—20 lbs. Per Oxide Silicates.
N. Y. State Experiment Station, Geneva, N. Y.—Strawberry Plants.
U. S. Dep't of Agriculture, Washington, D. C.—Seeds; Scions of Kelsey Plum; Specimen of Cocoanut.
Sherman & Crouch, Sydney, N. Y.—Plant Protectors.
Michigan Experiment Station, Agricultural College, Mich.—Tomato Seeds.
T. H. Hoskins, Newport, Vt.—Apple Scions.
H. M. Jaques, Wright's Corners, N. Y.—Apple Scions.
L. H. Bailey, South Haven, Mich.—Apple Scions.
Dr. E. L. Sturtevant, S. Framingham, Mass.—Seeds.
Nauvoo Fruit Growers' Association, Nauvoo, Ill.—Strawberry Plants.
N. Hallock, Creedmoor, N. Y.—Strawberry Plants.
A. W. Smith, Americus, Ga.—Four varieties of Moon Flower.
Alabama Experiment Station, Auburn, Ala.—White Field Corn.
South Carolina Experiment Station, Columbia, S. C.—White and Yellow Corn.
Delaware Experiment Station, Newark, Del.—Apple Scions.
Dakota Experiment Station, Brookings, S. Dak.—Apple Scions.
Foster Udell, Brockport, N. Y.—Apple Scions.
F. L. Peirs, New Providence, Ind.—Crab Scions.
Dr. J. F. Appell, Lake City, Fla.—Two species Wild Garlic; Specimens of diseased Peach root.
Northrup, Braslan & Goodwin Co., Minneapolis, Minn.—Seeds.

REPORT OF THE TREASURER.

The Cornell University Agricultural Experiment Station,
In account with
The United States Appropriation.

			Dr.
1889.	To Balance of Appropriation for 1888 on hand July 1, 1888, ...		$ 41 91
	To Receipts from Treasurer of the United States, as per appropriation for year ending June 30, 1889, under Act of Congress approved March 2, 1887, ...		$14,958 09
			$15,000 00
		Cr.	
June 30.	By Salaries, ...	$8,335 42	
	" Buildings, ...	750 00	
	" Printing, ...	1,306 63	
	" Office Expenses, ...	436 34	
	" Equipment, Labor and Current Expenses:		
	Agriculture, ...	606 22	
	Horticulture, ...	2,493 53	
	Entomology, ...	260 46	
	Botany, ...	597 13	
	Chemistry, ...	214 27	
			$15,000 00
	Receipts for Produce sold:		
	Agricultural Department, ...	$ 190 87	
	Horticultural Department, ...	103 38	
			$ 294 25

We, the undersigned, duly appointed auditors for the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of Cornell University for the fiscal year ending June 30, 1889; that we have found the same well kept and correctly classified as above, and that the receipts for the time named are shown to have been $15,000, including unexpended balance of July 1, 1888, and the corresponding disbursements, $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct:

(Signed.) H. B. LORD, GEO. R. WILLIAMS, } Auditing Committee Board of Trustees.

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the Institution named.

(Signed.) EMMONS L. WILLIAMS,
Treasurer.

STATE OF NEW YORK, }
TOMPKINS COUNTY. } SS.

On this 31st day of January, 1890, appeared before me Emmons L. Williams, personally known to me to be the person whose signature is attached to the above certificate, and acknowledged that he executed the same.

(Signed.) HORACE MACK,
[L. S.] Notary Public.

REPORT OF THE CHEMIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR :—

I submit herewith a summary of the work of this division of the Experiment Station.

All the actual analytical work mentioned below was done by Mr. W. P. Cutter, the assistant chemist, or under his immediate supervision. The number of analyses to be made was so large that additional help was necessary in the laboratory of the Station during a small portion of the year.

Upon Mr. Cutter, also, devolved the preparation of the samples of fodder to be used in testing methods of analysis, and their distribution to the several Experiment Station Chemists, who consented to make the analyses for the Association of Official Agricultural Chemists; and much time was given by me in the course of the summer to the preparation of the report to the Association on these results, and a complete bibliography of journal literature on methods of analysis of cattle foods. This work appears in the Annual Report of the Association, now going through the press.

The material equipment of the laboratory of the Station is essentially the same as it was at the time of the last report, no important additions having been made.

Yours Respectfully,

G. C. CALDWELL,
Chemist.

LIST OF ANALYSES MADE FOR THE CORNELL UNIVERSITY EXPERIMENT STATION—1889.

Fodders.

48 Samples Fodder Corn.
4 Samples of Corn.
1 Sample Corn Germ Meal.
1 Sample Condimental Cattle Food.
9 Samples for Digestion Experim'ts.
1 Sample Buckwheat Hulls.
1 Sample Sunflower Seed.
3 Samples for the Association of Official Agricultural Chemists.
1 Sample Malt Sprouts.
1 Sample Wheat Bran.
1 Sample Clover Hay.
Total 71.

Fertilizers and Amendments.

6 Samples for the Association of Official Agricultural Chemists.
9 Samples Farm Yard Manure.
1 Sample Soot.
14 Samples Manure Leachings.
2 Samples Ashes.
6 Samples Sheep Manure.
Total 38.

Feeding Experiments.

2 Samples from Sheep.
15 Samples from Pigs.
4 Samples from Chickens.
Total 21.

Dairy Products.

98 Samples Whole Milk.
12 Samples Skimmed Milk.
5 Samples Butter.
1 Sample Cheese.
Total 116.

Summary.

Fodders	71
Fertilizers and Amendments	38
Feeding Experiments	21
Dairy Products	116
Total	246

INCIDENTAL WORK.

The determination of moisture in fodders.
Testing new apparatus for fodder analysis.

W. P. CUTTER,
Assistant.

REPORT OF THE BOTANIST AND ARBORICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR:

The work of this division for the present year, so far as the division has any special relation to the Experiment Station, has been devoted wholly to the investigation of the diseases of plants. This work has been carried on by Assistant Professor Dudley, and the results have in part been embodied in one of the bulletins of the Station devoted to the diseases of the strawberry plant.

In the organization of the department with reference to Station work, it was thought that, in addition to the special subject above mentioned, some facts of a more general nature and of minor importance might occasionally be brought out in the ordinary working of the department as a department of instruction in the University, which might possess some interest in their bearing upon agricultural pursuits. A few notes of this kind have been prepared for one of the Station bulletins; but it should be mentioned that the Station has been to no expense whatever in connection with the experiments on which these notes are based.

The appropriation made to this department from the funds belonging to the Station for the current year has been wholly expended in paying for the work of investigating plant diseases, or in perfecting facilities for prosecuting such investigations. In this connection it should be borne in mind that this special subject, more than most, calls for a large amount of careful and painstaking work, which in its very nature is not productive of material suitable for publication in Station bulletins.

A. N. PRENTISS,
Botanist and Arboriculturist.

REPORT OF THE CRYPTOGAMIC BOTANIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR:

The work of investigation accomplished during the past year is, to a certain extent, indicated in Bulletin XIV., on the diseases of the strawberry plant. But a large amount of time has been consumed in getting under way investigations on the development and habits of several little known parasitic fungi, some of which are indicated below. Correspondence developed the presence of several of these maladies not hitherto recognized in the State, or which have appeared but recently; and work on the fungi infesting the following host-plants is more or less advanced in this laboratory, especial attention being given to the life of the parasite during the winter and spring months:

The Onion.
The Strawberry.
The Cultivated Currant.
The Clover.

Considerable work, also, has been already accomplished on the disease causing the cracking of Quinces and Pears (mentioned in the First Annual Report.) A disease of wheat, caused by a *Cladosporium*, appeared in 1889, in this vicinity, doing much injury; and so far as time permits in the coming spring, this will receive attention. Reports of progress on the above may be published, and from time to time a completed study; but for the completion of biological studies presenting such extraordinary difficulties as the work on the fungi, it is impossible to predict the exact amount of time required. The great aim should be care and thoroughness.

Between four and five thousand specimens of fungi belonging to the Station have been mounted and catalogued during the year. Five cases for the storing of apparatus, reagents, herbarium-specimens and books, and a large table for the various operations of experimental work, with numerous drawers and compartments for working material, have been constructed.

One of the possibly unavoidable limitations,—among those affecting both the quality and quantity of the work in this laboratory,—is that of proper working space. There are needed a small room for instruments and apparatus, one for the operations of sterilizing, etc., and another for artificial cultures, wherein the conditions necessary to such experiments, especially those of temperature, could be controlled. Provision for these would greatly improve the means for successful work.

WILLIAM R. DUDLEY,
Cryptogamic Botanist.

REPORT OF THE ENTOMOLOGIST.

To the Director of the Cornell University Agricultural Experiment Station :

SIR :

In compliance with your request I beg leave to submit the following report of the work of this division during the year just closed.

The year has been a very successful one ; certain experiments have been brought to a satisfactory conclusion ; and others recently started, promise to give important results.

The study of *Cephus pygmaeus*, a saw-fly borer in wheat, has been nearly completed, and a Bulletin, (No. XI), has been published giving the results obtained. In this Bulletin the complete life-history of the species is described in detail, and practical conclusions are drawn from the results obtained. Further observations are desirable in order to determine in what other plants the insects can live. It is my purpose to make these observations during the coming summer.

The study of the Clematis disease is well advanced ; and a preliminary report on it was presented to the Western New York Horticultural Society at their recent meeting, as it was from members of this society that the diseased plants were received. I have definitely determined that the cause of the disease is a Nematode worm belong to the family *Anguillulidae*, as suggested in my report of last year. The species is *Heterodera radicicola.* This worm has attracted much attention in various parts of the country during the past year, as it has been found to infest a great variety of plants, and to do much injury. Much material including a full account of the life-history of the pest, with figures of its different stages, is at hand ; and I purpose to submit a Bulletin upon it at an early date. These studies have been carried on in the Insectary. I wish now to conduct a series of experiments in the field for the purpose of determining the best method of combatting this pest. Should there be funds available for this purpose, I recommend the preparation in the spring of a series of plats, separated by walls through which the worms cannot pass, for these experiments. As this worm infests to a serious extent nearly all of our common garden vegetables, it will be an easy matter to obtain material for experimentation.

The work upon wire-worms is still in progress. Several species have been reared to the adult state, and experiments have been tried to determine the value of the growing of buckwheat, and of mustard, on infested lands in order to starve the worms. I am not yet ready to announce any definite results; but our experiments seem now to indicate that the importance of this remedy has been greatly over-estimated.

Much attention is being given, especially by several of the agricultural students, to the study of greenhouse pests. One of these pests, which occurred in great numbers both in the Insectary and in the plant-houses of the Horticultural Department, is a species which has not previously been mentioned as occurring in this country, although it is a well known European pest. It is in its early stages a scale-like insect, infesting the lower surface of the leaves of various plants. In the adult state it is a minute fly, which is very conspicuous on account of a white, mealy powder with which the body and wings are covered; it is known to entomologists as *Alcyrodes vaporiorum*. Two of the agricultural students are making studies in the Insectary upon mealy bugs, upon which they are to write their theses. I confidently expect that conclusions will be reached by them which will be of practical importance.

The preparations for the study of hop insects are now complėted; as our hop-yard is well established, and the hop Aphis appeared in it last fall.

The experience of the past year has realized our expectations in regard to the value of an Insectary. This building has proved indispensable to our work; and the importance of such a building is being appreciated elsewhere, for similar structures have been erected at two other Stations.

I am your obedient servant,

J. H. COMSTOCK,

Entomologist.

REPORT OF THE AGRICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR:

The work of this division of the Experiment Station has been, in the main, that outlined in the report made to you one year ago. During the year investigations have been completed and published as follows:

In Bulletin No. V.—The Production of Lean Meat in Mature Animals.—The Effect of Heating Milk on the Quantity and Quality of Butter.

In Bulletin No. VIII.—The Effect of Nitrogenous and Carbonaceous Foods on Fattening Lambs.

In Bulletin No. XIII.—The Deterioration of Farm Yard Manures by Leaching and Fermentation.—The Effect of a Grain Ration for Cows at Pasture.

Beside the above, the work of which has nearly all been done within the calendar year, investigations in the following lines have been made, and are now either in process of or awaiting publication:

A comparative field and chemical test of all of the varieties of field corn recommended as valuable for ensilage purposes.

A determination of the loss of weight and dry matter in the process of ensilaging green fodder.

A repetition of the experiments of last year in regard to the changes in the composition of the corn plant at different stages of growth.

Another series of experiments on the production of lean meat in mature animals.

The main lines of investigation now under way are:

The effect of different nitrogenous foods on meat production (lambs are the subject of experiment.)

The effect of nitrogenous and carbonaceous foods on development and fecundity (swine are the subject of experiment.)

A comparative test of different breeds and crosses of sheep in the production of winter lambs.

A continuation of the work in the field experiments with fertilizers.

Some investigations in the manufacture and ripening of cheese.

For the future, beside a repetition of numerous of our investigations that we feel need further elucidation, experiments have been outlined in soil culture, and in the relations of the clover plant to soil exhaustion.

The work of the division has progressed during the year smoothly and, in the main, successfully. The details of the experiments in the fields and barns have been almost entirely in the hands of Mr. Ed Tarbell, Assistant in Agriculture, to whom credit is due for careful and faithful work.

HENRY H. WING,

REPORT OF THE HORTICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR:

The past year has been a prosperous one for the Horticultural Division. The area set aside for orchards and gardens has been placed under culture, and permanent improvements have been made upon the greater part of it. Plantations have been made of all fruits suited to the climate, in considerable variety. The primary object in the setting of the fruit is the determination of certain points in culture and treatment, rather than the mere testing of varieties. An orchard of pears and plums has been set upon land which has never received stable manure, and it is designed to maintain it solely upon commercial fertilizers and methods of cropping.

The origination of varieties of fruits and vegetables is designed as the leading perennial experiment of the department. Already great quantities of seeds of fruits have been sown. The Ignotum tomato, a superior variety, which originated with the writer in 1887, has been further selected and tested, and this year it has been put upon the market. Endeavors towards the origination of varieties demand the study of all features of the variation of plants under culture. Extensive labors have been inaugurated in hybridization and crossing, particularly in the *Cucurbitaceæ*, the pumpkin and melon family. Hybridization is little understood in plants of this family, although much discussed. So extensive have been the studies among these plants during the past year, that several acres will be required the coming season upon which to grow the crosses and selections.

Large and satisfactory tests have been made upon tomatoes and egg-plants; and the leading results of the studies of tomatoes have been published in a bulletin. Extensive tests have also been made upon the influence of many fertilizers in hastening maturity of plants. These, and several other experiments which we have in hand, must run through several years before definite reports can be made.

Three bulletins have been published by the division: "On the Influences of Certain Conditions upon the Sprouting of Seeds," "Windbreaks in their Relation to Fruit Growing," and "Tomatoes."

Some good forcing-houses have been completed, and various experiments are now proceeding in them. One house, 20×30 feet, is now carrying an experimental crop of tomatoes; another of the same size contains chiefly cucumbers and melons, and a small lean-to is being used for radish tests. The most conspicuous experiment under glass, however, is one now in progress to determine the influence of the electric light upon the growth of plants. A house, 20×60 feet, has been divided, and one part is lighted all night by an arc-light, while the other is left in darkness. The areas are large enough to allow of several hundred plants being grown in each compartment, and valuable results are anticipated. This is probably the largest and completest experiment of the kind yet projected.

Many minor yet valuable experiments are always in progress, and it is gratifying to know that records of them can be made in the closing bulletin of each year. It is now desirable that some provision be made for the publication of such extended and technical papers as must result from prolonged studies in particular directions.

Respectfully submitted,

L. H. BAILEY,
Horticulturist.

APPENDIX I.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

V.

APRIL, 1889.

I. On the Production of Lean Meat in Mature Animals.

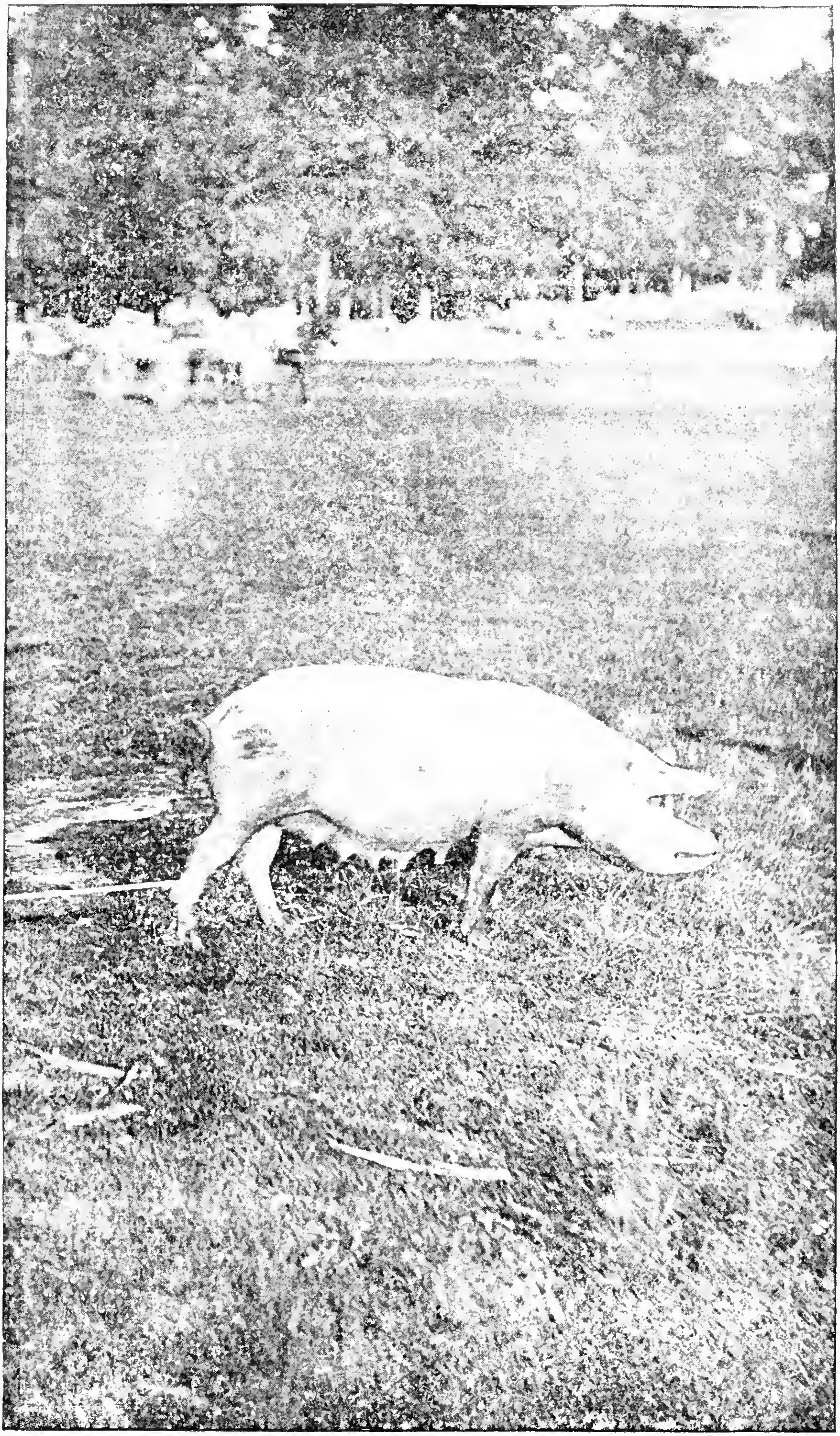
II. Does Heating Milk Affect the Quality or Quantity of Butter.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.,
1889.

Offices of the Director and Deputy Director, 18 A, Morrill Hall.

Persons who desire this Bulletin will be supplied on addressing
CORNELL UNIVERSITY EXPERIMENT STATION,
Ithaca, N. Y.



ON THE PRODUCTION OF LEAN MEAT IN MATURE ANIMALS.

It has been pretty conclusively shown in experiments by Henry,* Sanborn,† and at this Station,‡ that the relation between the lean and fat in the carcass of young animals can be varied in quite wide limits by varying the relation between the nitrogenous and carbonaceous matters in the ration fed. But it has been stoutly maintained that, in the mature animal or the animal whose muscles have once been formed, it is practically impossible to increase, either relatively or absolutely, the amount of muscle or lean meat. It was to throw some light on this question that the experiment recorded below was determined upon.

At the outset numerous difficulties confronted us, chief among them being the necessity of relying wholly on comparison between individuals, for the composition of an animal's body manifestly cannot be determined at two different periods of its life.

Another obstacle in work of this kind is the difficulty of completely separating the fat and lean of the carcass by mechanical means, particularly when there is any considerable amount of what may be termed "intermuscular fat" and connective tissue.

After a careful consideration of all the difficulties involved, it was finally determined to make a preliminary trial upon the following basis: Two mature animals in poor condition, as nearly alike as may be, and if possible of near blood relationship, to be selected. One of these to be slaughtered, the carcass rendered and the nitrogenous matter and fat determined in the products by chemical analysis. The other to be fed with a ration calculated to produce muscle or lean meat for a sufficient length of time and then treated as the first.

After some search, two animals fairly satisfactory were secured in two grade Yorkshire sows, three and four years old, one the

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* Fourth Annual Report of the Agricultural Experiment Station of Wisconsin, p. 83, and Fifth do., p 92. † Bulletins, Nos. 10, 14, 19, and 27, of the Missouri Agricultural College Farm. ‡ Bulletin, No. II, Cornell University Agricultural Experiment Station.

mother of the other. The younger we shall designate No. 1, the other No. 2. They were very thin in flesh, as each had run on pasture and suckled a litter of pigs during the summer. Some idea of their condition may be formed from the photo-engraving of No. 2, forming the frontispiece of this Bulletin.

For two reasons we determined to slaughter No. 1, and feed No. 2. First, No. 1 had apparently a little more fat. Second, No. 2 from her greater age would be less likely to form muscle or lean meat as a result of the feeding.

Accordingly, Sept. 22, 1888, No. 1 was slaughtered, and the following data secured :

Live weight,	207	lbs.
Dressed weight including kidneys,	131	"
Bones,	13	"
Total nitrogenous matter,	18.10	"
Total fat,	16.70	"
Percentage protein matter in carcass,	13.82	"
Percentage fat in carcass,	12.75	"

At the time that No. 1 was killed, No. 2 weighed 240 pounds. We then commenced to feed her a ration of four pounds of wheat bran, two pounds of cotton seed meal, and two pounds of shelled corn per day. After a few days feeding she refused to take a ration so rich in nitrogenous matter, and the cotton seed meal was lessened. She would hardly take any for a time, but gradually she was induced to eat one-half a pound per day.

The amounts of the various fodders consumed in the course of the experiment is given in the table below :

	WHEAT BRAN. LBS.	COTTON SEED MEAL. LBS.	CORN. LBS.
Sept. (from 22d) and October,	69.	30.75	64.
November,	72.	15.	34.
December,	77.5	15.5	62.
January,	77.5	15.5	62.
February (to 12th,)	31.25	6.25	25.
Total food consumed,	327.25	83.	247.

The composition of the ration varied somewhat during the course of the experiment from the fact that we were not able to get the hog to take as much of the cotton seed meal as we desired.

Below is given the digestible composition of the ration for the first month, a part of the last month, and for the whole period :

	*Protein, Pounds.	Fat, Pounds.	*Nitrogen—Free Extract lbs.	*Fibre, Pounds.	*Nutritive Ratio.
Ration for Sept. and Oct.,	18.23	7.27	73.95	.89	1:5.1
Ration for February,	6.68	2.27	29.58	.29	1:5.3
Ration for whole period,	71.71	25.05	304.16	3.31	1:5.2

It will be seen that the nutritive ratio of the ration was not particularly narrow, averaging 1:5.2 for the whole period and not varying greatly from it at any time. In the experiments by Henry already referred to, the ration of the pigs making the most striking development of lean meat, had a nutritive ratio of 1:2. The feeding standard recommended by Armsby † for fattening swine has a nutritive ratio of 1:6. It is probable that in warm pens a narrower nutritive ratio than this could be economically used. We had intended to use a nutritive ratio of about 1:3.5, but in this were balked by the individual tastes of our subject.

The experiment continued without any accident for 143 days, or until Feb. 12th, 1889, at which time the animal was slaughtered and the following data secured. For convenience of comparison we repeat the data already secured from No. 1 :

	Hog slaughtered before feeding. No. 1.	Hog slaughtered after feeding. No. 2.
Live weight, ...	207.	296.
Dressed weight including kidneys,	131.	211.
Bones, lbs.	13.	16.63
Total protein matter, lbs.	**18.10**	**59.09**
Total fat, lbs.	**16.70**	**48.29**
Per cent. protein in carcass,. . . .	**13.82**	**28.**
Per cent. fat in carcass,.	12.75	22.89
Per cent. dressed to live weight,. .	63.29	71.28

* By *Protein* or *Crude Protein* is meant a class of substances containing nitrogen, estimated by multiplying the total nitrogen in a substance by 6¼. The protein compounds are often called albuminoids, and are often familiarly spoken of as flesh formers.

Nitrogen-Free Extract is made up of a class of substances soluble in water and containing no nitrogen. Sugar, starch and gum are the most common and familiar examples of this class. They are often called carbhydrates.

Fibre is also a carbhydrate, but is not soluble in water or dilute acids. It is less digestible than the other carbhydrates and therefore less valuable as a constituent of fodders.

The fat, the nitrogen-free extract and the fibre are often spoken of collectively as heat and fat formers.

The *Nutritive Ratio* is the ratio of the nitrogenous substances to the non-nitrogenous, and since fat will make nearly two and one-half times as much heat as an equal weight of other non-nitrogenous substances, it is multiplied by two and one-half and added to the carbhydrates in calculating the nutritive ratio. In other words the nutritive ratio is the ratio of the protein to the carbhydrates plus two and one-half times the fat.

† Manual of Cattle Feeding, p. 492.

As has been stated the hog that was slaughtered before feeding was evidently in slightly better condition. We may be fairly certain that the one slaughtered before feeding, or No. 1, was at least not richer in nitrogenous matters than the one fed, or No. 2. We will therefore assume that the two hogs were of the same composition at the time the first one was slaughtered. On this assumption the composition before and after feeding of the hog fed, and the gain or loss of the various constituents, are shown in the following table :

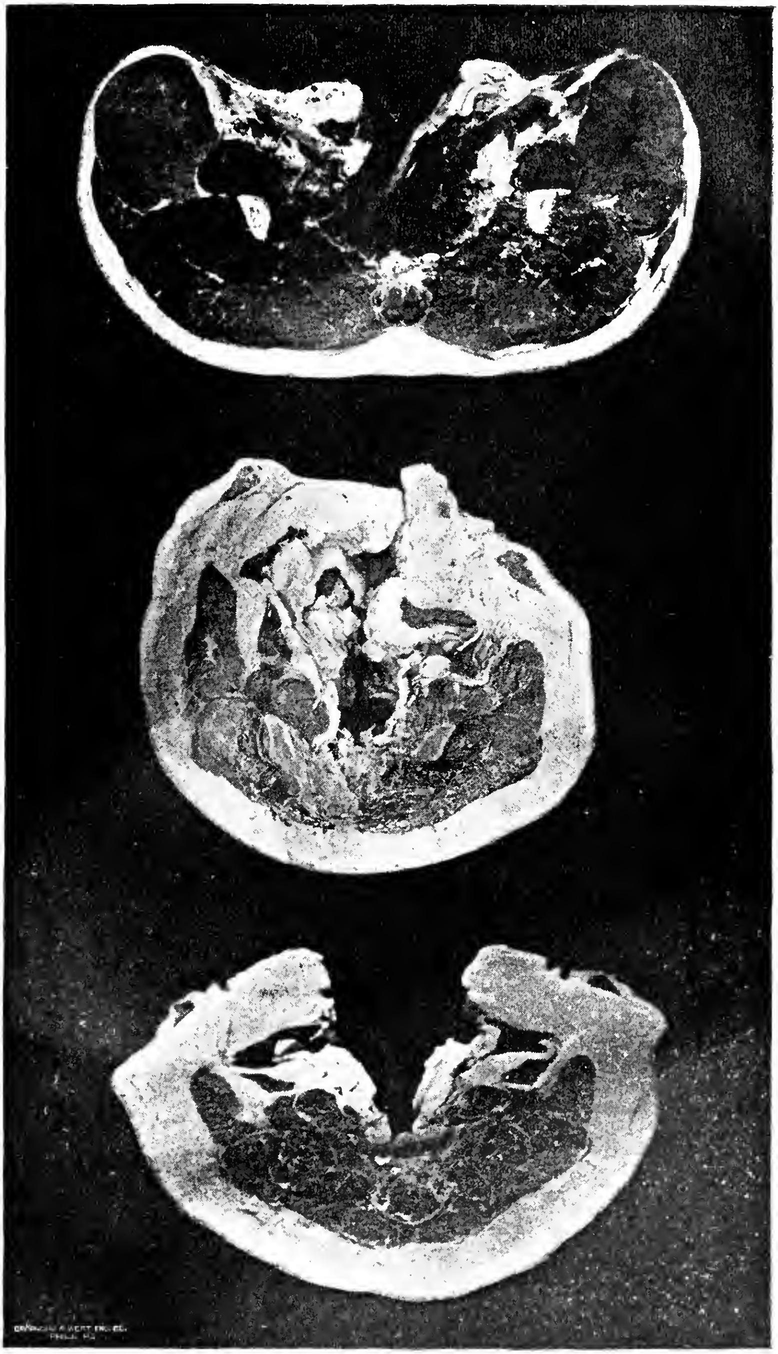
HOG No. 2.	*Assumed composition before feeding on basis of analysis of No. 1.*	Composition after feeding as found by analysis.	Gain* or loss† in pounds.
Live weight, ...	240.	296.	*56.
Dressed weight, ...	151.9	211.	*59.1
Bones, ...	16.63	16.63	. . .
Protein matter, ...	20.99	59.09	*38.1
Fat, ...	19.37	48.29	*28.92
Water and ash (by diff.) .	94.91	86.99	†7.92

The table shows a marked increase of the nitrogenous matter over the fat and a considerable falling off of water as a result of the feeding. This experiment was in every sense preliminary and of course the data are insufficient to furnish positive proof as to the questions asked, still all the indications are that a mature animal can be readily made to increase in muscle or lean flesh. This is apparent to the eye in comparing the photo-engravings of sections of the hog No. 2 and sections of hogs of about the same weight, fattened in the ordinary manner, as found in the Ithaca markets.

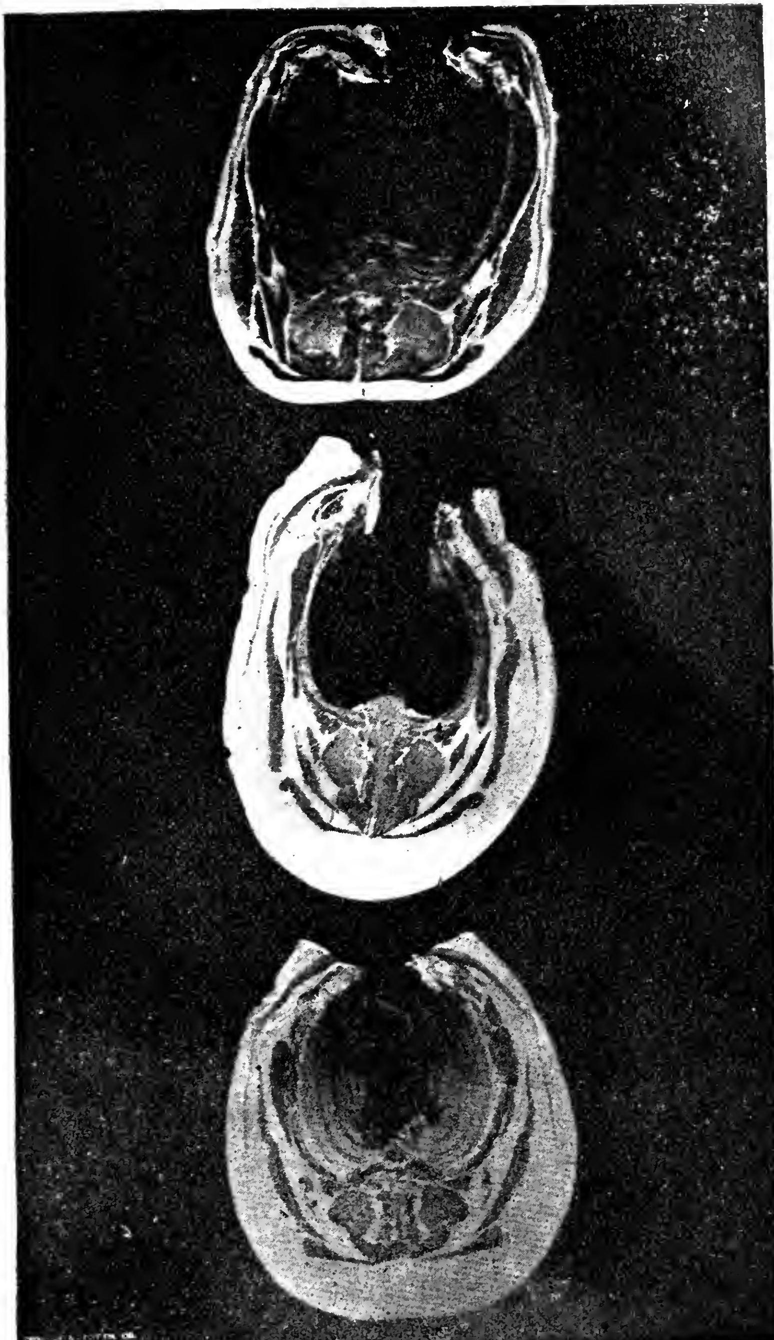
The upper section in each plate is from hog No. 2, the middle and lower sections are from carcasses selected in the Ithaca market ; both of them of about the same weight as our hog No 2, and both considerably younger. They were fattened by farmers in the neighborhood, in the usual way, largely on corn. The reader will notice the remarkable proportion of lean to fat in the carcass of hog No. 2.

We had carried on an entirely parallel experiment with mature grade Merino ewes, except that an additional lot was added that were fed a strongly carbonaceous ration ; unfortunately an accident occurred during the rendering of the carcasses and all comparative results by analysis were lost. In so far as the results could be judged by the eye they were in accordance with those obtained from the carcass of the hog. I. P. ROBERTS.

SECTIONS THROUGH LOIN.



SECTIONS THROUGH FIFTH RIB



DOES HEATING MILK AFFECT THE QUANTITY OR QUALITY OF BUTTER.

It is generally conceded that for best results in butter making, where the milk is set in deep cans, the milk should be placed in the creamer as nearly as possible at the temperature at which it is drawn from the cow; there being a considerable loss of fat in skim milk if the milk is allowed to cool to any great extent before being set.

Of late there has been considerable controversy as to whether it is advisable under any conditions to warm the milk before setting, and the limit of temperature beyond which it is not safe to go.

Mr. E. W. Stewart in the *Country Gentleman* of Feb. 14th, 1889, in answer to a correspondent in regard to milk from thoroughbred and high grade Jersey cows that had been in milk for a long time, and from which only a pound of butter was secured from 28 pounds of milk, says:

"It is highly probable that not more than two thirds of the fat is obtained from this milk. If this milk were heated in a water bath to 135 degrees, immediately after milking, and set in shallow pans in a temperature of about 60 degrees, the amount of cream and butter would be largely increased, and the cream would churn in the same time as from fresh milch cows, and probably it would not take more than 17 to 20 pounds of milk to a pound of butter. But if the cream be raised by cold deep setting, then it should be set directly from the cow, and the cream may be heated to 130 degrees when skimmed, and after ripening will churn much better for it and make more butter."

On the other hand we have the following report from a firm of extensive and very successful dairymen:

"We took some milk from the vat just after milking, and after stirring it thoroughly we took two samples of exactly the same amount. One sample was scalded at 120 degrees, the other without scalding, and both stood for twenty-four hours in ice water at 40 degrees; they were then both closely creamed, the cream ripened and the two samples churned, worked, and in every way except the scalding treated exactly the same. The scalded milk produced 6 lbs. 11 ozs. and the other 5 lbs. 15¼ ozs. The former was white and pasty and could not be worked into butter; it was impossible to get the buttermilk and curd out of it; the latter made a good product of marketable butter.

"We then took two samples, each of the same amount exactly, heated one to 120 degrees and left the other normal and put both in ice water the same as before for 20 hours. They were then ripened without skimming and treated exactly the same, churned the same and worked the same and in every way treated alike except the heating. The scalded milk produced 4 lbs. 5 ozs. and the other 2 lbs. 1¾ ozs. That from the scalded milk had the appearance of Dutch cheese and could not be worked into butter; it was impossible to get rid of the curd and buttermilk. The other was a very handsome sample of well colored marketable butter. These tests were both made with the utmost care in every particular. The test of the scalded milk made without skimming showed more curd than when skimmed, and hence the larger proportionate product."

We have made the following experiments intended to throw light on this important point.

February 17, 1889. The mixed evening milk of six grade Jersey cows was used. Three of the cows had dropped calves in January, 1889, two in August, 1888, and one in May, 1888. The milk was divided into four parcels of 14 pounds each and treated as follows:

No. 1 set direct from the cow without treatment at a temperature of 93 degrees.

No. 2 cooled to 60 degrees with more or less stirring, strained into another can and set.

No. 3 cooled to 60 degrees as No. 2, then warmed to 93 degrees in a water bath and set.

No. 4 cooled to 60 degrees as No. 2, then warmed to 135 degrees in a water bath and set.

All were set in the same Cooley creamer with water at 40 degrees and were skimmed after setting twenty-two hours. Ten pounds of skim milk were taken from each can. There was no perceptible difference in the bulk of cream.

The different lots of cream were then ripened and on February 21 were churned all at the same time in the same test churn.

The butter was washed in the granular state, allowed to drain thoroughly and weighed without working or salting. The results were as follows :

No. 1,	1.03125 lbs.
No. 2,	1.1875 lbs.
No. 3,	.9375 lbs.
No. 4,	.9375 lbs.

The butter so far as we were able to judge was very uniform in quality from all the lots of cream. These results gave no confirmation to either theory. We had no pasty, cheesey butter, and the difference in weight, as we afterwards learned, was in all probability due to a varying percentage of water in the different samples of butter

Thinking that a larger quantity of cream churned in an ordinary churn might give us results more comparable with actual practice, the experiment was repeated as follows :

No. 1 February 26th, 1889, the mixed evening milk from the same Jersey cows used before. 48 pounds set without treatment at 90 degrees.

No. 2, February 27, 1889. Same amount of the evening milk from the same cows. First cooled to 60 degrees by pouring from can to can, then warmed to 135 degrees and set.

No. 3, February 28, 1889. The mixed evening milk of five grade Holstein cows. Three had dropped calves in September, one in August, and one in October, 1888. 48 pounds of milk set without treatment at 88 degrees.

No. 4, March 1st 1889. Same amount of milk from the same cows as No. 3 set in the same manner as No. 2.

In this trial all the milk was skimmed after setting twelve hours, ripened, and churned in an ordinary barrel churn. The results of the churnings were as follows :

No. 1 Jersey cows, untreated	-	3.15625 lbs.
No. 2 " " warmed to 135°	-	3.25 "
No. 3 Holstein cows, untreated	-	2.0625 "
No. 4. " " warmed to 135°		2.25 "

These results as far as they showed anything indicated the accuracy of our former work but otherwise left us in much the same position as before. We therefore determined to go over the whole ground again, if possible, more thoroughly and more carefully than before, and to make analyses of skim milk and the butter from the various kinds of treatment. In this trial the data were as follows: In all cases the mixed milk of five cows was used. The cows of the two breeds were the same as had been used in the previous experiments. The milk was set in a Cooley creamer in which the temperature of the water was 40 degrees. The cream was churned in an ordinary barrel churn. The butter was washed in granular form drained dry as possible and weighed without working or salting.

No. 1, Grade Holstein cows, Monday evening, March 25, 48 pounds of milk set without treatment at 91 degrees, skimmed after thirteen and three-quarter hours.

Tuesday morning March 26th, 48 pounds of milk set without treatment at 89 degrees, skimmed after eleven and one-quarter hours.

The two samples of cream were mixed and ripened and churned Friday, March 29th. Temperature of churning 64 degrees. Time of churning seventeen minutes. Weight of butter 4.28 pounds or 22.43 pounds of milk to one of butter.

No. 2, Grade Holstein cows, Tuesday evening, March 26th, 48 pounds of milk cooled to 60 degrees and set at that temperature, skimmed after fourteen hours.

Wednesday morning, March 27th, 48 pounds of milk cooled to 60 degrees and set at that temperature, skimmed after eleven and one-quarter hours.

The two samples of cream were mixed and ripened and churned Tuesday, April 2nd. Temperature of churning 63 degrees. Time of churning sixteen minutes. Weight of butter 4.03 pounds or 23.82 pounds of milk to one of butter.

No. 3, Grade Holstein cows, Wednesday evening, March 27th, 48 pounds of milk cooled to 60 degrees and then warmed to 135 degrees in a water bath and set. Skimmed after thirteen and one-quarter hours.

Thursday morning, March 28th, 48 pounds of milk cooled to 60 degrees and then warmed to 135 degrees and set, skimmed after twenty-two and one-quarter hours.

The two samples of cream were mixed and ripened and churned Wednesday, April 3rd. Temperature of churning 64 degrees. Time of churning eleven minutes. Weight of butter 4.37 pounds or 21.96 pounds of milk to one of butter.

No. 4, Grade Jersey cows, Thursday evening, March 28th, 48 pounds of milk set without treatment at 90 degrees, skimmed after thirteen and three-quarter hours.

Friday morning, March 29th, 48 pounds of milk set without treatment at 90 degrees, skimmed after 24¼ hours.

The two samples of cream were mixed and ripened and churned Wednesday, April 3d. Temperature of churning 64 degrees. Time of churning fifteen minutes. Weight of butter 6.4061 lbs., or 14.98 lbs. milk to one of butter.

No. 5, Grade Jersey cows, Friday evening, March 29th, 46 lbs. of milk cooled to 60 degrees and set at that temperature, skimmed after fourteen and one-half hours.

Saturday morning, March 30th, 48 lbs. of milk cooled to 60 degrees and set at that temperature, skimmed after twenty-four hours.

The two samples of cream were mixed and ripened and churned Wednesday, April 3d. Temperature of churning 64 degrees. Time of churning eighteen minutes. Weight of butter 6.5 lbs. from 94 lbs. of milk, or at the same rate 6.6 lbs. from 96 lbs. of milk, or 14.46 lbs. milk to one of butter.

No. 6, Grade Jersey cows, Saturday evening, March 30th, 48 lbs. of milk cooled to 60 degrees and then warmed to 135 degrees, skimmed after fourteen hours.

Sunday morning, March 31st, 48 lbs. of milk cooled to 60 degrees and then warmed to 135 degrees, skimmed after twenty-three hours.

The two samples of cream were mixed and ripened and churned Wednesday, April 3d. Temperature of churning 64 degrees. Time of churning thirteen minutes. Weight of butter 6.406 lbs., or 14.96 lbs. milk to one of butter.

It will be seen that in some cases the milk stood about twelve hours and in others about twenty-four before skimming. That the creaming was perfect is shown by the fact that none of the skimmed milk showed any more cream after standing for some time, and also by the analysis of the skimmed milk given below.

No.	Temp. of Setting Milk.	Evening.	Per Ct. Fat.	Morning.	Per Ct. Fat.	Ave.	
1	90°	March 25, .	.90	March 26, .	.80	.85	Milk fr.
2	60°	March 26, .	1.02	March 27, .	.97	1.00	Grade Holst'n
3	135°	March 27, .	.68	March 28, .	.35	.52	cows.
4	90°	March 28, .	.24	March 29, .	.18	.21	Milk fr.
5	60°	March 29, .	.41	March 30, .	.14	.28	Grade Jersey
6	135°	March 30, .	.04	March 31, .	.07	.06	cows.

Two things are shown by the table: first, that the Jersey milk was more completely creamed than the Holstein; second, that the treatment of the milk before setting had a slight, but well marked, influence upon the amount of fat left in the skimmed milk. If we rearrange our table this last will be brought out more clearly.

PERCENTAGE OF FAT IN SKIM MILK.				
Treatment of Milk.	Nos.	Holstein M . .	Jersey Milk.	Ave.
Set direct from cow, ...	1 and 4	.85	.21	.53
Cooled to 60 degrees, ...	2 and 5	1.00	.28	.64
Cooled to 60 degrees, warmed to 135 degrees, ...	3 and 6	.52	.06	.29

* Average percentage of fat in skim milk of between 200 and 300 settings, with three Jersey and grade Jersey cows, - - - - - .35

It will be seen that the difference in the amount of fat in the skim milk from the different treatment before setting is so small as to appear insignificant, being only .11 of one per cent. against allowing the milk to cool before setting and only .24 of one per cent. in favor of heating the milk up to 135 degrees. Yet even this slight difference with a herd of thirty cows giving thirty pounds of milk per day would involve a loss of just about a pound of butter fat in the one case and a gain of about two pounds and a sixth in the other.

The next point that demands attention, is the relative amount of butter secured from the cream raised at different temperatures of setting. When we came to analyze the butter, as will be shown further on, it was found that the percentage of water was both very high and very variable. (It will be remembered that the

* Dr. H. P. Armsby. Bulletin No. 7, Wisconsin Agricultural Experiment Station, Oct. 1885, p. 11.

butter was not worked, but merely drained as dry as possible in the granular condition.) We have therefore reduced the butter to a uniform water content of 12%.

WEIGHT OF BUTTER FROM 96 POUNDS OF MILK.

No.	Temp. of Setting.	Weight butter. Lbs.	Per cent. water in butter.	Weight of butter containing 12 per ct. of water. Lbs.	Pounds of milk required to make one of butter.	
1.	90°	4 28	16.20	**4.10**	23.41	Milk fr. Grade Holst'n cows.
2.	60°	4.03	19.60	**3.72**	25.81	
3.	135°	4.37	17.99	**4.04**	23.76	
4.	90°	6.41	15.73	**6.17**	15.56	Milk fr. Grade Jersey cows.
5.	60°	6.60	18.54	**6.17**	15.56	
6.	135°	6.41	19.60	**5.92**	16.21	

AVERAGES.

TREATMENT OF MILK.	Nos.	Weight of butter. Lbs.
Set direct from the cow, ...	1 and 4	5.14
Cooled to 60°, ...	2 and 5	4.94
Cooled to 60° then warmed to 135°.	3 and 6	4.98

The differences in the amount of butter, as in the richness of the skimmed milk, are small, but they do not correspond. While there is a falling off in the amount of butter from the milk that was allowed to cool, there was not a corresponding increase in the butter from the milk that was heated to 135°, in fact, there was almost as great a loss.

The quality of butter, especially as to the amount of casein or curd in it, is shown in the following table of chemical analysis, which has been reduced to the uniform basis of 12% of water in all the samples.

Nos.	Temp. of Setting.	Water.	Curd.	Ash.	Fat.	
1.	90°	12.00	1.03	.06	86.91	Milk fr. Grade Holst'n cows.
2.	60°	12.00	1.29	.05	86.66	
3.	135°	12.00	1.15	.05	86.80	
4.	90°	12.00	1.17	.05	86.78	Milk fr. Grade Jersey cows.
5.	60°	12.00	1.29	.04	86.67	
6.	135°	12.00	.81	.04	87.15	
Aver. 1 and 4	. .	**12.00**	**1.10**	**.06**	**86.84**	
Aver. 2 and 5	. .	**12.00**	**1.29**	**.05**	**86.66**	
Aver. 3 and 6	. .	**12.00**	**.98**	**.05**	**86.97**	

While there is a slight variation in the percentage of curd, there is no increase in the amount of curd that can be attributed to the warming of the milk. In fact the sample containing the least amount of curd of any was obtained from the Holstein milk that had been heated to 135 degrees.

SUMMARY.

We may conclude as the result of these investigations, first, that there is a loss of butter when the mllk is allowed to cool much below the normal heat of the cow before being put in the creamer; second, that while there may not be any very great increase of butter when the milk is heated there is no risk of injuring the quality of the butter by incorporating an excess of casein even when the milk is heated as high as 135 degrees.

I. P. ROBERTS.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

VI.

JUNE, 1889.

I. On the Determination of Hygroscopic Water in Air-Dried Fodders.

II. The Determination of Nitrogen by the Azotometric Treatment of the Solution Resulting from the Kjeldahl Digestion.

III. Fodders and Feeding Stuffs.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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ON THE DETERMINATION OF HYGROSCOPIC WATER IN AIR-DRIED FODDERS.

The determination of moisture is one of the most important operations in fodder analysis, but as yet little attention has been given to fixing a standard method, based on the results of actual experiments. The amount of dry matter, which serves as a basis for the calculation of the amount of ether-extract, nitrogen, ash, crude fibre, and nitrogen-free extract being directly dependent on the amount of moisture, any inaccuracy in this determination affects the amount of the several other constituents found.

Dr. Jenkins of the Connecticut Experiment Station, in his report to the Committee on Cattle Foods of the Association of Official Agricultural Chemists, published in Bulletin No. 19, Division of Chemistry, Department of Agriculture, gave results obtained (1) by drying at 100° in an air bath; (2) by drying in a current of hydrogen at the same temperature; and (3) by drying in hydrogen at 110°–115°.

He shows that in three samples of fodder the amount of moisture found is larger when the current of hydrogen is employed—also that a temperature of 110°–115° causes a greater loss than takes place at 100°. In a similar report, as yet unpublished, he obtains somewhat similar results.

The following experiments were undertaken to throw some further light on this important matter.

Three samples of fodder, viz.: hay, wheat bran, and cotton-seed meal, were pulverized as for a complete analysis. Ten different methods of drying were tested, described briefly as follows:

A.—Drying in watch-glasses in a boiling water bath, temperature quite constant viz., 97°.

B.—Drying in watch-glasses in an air bath. The temperature did not vary one degree either way from 100°.

C.—Similar to B, the temperature, however, being raised to 110°–115°.

D.—The substance was placed in a tube through which a current of dry air was passed, the tube being heated in the water bath at 97°.

E.—The substance was treated, as in D, with the temperature at 100°

F.—Similar to E, temperature 110°.

G.—Similar to D, dry hydrogen being used in place of air, temperature 97°.

H.—Similar to G, temperature 100°.

I.—Similar to G, temperature 110°.

J.—Drying in a vacuum, over sulphuric acid for 72 hours.

Three gms. of substance were used in every case, and the samples were cooled in a desiccator thirty minutes before weighing. Complete drying was assured by further treatment for one hour, and re-weighing; except when otherwise mentioned the full time of treatment was three hours.

The results obtained are shown in the following table, each result being the average of four determinations, the highest and lowest agreeing within .15 per cent.

	In open watch glass.			In tube, in current of dry air.			In tube, in current of dry hydrogen.			In a vacuum.
	97°	100°	110°	97°	100°	110°	97°	100°	110°	
	A	B	C	D	E	F	G	H	I	J
Hay - - - - -	8.39	9.46	12.93	8.87	9.81	12.26	8.52	9.75	10.40	9.58
Bran - - - -	7.73	8.13	8.31	8.59	8.54	8.71	7.90	8.02	8.91	8.02
Cottonseed Meal	6.78	7.89	7.91	7.29	8.16	8.11	7.02	8.03	8.43	7.98

The conclusions to be arrived at from inspection of the foregoing table are—

1. Raising the temperature raises the percentage of loss, as would be expected.

2. The loss at 100° in an air bath corresponds closely to the loss in a vacuum.

3. The effect of the temperature of 110° is greater in the determination on the hay, than on the bran and cotton seed meal. This seems to indicate either the presence of a greater percentage of easily volatilized constituents in the hay, or that the hay gives up its moisture with more difficulty.

The first explanation is supported by the results of the following experiment. The current of air after passing through the substance [methods D. E. F.] was passed over red hot copper oxide, through a series of drying tubes containing sulphuric acid, and finally through a Geissler potash bulb. The gain in weight of this bulb, due to the carbonic acid formed by the oxidation of the volatile carbonaceous constituents carried along by the current of air, was used as a measure of those constituents. The amount of carbonic acid obtained from three gms. of the different substances was as follows :

	At 100°	At 110°
Hay,	.0156	.0213
Bran,	.0032	.0069
Cottonseed Meal,	.0026	.0042

The hay loses much more by volatilization and oxidation than the bran or cottonseed meal.

In another experiment, indicating loss by oxidation alone, the current of air was passed through the sulphuric acid and potash bulb without the interposition of the copper oxide. Coloration in the sulphuric acid showed the volatile constituents to have been absorbed there ; the yield of carbonic acid was as follows :

	100 cc.	110 cc.
Hay,	.0069	.0125
Bran,	.0020	.0030
Cottonseed Meal,	.0008	.0013

The hay contains a larger percentage of easily oxidizable constituents, with volatile oxidation products than the other two.

It is evident from these results that in the determination of moisture in fodder there is a decided choice as to methods of treatment. Drying by heat with exposure to air is plainly inadmissible, as it involves more or less of substance not moisture, which is even evident to the senses if done in an open dish at 110°. Drying in vacuum over sulphuric acid may be free from any such objection, but requires too much time. Drying in hydrogen at 110° gave such a large increase in loss of weight over the loss at 100° as to arouse suspicion, which was supported by the following results : when this hydrogen was carried from the substance through potash, the increase in weight of the potash bulb after three hours treatment at 100° was less than one mgm. ; but it was from 3 to 20 mgms. with a heat of 110°, on another portion of the substance. The hydrogen used may possibly have contained a little oxygen, being made in an ordinary generator, from chemically pure zinc and sulphuric acid, and this might have affected the result somewhat, although slightly.

Drying at 100° in a current of hydrogen appears, therefore, all things considered, to offer the least objection, and the nearest approach to a correct determination of the hygroscopic moisture in fodder. W. P. CUTTER.

THE DETERMINATION OF NITROGEN BY THE AZOTOMETRIC TREATMENT OF THE SOLUTION RESULTING FROM THE KJELDAHL DIGESTION.

In the Chemiker Zeitung, vol. 12, p. 217, Schoenherr states that, if the solution resulting from the Kjeldahl digestion is diluted, neutralized, and an aliquot portion treated with sodium hypobromite in an azotometer, the results obtained are very accurate. In order to test this apparently very convenient method, the following experiments were performed.

The solution of sodium hypobromite was prepared by dissolving 50 gms of sodium hydrate in 125 cc. of water and adding 12 cc. of bromine.

A. In order to test the hypobromite solution and the azotometer, a solution of ammonia containing 3.265 gms nitrogen in one liter was prepared.

Ten cc. of this ammonia solution when treated with 50 cc. of hypobromite, gave 32.60, 32.52, 32.60, 32.70 mgms. of nitrogen, the theoretical amount being 32.65.

B. A sample of cotton seed meal [Sample No. 2 from the Nitrogen Committee of the Association of Official Agricultural Chemists, 1888], on treatment by the ordinary Kjeldahl method, gave as an average of several determinations, 7.54 per cent. of nitrogen. In attempting to determine the nitrogen by the azotometer, results much lower were obtained, viz., 5.92, 5.30, 5.92, 5.40.

C. When repeating the experiment, by mistake the solution was *not neutralized* before treatment with hypobromite. The results obtained were 7.55, 7.67. Repeated without neutralizing 7.67, 7.55, 7.54, 7.60.

Repeating these determinations, the following results on a sample of wheat bran and a mixed fertilizer, were obtained :

Bran	Distillation,	2.71	2.73				Average 2.72
	Azotometer,	2.67	2.68	2.67	2.72	2.71	Average 2.69
Fertilizer	Distillation,	3.36	3.36				Average 3.36
	Azotometer,	3.31	3.32	3.36	3.34		Average 3.33

Several repetitions of the method, partially neutralizing, as directed by Schoenherr, gave results very much too low. The solution of ammonia used in A, having sulphuric acid added, after neutralization, gave on treatment in the azotometer, about half the nitrogen originally present. Attempts to neutralize the solution by barium carbonate gave similar results.

The method, compared with a single determination by distilling with soda, is much simpler. But as with a single azotometer only one determination can be made at a time, and the labor of calculation is much greater, it is doubtful if the method is of great practical value. The chief argument in its favor is the fact that the purity of the reagents is of less importance than in the usual method.

For the benefit of anyone who may care to repeat these experiments, the following directions are given:

To 1 gm of substance in a 250 cc. Kjeldahl flask add 20 cc. of c. p. sulphuric acid and .7 gm. mercuric oxide. Digest until colorless, and add potassium permanganate until the solution is green. Cool, make up to 100 cc. and at once measure out 25 cc. portions for treatment in the azotometer. Add the liquid to the hypobromite cautiously. Measure the nitrogen evolved and calculate to standard temperature and pressure.

A modification of the Knop-Wagner azotometer, constructed in this laboratory, was used.

W. P. CUTTER.

FODDERS AND FEEDING STUFFS.

The analyses recorded below were made partly in connection with experiments on the farm or at the barn, and have been already in some cases partially reported in other Bulletins where these experiments are described. The results of these analyses are thus brought together in full, in tabular form, in order that they may be more conveniently referred to as a contribution to our knowledge of this subject. Many other analyses were made, some of fodders called timothy, or clover, alone:

but as no sample really consisted of pure or even nearly pure timothy or clover, the results of these analyses have no value except in connection with the experiments concerned.

The method of analysis followed was in all cases the latest recommended by the Association of Official Agricultural Chemists.

In the case of the fodder corn, some of the very noticeable differences in the percentages when reckoned to dry substance, may be explained by the fact that the plots from which these samples were taken were treated differently, for purposes of experiment. By referring each sample, as designated in the table, to corresponding numbers in Bulletin No. IV, December 1888, pp. 50, 51, 52, the data in regard to treatment of these plots may be found. The most marked of these differences, the lower per cent. of protein in numbers 3 and 4 seems to find an explanation in the crowded stand of the plants that is usual when the seed is sown broadcast.

	Substance as Received.		Composition of Dry Substance.				
Fodder Corn.	Moisture.	Dry Matter.	Crude Ash.	Ether Extract.	Crude Protein.	Crude Fibre.	N-free Extract.
Table IV—I,	14.74	85.26	8.19	2.10	12.53	23.87	53.31
" —II,	13.51	86.49	6.43	2.03	9.1[illegible]	23.65	58.77
" —III,	12.35	87.65	3.64	2.76	8.12	28.04	57.44
Plot 1,	7.38	92.62	5.04	2.18	10.05	21.24	62.48
Plot 2,	8.92	91.08	5.19	2.10	10.00	22.18	61.53
Plot 3,	11.54	88.46	4.77	1.64	7.56	20.65	65.38
Plot 4,	43.58	56.42	6.92	2.41	7.19	24.64	58.84
Plot 5,	17.78	82.22	8.11	2.45	13.12	29.24	47.08
Plot 6,	9.88	90.12	5.37	2.66	10.00	23.62	58.35
Plot 7,	20.08	79.92	6.56	1.65	13.54	26.25	52.00
Plot 8,	38.60	61.40	6.02	2.23	11.62	26.56	53.57
Average,	18.03	81.97	6.02	2.20	10.26	24.54	56.98
Wheat Bran,	8.45	91.55	7.58	4.54	19.13	10.86	57.89
" "	13.70	86.30	7.32	4.87	13.21	8.82	68.77
" "	8.84	91.16	7.00	4.88	16.97	9.72	62.63
" "	11.81	88.19	5.00	4.79	14.88	7.40	56.12
Cotton Seed Meal,	6.76	93.24	9.23	10.68	50.93	6.70	22.46
" " "	10.68	89.32	6.88	11.86	37.68	6.72	36.86
" " "	7.66	92.34	8.86	9.93	52.32	5.83	33.06
" " "	7.95	92.05	4.41	11.73	53.91	3.45	26.50
Turnips,	90.90	9.10	10.00	11.07	15.60	10.11	53.22
"	91.51	8.49	11.10	5.61	13.08	11.87	58.34
Cotton Seed Hulls,	9.70	90.30	2.20	2.64	4.84	55.04	35.28

W. P. CUTTER.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

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VII.

JULY, 1889.

On the Influences of Certain Conditions upon the Sprouting of Seeds.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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CORNELL UNIVERSITY EXPERIMENT STATION,

Ithaca, N. Y.

On the Influences of Certain Conditions upon the Sprouting of Seeds.

IT is well known that germination of seeds is more or less influenced by many comparatively trivial circumstances and conditions; yet there have been no general inquiries in this country into the exact effects of these conditions, or their importance to the cultivator. Their relations to seed-testing have always seemed to the writer to be of special importance, and it is in this direction that the present investigation has been undertaken. Most of the published records of seed-tests are obviously nearly valueless, because they take no account of the conditions of test. This is particularly true of those cases in which germinative vitality is recorded as low, for no assurance is given the reader that other or more careful management might not have increased the percentages. The writer has found repeatedly that a sample which gives very poor results under one treatment may give good results under another. The notes of experiments which follow may serve as suggestions to those who test; at all events, it is not too much to expect that the importance of care and uniformity in seed-testing will be emphasized. It is not to be expected that laws can be announced as the results of these somewhat discursive tests, but indications may be safely drawn in some instances.

Seed-tests are of two sorts: the determination of the purity of the sample as regards foreign material, as weed seeds, chaff, dirt, and the like; and the determination of the germinative vitality. The former series of tests require a simple mechanical separation of the ingredients of the sample.*

Germinative vitality is commonly estimated by per cent. and rapidity of sprouting.† Rapidity of sprouting is held to indicate vigor or strength of seed, yet the results of many tests show that it is even more influenced by conditions than is the ultimate per-

* About a hundred packages of seeds have been carefully separated for impurities, and it was the intention to present the figures in this paper, but space will not permit. The results show that impurities in garden seeds are trifling.

† The verb *sprout* is used in preference to *germinate*, as germination is complete only when the plantlet has assumed its true leaves and has begun to assimilate. In seed-testing, the process is rarely carried to full germination.

centage of sprouting. Causes which determine the viability and vigor of seeds are either congenital, or due to the conditions of harvesting or storing. The expression or measure of this viability and vigor is again determined by the conditions of germination. In the present investigation, with the exception of studies of the relations of weight and color to sprouting, only the conditions of germination have received attention. Seeds can be so readily selected in reference to weight and color, that it was thought advisable to study these phases of the subject in connection with conditions which may be fully controlled by the operator.

The importance of seed-testing is obvious, yet its value is apparently commonly misapprehended. Its primary value is the determination of the vitality of a given sample. This testing, except in rare instances, should be conducted by the grower himself. The proper work for the experiment station is that of determining the best methods and conditions of testing each species and variety ; in other words, it seems that the sphere of the stations is to discover and announce laws and rules, rather than to perform the petty tests for the multitude. Merely testing seeds for the purpose of determining how many will grow, is surely not experiment, and the publication of disconnected tests seems to be entirely unprofitable. The endeavor to determine the relative merits and honesty of seedsmen, by means of testing their seeds, is the merest folly.

There appears to be no necessity for seed-control stations in this country, certainly not for such seeds as fall to the hands of the horticulturist. The control stations of the Old World have sufficiently exposed the tricks of seedsmen, and have rendered open dishonesty unprofitable. There is now such sharp competition in the seed business that seedsmen themselves must exercise every caution in order to demand trade. Improved methods and apparatus for harvesting and cleaning are giving us clean samples. The greatest risk in the purchase of seeds is the possibility that inferior strains or varieties may be procured, but this is a risk which the control station could not assume to govern, inasmuch as the substitution becomes apparent only when the crop is grown. The experiment stations may be expected to influence sufficient control in the seed business, as occasion shall require.

The tests enumerated in the following pages have been conducted with the greatest care. Unless otherwise recorded, they have been made in a steam-heated forcing-house. As a rule, they have been made in earth in shallow earthen seed-pans. These pans are exceedingly convenient, and they afford good drainage. In some cases, lily-pans have been used, but they differ from the seed-pans only in their circular outline and somewhat greater depth. Illustrations of seed-pans may be seen in Figs. 3 to 7. For sowing seeds at uniform depths, two devices have been used. The simpler of these, (Fig. 1), is nothing more than a block of half inch stuff, two inches wide, of the required length, upon which is nailed a cleat equal in thickness to the depth of sowing. The cleat is pressed into the soil evenly, and the seeds are dropped into the furrow it makes. The other device, (Fig. 2). may be called the Tracy planter.* It consists of two strips of heavy tin plate nearly three inches wide, hung upon two wire pivots or hinges some two inches long. At their upper edges and equidistant from either end, the plates are joined by a firm spiral spring, which serves to throw the upper edges apart, and to cause the lower edges to join. This trough is now filled with the required number of seeds, and is then inserted into the earth to a given depth, when the fingers push inward on the spring and the trough opens and delivers the seeds.

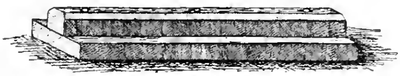

FIG. 1.

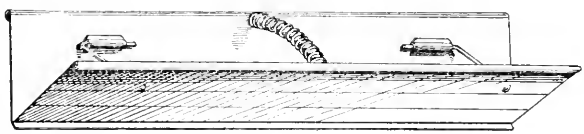

FIG. 2.

In this paper, the following points are discussed :

I. Influences of temperature upon sprouting.
II. Influences of varying amounts of water.
III. Influences of soaking seeds before sowing.
IV. Influences of soil.
V. Influences of light.
VI. Influences of weight of seed.
VII. Influences of color of seed.
VIII. Influences of latitude.
IX. Duplicate tests.
X. Comparisons of tests and actual plantings.
XI. Impurities in samples.
General Summary.

* Mr. W. W. Tracy, of the firm of D. M. Ferry & Co., gave the writer the plan for this implement.

I. INFLUENCES OF CONSTANT AND VARIABLE TEMPERATURES.

The tests here enumerated were made in an incubator of which the temperature was controlled by a galvanic current communicating with clock-work, and in a steam-heated forcing-house. In the incubator the temperature rarely varied three degrees, while the position of the seed-table in the forcing-house was such that variation sometimes amounted to sixty-five degrees. In some cases, duplicate tests were made in an out-door cellar which was used for the storing of nursery stock.

1. Bean, *Green Flageolet*.—Department of Agriculture.

No. 1, 100 beans in folds of cloth in seed-pan, in incubator.
No. 2, same in forcing-house.

SOWN MAR. 29.

SAMPLES.	DAILY SPROUTINGS. APRIL.					Total.	Per cent.	Average temperature during test.	Extremes of temperature.
	2	3	4	5	6				
No. 1 Incubator,	**56**	18	15	2		91	**91**	75°	73°, 76°
No. 2 Forcing-house,	**30**	38	11	2	1	82	**82**	76°	118°, 53°

Epitome.—Under constant temperature sprouting was much more rapid, and the total per cent. was also greater, although the mean temperature in the other test was somewhat higher.

2. Bean, *Green Flageolet*.—Department of Agriculture.

No. 1, 100 beans on sand and covered with cloth in seed-pan, in the incubator.
No. 2, same in forcing-house.

SOWN MAR. 29.

SAMPLES.	DAILY SPROUTINGS. APRIL.					Total.	Per cent.	Average temperature during test.	Extremes of temperature.
	1	2	3	4	5				
No. 1 Incubator,	**1**	**31**	41	19		92	**92**	75°	73°, 76°
No. 2 Forcing-house,	**3**	**22**	51	18	1	95	**95**	76°	118°, 53°

Epitome.—Sprouting was rather more rapid under constant temperature, although total per cent. of sprouting was slightly higher under varying temperatures. It is probable that this method of sowing is unreliable, as the repetition of this test appears to indicate:

3. **Bean**, *Green Flageolet*.—Department of Agriculture.

No. 1, 50 beans on sand and covered with cloth in seed-pan, in incubator.
No. 2, same, in forcing-house.

SOWN APR. 15.

SAMPLES.	DAILY SPROUTINGS. APRIL. 17	18	19	20	21	Total.	Per cent.	Average temperature during test.	Extremes of temperature.
No. 1 Incubator,		**2**	**36**		1*	39	**78**	75°	73°, 76°
No. 2 Forcing-house,	**3**	**26**	**11**	1	2	43	**86**	78°	101°, 57°

* The beans decayed badly.

Epitome.—Better results, both in rapidity and per cent. of sprouting, occurred under varying temperatures. In constant temperature the beans decayed badly, owing, perhaps, to the manner in which they were sown; the sprouting was slow, evidently from the same reason, as the beans were probably too moist in the confined atmosphere of the incubator.

4. **Bean**, *Green Flageolet*.—Department of Agriculture.

No. 1, 100 beans in folds of cloth in seed-pans, in incubator.
No. 2, same in forcing-house.

SOWN APR. 15.

SAMPLES.	DAILY SPROUTINGS. APRIL. 17	18	19	20	Total.	Per cent.	Average temperature during test.	Extremes of temperature.
No. 1, Incubator,	**25**	**63**	5	3	96	**96**	75°	73°, 76°
No. 2, Forcing-house,	**8**	**50**	32	3	93	**93**	78°	101°, 57°

Epitome.—Much greater rapidity of sprouting occurred under constant temperature, although the mean temperature was higher in the other case. The total per cent. of sprouting was also slightly higher under constant temperature.

5. **Bean**, *Green Flageolet*.—Department of Agriculture.

No. 1, 50 seeds, green-colored, between cloth, in a seed-pan, in incubator,
No. 2, same in forcing-house.

SOWN APR. 23.

SAMPLES.	DAILY SPROUTINGS. APRIL. 25	26	27	28	Total.	Per cent.	Average temperature during test.	Extremes of temperature.
No. 1, Incubator,	**13**	18	12	2	45	**90**	74°	72°, 75°
No. 2, Forcing-house,	**1***	22	7	1	31	**62**	73.6°	90°, 60°

* No. 2 was not so uniformly moist during the first day as No. 1.

Epitome.—Sprouting was more rapid under constant temperature, and the total amount was nearly 30 per cent. higher.

6. Bean, *Green Flageolet.*—Dreer.

No. 1, 100 white beans on sand in 5-inch seed-pan, in incubator.
No. 2, same, in forcing-house. SOWN MAY 6.

SAMPLES.	DAILY SPROUTINGS. MAY.				Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	8	9	10	11				
No. 1, Incubator,	**19**	**66**	7		92	**92**	74°	72°, 75°
No. 2, Forcing-house,	**17**	**33**	23	8	81	**81**	76°	105°, 46°

Epitome.—Sprouting was much more rapid under the constant temperature, although the mean temperature in the other test was 2° higher. The total sprouting was also greater under constant temperature.

7. Bean, *Green Flageolet.*—Dreer.

No. 1, 100 green-colored beans on sand in 5-inch seed-pan, in incubator.
No. 2, same in forcing-house. SOWN MAY 6.

SAMPLES.	DAILY SPROUTINGS. MAY.					Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	8	9	10	11	12				
No. 1, Incubator,	**4**	**78**	16			98	**98**	74°	72°, 75°
No. 2, Forcing house,	**5**	**14**	30	36	11	96	**96**	76°	105°, 46°

Epitome.—Sprouting was much more rapid under constant temperature, although the mean temperature in the other test was 2° higher. The total amount of sprouting was slightly higher under constant temperature.

8. Pea, *White Garden Marrowfat.*—Thorburn.

30 Peas in each of six 5-inch seed-pans, ½ inch deep in sand.
Nos. 1 and 2, placed in incubator.
Nos. 3 and 4, in forcing-house.
Nos. 5 and 6, in cellar. SOWN APRIL 29.

SAMPLES.	DAILY SPROUTINGS. MAY.											Total.	Per Cent.	Average Temperature during test.	Extremes of Temperature.
	3	4	5	6	7	8	9	10	11	12	13				
No. 1 Incubator,	**9**											*		74°	72°, 75°
No. 2 Incubator,	**29**														
No. 3 Forcing-house,		**3**	16	3	2	1						25	**83**	74°	105°, 46°
No. 4 Forcing house,		**3**	16	5	4	1	1					30	**100**		
No. 5 Cellar,								**10**	14	2		26	**86⅔**	53° (For first 7 days 46°.)	83°, 43°
No. 6 Cellar,								**12**	6	1	1	20	**66⅔**		

*Owing to a defect in the incubator, the temperature ran up to 90° on May 4. At this time the remainder of the seeds (91) had sprouted, but this test was discontinued, and this part of the experiment was repeated with the following results :

SOWN MAY 4.

SAMPLES.	Daily Sproutings. May. 6th.	7th.	8th.	9th.	Total.	Per Cent.	Temperature.
No. 1 Incubator,		**5**	19	2	26	**86⅔**	On the fifth day the temperature again ran too high and the test was discontinued.
No. 2 Incubator,	**1**	**20**	6		27	**90**	

Epitome.—The rapidity of sprouting was much greatest under constant temperature, while in the cellar, with a mean temperature 21° lower, the seeds were about nine days behind. Percentages were rather better under variable high temperatures, and lowest under variable low temperatures.

9. Radish, *Half-Long Early Scarlet.*—Vilmorin.

50 seeds in each of 6 5-inch seed-pans, ¼ inch deep in sand.
Nos. 1 and 2, placed in incubator.
Nos. 3 and 4, in forcing-house.
Nos. 5 and 6, in cellar.

SOWN APR. 26.

SAMPLES.	Daily Sproutings. Apr. 28	Apr. 29	Apr. 30	May 1	May 2	May 3	May 4	May 5	May 6	May 7	May 8	May 9	May 10	May 11	May 12	May 13	Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
No. 1, Incubator,		**24**	6	8		3											41	**82**	74°	72°, 75°
No. 2, Incubator,		**21**	3	1	2												27	**54**		
No. 3, Forcing hse,		**22**	3	2	1	1											29	**58**	71°	82°, 63°
No. 4, Forcing-hse,	**3**	**24**	2	3	2	2											36	**72**		
No. 5, Cellar,								**3**	**5**	10	10	2	3	1		1	35	**70**	54°*	83°, 43°
No. 6, Cellar,									**7**	17	8	4	2	2			40	**80**		

* Average for first nine days, 48½°.

Epitome.—There is no marked difference in rapidity of sprouting, between samples in constant temperature and those in varying temperatures with a high mean, but there is great difference between these two sets of samples and those under varying temperatures with a mean 17° lower. Three days after sowing, 45 seeds had sprouted in the incubator, and 49 in the forcing-house, while it was not until the eleventh day that 42 seeds had sprouted in the cellar. Yet the total sprouting was greatest in the cellar by 7 and 10 per cent.

10. Turnip, *Red Top Strap Leaf.*—Thorburn.

50 seeds of each number, ¼ inch deep in sand, in 5-inch seed-pans.
Nos. 1 and 2, placed in incubator.
Nos. 3 and 4, in forcing-house.
Nos. 5 and 6, in cellar.

SOWN APR. 24.

SAMPLES.	DAILY SPROUTINGS.														Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	APR.					MAY												
	26	27	28	29	30	1	2	3	4	5	6	7	8	10				
No. 1, Incubator,	**8**	**27**				1	1	1							38	**76**		
No. 2, Incubator,	**13**	**22**	1		1	1	1	1							39	**78**	74°	72°, 75°
No. 3, Forcing-house,	**1**	**27**	8	1	2	1	2	1							43	**86**		
No. 4, Forcing-house,		**16**	21	3	2										42	**84**	74½°	105°, 56°
No. 5, Cellar,										**3**	16	17		1	37	**74**		
No. 6, Cellar,									**9**	**8**	14	7	1		39	**78**	51.8°	83°, 43°

Epitome.—Sprouting was decidedly most rapid under constant temperatures, and it was fully nine days behind in the cellar where the mean temperature was about 22° lower. The rapidity was also greater in samples under constant temperatures than in those under equally high varying temperatures. The greatest per cent. of sprouting occurred under high variable temperatures, while there was scarcely any difference between percentages under constant and low variable temperatures.

11. Turnip, *Red Top Strap Leaf.*—Thorburn.

50 seeds in each of four 5-inch seed-pans, ¼ inch deep in sand.
Nos. 1 and 2, placed in incubator.
Nos. 3 and 4, in forcing house.

SOWN MAY 4.

SAMPLES.	DAILY SPROUTINGS.			Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	MAY						
	7	8	9*				
No. 1, Incubator,	**38**	2		40	**80**		72°, 75°
No. 2, Incubator,	**34**	3	1	38	**76**	74°	
No. 3, Forcing-house,	**41**	1		42	**84**		
No. 4, Forcing-house.	**44**	3	1	48	**96**	77°	101°, 56°

* At this time trouble with the incubator caused the work to be concluded.

Epitome.—Sprouting was somewhat more rapid under varying temperatures, while the total amount of sprouting at the end of five days was 12 per cent greater under varying temperatures.

12. Onion, *Giant Yellow Globe Rocca.*—Department of Agriculture.

No. 1, 50 seeds, soaked in water 10 hours and sown ¼ inch deep in sand in 5-inch seed-pan, in incubator.
No. 2, same, in forcing-house.

SOWN MAR. 29.

SAMPLES.	DAILY SPROUTINGS. APRIL.							Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	3	4	5	6	7	9	10				
No. 1, Incubator,	**7**	**17**	11	3	2	3	1	44	**88**	74°	72°, 75°
No. 2, Forcing-house,		**6**	13	15	9	2		45	**90**	76°	118°, 53°

Epitome.—Under constant temperature, rapidity of sprouting was much greater, while per cent of sprouting was essentially the same in both tests.

13. **Onion,** *Giant Yellow Globe Rocca.*—Department of Agriculture.

No. 1, 50 seeds soaked in water 20 hours and sown ¼ inch deep in sand in 5-inch seed-pan, in incubator.

No. 2, same, in forcing-house.

SOWN MAR. 29.

SAMPLES.	DAILY SPROUTINGS. APRIL.									Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	3	4	5	6	7	8	9	10	11				
No. 1, Incubator,	**9**	**8**	6	3	2	1	2	1	1	33	**66**	74°	72°, 75°
No. 2, Forcing-house,		**3**	14	8	6	2	1	1	2	37	**74**	76°	118°, 53°

Epitome.—Under constant temperature, sprouting was more rapid, but the total per cent. was slightly less.

14. **Onion,** *Giant Yellow Globe Rocca.*—Department of Agriculture.

No. 1, 50 seeds soaked 30 hours in water and sown ¼ inch deep in sand, in 5-inch seed-pan, in incubator.

No. 2, same, in forcing-house.

SOWN MAR 29.

SAMPLES.	DAILY SPROUTINGS. APRIL.							Total.	Per cent.	Average temperature during test.	Extremes of temperature
	4	5	6	7	8	9	11				
No. 1, Incubator,	**11**	**14**	5	4	3		2	39	**78**	74°	72°, 75°
No. 2, Forcing-house,	**7**	**18**	11	6		1	1	44	**88**	76°	118°, 53°

Epitome.—Under constant temperature, sprouting was a trifle more rapid, although, at the end of the second day, the same number of seeds had sprouted in each test. The per cent. of sprouting was greater under varying temperatures.

15. **Onion,** *Giant Yellow Globe Rocca.*—Department of Agriculture.

50 seeds of each number sown ¼ inch deep in sand, in 5-inch seed-pans.
No. 1, placed in incubator.
No, 2, in forcing-house.
No. 3, in cellar.

SOWN APR. 23

SAMPLES.	DAILY SPROUTINGS.										Total.	Per Cent.	Average temperature during test.	Extremes of temperature.
	APR.			MAY.										
	28	29	30	1	2	3	10	11	12	13				
No. 1, Incubator,	**6**	**23**	15	2	1						47	**94**	74°	72°, 95°
No. 2, Forcing-house,	**7**	**25**	5	2	2	1					42	**84**	72°	90°, 60°
No. 3, Cellar,							**25**	11	1	3	40	**80**	†53°	*83°, 43°

* The door was open and the sun shone in in the afternoon.

† Average for the first thirteen days, 49°. There was no sign of germination in the cellar until circumstances demanded the admission of air and sunlight for the good of other things in the cellar.

Epitome.—There were no important differences in rapidity of sprouting between the sample under constant temperature and that under high variable temperatures, but the seeds in the cellar, in which the mean temperature was 19° and 21° lower than in the other cases, were about twelve days behind. Percentages of sprouting decreased with the decrease of the mean temperature, though not proportionately.

CONCLUSIONS From the Foregoing Tests, upon the Influences of Constant and Variable Temperatures upon the Sprouting of Seeds.

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1. Different results are obtained from the same sample of seeds under different variations of temperature, of which the daily mean is essentially the same.

2. Sprouting takes place more quickly under essentially constant temperature of about 74° than under a temperature ordinarily variable, which gives about the same mean.

3. Rapidity of sprouting is particularly marked in beans and peas.

4. As the mean temperature becomes lower, rapidity of sprouting becomes slower.

5. Greater rapidity of sprouting does not appear to be correlated with greater per cent. of total sprouting.

6. Constant temperature, of the degree here mentioned, does not appear to give greater percentages of sprouting ; at least, the variation in this respect between the constant and variable temperatures is no greater than that which is usually obtained from tests conducted under identical conditions. In the seven tests with beans, however, there is an average gain of 5 per cent. in favor of those under constant temperature.

II. INFLUENCES OF DIFFERENT QUANTITIES OF WATER UPON SPROUTING.

Mr. W. W. Tracy, of Detroit, well known as an expert in the handling and testing of seeds, once said to me that he rarely obtained the same results from different tests of the same sample, if made in houses under the care of different men. He attributed this variation mostly to the various amounts of water habitually used by the different men. Acting upon this suggestion, a number of very careful tests have been made in weighing the amounts of water used. The results have been the most marked of any which have ever come under my notice in the testing of seeds.

The tests were all made side by side in a forcing-house, unless otherwise recorded, in earthen pans. The soil, with one exception, was a good quality of light potting earth, containing a good admixture of field sand. Although the pans were very shallow, extra drainage was given by the use of broken pots. The samples which received the most water were rarely wet enough to drip ; in fact, they had no more water than is given in many houses. The pans sparingly watered were drier than they would be kept in most houses. The 8-inch round lily-pans are 4½ in. deep. The 10-inch seed-pans are 2½ in. deep, and the 12-inch pans 3 in. deep.

16. Tomato, *Green Gage.*—Thorburn.

100 seeds in 8-inch round lily pans, sown ¾ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 7, 6 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.						SPROUTINGS.						
	MAY.					Total.	MAY.					Total.	Per cent.
	7th 6 P. M.	8th 5 P. M.	9th 5 P. M.	11th 6 P. M.	14th 6 P. M.		13th	14th	15th	16th	17th		
No. 1, Profusely watered,	16	9	7	6	6	44 oz		**13**	2	13	19	47	**47**
No. 2, Sparingly watered,	7		3	3	6	19 oz	**12**	**18**	8	21	5	64	**64**

Epitome.—Sprouting was much more rapid in the seeds which were sparingly watered, and the total per cent. of sprouting was 17 per cent. greater in the same test.

Two other pans were prepared in the same manner but were subjected to a lower temperature for two consecutive nights to imitate the conditions of testing in an ordinary kitchen. The results are recorded in the next table.

17. Tomato, *Green Gage.*—Thorburn. (Compare with No. 16.)

100 seeds in 8-inch round lily-pans, sown ¾ inch deep, and placed in a cellar, with a temperature at 45°, for the first two nights after sowing. The pans were at other times set in the forcing-house alongside those of No. 16.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 7, 6 P. M.

SAMPLES.	AMOUNTS OF WATER IN OUNCES.						SPROUTINGS.					
	MAY.					To-tal.	MAY				Total.	Per Cent.
	7th 6 P. M.	8th 5 P. M.	9th 5 P. M.	11th 6 P. M.	14th 6 P. M.		14th	15th	16th	17th		
No. 1, Profusely watered,	16	9	7	6	6	44 oz	**2**	**11**	20	14	47	**47**
No. 2, Sparingly watered,	7	3	3	6		19 oz	**12**	**56**	6		74	**74**

Epitome.—Sprouting was very much quicker in the sample which was sparingly watered, and the per cent. of sprouting was 27 per cent. greater. The low temperature of the cellar delayed sprouting about twenty-four hours, or essentially the length of time the seeds remained in the cellar.

18. Cucumber, *Nichol's Medium Green.*—Department of Agriculture.

50 seeds in 8-inch round lily pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 8, 6 P. M.

SAMPLES.	AMOUNTS OF WATER IN OUNCES.					SPROUTINGS.					
	MAY.					MAY.					
	8th 6 P. M.	9th 5 P. M.	11th 6 P. M.	14th 6 P. M.	Total.	13th	14th	15th	16th	Total	Per Cent.
No. 1, Profusely watered,	16	7	6	10	39 oz	**2**	26	5	5	38	**76**
No. 2, Sparingly watered,	7	3	3	5	18 oz	**28**	4	1		33	**66**

Epitome.—Sprouting was very much more rapid in the sample which was sparingly watered, although the total amount of sprouting was 10 per cent. less. The lower percentage appeared to be due to the fact that near the close of the test the pan became too dry.

Two similar pans were prepared and set in a cellar for two nights, after the manner of the preceding experiment. The results are as follows :

19. Cucumber, *Nichol's Medium Green.*—Department of Agriculture. (Compare with No. 18.)

50 seeds in 8-inch round lily-pans, sown ½ inch deep, and placed in a cellar, with a temperature of 45°, for the two nights following sowing. At other times the pans were placed in the forcing-house with those of No. 18.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 8, 6 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.						SPROUTINGS.				
	MAY.						MAY.				
	8th 6 P. M.	9th 5 P. M.	10th 5 P. M.	11th 6 P. M.	14th 6 P. M.	Total.	14th	15th	16th	Total.	Per cent.
No. 1, Profusely watered,	16	7		6	10	39 oz	**18**	7	11	36	**72**
No. 2, Sparingly watered,	7	3	3	3	5	21 oz	**30**	5	1	36	**72**

Epitome.—Sprouting was more rapid in the drier pan, while per cent. of sprouting was the same in each. The low temperature of the cellar delayed sprouting about twenty-four hours, or essentially the length of time the seeds were left in the cellar.

20. Lettuce, *Boston Market.*—Department of Agriculture.

100 seeds in 12-inch seed-pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered, SOWN MAY 7, 5 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.							SPROUTINGS.						
	MAY.						Total.	MAY.					Total.	Per Cent.
	7th 5 P. M.	8th 5 P. M.	9th 5 P. M.	10th 5 P. M.	11th 6 P. M.	14th 6 P. M.		11th	13th	14th	15th	16th		
No. 1, Profusely watered,	27	10	20		6	6	69 oz.	**29**	**10**	5	1	2	47	**47**
No. 2, Sparingly watered,	8	5	7	5	3	6	34 oz.	**34**	**17**	5	8	13	77	**77**

Epitome.—Sprouting was considerably more rapid in the drier pan, while total sprouting was 30 per cent. greater.

21. Carrot, *Vermont Butter.*—Hoskins. (Fig. 3.)

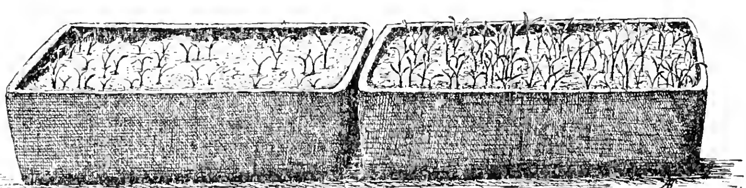
100 carpels, in 10 inch seed-pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered. SOWN MAY 4, 6 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.											
	MAY.											To-tal.
	4th 6 p. m.	6th 10 a. m.	6th 2 p. m.	6th 6 p. m.	7th noon	7th 5 p. m.	8th 5 p. m.	9th 5 p. m.	10th 5 p. m.	11th 6 p. m.	14th 6 p. m.	
No. 1, Profusely watered,	16	9		4	9		10	7			6	61 oz
No. 2, Sparingly watered,	4		2		3	2	5	5	3	3	4	31 oz

SAMPLES.	SPROUTINGS.							Total.	Per Cent.
	MAY.								
	10	11	13	14	15	16	17		
No. 1, Profusely watered,		**1**	**3**	8		14	9	35	**35**
No. 2, Sparingly watered,	**17**	**38**	**19**	7	1			82	**82**

Epitome.—Sprouting was remarkably more rapid in the drier pan, and the per cent. of sprouting was also very much greater, amounting to 47 per cent.

Figure 3, from a photograph, represents this test at its conclusion.



Wet Pan. FIG. 3.—Table 21. *Dry Pan.*

22. Carrot, *Early Forcing*.—Thorburn.

100 carpels, in 8-inch round lily pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 6, 3 P. M.

SAMPLES.	Amounts of Water, in Ounces. May. 6th 3 p. m.	6th 6 p. m.	7th noon.	8th 5 p. m.	9th 5 p. m.	10th 5 p. m.	11th 6 p. m.	14th 6 p. m.	To-tal.	Sproutings. May. 13	14	15	16	17	18	Total.	Per Cent.
No. 1, Profusely watered,	16	4	9	9	7		6	3	54 oz.		**1**	**5**	9	6	11	32	**32**
No, 2, Sparingly watered,	4			3	3	3	3	3	19 oz.	**9**	**7**	**28**	24	4	2	74	**74**

Epitome.—Sprouting was remarkably more rapid in the drier pan, and the total sprouting at the end of the twelfth day was 42 per cent greater.

23. Celery, *White Plume*.—Cornish.

100 carpels, in 8-inch round lily-pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 6, 3 P. M.

SAMPLES.	Amounts of Water, in Ounces. May—June. 6th, 3 p. m.	6th, 6 p. m.	7th, 12 m.	8th, 5 p. m.	9th, 5 p. m.	10th, 5 p. m.	11th, 6 p. m.	14th, 6 p. m.	16th, 6 p. m.	17th, 6 p. m.	18th, 6 p. m.	22d, 6 p. m.	25th, 6 p. m.	28th, 6 p. m.	30th, 6.30 p. m.	2d, 6 p. m.	6th, 4 p. m.	10th, 6 p. m.	Total.
No. 1, Profusely watered,	16	4	9	9	7		6	3	3	7	7	3	4	4	4	4	6	4	100
No. 2, Sparingly watered,	4			3	3	3	3	3	3	4	4	3	4	4	4	4	6	4	59

SAMPLES.	Sproutings. May—June. 20	21	24	25	27	28	30	1	4	6	8	10	14	Total.	Per Ct.
No. 1, Profusely watered,	**1**				**2**			1	1	2	3	9	3	22	**22**
No. 2, Sparingly watered,	**4**	**1**	**2**	**2**	**3**	**12**	7	2	16	3	4	4		60	**60**

Epitome.—Sprouting was much more rapid and regular in the drier pan, and the per cent. of sprouting was nearly three times greater.

24. Turnip, *Early Six Weeks*.—Department of Agriculture.

100 seeds in 12-inch seed-pans, sown ½ inch deep in silver sand.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 7, 5 P. M

SAMPLES.	AMOUNTS OF WATER IN OUNCES.						SPROUTINGS.					
	MAY.						MAY.					
	7th 5 P.M.	8th 5 P.M.	9th 5 P. M.	11th 6 P. M.	14th 6 P. M.	Total.	10th.	11th.	13th.	14th.	15th.	Total.
No. 1, Profusely wat'red,	30	20	20	6	5	81 oz		**10**	11	2		23*
No. 2, Sparingly wat'red,	9	5	7	3	12	36 oz	**7**	**15**	8		2	32

*Both pans accidently became very dry on May 15, and the test was concluded.

Epitome.—There was a very great gain in rapidity of sprouting in the pan sparingly watered, and a corresponding gain in percentage, at the premature conclusion of the test.

25. Pepper, *Golden Dawn.*—Henderson.

100 seeds, in 8-inch round lily-pans, sown ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 6, 6 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.																	Total.
	MAY—JUNE.																	
	6th, 6 p. m.	7th, 12 m.	8th, 5 p. m.	9th, 5 p. m.	10th, 5 p. m.	11th, 6 p. m.	13th, 4 p. m.	14th, 6 p. m.	16th, 6 p. m.	18th, 6 p. m.	20th, 6 p. m.	25th, 6 p. m.	28th, 6 p. m.	30th, 6.30 p. m.	2nd, 6 p. m.	6th, 4 p. m.	10th, 6 p. m.	
No. 1, Profusely watered,	16	9	9	7		3	7	3	7	7	5	4	4	4	4	6	4	99 oz.
No. 1, Sparingly watered,	4		3	3	3	6	3	3	3	4	3	4	4	4	4	6	4	61 oz.

SAMPLES.	SPROUTINGS.											Total.	Per cent.
	MAY—JUNE.												
	18	20	21	22	23	25	27	28	1	6	10		
No. 1, Profusely watered,		**3**	10	4	6	6	5	7	10	1	1	53	**53**
No. 2, Sparingly watered,	**28**	**23**	4	1	1	1	1		2			61	**61**

Epitome.—Sprouting was most remarkably more rapid in the drier pan, although the total sprouting was only 8 per cent. greater.

26. Lima Bean, *Large White.*—Dreer.

30 large white beans, in 10-inch seed-pans, sown 1 inch deep.
No. 1, profusely watered.

No. 2, sparingly watered.

SOWN MAY 4, 6 P. M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES												SPROUTINGS.										
	MAY.												MAY—JUNE.										
	4th, 6 p. m.	6th, 10 a. m.	6th, 2 p. m.	6th, 6 p. m.	7th, noon	8th, 5 p. m.	9th, 5 p. m.	11th, 6 p. m.	14th, 6 p. m.	21st, 6 p. m.	23rd, 7 p. m.	Total.	16	18	20	21	1	4	5	9	13	Total.	Per Cent.
No. 1, Profusely watered	16	9		4	9	10	7		4	7	6	72 oz.		**3**	1							4	**13**⅓
No. 2, Spari'gly watered	4		2		3	5	5	3	5	7	4	38 oz.	**3**	1	1	1	2	4	2	1	1	16	**53**⅓

Epitome.—There was a gain in rapidity of sprouting in the drier pan, and 40 per cent. gain in per cent. of sprouting. The seeds appear to have been poor from the first.

Beans of which the epidermis was slightly broken were taken from the same package, and tested in the same manner with the following results :

27. **Lima Bean,** *Large White.*—Dreer. (Compare with No. 26.) Fig. 4.

28 beans, of which the epidermis had been slightly broken in threshing or cleaning, in 10-inch seed-pans, sown one inch deep.

No. 1, profusely watered.

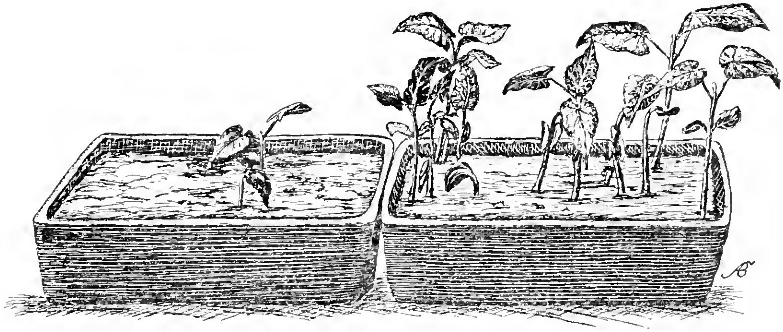
No. 2, sparingly watered.

SOWN MAY 4 6 P.M.

SAMPLES.	AMOUNTS OF WATER, IN OUNCES.												SPROUTINGS.							
	MAY.												MAY.							
	4th, 6 p. m.	6th, 10 a. m.	6th, 2 p. m.	6th, 6 p. m.	7th, noon.	7th, 5 p. m.	8th, 5 p. m.	9th, 5 p. m.	10th, 5 p. m.	11th, 6 p. m.	14th, 6 p. m.	To-tal.	11	13	15	16	20	22	To-tal.	Per cent.
No. 1, Profusely watered,	16	9		4	9		10	7			4	59 oz.	2						2	**7** 1-7
No. 2, Sparingly watered,	4		2		3	2	5	5	3	3	5	32 oz.		2	3	6	1	10	22	**78.5**

Epitome.—Per cent of sprouting was over 70 per cent. greater in the drier pan. This was due to the fact that more of the beans rotted in the wet pan. On May 22nd, twenty-six of the beans in the wet pan were rotten. Only six were rotten in the drier pan and ten were sprouting. It is known that seeds with a slight surface abrasion often germinate better than those which are uninjured ; but this test indicates that great care must be exercised to water such seeds sparingly, as they are more likely to rot.

Figure 4, from a photograph, represents this test on May 20th.



Wet Pan. Fig. 4.—Table 27. *Dry Pan.*

28. Cobœa scandens.—Vaughan.

50 seeds, in 10-inch seed-pans, planted on edge, the middle of the seed being ½ inch deep.

No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 4, NOON.

Samples.	Amounts of Water, in Ounces. May—June. 4th, noon.	6th, 10 a. m.	6th, 2 p. m.	7th, noon.	8th, 5 p. m.	9th, 5 p. m.	10th, 5 p. m.	11th, 6 p. m.	14th, 6 p. m.	17th, 6 p. m.	18th, 6 p. m.	20th, 6 p. m.	21st, 4 p. m.	23d, 7 p. m.	25th, 6 p. m.	28th, 6 p. m.	30th, 6 p. m.	2nd, 6 p. m.	6th, 5 p. m.	9th, 5 p. m.	Total.
No. 1, Profusely watered,	16	9		8	8	6	5	3	6		4	5	5	4	5	6	6	4	6	6	112 oz.
No. 2, Sparingly watered,	8		2	3	6	6	5	3	5	6	4		5	4	5	6	6				74 oz.

Samples.	Sproutings. May—June. 18	20	21	24	25	28	1	4	Total.	Per Cent.
No. 1, Profusely watered,	2	5	4					1	12	**24**
No. 2, Sparingly watered,		4	6	1	1	1	5		18	**36**

Epitome.—The differences in rapidity between these tests are not pronounced, although the per cent. is considerably higher in the drier pan. Owing to an accident, pan No. 2 became very wet June 1, and it was discarded. At this time thirty of the unsprouted seeds were rotten. This indicates that the common advice of catalogues to keep cobœa seeds nearly dry during sprouting is correct, as even in the drier pan over half the seeds rotted. The seeds were probably not good, else the totals of sprouting would have been greater.

29. Cobœa scandens.—Vaughan.

50 seeds, in 10-inch seed-pans, planted flatwise, ½ inch deep.
No. 1, profusely watered.
No. 2, sparingly watered.

SOWN MAY 4, NOON.

SAMPLES.	Amounts of Water, in Ounces. May—June.																				
	4th, noon.	6th, 10 a. m.	6th, 2 p. m.	7th, noon.	8th, 5 p. m.	9th, 5 p. m.	10th, 5 p. m.	11th, 6 p. m.	14th, 6 p. m.	17th, 6 p. m.	18th, 6 p. m.	20th, 6 p. m.	21st, 4 p. m.	23rd, 7 p. m.	25th, 6 p. m.	28th, 6 p. m.	30th, 6 p. m.	2nd, 6 p. m.	6th, 5 p. m.	9th, 5 p. m.	Total.
No. 1, Profusely watered,	16	9		8	8	6	5	3	6		4	5	5	4	5	6	6	4	6	6	112 oz
No. 2, Sparingly watered,	8		2	3	6	6	5	3	5	6	4		5	4	5	6	6	4	6	6	90 oz

SAMPLES.	Sproutings. May—June.											
	16	17	18	20	21	23	24	25	27	28	1	Total.	Per Cent.
No. 1, Profusely watered.	1	1	2		1					1	1	7	**14**
No. 2, Sparingly watered,				1	8	1	3	2	1			16	**32**

Epitome.—Here, as in the preceding test, rapidity of sprouting is not markedly different in the two cases, but the total is twice larger in the drier pan.

CONCLUSIONS Drawn from the Tests with Different Quantities of Water.

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1. The quantity of water applied to seeds under test may make a remarkable difference in the results.

2. Sprouting is decidedly more rapid in tests which receive less than the usual amounts of water given in green-houses. This is markedly the case in all the tests, with the exception of three indifferent and comparatively unimportant instances, (Nos. 27, 28 and 29).

3. Per cent of sprouting is much greater, as a rule, in the drier tests.

4. The addition of water above the amount to keep the earth simply moist, is injurious.

5. The wide differenees between the results of the wet and moist tests, are not necessarily due to the rotting of the seeds in the wet tests. This is shown in the tests with cucumber seeds, (Nos. 18 and 19), in which the drier tests gave similar or even smaller totals than the wet tests.

III. INFLUENCES OF THE SOAKING OF SEEDS BEFORE SOWING.

It is a common practice in both field operations and seed-testing to soak seeds in water before sowing. The following tests indicate very clearly the leading results of this custom. In this connection it is interesting to study results with the Geneva seed-tester, which tests seeds by soaking them. A number of tests were made with the Geneva tester in comparison with sowing in potting soil in forcing house. The results, which are too extended to be detailed here, indicate that higher sprouting tests are given by the Geneva tester than by planting under known conditions. Ten tests in each case with Marblehead Mammoth Cabbage seeds gave an average germination of 88 per cent. in the tester, against 77.6 per cent. in the soil. The earliness at which the sprouting is visible in the tester, renders testing expeditious. But it must be remembered that full germination cannot often be secured in the apparatus. (Cf. § IX.)

30. Carrot, *Early Forcing*.—Thorburn.

100 carpels in 10-inch seed-pans, sown ½ inch deep in sand.
No. 1, dry.
No. 2, soaked in water 10 hours before sowing.
No. 3, soaked in water 36 hours before sowing.

SOWN MAY 18.

SAMPLES.	SPROUTINGS. MAY—JUNE.										Total.	Per Cent.
	25	26	27	28	29	30	31	1	2	3		
No. 1, Dry,	**1**	**5**	17	35	8	1	2			1	70	**70**
No. 2, 10 hours,	**5**	**12**	14	32	11	1	1	1	1		78	**78**
No. 3, 36 hours,		**12**	16	31	3	2	3	2	1		70	**70**

Epitome.—Sprouting was most rapid in the seeds which had been soaked 10 hours, and slowest in those which had not been soaked. The total percentages were essentially the same, although the seeds soaked 10 hours gave the best results by 8 per cent.

31. Carrot, *Vermont Butter*.—Hoskins.

100 carpels in 10-inch seed-pans, ½ inch deep in sand.

No. 1, dry.

No. 2, soaked 24 hours.

No. 3, soaked 36 hours.

SOWN MAY 21.

SAMPLES.	SPROUTINGS.								
	MAY.			JUNE.				Total.	Per Cent.
	29	30	31	1	2	3	4		
No. 1, Dry,		15	35	11	4			65	**65**
No. 2, 24 hours,		3	54	14	6	3		80	**80**
No. 3, 36 hours,	1	23	36	8	5		1	74	**74**

Epitome.—Sprouting was most rapid in the sample soaked 36 hours, although at the end of the third day there was little difference in the results, those soaked 36 hours showing 60 per cent. of sprouting, those soaked 24 hours showing 57 per cent., and the dry sample 50 per cent. Total sprouting was greatest in the 24-hour sample, although but 6 per cent. higher than in the 36-hour sample. The dry sample showed a considerable lower figure.

32. Tomato, *Green Gage*.—Thorburn.

100 seeds in 10-inch seed-pans, ½ inch deep in sand.

No. 1, dry.

No. 2, soaked 8 hours.

No. 3, soaked 46 hours.

SOWN MAY 18.

SAMPLES.	SPROUTINGS.													Total.	Per Cent.
	MAY—JUNE.														
	25	26	27	28*	29	30	31	1	2	3	4	5	6		
No. 1, Dry,				**21**	19	10	12	6	3	1				72	**72**
No. 2, 8 hours,	**2**		**4**	**30**	8	12	5	4	3		1			69	**69**
No. 3, 46 hours,	**1**	**8**	**21**	**22**	7	1	8	1	1	1		1	1	73	**73**

Epitome.—Sprouting was most rapid in the 46-hour sample, and slowest in the dry sample. Totals of sprouting were not essentially different.

33. Tomato, *Belle*.—Cornish.

100 seeds in 12-inch seed-pans, ½ inch deep in sand.

No. 1, dry.

No. 2, soaked 24 hours.

* The sudden increase in sprouting on the 28th, in this and the next test, was due to the turning on of steam, necessitated by the unprecedented cold weather. Fire had been out for some days.

SOWN MAY 2.

SAMPLES.	SPROUTINGS.				Total.	Per cent.
	MAY.					
	7	8	9	10		
No. 1, Dry,		18	21	4	43	**43**
No. 2. 24 hours,	15	73	4	1	93	**93**

Epitome.—Sprouting was decidedly more rapid in the soaked seeds, and the totals were 50 per cent. more in the same instance. This test is unlike all others made in this series in its total results, and is evidently abnormal. The test was twice repeated, with the following results :

34. Tomato, *Belle.*—Cornish.

100 seeds, sown in 12-inch seed-pans, ½ inch deep in sand.
No. 1, dry.
No. 2, soaked 24 hours.

SOWN MAY 15.

SAMPLES.	SPROUTINGS.												
	MAY.											Total.	Per Cent.
	20	21	22	23	24	25	26	27	28	29	31		
No. 1, Dry,	**1**	**11**	38	17	7	3	3		5	1		86	**86**
No. 2, 24 hours,	**4**	**26**	32	5	3	5	1	1	5		1	83	**83**

Epitome.—Sprouting was more rapid in the soaked seeds, but the totals were essentially the same in the two cases.

35. Tomato, *Belle.*—Cornish.

100 seeds in 12-inch seed-pans, ½ inch deep in sand.
No. 1, dry.
No. 2, soaked 24 hours.

SOWN JUNE 7.

SAMPLES.	SPROUTINGS.							Total.	Per Cent.
	JUNE.								
	12	13	14	15	16	17	18		
No. 1, Dry,		**3**	50	27	11	5		96	**96**
No. 2, 24 hours,	**6**	**66**	11	3	2		1	89	**89**

Epitome.—Sprouting was very decidedly more rapid in the soaked seeds, but the total was 7 per cent. less than in the dry sample.

36. **Turnip,** *Early Six Weeks.*—Department of Agriculture.

100 seeds in 8-inch lily-pans, ¼ inch deep in sand.
No. 1, dry.
No. 2, soaked 15 hours.

SOWN MAY 21.

SAMPLES.	SPROUTINGS.									
	MAY—JUNE.								Total.	Per Cent.
	26	27	28	29	30	31	1	2		
No. 1, Dry,	**7**	62	9	8	4	1	1	3	95	**95**
No. 2, 15 hours,	**36**	33	16	3	2	4			94	**94**

Epitome.—Sprouting was more rapid in the soaked sample. Totals were essentially the same.

37. **Radish,** *Early Scarlet Globe.*—Henderson.

100 seeds in 20-inch seed-flats, ½ inch deep in potting earth.
No. 1, soaked 12 hours.
No. 2, soaked 24 hours.

SOWN APR. 27.

SAMPLES.	SPROUTINGS.										Total.	Per cent.
	APRIL—MAY.											
	29	30	1	2	3	4	5	6	9	11		
No. 1, 12 hours,	**9**	**40**	22	5	1	1	1	1			80	**80**
No. 2, 24 hours,		**13**	44	11	4	5	2	1	1	1	82	**82**

Epitome.—Sprouting was decidedly more rapid in the 12-hour sample, while the totals were essentially the same.

38. **Radish,** *Early Scarlet Globe.*—Henderson. (Compare with No. 37.)

100 seeds in 20-inch seed-flats, ½ inch deep in potting earth.
No. 1, dry.
No. 2, soaked 6 hours.

SOWN MAY 3.

SAMPLES.	SPROUTINGS.							
	MAY.						Total.	Per Cent.
	6	7	8	9	11	12		
No. 1, Dry,	**5**	**56**	3	5	1	1	71	**71**
No. 2, 6 hours,	**2**	**58**	4	7		1	72	**72**

Epitome.—There were no marked differences in results between these tests, owing, no doubt, to the fact that the soaking of the second sample, was not long enough continued. In comparison with No. 37, it is found that quickest returns were obtained from the sample soaked 12 hours.

39. Onion, *Giant Yellow Globe Rocca.*—Department of Agriculture.

50 seeds in 5-inch seed-pans, ¼ inch deep in sand. Nos. 1–3, in forcing-house; Nos. 4–6, in incubator.

No. 1, soaked 10 hours.
No. 2, soaked 20 hours.
No. 3, soaked 30 hours.
No. 4, soaked 10 hours.
No. 5, soaked 20 hours,
No. 6, soaked 30 hours.

SOWN MARCH 29.

SAMPLES.	SPROUTINGS.										
	APRIL.									Total.	Per Cent.
	3	4	5	6	7	8	9	10	11		
FORCING-HOUSE:											
No. 1, 10 hours,		6	13	15	9		2			45	**90**
No. 2, 20 hours,		3	14	8	6	2	1	1	2	37	**74**
No. 3, 30 hours,		7	18	11	6		1		1	44	**88**
INCUBATOR:											
No. 4, 10 hours,	7	17	11	3	2		3	1		44	**88**
No. 5, 20 hours,	9	8	6	3	2	1	2	1	1	33	**66**
No. 6, 30 hours,		11	14	5	4	3			2	39	**78**

Epitome.—The results are conflicting, and indicate that marked differences from different periods of soaking are less likely to occur in onions than in some other seeds.

CONCLUSIONS Drawn from the Foregoing Tests upon the Influences of Soaking upon the Sprouting of Seeds.

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1. Great gain in rapidity of sprouting, counting from the time of planting, may be expected as a rule, if seeds are previously soaked in water; and the longer the seeds are soaked, within reasonable limits, the greater is usually the gain in rapidity of sprouting. This fact is interesting, in face of the experience that very profuse watering after sowing gives an opposite result. (Cf. § II.)

2. This gain in rapidity of sprouting in soaked samples is really fictitious, however, inasmuch as germination actually begins in the soaked seeds before the dry samples are sown. In truth, the soaked seeds are sown earlier than the dry ones. If this advance in period of sowing is added to the date of sowing of the dry seeds, it will be found that dry seeds as a rule sprout fully as early as soaked seeds, and many times much earlier.

3. Total amount of sprouting does not appear to be influenced by soaking.

4. Similar results are not to be expected from all species of plants.

IV. INFLUENCES OF CHARACTER OF SOIL UPON SPROUTING.

It is well known that texture of soil often has much to do with the germination of seeds in the field. Soils which bake, which become very dry, or which hold too much moisture, always tend to give a poor "stand" of crop. But the soils used in houses are such as to occasion no thought of their influence upon germination ; yet there are cases in which such soils cause variation in seed tests. This was particularly marked in a lot of beans which we tested this spring. Samples happened to be sown at the same time in potting soil on a bench, and under a cloth on the surface sand. Those in soil gave much poorer germinations than the others. Other sowings were therefore made from the same lot at given depths in sand for purposes of comparison. The figures cannot be presented in the limited space of this article, but it was found that sproutings were in some cases nearly twice as many in sand as in potting soil. More beans rotted in the soil than in the sand. The soil had not been sifted, and it contained some manure, yet it was only four inches deep on the bench and it would seem that the drainage was good. Our tests in this direction warrant the following

CONCLUSIONS.

1. Variations in results of testing may sometimes be expected in consequence of character of soil in which the tests are made.

2. In the present instance, low results in potting soil as compared with tests in sand, appear to be due to the greater amount of water held in the earth, causing the seeds to rot. The results may, therefore, be studied in connection with those upon the influence of varying amounts of watering. (Cf. § II.)

V. INFLUENCES OF LIGHT UPON THE SPROUTING OF SEEDS.

"On other occasions, from the want of time, the seeds, instead of being allowed to germinate on damp sand, were sown on the opposite sides of pots, and the fully grown plants measured. But this plan is less accurate, as the seeds sometimes germinate more quickly on one side than on the other. It was, however, necessary to act in this manner with some few species, as certain kinds of seeds will not germinate well when exposed to the light. . . . . This occurred in the plainest manner with the seeds of *Papaver vagum* and *Delphinium Consolida*, and less plainly with those of *Adonis æstivalis* and *Ononis minutissima.* Rarely more than one or two of the seeds of these four species germinated on the bare sand, though left there for some weeks; but when these same seeds were placed on earth in pots, and covered with a thin layer of sand, they germinated immediately in large numbers."—*Darwin, Cross and Self Fertilization, Amer. ed. 13.*

Of late years there has been more or less said concerning the sowing of seeds for test upon the surface of soil and covering with glass, in order that every seed may be watched, and certain seed testing apparatuses have been devised upon this principle. It appears from Darwin's experience that with some seeds grave errors may occur from this practice, and further evidence of the same nature is furnished from the tests here recorded. The seeds, in the following trials, were sown upon the surface of soil in pots or pans, the pots, unless otherwise mentioned, being plunged in sphagnum moss, to keep the soil moist. Over the top of the pot or pan was placed a pane of glass, or a close fitting iron saucer or a board.

40. Papaver Rhœas, *English Poppy.*—Henderson.

50 seeds on sand, in 4-inch pots plunged in sphagnum.
No. 1, covered with glass.
No. 2, covered with a plate. SOWN MAY 27.

SAMPLES.	SPROUTINGS.												Total.	Per Cent.
	JUNE.													
	1	2	3	4	5	6	7	8	9	10				
No. 1, In light,			**3**	9	3	2	1	7	3				28	**56**
No. 2, In darkness,	**14**	**10**	**6**	3	1					3			37	**74**

Epitome.—Sprouting was very much slower in the seeds exposed to light, and total sprouting was 18 per cent. less in the same case.

41. Larkspur, *Dwarf Rocket.*—Vaughan.

100 seeds on sand, in 4-inch pots plunged in sphagnum.
No. 1, light-colored seeds covered with glass.
No. 2, light-colored seeds covered with a plate.
No 3, dark-colored seeds covered with glass.
No. 4. dark-colored seeds covered with a plate. SOWN MAY 10.

SAMPLES.	SPROUTINGS. MAY—JUNE.							Total.	Per Cent.
	26	28	2	8	12	22			
Light Colored Seeds.									
No. 1, In light,								0	**0**
No 2, In darkness,	1	1	11		3	4		20	**20**
Dark-Colored Seeds.									
No. 3, In light,								0	**0**
No. 4, In darkness,	4	6	10	5	2	3		30	**30**

Epitome.—There were no sproutings in the seeds exposed to light. The low totals in the seeds which sprouted indicate that this method of sowing is not advisable, for other samples of these seeds germinated well when sown in the ordinary manner.

42. Adonis æstivalis.—Henderson.

25 seeds on sand, in 4-inch pots plunged in sphagnum.
No. 1, covered with glass.
No. 2, covered with a plate. SOWN MAY 27.

SAMPLES.	SPROUTINGS. JUNE.						Total.	Per Cent.
	8	9	11	13	15	21		
No. 1, In light,			1				1	**4**
No. 2, In darkness,	3	3	4	1	3	3	17	**68**

Epitome.—But one seed sprouted in the samples exposed to light, and even this seed had become embedded in the sand so as to be but partially exposed.

43. Radish, *Early Scarlet Globe.*—Henderson.

100 seeds on sand, in 5-inch seed-pans
No. 1, covered with glass.
No. 2, covered with a board. SOWN MAY 27.

SAMPLES.	SPROUTINGS. MAY—JUNE.								Total.	Per Cent.
	29	30	31	1	2	3		5*		
No. 1, In light,	**15**	**54**	2	16		4			91	**91**
No. 2, In darkness,	**2**	**30**	18	16	1	1		3	71	**71**

* All that remained of No. 1, were decayed at this date ; 12 of No. 2 were still sound, but though left two or three days showed no signs of germinating.

The test was repeated with the following result :

SOWN JUNE 11.

SAMPLES.	SPROUTINGS. JUNE.						Total.	Per Cent.
	16	17	18	19	21			
No. 1, In light,	**62**	13	2	4	1		82	**82**
No. 2, In darkness,	**84**	4	3	1			92	**92**

Epitome.—The two tests with radish seeds show marked differences, yet the totals of sprouting are not very widely dissimilar. The results indicate that light has less influence upon radish seeds than upon seeds of some other plants.

Similar indifferent results were obtained with onion seeds.

CONCLUSIONS from the Test of the Influence of Light upon Sprouting.

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1. Very great differences in results may sometimes be expected between samples exposed to light during the process of sprouting, and those kept in darkness.

2. When such differences occur, they indicate that light retards or even wholly prevents germination.

3. In some species this influence of light is greatly marked, while in others it is not apparent.

4. It is apparent that those apparatuses which test seeds by holding them on a porous plate above water, are to be looked upon with distrust, unless provided with an opaque covering ; and even then they may prove unsatisfactory, as the experience with the larkspur seeds indicates that best sproutings follow planting in the soil.

VI. WEIGHT OF SEED IN RELATION TO SPROUTING.*

Many experiments have been conducted here this year upon the relation of weight of seed to germination, but the figures are too numerous to be recorded here. The general results of the tests may be indicated, however.

*Most of the work recorded in Sections VI and VII was performed, under the direction of the writer, by Mr. B. R. Wakeman, of the class of 1889, in preparation of a thesis for graduation.

Of itself, *per se*, weight appears to exercise no influence upon germination, but it is often a tolerably accurate measure of viability as determined by various causes. Broadly stated, it may be said that comparative lightness in a seed indicates arrested growth, and consequent lowness of germinative vitality. A few instances may be given :

44. Cabbage, *Flat Dutch.*—Thorburn.

100 seeds in seed-pans, sown ½ inch deep in sand. A parcel of seeds were thrown in a pan of water, and allowed to remain one minute, when 100 of those which sank and 100 of those which floated were chosen for test.

No. 1, heavy seeds (average weight .065 grains).

No. 2, light seeds (average weight .052 grains).

SOWN APRIL 25.

SAMPLES.	SPROUTINGS.									Total.	Per cent.
	4th Day.	5th Day.	6th Day.	7th Day.	8th Day.	9th Day.	10th Day.	11th Day.	12th Day.		
No. 1, Heavy,	**16**	31	18	3	3	3	2		1	77	**77**
No. 2, Light,	**4**	9	7	2	3	2	2	2	1	32	**32**

Epitome.—Total of sprouting was over twice greater in the heavy samples, and rapidity of sprouting was proportionately greater.

45. Cabbage, *Red Dutch.*—Thorburn.

100 seeds in seed-pans, ½ inch deep in sand.

The samples were separated in the same manner as in the preceding test.

No. 1, heavy seeds (average weight .075 grains).

No. 2, light seeds (average weight .07 grains).

SOWN APRIL 18.

SAMPLES.	SPROUTINGS.						Total.	Per Cent.
	4th Day	5th Day	6th Day	7th Day	8th Day	9th Day		
No. 1, Heavy,	**45**	23	7	1	3		79	**79**
No. 2, Light,	**22**	32	8		4	1	67	**67**

Epitome.—Sprouting was both more rapid and greater in amount in the heavy sample. The difference in total sprouting was less in this test than in No. 44, owing to the much smaller difference in weight between the heavy and light samples.

46. Radish, *Early Scarlet Globe.*—Henderson.

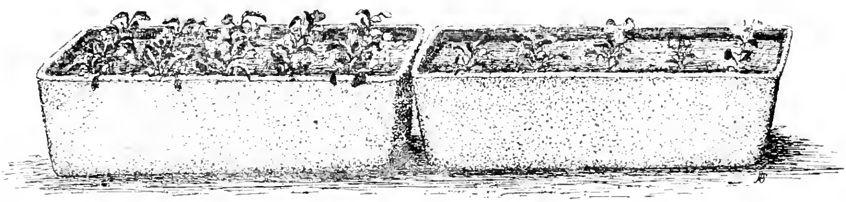
100 seeds in seed-pans, ½ inch deep in sand, selected by hand.*
No. 1, heavy seeds, (average weight 2.53 grains).
No. 2, light seeds, (average weight .13 grains).

SOWN APR 26.

Samples.	Sproutings.					Total.	Per Cent.
	3rd Day.	4th Day.	5th Day.	6th Day.	7th Day.		
No. 1, Heavy,	**13**	48	5	8	4	78	**78**
No. 2. Light,	**6**	30	8	3	3	50	**50**

Epitome.—Sprouting was higher and quicker in the heavy seeds.

Figure 5, from a photograph, illustrates another test with radish seeds, in which the differences were more marked than in the above instance.



Heavy Seeds. Fig. 5—Radish. *Light Seeds.*

It is often true that over-ripe seeds germinate more slowly, and give lower total results than others, and this over-ripeness is sometimes indicated by additional weight. It is to be expected, therefore, that in some instances best results in germination come from the seeds of lighter weight. Possibly the two following tests are instances in point ;

47. Bean, *Improved Green Flageolet.*—Department of Agriculture.

25 selected white beans in seed-pans, ¾ inch deep in sand.
No. 1, heavy seeds, (6.25 grains).
No. 2, light seeds, (2 grains).

---

* In selecting the samples, it is advisable to choose only such seeds as represent nearly the extremes of weight. By thus discarding the intermediate weights, the results become more marked, and give more accurate measures of the relative values of heavy and light seeds.

SOWN APR. 11.

SAMPLES.	Sproutings.			Total.	Per Cent.
	4th Day.	5th Day.	6th Day.		
No. 1, Heavy,	**6**	10	4	20	**80**
No. 2, Light,	**23**	1		24	**96**

48. **Lathyrus sativus** (*Gesse*).—Michigan Experiment Station.

100 seeds in seed-pans, ½ inch deep in sand.
No. 1, heavy seeds, (7.1 grains).
No. 2, light seeds (3.27 grains).

SOWN APR. 8.

SAMPLES.	Sproutings.							Total.	Per Cent.
	2d Day	3d Day	4th Day	5th Day	6th Day	7th Day	8th Day		
No. 1, Heavy,	**1**	**3**	61	32	2			99	**99**
No. 2, Light,		**23**	67	5	1	1	1	98	**98**

Epitome.—Light seeds in each case sprouted more rapidly than heavy ones, while in the beans they gave 16 per cent. higher total sprouting.

CONCLUSIONS From Many Tests upon the Influences of Weight of Seed upon its Sprouting.

1. Variations in results of testing, both as regards rapidity of sprouting and the total amount, may be expected between seeds of different weights in the same sample.

2. This variation is much greater in some species than in others. In our tests, the variation was particularly marked in cabbage, radish, sweet pea, bean, gesse (*Lathyrus sativus*), burnet (*Poterium Sanguisorba*), martynia, orach.

3. As a rule, the heaviest seeds in any sample give earliest and highest results.

4. In some cases, the lightest seeds in the sample give earliest and highest results, apparently because the heaviest seeds, with which they are compared, are over-ripe ; or, in some instances, under-maturity may result in earlier germinations, and such seeds are sometimes light in weight.

VII. COLOR OF SEED IN RELATION TO SPROUTING.

Color may be assumed to indicate, in most cases, some vital character of the seed, as determined by various causes. In one species, or even in one individual sample, it may indicate a different character than the same color does in another species or sample. It may indicate degree of maturity, method of curing, age of seed, or other peculiarity. It is to be expected, therefore, that color may sometimes designate more or less accurately the germinative vitality of the seed. It follows, however, that no general law of relation of color to germination can be announced: every species, and sometimes every sample, must be investigated for the law which governs itself. Many tests in this direction have been made, but one example will show something of the extent of variation in seeds of different colors:

49. **Bean,** *Green Flageolet.*—Dreer.

50 beans in soil on a bench.
No. 1, white beans, ½ inch deep.
No. 2, green-colored beans, ½ inch deep.
No. 3, white beans, 1½ inch deep.
No. 4, green-colored beans, 1½ inch deep.

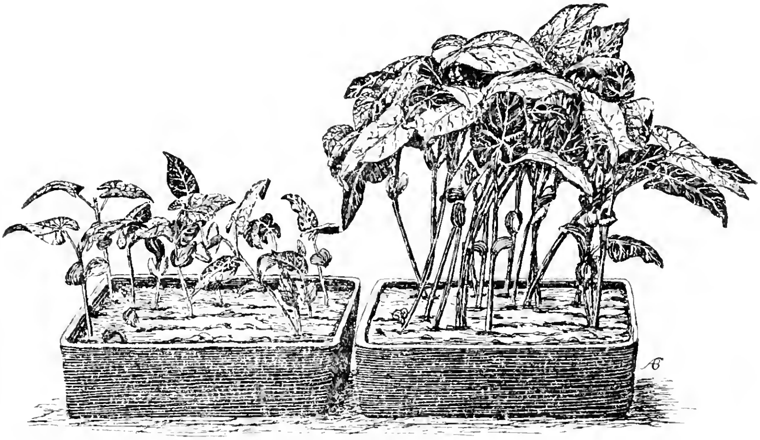
SOWN MAY 6.

SAMPLES.	SPROUTINGS. MAY.										Total.	Per Cent.
	10	11	12	13	14	15	16	17	18	19		
ONE-HALF INCH DEEP:												
No. 1, White.	9	4	2		2						17	**34**
No. 2, Green-colored,	24	9	7	1	1	1	1				44	**88**
ONE AND A HALF IN. DEEP:												
No. 3, White,			3	9		1	1	2		2	18	**36**
No. 4, Green-colored,		1	8	7	7	6	5	3	4		41	**82**

Epitome.—Sproutings were most rapid, and higher in total per cent. in the green-colored samples.

This test was twice repeated with similarly marked results. The same variety from the Department of Agriculture gave opposite results, however.

Fig. 6 shows tests of white and green-colored Lima beans, sown at the same time. The green-colored seeds are ahead. The white sample is the No. 2 of Table 26. The other had the common care of the forcing-house.



White Seeds. Fig. 6—Lima Bean. *Green-Colored Seeds.*

Four tests with Morning Glories (both *Convolvulus major* and *C. minor*) gave results uniformly in favor of white seeds as contrasted with black ones in the same sample.

From a considerable study of the importance of color in relation to germination, we have drawn the following

CONCLUSIONS.

1. Seeds which differ widely in color in any sample frequently give different results under test.

2. This variation in results may lie in greater rapidity of sprouting, or in higher total amounts, or in both.

3. The relative values of seeds of different colors vary with each species, or sometimes with each sample.

VIII. INFLUENCES OF LATITUDE UPON THE SPROUTING OF SEEDS.

Plants of high latitudes are more sensitive to heat and cold than those of the same species growing nearer the equator, *i. e.*, they start or vegetate relatively earlier in Spring. This subject has been investigated in several directions, but, so far as the writer is aware, it has not been pursued in this country in relation to germination of seeds. The following tests are incidental to this investigation, being a part of a general series of researches upon the influence of latitude upon plants, but they are suggestive in this connection.

A sample of white dent corn was secured from the Alabama Experiment Station, and samples of white and yellow dents were obtained from the South Carolina Station. The germination of these samples was compared with that of corn grown on the farm of this University.

50. **Corn,** from different latitudes, 50 kernels in each sample, sown one inch deep in 12-inch seed pans. (Fig. 7.)

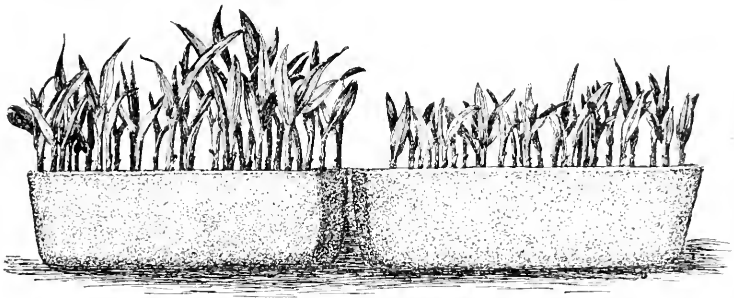
No. 1, yellow dent (*Pride of the North*), from Ithaca.
No. 2, yellow dent, from South Carolina.
No. 3, white dent, from South Carolina.
No. 4, white dent, from Alabama.

SOWN MARCH 19.

SAMPLES.	SPROUTINGS. MARCH.					Total.	Per Cent.
	23	24	25	26	27		
No. 1, Ithaca,	**14**	33	2			49	98
No. 2, South Carolina,		35	12	1		48	96
No. 3, South Carolina,		29	15	3	2	49	98
No. 4, Alabama,		34	5	1		40	80

Epitome.—Sprouting was much the most rapid in the New York corn, but differences in totals were evidently not due to influence of latitude. The difference in rapidity of germination was much more marked than would appear from the table. The plants from New York seed were by far the largest and most vigorous of any in the test during the month which they remained in the house. The Alabama seed gave the least vigorous plants, while the South

Carolina seeds gave intermediate results. Figure 7, from a photograph, illustrates the New York and Alabama samples, ten days after sowing.



Ithaca. Fig. 7—Table 50. *Alabama.*

Three other tests were made, with the same result. In one test the sample from New York was represented by seed taken from a crib of soft corn, yet this sample gave earliest results, though less marked than in the other instances.*

CONCLUSION.

Northern grown corn appears to germinate more quickly than southern grown corn.

IX. VARIATIONS IN DUPLICATE TESTS UNDER LIKE CONDITIONS.

It may be well to briefly call attention to the fact that scarcely any two tests made with seeds from the same sample, under conditions apparently identical, are exactly alike in results. It frequently happens that these results are so dissimilar as to give us no warrant for expressing an opinion of the value of a sample, from two or three tests. The variation in a certain tomato test recorded in this paper, (Cf. Nos. 33 and 34), may be taken as an illustration in point. The following table shows the variations between twenty tests :

*A similar lesson appears to be taught by the behavior of the seeds of species of Carex, which were planted this spring. Of some 80 pots of seeds, collected by the writer in Europe last year, 13 show germination at the present time, and of these, all the most forward, with two exceptions, are northern species, collected in Scotland.

51. **Cabbage**, *Marblehead Mammoth*.—Department of Agriculture.

50 seeds in each of ten tests in both the Geneva tester,* bearing folds of cotton flannel, and in potting soil in forcing-house.

Series I.—Tests in Geneva tester.

Series II.—Tests in earth.

SERIES I—GENEVA TESTER.				SERIES II—EARTH.			
Average per cent. of Sprouting	Actual per cents. of Sprouting	Per cent. of variation from the mean.	Average per cent. of variation.	Average per cent. of Sprouting	Actual per cents. of Sprouting	Per cent. of variation from the mean.	Average per cent. of variation.
	72	16			58	19.6	
	80	8			70	7.6	
	82	6			72	5.6	
	86	2			78	.6	
88	90	2	6.4	77.6	80	2.6	6.7
	92	4			80	2.6	
	94	6			82	4.6	
	94	6			82	4.6	
	94	6			84	6.6	
	96	8			90	12.6	

CONCLUSIONS.

1. One test cannot be accepted as a true measure of any sample of seeds.

2. Variation in duplicate tests is likely to be greater when seeds are planted in soil than when tested in some sprouting apparatus like the Geneva tester. (Cf. introduction to § III.)

X. COMPARISONS OF RESULTS OF SEED-TESTS WITH RESULTS OF ACTUAL SOWING IN THE FIELD.

It has been said recently that the ideal test of seeds is actual sowing in the field, inasmuch as the ultimate value of the seed is its capability to produce crop. This notion of seed tests is obviously fallacious, although the statement upon which it is based is true. In other words, actual planting rarely gives a true measure of the capabilities of all the seeds of any sample, because of the impossibility to control conditions and methods in the field. The

* This apparatus holds the seeds in pockets of cloth which hang over a pan of water. For a full description, see Second Rep. N. Y. Exp. Sta. 67.

object of seed tests is to determine how many seeds are viable and what is their relative vigor; if planting shows poorer results, because of covering too deeply or too shallow, by exposing to great extremes of temperature or moisture or a score of other untoward conditions, the sample cannot be held to account for the shortcoming. The following table indicates the extent of variation which may be expected between tests and actual plantings of seeds from the same samples:

52. Various samples tested in-doors and actually planted in the field. The seeds were sown in the field June 5, and the last notes were taken from them July 5. They were sown on a gravelly knoll. Rain fell about every alternate day, and the soil was in good condition for germination throughout the month. The in-door tests were made in loose potting earth, or in sand in seed-pans.

SAMPLES.	No. of Germ. in house.	Per Cent. of Germ. in house.	No. of Germ. in field. (200 Seeds sown.)	Per Cent. of Germ. in field.	Per Cent. of Difference.
Endive, *Green-Curled*, Thorburn.	200 Seeds. 88	44	53	26.5	**17.5**
Tomato, *Green Gage*, Thorburn.	100 Seeds. 72	72	93	46.5	**25.5**
Turnip, *Early Six Weeks*, Dept. of Agriculture.	200 Seeds. 180	90	65	32.5	**57.5**
Pea, *White Garden Marrowfat*, Thorburn.	60 Seeds. 55	91.6	181	90.5	**1.1**
Celery, *White Plume*, Thorburn.	100 Seeds. 41	41	22	11	**30**
Onion, *Red Wethersfield*, Thorburn.	200 Seeds. 148	74	84	42	**32**
Carrot, *Early Forcing*, Thorburn.	100 Seeds. 70	70	39	19.5	**50.5**
Carrot, *Vermont Butter*, Hoskins.	100 Seeds. 65	65	45	22.5	**42.5**

CONCLUSION.

1. The table indicates that actual planting in the field gives fewer germinations than careful tests in conditions under control. This difference in total of germination, even under favorable conditions of planting, may amount to over 50 per cent.

2. In planting, due allowance should be made for the comparatively bungling methods of field practice by the use of greater quantities of seeds than would seem, from the results of tests, to be sufficient.

XI. IMPURITIES IN SAMPLES OF GARDEN SEEDS.

Over one hundred packages of seeds have been carefully examined for impurities, and in ninety separate instances the results have been tabulated and compared. This examination consisted in counting every seed in the sample, counting the impurities, weighing the seeds and the impurities, and determining, so far as possible, the character of the impurities. The percentages of impurities, both by number and weight, have been calculated. From these analyses it is easy to draw conclusions as to the probable extent of adulteration or impurity in garden seeds. No evidence of adulteration was found, and weed seeds were few and unimportant. In some cases the sample had not been properly cleaned, but in general the more important seeds were very free from impurities. The impurities were very largely immature and imperfect seeds. The average of impurities, by number, was found to be 2.76 per cent., and by weight, 1.38 per cent. The investigation appears to indicate that there is no necessity for seed-control stations in this country, for the purpose of preventing dishonesty and carelessness in the sale of garden seeds. The detailed results will soon appear in *Agricultural Science.*

GENERAL SUMMARY.

I. The results of a seed-test depend very largely upon the known conditions under which the test is made :

1. Variations in temperature may cause variations in rapidity of sprouting.

2. An essentially constant temperature of about 74° gives quicker results than an ordinarily variable temperature of a similar mean.

3. It is probable that any constant temperature gives quicker results than a variable temperature of which the mean is the same as the constant temperature.

4. As the mean temperature lowers, sprouting, as a rule, becomes slower.

5. In some instances, greater rapidity of sprouting due to a constant temperature of 74°, does not appear to be correlated with greater per cent. of total sprouting. In beans, however, greater per cent. of sprouting appears to follow greater rapidity of sprouting.

6. There is probably a tolerably well-defined optimum temperature for each species of plant, in which best results from seed-tests can be obtained. This limit is not closely determined for most garden seeds.

7. The quantity of water applied to seeds may determine both the rapidity and per cent. of sprouting.

8. A comparatively small amount of water gives quickest and largest results.

9. Greater quantities of water than are required for best results, lessen rapidity and per cent. of sprouting either by causing the seeds to rot or by retarding germination, or by both.

10. The soaking of seeds in water before planting does not appear to hasten sprouting, if the planting time is reckoned from the time at which the seeds are put to soak. But if planting time is counted from the time of placing the seeds in soil, quicker sproutings are the result; this method of reckoning is incorrect, however.

11. The soaking of seeds does not appear to influence the total amount of sprouting.

12. The results of soaking appear to vary in different species.

13. The character of soil in which the test is made may influence the results, both in rapidity and per cent. of sprouting.

14. Light has great influence upon the sprouting of the seeds of some species.

15. When light has any influence, it retards or wholly prevents sprouting.

16. The effects of light upon sprouting are different in different species.

17. The weight of the seed is often a tolerably accurate measure of its viability, as determined both by rapidity and per cent. of sprouting.

18. As a rule, heavy seeds germinate better than light ones of the same sample.

19. Seeds of different species may vary in sprouting in reference to weight.

20. The color of the seed in some cases is a tolerably accurate measure of rapidity and per cent. of sprouting.

21. When there is any variation in viability in reference to color, it is usually found that the stronger sproutings occur in the darker colored seeds.

22. The relative values of seeds of different colors vary with each species, or sometimes with each sample.

23. The latitude in which seeds are grown may determine their behavior in germination.

24. Northern grown corn appears to germinate quicker than southern grown corn. It is to be expected, from our knowledge of the variation of plants in reference to latitude, that seeds of most species will give similar results.

25. Variation in results of seed-tests may be due to the apparatus in which test is made.

26. Those apparatuses in which the seeds are exposed to light are to be distrusted.

27. Those apparatuses which afford no protection to the seeds other than a simple layer of cloth, paper, board, or similar cover, are usually unsafe, from the fact that they allow of too great extremes in amounts of moisture. (Cf. Tables 2, 3, and 41.)

28. The so-called Geneva tester appears to give better results of sprouting than tests made in soil, probably from the fact that moisture and temperature are less variable than in the soil tests.

29. In order to study germination to its completion, tests must be made in soil.

30. Tests made in-doors are more reliable than those made in the field.

II. Results commonly vary between tests made under apparently identical conditions, even with selected seeds. Therefore,

31. One test cannot be accepted as a true measure of any sample of seeds.

III. The results of actual ordinary planting in the field cannot be considered a true measure of the viability or value of any sample.

IV. Rapidity of sproutings, unless under identical conditions, is not a true measure of vitality or vigor of seeds.

V. There appears to be no pernicious adulteration of garden seeds in this country, and, as a rule, there are no hurtful impurities.

In the ordinary farmer's garden seed-testing is perhaps of little or no value, but to the market gardener, who plants considerable areas to special crops, and to the seedsman, it is highly profitable. It is possible that in some cases the character of the crop can be prognosticated with some degree of certainty from behavior of plants in germination, wholly aside from percentages of sprouting. The studies of experts in this country and Germany indicate that when accurate information is desired as to the value of seeds, the seed-test should present at least the following data: Name of variety; where grown; when grown; how kept; per cent. by weight of foreign matter; per cent. by weight of apparently good seeds; nature of foreign material; weight of seeds; manner of testing; number tested; average and extreme temperatures during trial; first germinations in hours; last germinations in hours; per cent. by number germinated; per cent. unsprouted but sound at end of trial; date of test; estimate of agricultural value.

L. H. BAILEY.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

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OF THE

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AGRICULTURAL DEPARTMENT.

VIII.

AUGUST, 1889.

On the Effect of Different Rations on Fattening Lambs.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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THE EFFECT OF DIFFERENT RATIONS ON FATTENING LAMBS.

THESE experiments were, in the main, a continuation of those carried on at this station one year ago, and reported in Bulletin No. II, and very nearly the same foods were used, none of them being out of the reach of the general mass of farmers.

GENERAL PLAN OF THE EXPERIMENT.

The period of feeding lasted five full months, from November 25th, 1888, to April 25th, 1889. The lambs, twelve in number, were selected from a lot that had been picked up in the surrounding country for shipment. They were coarse wool grades, Shropshire or Southdown, dropped late the previous spring, and had evidently been scantily fed during the summer. They were not such animals as would have been selected to give the best financial results, but being thin in flesh and fairly uniform, were well adapted to the purposes of the experiment. The twelve were closely shorn, and then divided into four lots of three each, in such a manner as to have as nearly as possible an equal weight in each lot. Three lambs were used in each lot, so that if for any reason there should be an accident to one there might be two left at the end, from which to gather data in regard to the effects of the rations.

The lots were numbered respectively III, IV, V and VI, and each lamb was labeled with a separate numbered ear tag, so that data in regard to increase in weight, etc., could be collected individually and by lots.

The experiment progressed satisfactorily from beginning to end, with but two exceptions. Lamb No. 12, in lot III, made scarcely any growth from beginning to end, as shown by the weekly weighings. Lamb No. 18, in lot IV, grew and thrived as well as any until about February 1st, when it began to lose weight, though not noticeably ailing. About March it became sick, refused to eat, and was doctored for costiveness, but continued to grow worse, and died March 13. A post mortem examination showed that death was caused by a stone in the bladder. For these reasons all the figures and computations are based upon the two heaviest lambs in each lot.

THE RATIONS FED.

Lot III was fed what may be called a carbonaceous ration. The lambs were given all the timothy hay and whole corn they would readily eat, and in addition about a half pound of roots each per day. Turnips were fed as long as the supply lasted; after that mangels were used.

Lot IV was fed a nitrogenous ration, although it was not so excessively rich in nitrogen as that used by some experimenters in trials of this kind. The grain ration was made up of two parts wheat bran and one part cotton seed meal. A pound per day per lamb of this mixture was fed at first; afterward it was somewhat increased or diminished, as the needs of the case required, the object being to feed about all that would be readily eaten. This lot received clover hay instead of timothy, and roots, as lot III.

Lot V was fed an intermediate ration. The grain part was composed of three parts corn and one part each of wheat bran and cotton seed meal. It was eaten in about the same quantity as lot IV. Timothy hay was used for this lot, and roots were fed as in each of the others.

Lot VI was fed the same as lot V, except that they received no roots at all. In the table below is given the amount of the various fodders consumed by each lot, together with the amount of the various digestible nutrients that each contained, and the cost at the following prices: Corn, $20 per ton; timothy hay, $10 per ton; mangels, 5 cents per bush.; turnips, 5 cents per bush.; wheat bran, $18 per ton; cotton seed meal, $22.50 per ton; and clover hay, $7 per ton.

RATIONS.

LOT III.

	Cost.	Protein.	N-Free.	Fibre.	Fat.
		Lbs.	Lbs.	Lbs.	Lbs.
238 lbs. Corn, ...	$2.38	20.15	152.74	2.37	10.54
228 " Timothy hay, . . .	1.14	6.39	76.74	32.94	1.99
125 " Mangels, ...	.10	1.38	11.38	1.13	.13
97 " Turnips, ...	.08	1.08	4.83	.83	.58
Total, ...	3.70	29.00	245.69	37.27	13.24

LOT IV.

	Cost.	Protein.	N-Free.	Fibre.	Fat.
		Lbs.	Lbs.	Lbs.	Lbs.
233 lbs. Wheat bran, . . .	$2.10	19.91	96.73	6.56	3.63
106 " Cotton seed meal, .	1.19	37.89	10.39	1.31	8.85
312 " Clover hay, ...	1.17	15.43	95.48	36.75	7.34
151 " Mangels, ...	.13	1.66	13.73	1.36	.15
49 " Turnips, ...	.07	.99	4.49	.77	.54
Total, ...	4.66	75.88	220.82	46.75	20.51

LOT V.

	Cost.	Protein.	N-Free.	Fibre.	Fat.
		Lbs.	Lbs.	Lbs.	Lbs.
62 lbs. Wheat bran, . . .	$ .56	5.32	25.83	1.75	.97
62 " Cotton seed meal, .	.70	22.28	6.11	.77	5.20
204 " Corn, ...	2.04	17.27	130.90	2.03	9.03
255 " Timothy hay, . . .	1.28	7.17	86.00	36.92	2.23
143 " Mangels, ...	.12	1.38	13.04	1.29	.14
99 " Turnips, ...	.08	1.09	4.91	.85	.59
Total, ...	4.78	54.71	266.79	43.61	18.16

LOT VI.

	Cost.	Protein.	N-Free.	Fibre.	Fat.
		Lbs.	Lbs.	Lbs.	Lbs.
62 lbs. Wheat bran, . . .	$ .56	5.32	25.83	1.75	.97
62 " Cotton seed meal, .	.70	22.28	6.11	.77	5.20
208 " Corn, ...	2.08	17.55	133.04	2.06	9.18
234 " Timothy hay, . . .	1.17	6.58	78.91	33.88	2.05
Total, ...	4.51	51.73	243.89	38.46	17.40

We get a much better understanding of the above rations if we compare them by the standard known as the nutritive ratio. The nutritive ratio in a given ration is obtained by multiplying the amount of digestible fat by 2½, and to this adding the amount of digestible fibre and nitrogen free-extract, and dividing the whole by the amount of the digestible protein; or, in other words, the nutritive ratio is the ratio of the protein to the carbhydrates plus 2½ times the fats.

Applying this formula now to the rations given above, we get the nutritive ratio of the rations of the various lots as follows, and since Lot II and Lot I of the experiments reported in Bulletin II were fed rations similar in character to Lots III and IV respectively, we give the nutritive ratios of the rations of those Lots for purposes of comparison.

	Nutritive Ratio.		*Nutritive Ratio.*
Lot III	1 : 10.9	Lot II (Bull. II)	1 : 8.4
Lot IV	1 : 4.2	Lot I (Bull. II)	1 : 3.3
Lot V	1 : 6.5		
Lot VI	1 : 6.3		

As stated in Bulletin II, according to the German standards, as laid down by Armsby (Manual of Cattle Feeding, Page 401), 1 : 4 is the narrowest and 1 : 7 the widest ratio advisable for fattening sheep. It will be seen then that our Lots Nos. V and VI were fed what might be called an intermediate ration, from the use of which good results might be expected, while Lot III received a ration far too rich in carbonaceous matter, and Lot IV a ration approaching the limit of richness in protein. The ration of Lot III was considerably richer in carbonaceous matter than that of Lot II of last year, while the ration of Lot IV was not so rich in protein as that of Lot I of last year. This should be borne in mind, in what follows.

THE WATER DRANK.

The lambs had access to water the whole time. In the winter it was warmed to about 80° before being offered them. The weight was obtained in the following manner: A pail of water was weighed and placed in the pen, where it remained till the next morning, the sheep drinking whenever they wished. Each morning the pail, with whatever water remained in it, was weighed back, the difference in weight being the amount consumed. A fresh pailful was then weighed out, and the process repeated. This was kept up during the whole course of the experiment. The water was warmed when it was first put in, and during the cold weather the lambs soon learned to take nearly all their water as soon as fresh water was given them. From the first a marked difference was seen in the amount of water consumed by the different lots, and this difference continued through the whole course of the experiment. Below is given the total amount of water drank:

Lot III drank 308 lbs., or 1.03 lbs. per lamb per day.
Lot IV drank 1185 lbs., or 3.95 lbs. per lamb per day.
Lot V drank 735 lbs., or 2.45 lbs. per lamb per day.
Lot VI drank 847 lbs., or 2.82 lbs. per lamb per day.

The very much larger quantity of water consumed by the lambs fed a highly nitrogenous ration is at once apparent. It will be seen that Lot IV drank nearly four times as much as Lot III (fed carbonaceous food), and about 60 per cent. more than Lot V. These three lots were all fed roots in equal kind and quantity, so that it would seem that the different amounts of water consumed must be due to the nitrogen in the ration. The same thing was noticed in the experiments reported in Bulletin No. II, although in that experiment the water was only weighed for six days at one time in the course of the experiment. In that case Lot I (fed on nitrogenous food) drank three times as much water as lambs fed on corn and hay.

Lot V and Lot VI were fed on the same ration, except that Lot VI had no roots. Probably for this reason they drank about 15 per cent. more water.

THE GAIN IN LIVE WEIGHT.

Below is given, in tabular form, the gain in pounds, and also in per cent. of weight at beginning, of each lamb in each lot:

	Wt. Nov. 25	Wt. Apr. 25	Gain, Lbs.	Gain, per ct.
LOT III—				
No. 11 . . .	59.	78.88	19.88	33.7
No. 21 . . .	36.	64.88	28.88	80.2
Average	47.5	71.88	24.38	51.3
LOT IV—				
No. 13 . . .	45.5	85.13	· 39.63	87.1
No. 16 . . .	50.5	88.19	37.69	74.6
Average	48.	86.66	38.66	80.5
LOT V—				
No. 14 . . .	53.	96.44	43.44	82.
No. 20 . . .	50.	81.69	31.69	63.4
Average	51.5	89.06	37.56	73.
LOT VI—				
No. 15 . . .	58.	91.88	33.88	58.4
No. 19 . . .	51.5	75.31	23.81	46.2
Average	54.75	83.59	28.84	52.7

The lambs fed on nitrogenous food, or Lot IV, made much the largest average gain, and those fed on carbonaceous food, or Lot III, made the smallest gain, though not very much smaller than Lot VI.

Animal individuality, a very perplexing consideration in all work of this kind, shows its influence very strongly here. If we study the individual gains of the animals we find that there is a much greater difference in the gain of the two lambs in Lot III than there is in those of any of the other lots. Lamb No. 21, in Lot III, the smallest of all at the beginning, made almost as large a gain as any in the whole lot, and far greater than its companion. Of course, it is impossible to say that this is an individual variation; and it may be urged that No. 11 was quite as likely to be the eccentric individual as No. 21, but it will be remembered that the third lamb of this lot, No. 12, made almost no gain at all, so that circumstances indicate that No. 21, the smallest of all at the beginning, was affected by influences not affecting the others. However this may be, the calculations are based on the figures as they stand.

Notwithstanding the gain in live weight was very markedly in favor of the lambs fed on nitrogenous food, it is when we come to compare the amount of gain in relation to the amount and cost of the food consumed that the most striking figures are brought out.

This is shown below in tabular form :

Gain in Live Weight in Relation to Amount and Cost of Food.				
Lot	III.	IV.	V.	VI.
Digestible carbonaceous food consumed, lbs.	296.20	288.08	328.56	299.75
Digestible nitrogenous food consumed, lbs.	29.	75.88	54.71	51.73
Total digestible nutrients consumed, lbs.	325.20	363.96	383.27	351.48
Nutritive Ratio	1 : 10.9	1 : 4.2	1 : 6.5	1 : 6.3
Total gain in weight (both lambs), lbs.	48.75	77.31	75.13	57.69
Pounds nutrients consumed for 1 lb. gain	**6.67**	**4.71**	**5.10**	**6.09**
Total cost of food consumed	$3.70	$4.66	$4.78	$4 51
Cost of gain per 100 pounds	**7.59**	**6.03**	**6.36**	**7.82**

Here again, both in the items, "Amount of food consumed for one pound of gain," and "Cost of gain per 100 pounds," the advantage is very markedly in favor of Lot IV—the lot fed on nitrogenous food. This is illustrated graphically on page 82.

It cost us a little more than a cent and a half per pound, or 26 per cent. more to put a pound of gain upon our lambs that were fed on corn, timothy hay and roots than it did to put a pound of gain on those that were fed wheat bran, cotton seed meal, clover hay and roots.

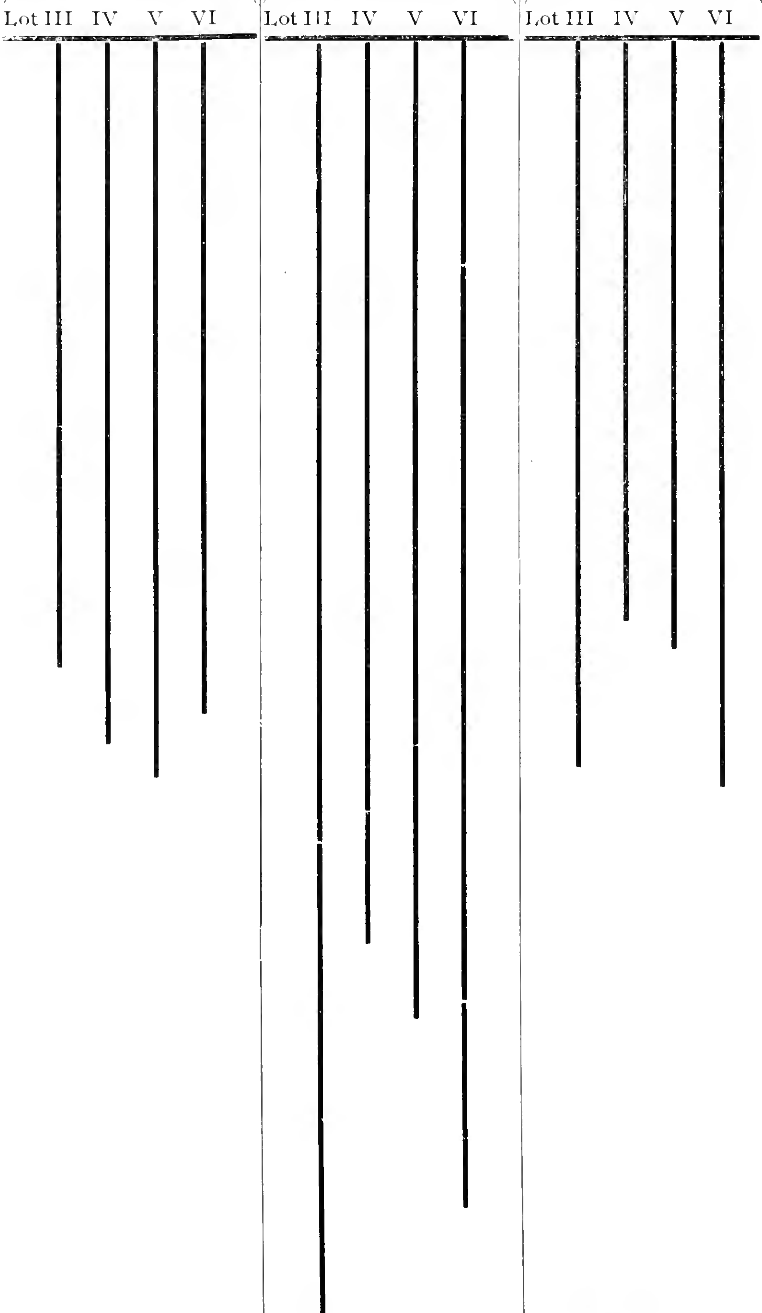
THE WOOL PRODUCED.

The lambs were shorn November 15th, or ten days before the beginning of the experiment. They were shorn again the day before they were slaughtered, so that the wool obtained was the growth of 160 days. The weight of the wool from both lambs in each lot was as follows :

		Per cent. increase over Lot III.
Lot III	4.25 lbs.	
Lot IV	7.31 lbs.	72
Lot V	6.63 lbs.	56
Lot VI	6.19 lbs.	46

This coincides with the results of our experiments last year, in that nitrogenous food seems to largely affect the growth of wool. It seems to show further that even a small increase in the nitro-

Amount of digestible dry matter consumed. Each inch in length represents 100 lbs.	Amount of Food required to make one pound of gain in live weight. Each inch in length represents one pound.	Cost of Gain per 100 lbs Each inch in length represents $2.00 per. cwt.



Lot	III	IV	V	VI
Digestible dry matter consumed	325	364	383	352
Food required per pound of gain	6.67	4.71	5.10	6.09
Cost of gain per 100 lbs	$7.59	$6.03	$6.36	$7.82

genous matter of a ration has a decided influence on the growth of the wool, for Lots V and VI, whose ration was intermediate in character, gave very nearly as much wool as Lot IV.

In the experiments of 1888, already referred to, the percentage was not so great in favor of the lambs fed on nitrogenous food. For the sake of comparison, both are given below:

In experiments of 1889, Lot IV gave 72 per cent. more wool than Lot III.
In experiments of 1888, Lot I gave 55 per cent. more wool than Lot II.

The nutritive ratios of the rations were as follows:

1889—Lot IV, 1 : 4.2; Lot III, 1 : 10.9.
1888—Lot I, 1 : 3.3; Lot II, 1 : 8.4.

While both were wider in 1889 than in 1888, there was a greater difference between them this year than last.

THE DRESSED WEIGHT AND INTERNAL ORGANS.

The lambs were slaughtered on April 25th. The blood was carefully caught in a clean pail, and it and all the important internal organs were weighed. The carcasses were hung up in a cool place to stiffen for two days, and were then cut up, and the parts carefully examined. Before they were taken down, however, they were weighed and most carefully inspected by the different members of the staff. The most striking difference that was apparent, as the carcasses hung upon the hooks, and after they were cut up, was the evident leanness of the two belonging to Lot IV (fed nitrogenous food.) The kidneys were not covered, and there was very little loose fat next the skin, while in all the other carcasses the kidneys were more or less completely covered, and there was a layer of tallow of greater or lesser thickness between the skin and body. The carcasses of Lot III had the most of this tallow. The same thing is shown in the amount of caul fat and kidney fat, as shown in the table of weights following. While an expert butcher would have undoubtedly selected the carcasses of Lots V and VI as furnishing the most saleable mutton, the carcasses of Lot IV had little or no unpalatable adipose matter, and those of Lot III showed much the largest percentage of waste, fatty matter about the root of the tail and in the flanks.

In the table below is shown the weights of the dressed carcasses and the various organs for each animal, and the averages for each lot:

	Dressed Weight. Lbs.	Skin, inclu. Head and Feet. Lbs.	Intestines. Lbs.	Blood. oz.	Heart. oz.	Lungs. oz.	Liver. oz.	Spleen. oz.	Kidneys. oz.	Kidney Fat. oz.	Caul Fat. oz.
Lot III. No. 11	39.	8.69	16.94	49.	4.	14.	19.	2.	2.	51.	55.
No. 21	32.	9.06	13.44	39.	3.	11.	17.	1.	3.	30.	32.
Average	35.5	8.88	15.19	44.	3.5	12.5	18.	1.5	2.5	40.5	43.5
Lot IV. No. 13	38.	12.19	21.69	65.	6.	19.	25.	2.	4.	15.	14.
No. 16	37.	13.56	22.88	60.	5.	16.	24.	2.	3.	17.	16.
Average	37.5	12.88	22.28	62.5	5.5	17.5	24.5	2.	3.5	16.	15.
Lot V. No. 14	42.	14.56	26.69	64.	7.	19.	24.	1.	5.	23.	18.
No. 20	37.5	12.63	21.69	56.	5.	18.	19.	2.	4.	22.	19.
Average	39.75	13.59	24.19	60.	6.	18.5	21.5	1.5	4.5	22.5	18.5
Lot VI. No. 15	46.	12.06	19.	51.	6.	16.	31.	1.5	3.	42.	44.
No. 19	36.	10.75	16.88	41.	4.	12.	19.	1.	2.5	41.	37.
Average	41.	11.41	17.94	46.	5.	14.	25.	1.25	2.75	41.5	40.5

In the proportion of dressed to live weight is to be found the main discrepancy between the experiments of 1888 and 1889. Last year the dressed weight of the nitrogeneous fed lambs was nine per cent. greater than those fed carbonaceous food. This year the difference was about as much in the other direction. Below is given the percentage of dressed to live weight for each lamb, and the averages for the lots.

	Live Wt.	Dressed Wt. incl. Kidneys.	Per cent. dressed to Live wt.	
Lot III.—No. 11,	77.	39.	50.6	
No. 21,	62.5	32.	51.2	av. **50.9**
Lot IV.—No. 13,	82.	38.	46.3	
No. 16,	84.	37.	44.	av. **45.2**
Lot V.—No. 14,	93.	42.	45.2	
No. 20,	78.5	37.5	47.7	av. **46.5**
Lot VI.—No. 15,	89.	46.	51.7	
No. 19,	72.	36.	50.	av. **50.9**

The differences between Lots III and IV in proportion to the live weight, in the dressed weight, wool, and some of the more important internal organs is shown in the following statement.

The following parts and organs were greater in the lambs fed on nitrogeneous food by the following percentages in proportion to the live weight:

Wool, ...	44 per cent.	Heart, . . .	40 per cent.
Kidneys, . .	18 "	Liver, ...	13 "
Blood, . . .	19 "	Lungs, . . .	18 "

The following were greater in the lambs fed on carbonaceous food:

Dressed Weight, ...	13 per cent.
Caul Fat, ...	242 "
Kidney Fat, ...	198 "

In the experiment of 1888 the organs greatest in the animals fed nitrogenous food, were:

Dressed Weight, . .	9 per cent.	Caul Fat, ...	13 per cent.
Wool, ...	26 "	Kidneys, ...	13 "

And those that were greatest in the animals fed carbonaceous food, were:

Heart, . . .	26 per cent.	Liver, ...	4 per cent.
Blood, . . .	9 "	Lungs, . . .	8 "

SUMMARY.

The weight of evidence of all of our experiments, together with results obtained by other experimenters in the same field, seems to show:

That corn, as an exclusive grain ration, does not give the best results, either in amount, quality or economy of production, when fed to growing or fattening animals.

That the amount of water drank (especially in the case of our lambs) is a pretty certain indication of the rate of gain.

That the production of wool is very greatly dependent upon the nitrogen in the ration.

THE MANURIAL VALUE OF THE RATIONS.

The value of the manure made from the animals fed is a matter of prime importance, to all eastern farmers at least. And often the manure left on the farm represents a large part, if not the whole, of the profit made from feeding a lot of animals. For this reason we have calculated the manurial value of the rations fed the different lots, and have placed it along side the cost of the foods used.

The basis of calculation has been that 80 per cent. of the manurial value of the food is recovered in the manure. With lambs so highly fed as these were, it is altogether likely that more than 80 per cent. of the manurial value of the foods was excreted.

Nitrogen is reckoned at 17 cents per pound, phosphoric acid at 7, and potash at 4½.

	Cost of Ration.	Manurial Value.	Cost of Ration less Value of Manure.
Lot III.—(Carbonaceous)	$3.70	$1.12	$2.58
Lot IV.—(Nitrogenous)	4.66	3.56	1.10
Lot V.—(Intermediate, with roots),	4.78	2.10	2.68
Lot VI —(" without roots),	4.51	1.97	2.54

This little table is certainly worth careful consideration by those who are accustomed to buy commercial fertilizers at the prices given above.

Since a large portion of the arable land in the State of New York is now cultivated at a positive loss or at a very small profit, and since the reason for this is largely want of plant food in the soil ; therefore, the value of the voidings of animals and the character of the plants raised on the farm, must necessarily receive our most careful consideration.

Referring to the table above, it will be seen that while the first cost of the ration of the nitrogeneous fed sheep was larger than that of the carbonaceous, yet when the value of the manure is subtracted, the cost of the former is less than half of the latter.

I. P. ROBERTS,
HENRY H. WING.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

HORTICULTURAL DEPARTMENT.

IX.

SEPTEMBER, 1889.

A Study of Windbreaks in their Relations to Fruit-Growing.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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Ithaca, N. Y.

Description of Plates.

Fig. 1.—Windbreak consisting of two rows of hard maple backing up a close row of Norway spruce. Considered to be a model shelter belt. Planted 15 years. On the farm of T. G. Yeomans and Sons, Walworth, Wayne Co., New York. From a photograph. [Frontispiece.]

Fig. 2.—Windbreak of Norway spruce, set about 6 ft. apart, with black raspberries in the foreground. Planted 25 years. On the farm of T. G. Yeomans and Sons, Walworth, New York. From a photograph. Page 97.

Fig. 3.—Windbreak of Lombardy poplars, protecting a peach orchard from heavy winds when laden with fruit and ice. Planted 11 years. Peach trees the same age. On the fruit farm of Charles Gibson, South Haven, Van Buren Co., Michigan. From a photograph. Page 103.

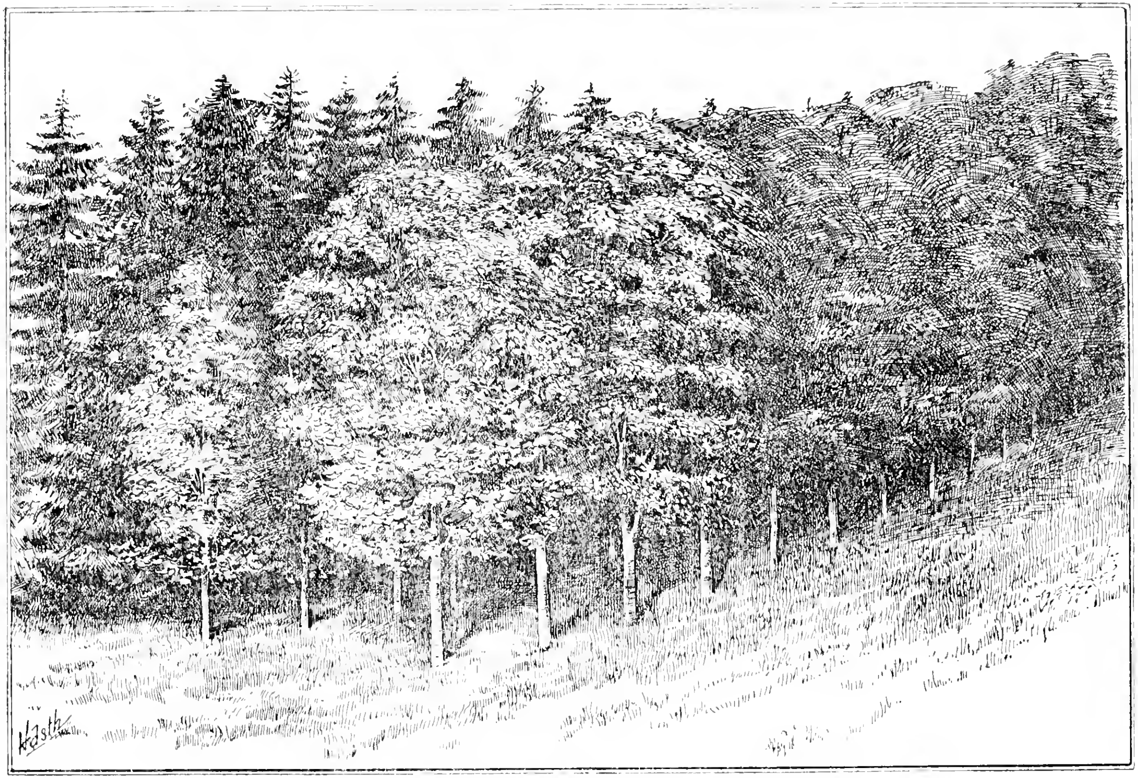

FIG 1.—*A model mixed Windbreak, fifteen years old.*

A STUDY OF WINDBREAKS IN THEIR RELATIONS TO FRUIT-GROWING.

I. INFLUENCES OF WINDBREAKS UPON FRUIT PLANTATIONS.

ALTHOUGH the best writers upon horticultural topics are nearly unanimous in recommending windbreaks for all fruit plantations, there is, nevertheless, wide difference in opinion and practice among good cultivators concerning them. Fruit-growers, as a rule, hold decided opinions concerning windbreaks. In fact, they usually hold extreme opinions, either wholly opposing shelter belts in all cases, or positively advocating them. All who are engaged in the growing of fruits or who attend fruit-growers' gatherings, have heard the most positive experiences cited in support of both opinions. There must be good reasons for these opposing views. No general studies of the subject appear to have been made, yet it is one of commanding importance in many directions. There appear to be no well-grounded maxims or precepts among growers themselves, and statements concerning the merits of shelter belts are commonly vague. Studies of temperatures as influenced by windbreaks are now being inaugurated at this station under excellent opportunities.

The present inquiry was undertaken about six months ago, and it is the outgrowth of previous experience and observation in the same direction. Many inquiries have been made and fruit farms have been visited. Three hundred circulars were addressed to leading fruit-growers in New York and Michigan, asking for definite information in regard to windbreaks. Seventy-seven replies were obtained. This is a large proportion, and the number may be assumed to include all the persons of the three hundred addressed, who have had experience, or have made direct observation. Forty-eight of these replies relate definite results. It is probable that nearly the whole range of experience with windbreaks in reference to fruit culture in the northeastern states is represented in these letters.

The present discussion is presented as follows:

I. Influences of Windbreaks upon Fruit Plantations.

II. Proper location of Windbreaks, and manner of making them. General Summary.

1.—Experiences Favorable to Windbreaks.

A. IN NEW YORK.

OBSERVER.	Site and Soil	Direction of Prevailing or severest winds.	Location in reference to large bodies of water.	Kinds of fruit grown.	Kind of Windbreak.	BENEFITS DERIVED.
Patrick Barry, *Rochester.*	Various.	W.N.	About 6 m. South Lake Ontario.	All kinds.	Norway spruce, European larch, and other evergreens.	"We regard windbreaks, in this country, as of vast importance, not only in fruit culture, but for the comfort of man and beast."
Irving Rouse, *Rochester.*	Same level as surrounding land. Clay.	N.	do	Apples.	Norway spruce, on Northwest.	Increased crop. Less loss from windfalls. No loss from severe cold.
J. Wentz, *Rochester.*	High, sandy loam.	W.	do	Plums.	Siberian arbor vitæ.	Good.
T. G. Yeomans & Sons, *Walworth.*	Undulating, strong, sandy loam.	W.	About 8 m. South Lake Ontario.	Apples, Dwf. Pears, Q'nces, small fruits.	Norway spruce, mixed belts, and natural forest.	Prevent windfalls. Render orchards more uniformly productive and longer lived. Render labor easier.
W. T. Mann, *Barkers.*	Slightly rolling, clay and sandy loams.	W.SW. NW.	2 m. South of Lake Ontario.	General.	Row of Norway spruce on W., set 2 ft. apart in 1874	Fruits, especiallly pears and berries, have blossomed and ripened several days earlier near windbreak. Fewer windfalls. Retains snow for 10 to 15 rods from wdbk.
B. W. Clark, *Lockport.*	—— ——	SW.	About 10 m. S. L. Ontario	General.	Norway spruce, natural forest.	Good.
G. W. Dunn, *Pierce's.*	Same elevation as surrounding orch'ds. Loam.	W.	On Lake Ontario.	Apples.	Beechwood land.	Trees start earlier. Fruit hangs on longer. Winter apples more easily gathered.
C. P. Whitney, *Orleans.*	Very high ridge, W. slope. "Limestone."	W.N.	N. of Canandaigaa and Seneca Lakes—about 8 miles.	Apples, set in '73 and '74	Natural forest.	"I see no difference in the growth of trees, except that they stand straighter where they are protected."
V. B. Wheat, *Orleans.*	High, sandy loam, ranging to gravel.	W.N.	do	Grapes, Apples, Peaches	Natural forest.	"I am very certain that the protection from forest is beneficial in various ways."

S. C. Davis, *Medina.*	High. Clay and gravelly loam.	W.N.	About 10 m. So. L. Ont.	General.	Norway spruce.	Good.
E. B. Norris, *Sodus.*	Mostly high. Sand, grav. loam.	W.N.	On Lake Ontario.	Apples.	Norway spruce.	Good.
C. H. Perkins, *Newark.*	——— ———	W.	About 15 m. South Lake Ontario.	Small fruits, grapes quinces and peaches.	Norway spruce.	Protects from cold snaps; "no telling the good a windbreak will do."
W. G. Ellwanger, *Canandaigua.*	High.	W.	On Canandaigua Lake.	Orchard fruits & nursery st'k.	——— ———	Fewer windfalls. Prevents ground from freezing too deep and destroying nursery stock.
H. J. Peck, *Seneca Castle.*	E. and W. slope. Heavy loam.	W.	Midway bet. Canandaigua and Seneca Ls. About 6 miles.	Apples, set in 1873.	Closely planted apple orchard on the west.	Fewer windfalls. Trees become more firmly rooted, and are more upright.
G. C. Snow, *Penn Yan.*	100 to 500 ft. elevation. Gravelly loam.	W.	At north end of Keuka L.	Peaches, apples, grapes.	Natural forest on W. and S.W.	Fewer windfalls. Less liability to damage to fruit buds from cold. Retains snow and leaves.
C. W. Pierson, *Waterloo.*	Slightly higher than adjacent lands. Sdy loam.	W.N.	Bet. Cayuga and Sen. L.—about 5 m.	Peaches and apples.	Norway spruce hedge, kept cut back to 10 or 12 ft	"The result, I think, has been beneficial to the peach crop."
A. I. Hulett, *Elba.*	Gravelly loam.	W.SW.	About 20 m. south Lake Ontario.	Apples and pears.	Natural forest.	"Apples and pears so protected rarely fail, while others, on equally as good soil and exposed, fail one year out of three."
P. B. Crandall, *Ithaca.*	High.	W.	At south end of Cayuga Lake.	Peaches.	Farm buildings on north.	"Trees will blossom full this spring; in the field with no protection, buds have been mainly destroyed."
J. J. Thomas, *Union Springs.*	——— ———	W.	Near N.E. cor. of Cayuga Lake	Pears.	Double row of Norway spruce on west.	Trees near the windbreak less injured by cold winter winds.
Anthony Lamb, *Syracuse.*	Same level as adjacent lands. Clay l'm	W.N.	Near Onondaga Lake.	Nursery stock, grass and grain	Norway spruce.	Much less injury to nursery stock from cold.
E. A. Powell, *Syracuse.*	do	W.N.	do	Nursery stock, also gen'l crops	Norway spruce.	Protects nursery stock from effects of cold.
G. T. Powell, *Ghent.*	100 feet above adjacent lands. Gravelly loam.	W.N.	About 8 m. east of Hudson River.	Apples, pears, grapes and cherries.	Elms, maples and Norway spruce.	"Saves a large amount of fruit from being blown off." Holds snow. Lessens evaporation from the soil. Encourages birds.

B. IN MICHIGAN.

Charles Gibson, *South Haven.*	High. Sand.	W.SW.	On east bank of Lake Michigan.	Peaches.	Lombardy poplars and natural forests.	Keeps fruit from blowing off, and prevents breaking of trees when loaded with fruit or ice.
R. Linderman, *South Haven.*	Very high. Sandy.	W.SW.	On east shore of L'k Michigan.	Peaches.	Norway spruce on the west.	Protects from cold winds, especially in blossoming time. In a certain year, a NW. wind in blossoming time destroyed half or more of the crop on west of screen, but the protected orchard had a full crop.
H. J. Edjell, *South Haven.*	Very high. Sandy.	W.SW.	On east shore of L'k Michigan.	General.	Norway spruce enclosure.	Temperature is 5° higher in protected places in very cold weather. The most productive grapes are next windbreak. "I am thoroughly convinced of the value of a windbreak."
L. H. Bailey, *South Haven.*	High. Sandy.	W.SW.	On E. shore L. Michigan.	Apples.	Apple orchard.	Windfalls are half less where trees are protected.
J. F. Taylor, *Douglas.*	80 to 100 ft. above lake. Sandy.	W.SW.	90 rods E. of L. Michigan.	Apples and peaches.	Nat. forest. Lomb. poplars, Scotch pine.	Retains snow. Prevents the falling off of fruit.
G.C. McClatchie *Ludington.*	High.	W.SW.	On Lake L. Michigan.	Peaches and plums.	Natural forest.	Retains snow, and thus greatly protects trees.
S. M. Pearsall, *Grand Rapids.*	Same elevation as surrounding lands. Gravelly loam.	N.W.	About 25 m. east of Lake Michigan.	Apples.	Black walnut and butternut.	"The trees were not affected by the winds as much as my other orchards, and, I think, withstand the frosts better."
H. H. Hayes, *Talmadge.*	50 to 100 ft. higher than adjoin'g lands. Clay.	E.NE.	About 20 m. east of Lake Michigan.	Apples, peaches, and grapes.	Natural forest.	Protects trees from cold snaps.
J. N. Stearns, *Kalamazoo.*	Same level as adjoining lands. Gravelly loam.	W.	40 miles east of Lake Michigan.	Bush fruits and grapes.	Norway spruce hedges, 12 to 15 ft. high.	Holds snow, the protected "plants coming out much more fresh than those exposed." In summer, prevents wind from drying up the fruit.
R. J Coryell, *Jonesville.*	High, sndy loam. S.W. exposure.	S.W.	Inland.	Apples and bush fruits.	Nat. forest and row of deciduous trees.	On side next the windbreak, more healthy trees and fairer fruit.

L. D. Watkins, *Manchester.*	60 ft. above adjoining lands. Gravelly loam.	W.N.	Inland.	Apples and peaches.	Second growth forest.	Protects from cold. "Peach crop has failed but once in eight years. All orchards failed in this vicinity except these and a few protected trees."
J. Austin Scott, *Ann Arbor.*	——— ———	N.W.	Inland.	Apples and pears.	Norway spruce and arbor vitæ hedges.	Good.
J. D. Baldwin, *Ann Arbor.*	Very high. Clay.	N.W.	Inland.	Apples, pears and peaches.	Second growth forest and Norway spruce.	Good, for apples and pears.
D. G. Edmiston, *Adrian.*	Somewhat elevated. Strong clay loam.	S.W.	Inland.	Apples and pears.	Norway spruce.	Protected trees are healthier, and better shaped than others.
E. P. Allis, *Adrian.*	High. Heavy	W.N. SW.	Inland.	Grapes, cherries, quinces, bush fruits.	Apple orchard.	"I think it is a great advantage."

PARTIAL SUMMARY OF TABLE I.

BENEFITS EXPERIENCED.	Number of observers.	No. occupying high sites.	No. occupying comparatively low sites.	No. occupying light soils.	No. occupying clay or heavy loams.	No. evidently influenced by bodies of water.	No. evidently not influenced by bodies of water.
In general, ...	37	21	8	17	11	27	10
Protection from cold, ...	12	7	3	5	3	9	3
Lessening of windfalls, . . .	11	6	4	6	4	10	1
Retention of snow,	6	4	2	4	2	4	2

2.—Definite Observations which Favor Windbreaks.

OBSERVER.	Site and Soil.	Direction of prevailing and severest winds.	Location in reference to large bodies of water.	Kinds of Fruit observed.	Kind of Windbreak observed.	BENEFITS OBSERVED.
O. J. Weeks, *West Webster.*	In general.	—— ——	Very near Lake Ontario.	Apples and pears.	Forests and artificial shelter belts.	Fewer windfalls; "some years, more than one-half the entire crop" blowing off in exposed orchards, while few blow off in those well protected.
D. Bogue, *Medina.*	Clay loam.	—— ——	About 10 m. S. of Lake Ontario.	Pears, apples, cherries and plums.	Norway spruce hedge.	Fewer windfalls.
W. C. Almy, *Dundee.*	In general.	N.W.	3 m. west of Seneca Lake	In general.	Natural timber.	"Where the wind is very severe, a windbreak on the north and west would be very valuable."
A. Hammond, *Geneva.*	In general.	N.W.	N. end of Seneca Lake	In general.	In general.	Fewer windfalls. High ground on the west is "quite important in many respects."
A. S. Dyckman, *S. Haven, Mich.*	High. Sandy.	W.SW.	On E. shore of L. Mich.	Peaches.	Evergreen hedge	Prevents the blowing off of snow and sand.
C. J. Monroe, *S. Haven, Mich.*	In general.	W.SW.	On E. shore of L. Mich.	General.	Street trees.	"If all our highways were bordered with good rows of trees, we should find much advantage from them."

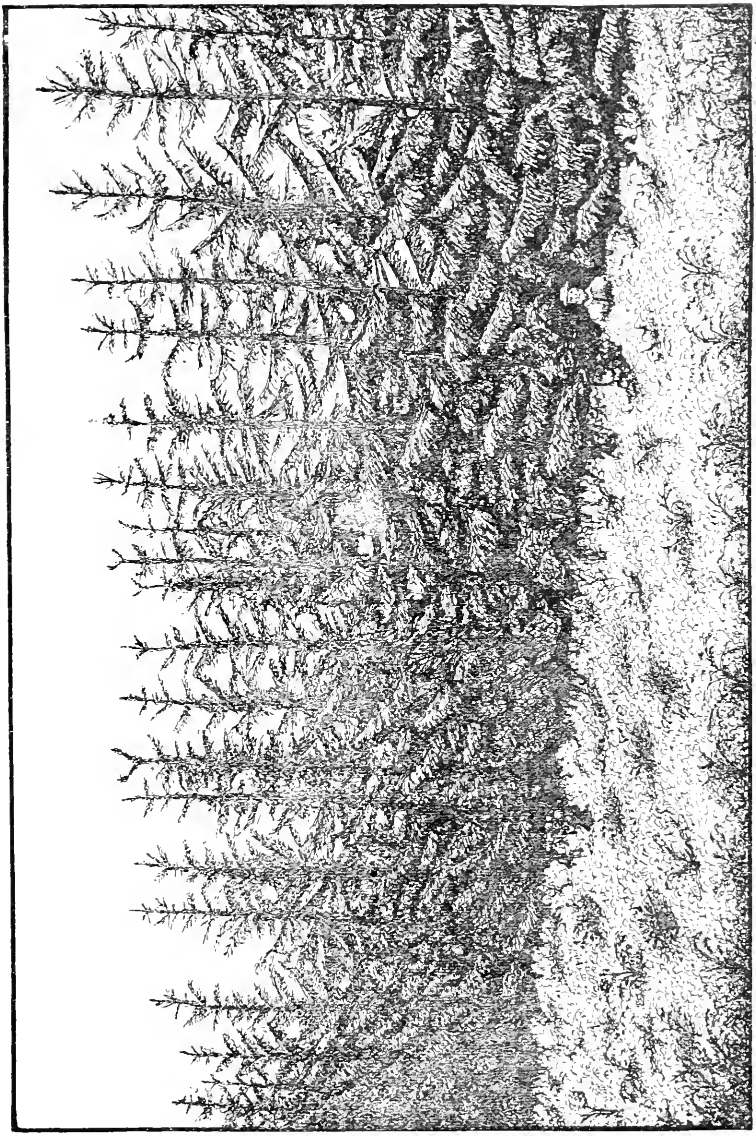

FIG. 2.—*A good Norway Spruce Windbreak, twenty-five years old.*

3.—Statements from Leading Authors.

It [the fruit garden] should be screened on the north and the east, either by high walls and fences, or, what is far better, either by hills or a deep and dense border of evergreen or other forest trees, intermixed with fruit trees and shrubs of ornament.—*Kenrick, New American Orchardist,* ix (1832).

As our native forests become cleared away the climate is changed and becomes more harsh; hence it is found desirable to construct some kind of protection from the point of most destructive harsh winds and storms. Belts of trees, either evergreen or diciduous, or both mixed, and surrounding or placed so as to screen from the northeast, north, and northwest, are considered highly advantageous.—*Downing, Fruits and Fruit Trees of America,* 54.

The atmospheric changes and conditions we cannot control, and we can modify them only in a very limited degree, by hedges, by timber belts, and by evergreen screens, the value of which begins to be appreciated.—*Warder, American Pomology,* 207.

In localities exposed to the sweep of winter winds, belts of evergreen or deciduous trees will be found of great service. In all instances where the side of an orchard, exposed to the prevailing winds, is less successful and productive than the opposite side, proof is afforded that shelter would be beneficial; belts, especially if of deciduous trees, standing too near fruit trees, have, however, rather injured than benefitted them. The orchard should be beyond the reach of their shade and roots, and be well exposed to sun and air.—*Thomas, Fruit Culturist, new ed.,* 48.

If possible, a situation should be chosen where some natural obstacle, as a hill, or a belt of woods, would break the force and influence of these destructive winds. Where no such obstacle naturally exists, a belt or border of rapidly growing trees * * * * should be planted simultaneously with the planting of the orchard. * * * Instances occur every year in our own section where sheltered orchards bear full crops, whilst those fully exposed to the winds fail entirely.—*Barry, Fruit Garden, new ed.,* 176.

Although having an orchard closely pent up by trees, etc., is injurious, nevertheless a screen of forest trees, at such distance from the fruit trees as that the latter will not be shaded by them, is of very great service in protecting the trees in spring from severe cold winds.—*Bridgeman, Gardener's Assistant, by Todd, II.* 39.

As the young wood and fruit buds [of the peach] often suffer from the piercing blasts of winter, a spot that is sheltered from these is much to be desired. And, as they usually come from the north and northwest, a site on the south or southeast of a wood or hill is, other things being equal, greatly to be preferred.—*Fulton, Peach Culture,* 68.

To shelter an orchard from the prevailing wind is often more important even than the aspect; for pear trees, especially when heavily laden with fruit and exposed to a wind storm, will suffer more injury from being shaken than from an ordinary late frost. * * * The evergreens should be planted in lines parallel with the pear rows, and they will more than pay for the ground they occupy in protecting the fruit trees from heavy gales.—*Quinn*, *Pear Culture for Profit*, 19.

It is within the power of man greatly to modify the character of a situation by the judicious planting of belts of evergreens, by a wise addition of elements and a proper culture of the soil, and by encouraging the shade of the vineyard itself wherever circumstances indicate its necessity.—*Strong*, *Culture of the Grape*, 101.

In general, it will be found necessary to secure protection on the west, north, and northeast. * * * No defense is better than a good belt of Norway spruce, and if they form a crescent in which the vineyard is embowered, but little danger need be apprehended from violent winds.—*Phin*, *Open Air Grape Culture*, 40.

If the land has no protection from the north and northwest, see what the facilities are for supplying one either by walls or a belt of trees. If trees are to be used, evergreens are best.—*Fuller*, *Grape Culturist*, 89.

The location [for the vineyard] should be sheltered from the cold winds from the north and northwest.—*Husman*, *Culture of the Native Grape*, 43.

EPITOME OF BENEFITS DERIVED FROM A WINDBREAK,

Stated somewhat in order of importance.

1. A windbreak may protect the plantation from cold.
2. Reduces evaporation from the surface of the soil, tending to mitigate drought in summer, and root injury in winter.
3. Lessens windfalls.
4. Lessens the breaking of trees which are laden with fruit or ice.
5. Retains snow and leaves, thus tending to prevent deep freezing and excessive evaporation.
6. Facilitates labor in the fruit plantation.
7. Protects blossoms from severe winds.
8. Enables trees to grow straighter than if exposed.
9. Reduces injury from the drying of small fruits on the plants.
10. Holds the sand in certain sections.
11. Sometimes causes fruits to ripen earlier.
12. Encourages birds.
13. It can be made an ornament.

4.—Experiences Adverse to Windbreaks.

OBSERVER.	Site and Soil.	Direction of Prevailing and severest winds.	Location in reference to large bodies of water.	Kinds of fruit grown.	Kind of Windbreak.	INJURIES SUSTAINED.
H. M. Jaques, *Lockport.*	— —	SW.	About 10 m. So. L. Ont.	Apples and Pears.	Natural forest on North.	"Apples next the woods are poor color and very wormy."
S. D. Redman, *Newfane.*	Level. Gravelly loam.	W.SW.	Very near L. Ontario.	Quince.	Norway spruce hedge on E. W. and N.	"Have not been able to detect any difference in trees or fruit from those not so protected."
Julius Harris *Ridgeway.*	Sandy loam.	W.	About 5 m. South Lake Ontario.	Apples and Peaches.	Natural forest.	Next the windbreak, trees less thrifty and apples fall more and earlier.
Geo. Catchpole, *North Rose.*	Same level as adjoining land. Sandy and clay loam.	W.	Aoout 5 m. South Lake Ontario.	Apples and Peaches.	Natural forest on East, North, and West.	"The more windbreaks, rail fences, brush, and other matter, the more insects."
Oscar Weed, *North Rose.*	— —	W.	About 5 m. South Lake Ontario.	Apples.	Natural forest on West.	"The trees along the woods for several rows were more infested with worms than the balance of the orchard and bore less fruit."
C. H. Hess, *Castile.*	Somewhat elevated. S. and E. exposure. Gravelly loam.	W.NW.	Inland. About 4 m. S. of Silver Lake.	Apples.	Natural forest on North and North West.	"It has been very noticeable that the fruit grown on the part of the orchard toward the piece of woodland is always wormy, knotty, and inferior, never suitable for barrelling."
N. J. Edmunds, *Brockport.*	High. Sandy loam.	W.	About 10 m. South Lake Ontario.	Peaches and Apples.	Natural forest.	"The best results in both apples and peaches were where the trees were most exposed to the wind and sun, and the poorest within ten rods of the forest."
M. F. Varney, *North Collins.*	— —	SW.	About 8 m. East Lake Erie.	Grapes.	Natural forest.	"Have noticed some times that grapes do the best where the wind is least broken."
W.G. Ellwanger, *Canandaigua.*	High.	W.SW.	On Canandaigua Lake.	Peaches.	— —	"I find that for peaches it is best to have no protection."

5.—Definite Observations Adverse to Windbreaks.

OBSERVER.	Site and Soil.	Direction of Prevailing and severest winds.	Location in reference to large bodies of water.	Kinds of fruit observed.	Kind of Windbreaks observed.	INJURIES OBSERVED.
W. Hopkins, *Lewiston.*	In general.	W.SW.	On Niagara R. about 8 m. So. L. Ont.	Apples and Peaches.	In general.	Fruit more wormy.
J. A. Root, *Skaneateles.*	In general.	——	On N. end of Skaneateles Lake.	In general.	In general.	"Late spring frosts do far more damage to grapes, peaches, etc., in a protected location than where the wind has free play."
A. S. Dyckman, *So. Haven, Mich.*	High. Sandy.	W.SW.	On E. shore of L. Mich.	Peaches.	Natural forest.	"More frosty."
Members of Grand R. Valley Hort. Society, *Grand Rapids, Mich.*	High. Gravelly.	W.	About 25 m. East of Lake Michigan.	Peaches.	In general.	"W. N. Cook, Chas. W. Garfield, S. M. Pearsall, and John Pailow were all agreed that windbreaks are not desirable, as a cold wave is likely to settle down on trees when immediately under the shelter, which those farthest away have escaped."
W. N. Cook, *Grand Rapids, Mich.*	In general.	W.	About 25 m. East of Lake Michigan.	Peaches.	In general.	"In the summer following the cold winter of 1872–3, I travelled over a large part of Kent and adjoining counties and closely observed the influence of windbreaks. Wherever peach trees were situated on the east side of such timber belts, they were all killed, and the Baldwin apple fared little better; while on exposed places of the same elevation the trees were alive and often bearing fruit. I saw several peach orchards with protecting thickets on the east, and they were uninjured."

J. A. Pearce, *Grand Rapids, Mich.*	High.	SW.	About 25 m. E. of Lake Michigan.	Peaches.	— —	Trees killed by cold winters next the windbreak.
J. F. Fitzsimmons, *Hillsdale, Mich.*	— —	SW. W. NW.	Inland.	— —	Natural forest.	"Have known orchards protected by woods on NW. and W. to do well, and have known them to do equally well without protection. Do not believe that a single windbreak is of any advantage."

EPITOME OF INJURIES SUSTAINED IN CONSEQUENCE OF A WINDBREAK.

1. A windbreak may render a plantation colder at certain times.
2. Fruit immediately adjoining the windbreak is apt to be much injured by insects and diseases, and to be small and inferior in color.
3. Trees immediately adjoining the windbreak are often less thrifty than others.
4. There may be greater damage from late spring frosts in sheltered plantations.

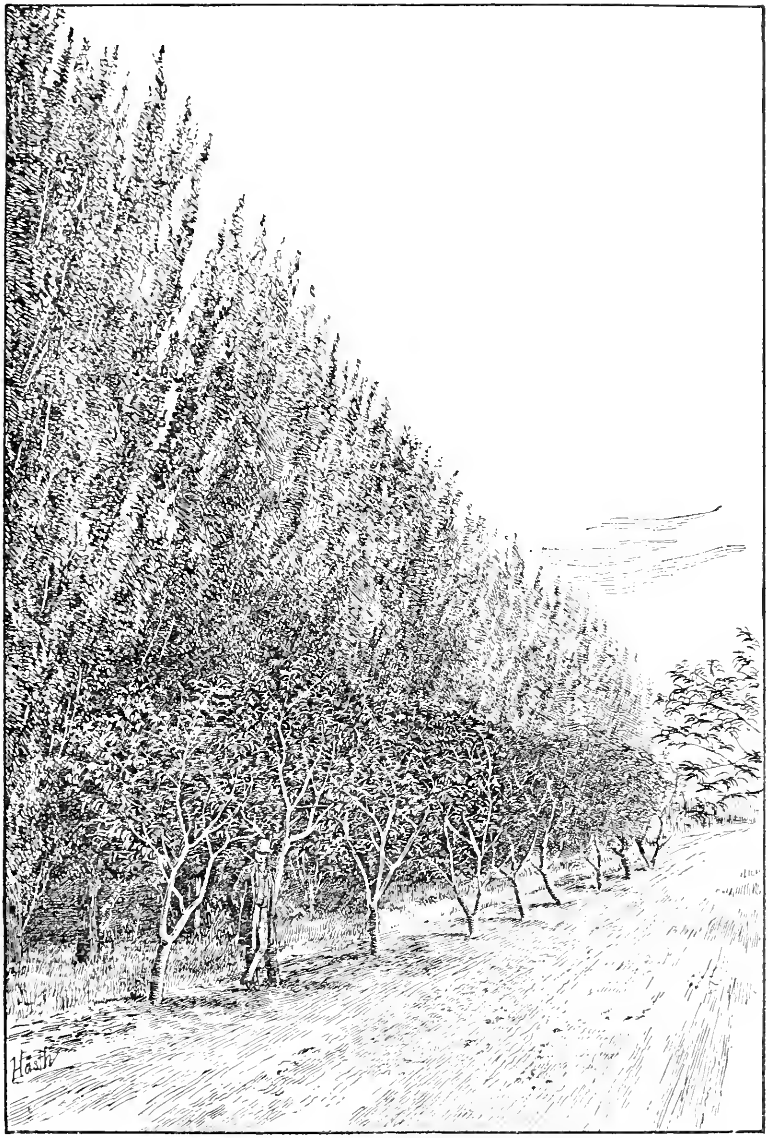

FIG. 3.—*A Lombardy Poplar Screen, eleven years old, for the protection of a Peach orchard.*

REVIEW OF THE INFUENCES OF WINDBREAKS UPON FRUIT PLANTATIONS.

The benefits derived from windbreaks are numerous, positive in character, and appear to possess sufficient importance to warrant the strongest recommendations of horticultural writers. Yet the injuries occasionally sustained in consequence of shelter belts may be serious, for it is a well attested fact that trees sometimes suffer from cold in the immediate vicinity of a dense windbreak when they escape injury in other places. This fact is easily explained, however. The influence of a windbreak upon the temperatures of an adjacent plantation is governed by its position with reference to prevailing or severe winds. Of itself, wind probably exerts little or no influence upon temperature. It acquires the temperature of surfaces over which it passes. If these surfaces are colder than the given area, cold winds are the result, or if warmer, as a large body of water, the winds are warm. But wind often causes great injury to plants because of its acceleration of evaporation; and winds which are no colder than the given area, if comparatively dry, may consequently do great damage to fruit plantations. This is particularly true at certain times during the winter season. Land winds, being cold and dry, are therefore apt to be dangerous, while winds which traverse large bodies of water, and are therefore comparatively warm and moist, are usually in themselves protectors of tender plants. The following table, giving the average temperatures of different winds at New Haven, Connecticut, as compared with the mean temperature of that place, shows that those winds which blow off the Sound are much warmer than the land winds*:

Direction of wind.	Average above the mean temp.	Direction of wind.	Average under the mean temp.
Southwest, . .	+ 4°	Northeast, . .	— 0.6°
South, ...	+ 3.2°	West, ...	— 1.1°
Southwest, . .	+ 1.2°	North, ...	— 2.7°
East, ...	+ 0.5°	Northwest, . .	— 4.5°

* Loomis' Meteorology, 88.

The mitigating influence of bodies of water is familiar ; the following figures will serve to show the extent to which they modify the mean temperatures of the four coldest months† :

A.—IN NEW YORK.

STATIONS.	Dec.	Jan.	Feb.	Mar.	Average	Latitude.	Elevation.	Period of observation
Fredonia,	30.8	28.7	27.4	35.3	**30.55**	42.26°	709 ft.	1830–1848.
Rochester,	28.5	26.0	26.4	33.1	**28.5**	43.07°	506	1830; 1833–1853.
Auburn,	29.5	24.4	24.6	33.5	**28.0**	42.55°	650	1827–1849.
Utica,	26.8	23.3	23.4	32.3	**26.45**	43.06°	473	1826–1848.

B.—IN MICHIGAN.

STATIONS.	Dec.	Jan.	Feb.	Mar.	Average	Latitude.	Elevation.	Period of observation
Detroit,	26.9	27.0	26.6	35.4	**28.97**	42.20°	580 ft.	1836–1846; 1849–1851.
Fort Gratiot,	26.6	25.3	25.3	33.2	**27.6**	42.55°	598	1830–1846; 1849–1852.
Battle Creek,	27.0	24.1	22.6	33.7	**26.85**	42.20°	800	1849–1855.
Ann Arbor,	25.3	23.6	21.0	32.7	**25.65**	42.15°	700	1854–1855.

It will be seen that the warmest stations are in most intimate connection with large bodies of water: Fredonia is on Lake Erie, Rochester near Lake Ontario, Auburn near the Central New York lake region. and possibly within the influence of Lake Ontario, while Utica is farther inland. Similar observations might be made concerning the Michigan stations. Temperatures of the coldest days would show much greater differences.

It should be observed that the influence of a body of water is not governed by its proximity, but by elevation of the land and direction of winds. Grand Rapids, Michigan, although about twenty-five miles from Lake Michigan, is greatly influenced by it.

It is evident that if a windbreak stops or deflects a warm wind, it may prove injurious. A still place in the lee of the windbreak may therefore be the coldest part of the plantation. So far as the

† Compiled from Blodget's Climatology of the United States, 38.

writer is able to learn, this sort of injury from windbreaks is confined to those regions which are directly influenced by bodies of water. The eastern shore of Lake Michigan has furnished many examples. Most growers in that region demand a free circulation of air from the lakeward, while desiring protection from the east. (Cf. Mr. Cook's letter in Table V.) This experience, however, does not argue that windbreaks should be entirely abolished on the lakeward sides of plantations, but that such breaks should be thin enough to allow of the passage of wind, while breaking its force. In such places, a windbreak should be what its name implies, a wind-break, not a wind-stop.

The advantages of windbreaks in lessening windfalls, and in preventing the breaking of trees do not appear to be sufficiently understood. In sections which are influenced by large bodies of water, or when the fruits grown are sufficiently hardy to endure the most trying winds, these are the chief advantages of shelter belts, and are ample reason for planting them. The greater facility with which labor can be performed in windy weather, under the protection of a windbreak, is worth consideration.

The injuries sustained through the greater abundance of insects immediately adjoining the windbreak, are easily overcome with the modern spraying devices. There are many instances in which the windbreak lessens the vigor of one or two adjoining rows of fruit trees, but such injury appears to occur only where cultivation is poor, or where the windbreak has already obtained a good foothold when the fruit is set. The writer has examined a number of excellent plantations this year in which the rows next the windbreak are as vigorous and productive as any in the orchard. In fact, a number of good observers declare that best fruit and greatest productiveness occur next the windbreak. Figures 2 and 3, show, respectively, thrifty raspberries and peaches next the windbreak.

The following, from T. G. Yeomans and Sons, Walworth, Wayne Co., New York, who have had extensive and pronounced experiences with windbreaks, is a judicious statement of the advantages to be derived from shelter belts :

"We have been extensively engaged in fruit culture for over forty years, and now have in bearing about 130 acres of apple orchard, 10 acres of dwarf pears, 10 of orange quince, and small fruits. For many years we have experimented with windbreaks, and now have many artificial shelter belts of various kinds and ages, the oldest having been planted nearly thirty years. We consider windbreaks to be of the greatest value to fruit culture, and we are confident that most fruit-growers do not realize their importance. They protect the trees and plants at all seasons, and prevent windfalls to a great extent. Orchards thus protected in this region are more productive, more uniform, and longer lived than others. They render labor among the trees and plants much easier in windy days, and enable men to work in very windy weather, when otherwise it would be impossible. We have always succeeded in raising good fruit close to the windbreak. * * * We consider land devoted to shelter belts as very profitable investment, even to ordinary farm crops. We should not attempt to grow dwarf pears, orange quinces, or raspberries, without shelter of some sort."

II. PROPER LOCATION, AND MANNER OF MAKING WINDBREAKS.

1. THE LOCATION.

The answer to this printed question must vary greatly with circumstances, and with the kind of fruit. Some localities are greatly exposed to prevailing winds; others are screened by hills or sheltered in depressions and do not need screens. But our hardiest fruits are better off with some protection.—*J. J. Thomas, Union Springs.*

Where we have occupied grounds with a western exposure, we have usually planted lines of Norway Spruce on the western border. * * * How to avoid the severity of the west winds has been a constant study with us.—*Patrick Barry, Rochester.*

Wherever the orchards or small fruit plantations would otherwise be exposed to strong winds.—*W. T. Mann, Barker's.*

Where the wind has a sweep of a mile or more.—*B. W. Clark, Lockport.*

Under all circumstances with which we are acquainted. Peach trees should not be planted nearer than 5 rods from a dense windbreak, or the drifting snow will break them down. Apple trees may be planted some nearer.—*Geo. W. Dunn, Pierce's.*

Should plant windbreaks for all fruits except apples. No telling the good a windbreak will do.—*C. H. Perkins, Newark.*

Where there is a long exposure to west and southwest winds.—*A. I. Hulett, Rochester.*

Under all circumstances where ground is exposed to severe winds.—*Irving Rouse, Rochester.*

In all bleak locations; also to a moderate extent as ornaments and for general protection.—*S. C. Davis, Medina.*

Where an orchard has a northern and western exposure.—*E. B. Norris, Sodus.*

1st. Where it is impossible to get a good exposure; 2d, where fruit is planted which is especially liable to loss from wind, as King apples or Duchess pears.—*H. J. Peck, Seneca Castle.*

Upon a site that is exposed to a cold and bleak north or west wind.—*C. W. Pierson, Waterloo.*

Where orchards and fruit plantations are so situated as to be exposed to cold bleak winds; in fact, in all exposed places I have no doubt windbreaks are very beneficial.—*Anthony Lamb, Syracuse.*

On all elevated, exposed locations, in order to hold the snow more evenly over the land and to prevent the evaporation that takes place rapidly with a high wind. Also to furnish nesting places for birds.—*Geo. T. Powell, Ghent.*

In all windy places.—*D. Bogue, Medina.*

Where the wind is very severe, a windbreak on the north and west would be very beneficial.—*Wm. C. Almy, Dundee.*

In exposed places where sandy ridges are liable to blow away.—*A. S. Dyckman, South Haven, Mich.*

I would set nut-bearing trees on the north and west of all fruit orchards, for protection and for the nuts.—*S. M. Pearsall, Grand Rapids, Mich.*

Where the snow blows off.—*Geo. C. McClatchie, Ludington, Mich.*

I would recommend them wherever land is exposed to raking winds, first, for retaining snows on the ground, second, to protect fruit from winds.—*J. F. Taylor, Douglas, Mich.*

In my situation, I should want the windbreak some 40 to 80 rods from the orchard on the west, and extend to the north. Do not think it would be safe to plant one close upon the west side of my orchard for fear of still air settling down over the break.—*H. H. Hayes, Talmadge, Mich.*

For all small fruits especially, for all soils and localities.—*J. N. Stearns, Kalamazoo, Mich.*

Where the land slopes to the prevailing wind. Should want it only high and thick enough to break the force of the wind, not to produce a dead calm.—*R. J. Coryell, Jonesville, Mich.*

In all exposed situations.—*L. D. Watkins, Manchester, Mich.*

Would plant my hedge on the side where most exposed to high winds.—*J. Austin Scott, Ann Arbor, Mich.*

Wherever the grounds are exposed to the south and west winds.—*D. G. Edmiston, Adrian, Mich.*

Epitome.—It appears that a windbreak is desirable wherever the fruit plantation is exposed to strong winds. In order to prevent possible injury from too little circulation of air in certain localities, particular care should be exercised in the construction of the windbreak (cf. next section). The west, southwest, and north winds are the ones which need greatest attention in general.

2. CHARACTER OF A GOOD WINDBREAK.

We have usually planted lines of Norway Spruce on the western border. Sometimes a line of European larch is planted with the spruce. These and the Scotch and Austrian and white pine are all good for windbreaks.—*Patrick Barry, Rochester.*

Evergreens are certainly preferable to deciduous trees. Judging from observation, Norway spruce in single row planted two feet apart is best.—*W. F. Mann, Barkers.*

We should recommend the Norway spruce planted in a single row from six to eight feet apart, or set four feet apart and every other one removed in a few years. If the location is much exposed, we would recommend a row or two of maples on the windward, set from eight to ten feet apart in the row, the rows being from ten to fourteen feet apart.—*T. G. Yeomans and Sons, Walworth.*

The best kind I ever used or saw was a good Norway spruce hedge set close enough together to make a tight break, and trimmed back until they had formed a tight hedge at least ten feet high.—*E. B. Norris, Sodus.*

I do not believe that a solid windbreak would be desirable, as a circulation of air is necessary. We need only to break the power and force of the wind.—*Geo. T. Powell, Ghent.*

Evergreens,—Norway spruce, Austrian pine, Scotch pine, etc.,—planted in wide belts and not to close, but irregularly, something like nature.—*A. Hammond, Geneva.*

Something tall but not too thick, that will allow a free passage of wind but moderate its force. I have some faith in Lombardy poplar trees for this purpose.—*A. S. Dyckman, South Haven, Mich.*

Norway spruce every time, set four feet apart. Keep well sheared, and you can have a perfect hedge as high as 20 or even 30 feet.—*J. Austin Scott, Ann Arbor, Mich.*

Epitome.—From a general study of the subject, it appears that in interior localities dense plantings are advisable, tight hedges being often recommended. In localities influenced by bodies of water, however, it is evidently better practice to plant a belt simply for the purpose of breaking or checking the force of the warmer winds, still allowing them to pass in their course. Such a belt gives the desired shelter to trees when laden with fruit and ice, and may hold the snow, while danger from comparatively still air is averted. The damage from still air is usually observed in the lee of natural forests, and it is in such places that injury is reported by Michigan correspondents. The writer has found no indisputable evidence to show that such injury ever accompanies artificial windbreaks; places where such injury was reported have been visited, but the loss of trees and fruit was plainly due to age of trees or other obvious reasons. Still, it is probable that a hedge-like windbreak may sometimes be the cause of mischief.

The coarser evergreens, planted close together, are therefore advisable for interior places, while deciduous trees, or evergreens somewhat scattered, are often better for the lake regions. In these latter cases, however, the lay of the land is important, for if atmospheric drainage is good there is less danger of injury from tight belts. Lower levels, upon which cold air settles, are therefore more in need of open belts than higher lands. For interior places, a strip of natural forest is the ideal windbreak. In artificial belts, the kind recommended by Messrs. Yeomans, and illustrated in Fig. 1, is undoubtedly one of the best. The illustration shows two rows of maples backing up a row of Norway spruce. "The maples then receive and break the force of the wind and prevent the spruces from becoming ragged. We never shear the spruces."

Our correspondents have advised the following trees for shelter belts :

	Recommended by		Recommended by
Norway spruce,	25 persons.	Hemlock spruce,	1 person.
Austrian pine,	5 "	Arbor vitæ,	1 "
Scotch pine,	3 "	Nut-bearing trees,	1 "
White pine,	2 "	Hard maple,	1 "
Native deciduous trees,	2 "	Elm,	1 "
Lombardy poplar,	2 "	Basswood,	1 "
European larch,	1 "	Willows,	1 "

GENERAL SUMMARY.

1. A windbreak may exert great influence upon a fruit plantation.

2. The benefits derived from windbreaks are the following : protection from cold ; lessening of evaporation from soil and plants ; lessening of windfalls ; lessening of liability to mechanical injury of trees ; retention of snow and leaves ; facilitating of labor ; protection of blossoms from severe winds ; enabling trees to grow more erect ; lessening of injury from the drying up of small fruits ; retention of sand in certain localities ; hastening of maturity of fruits in some cases ; encouragement of birds ; ornamentation.

3. The injuries sustained from windbreaks are as follows : Preventing the free circulation of warm winds and consequent exposure to cold ; injuries from insects and fungous diseases ; injuries from the encroachment of the windbreak itself ; increased liability to late spring frosts in rare cases.

a. The injury from cold, still air is usually confined to those localities which are directly influenced by large bodies of water, and which are protected by forest belts. It can be avoided by planting thin belts.

b. The injury from insects can be averted by spraying with arsenical poisons.

c. The injury from the encroachment of the windbreak may be averted, in part at least, by good cultivation and by planting the fruit simultaneously with the belt.

4. Windbreaks are advantageous wherever fruit plantations are exposed to strong winds.

5. In interior places, dense or broad belts, of two or more rows of trees, are desirable, while within the influence of large bodies of water thin or narrow belts, comprising but a row or two, are usually preferable.

6. The best trees for windbreaks in the northeastern states are Norway spruce, and Austrian and Scotch pines, among the evergreens. Among deciduous trees, most of the rapidly growing native species are useful. A mixed plantation, with the hardiest and most vigorous deciduous trees on the windward, is probably the ideal artificial shelter belt.

L. H. BAILEY.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

HORTICULTURAL DEPARTMENT.

X.

OCTOBER, 1889.

Tomatoes.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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Those desiring this Bulletin for friends, will send us the names of the parties.

Cornell University Experiment Station,
Ithaca, N. Y.

PLATE I.

IGNOTUM. Two thirds natural size

NOTES OF TOMATOES.

I. CULTURE.

Perhaps the most frequent and noteworthy observation made upon the culture of the tomato during several years of experimentation with the plant, is the great increase in vigor and productiveness which comes from careful handling and good tillage. It often appears as if this vigor is not only characteristic of the immediate generation, but that it is hereditary for a time to a profitable degree. "Handling" or transplanting of young plants, when frequently and properly done, is invaluable, and so far as the plant is concerned three or four transplantings are better than one. In our own work, in order to get the greatest results from tests, the plants are handled in pots—preferably rose pots—and are transplanted several times. The handling is expeditious, and is not too expensive for the use of any one who grows tomatoes for home use. For market culture we find that two transplantings are usually profitable. Stocky plants, vigorous and growing rapidly, are better than simply early plants, however, and frequency of transplanting in these remarks must not be confounded with early sowing and consequent necessity for several shiftings. Tomato plants—or any plants, in fact—should not be shifted for the simple purpose of preventing crowding or "drawing." Transplanting serves the purpose of maintaining a steady and symmetrical growth, and it should occur before the plant becomes checked from neglect. A good tomato plant, at time of setting in field, is one which is stocky enough to hold the weight of the earth and pot when a number of plants are grasped in the hand by their tops and are carried along the rows. They require no staking when set. A tall and weak plant with a blossom on the top we do not consider worth setting. It is a common mistake to set tomato plants in the field too early. Cold nights, even though several degrees above frost, check the plants, sometimes seriously.

How early the plants should be started for profit is a question which demands attention. A few writers have maintained of late that nothing is gained in earliness and productiveness by early starting under glass. This is undoubtedly true if the early plants are not well grown, but our experience is quite to the contrary with stocky and vigorous plants. But if this increase is worth what it costs is a question which must be answered by every grower for himself. The following figures show the increase in earliness and productiveness due to early sowing, there having been in each instance, unless otherwise recorded, eleven plants under trial :

VALUE OF EARLY SOWING.

VARIETY.	SEEDSMAN. 1889.	Date of Sowing.	Date of first six ripe fruits.	Average yield per plant
Acme,	Thorburn.	March 21.	Aug. 29.	14.3 lbs.
—	Livingston.	April 15.	Sept. 9.	4.6 "
—	Livingston.	May 15.	— 13. (18 plants.)	1.6 "
Optimus,	Thorburn.	March 21.	Aug. 24. (12 plants.)	12.7 "
—	Ferry.	April 10.	Sept. 2.	12.5 "
Paragon,	Thorburn.	March 21.	Aug. 21.	10.2 "
—	Livingston.	April 15.	Sept. 13.	5.6 "
Favorite,	Thorburn.	March 21.	Sept. 2. (12 plants.)	9.3 "
—	Livingston.	April 15.	Sept. 4.	9.5 "
Cincinnati Purple,	Ferry.	April 10.	Sept. 4.	14. "
— —	Ferry.	May 15.	Oct. 2. (10 plants.)	5.9 "
King of Earlies,	Johnson & Stokes.	April 12.	Aug. 17.	27.5 "
— —	Johnson & Stokes.	May 15.	Sept. 10.	5. "
Tom Thumb,	Rawson.	April 10.	Sept. 2.	4.5 "
—	Rawson.	May 15.	— 10. (9 plants.)	2.9 "
Perfection,	Thorburn.	March 21.	Sept. 2.	14.8 "
—	Henderson.	— 22.	Aug. 29.	10.3 "
—	Livingston.	April 15.	Sept. 4. (13 plants.)	10.3 "
Beauty,	Thorburn.	March 21.	Aug. 29.	13.8 "
—	Livingston.	April 15.	Sept. 9.	12.4 "

These figures indicate that in every instance the early sown plants gave earlier fruits than the others, and that in every case but one, in which the yields were practically the same, the total yield is much greater. The gain in earliness sometimes amounts to three or even four weeks. The disadvantage of very late planting—middle of May—is particularly pronounced, especially in point of productiveness. This productiveness, however, is really a measure of earliness inasmuch as it simply records the weight of fruit which had ripened up to October 10th, when the tomato season was closed by frost. Could the season have been sufficiently extended, no doubt the ultimate productiveness of the various plantings would have been the same. A part of the test is at fault from the fact that the variety in its different sowings was sometimes obtained from different sources, and there is possibility of variation in stock. Yet the varieties are such as are pretty clearly defined and therefore not liable to mixture, and there is substantial uniformity in results. Four of the varieties, however— two sowings of Acme, Cincinnati Purple, King of the Earlies, and Tom Thumb—were sown from the same packet.

It is a common notion, to which the writer has heretofore subscribed, that soils containing little or no manure are preferable to well enriched soils for tomato growing. It is supposed that rich soils tend to make vine at the expense of fruit, causing lateness of maturity and consequent lessening of yield; and the supposition is prevalent that rich soils tend to make fruits "rougher" or more irregular in shape. A careful test upon these points has been made during the present season. Three plats were set aside and treated as follows:

I. 60x30 ft., good rich garden soil, to which 5,460 lbs. of old and fine stable manure was added when the land was plowed in spring. The plat contained 78 plants of Ignotum.

II. 55x30 ft., adjoining I, considerably poorer in character, some of the surface soil having been removed, upon which 8 lbs. of nitrate of soda was sown soon after the plants were set. 66 plants of Ignotum.

III. 50x30 ft., poor soil, adjoining II, from which most of the rich surface soil had been removed. It received no fertilizer of any kind. 60 plants of Ignotum.

The three plats were planted and tilled alike. From the first there was great difference in appearance of the different areas. The plants on the heavily manured plat were uniformly most vigorous and largest. The nitrate of soda plantation gave stocky plants of medium size with a very dark color of foliage. The unfertilized plat gave small plants with a light cast to the foliage. Fig. 1, plate II, illustrates admirably the difference in size and vigor between plats I and III.

The first ripe fruits were found on plat III, but there were only two on the whole patch which ripened in advance of plat I, and the difference amounted to but a day. At the first picking, plat I produced by far the most fruits, and they were in every way superior to those from the other plats. During the whole season plat I continued to hold its superiority. In point of earliness plats II and III were about the same.

On October 10th the average total yield per plant was as follows:

Plat I, heavily manured, 12.7 lbs.
II, nitrate of soda, 9.1 lbs.
III, no fertilizer, 6.8 lbs.

There was a marked difference between plats I and III in the shape of the fruits. The Ignotum is the "smoothest," most regular, of our large tomatoes, yet on the unfertilized plat the fruits showed a decided tendency to become angled. Fig. 2, plate II, is a faithful representation of this tendency. The cut on the left shows representative fruits from plat III, while the other cut shows fruits from plat I. It will be interesting to determine if this variation shows any tendency to become hereditary.

It is evident, from the foregoing facts, that heavy manuring for tomatoes may result in decided benefits; yet it is possible that the character of the soil or season may have much to do with the behavior of the plants under these conditions. The soil upon which this test was conducted is a high gravelly loam which had been well enriched for a number of years. The season was very wet, yet the plats never suffered from too much water. As a whole, the season has been a cold one.

The manuring of plat I was excessive, nearly three tons of good manure having been applied to a space 60x30 ft., which was already rich. It is important to determine if this excessive fertilizing gives better results than ordinary treatment. An area adjoining plat I, and similar to it in fertility, was also planted to Ignotum. This area, in common with the general tomato plantation, was given a good dressing of stable manure,—one fourth or less as copious as that given plat I. These plants were similar to those in plat I in earliness, and the average total yield per plant was 12.5 lbs., or only about three ounces less than in the very heavily manured patch. The gain due to the very heavy dressing is therefore not sufficient to pay for the extra cost. But if excessive manuring does not greatly increase yield, neither does it always tend to an unprofitable production of vine at the expense of yield and earliness, as is commonly supposed.

II. VARIETIES.

The tomato is one of the most variable and inconstant of kitchen garden plants. As a rule, varieties differ but slightly from their allies, and a considerable plantation and a critical eye are needed to determine many of even the common sorts. It is certainly true that at least half of the varieties which have been offered in the last few years are practically the same as other varieties.

Varieties of tomatoes are as a rule short lived. Ten years may be considered the average profitable life of a variety, and many sorts break up and disappear in two or three years. This inconstancy of type is largely due, no doubt, to the haste with which new sorts are put upon the market. A variety should be selected and carefully handled for some time before it is offered to the public.

Almost any of the old sorts afford instances of the running out of varieties. The Tilden tomato, once popular, appears to be extinct. Only two seedsman in the country advertised the variety last spring, and neither one, as shown by our tests, had the Tilden of fifteen years ago. One of the samples gave us a small round tomato, late in ripening, and much resembling small sorts of the Red Apple kind. The other gave us a somewhat larger angular tomato. In 1887 the writer made an effort to secure the Tilden, but only inferior fruits were obtained. The record of that test is as follows: "This variety, once so popular, appears to have run out. As grown this year, the fruits are very small, irregular and worthless. Last year [1886] the fruits were somewhat larger, though smaller than Hathaway. When first introduced, now many years ago, it was a large tomato." * Mr. W. W. Tracy of Detroit, an expert in the seed trade, informs me that he has tried in vain for two or three years to secure true stock of the Tilden. The Trophy shows the same tendency to become inferior, and it is difficult to procure a good stock of it. In the test of 1887 this fact was noticed. "The Trophy is evidently not so good as formerly. Our crop this year, from seeds of last year's crop, showed a much greater per cent. of poor fruits than the crop of 1886." † Paragon begins to show the same weakness.

* Bailey, Bull. 31, Mich. Agr. Coll. 22.

† Ibid. 21.

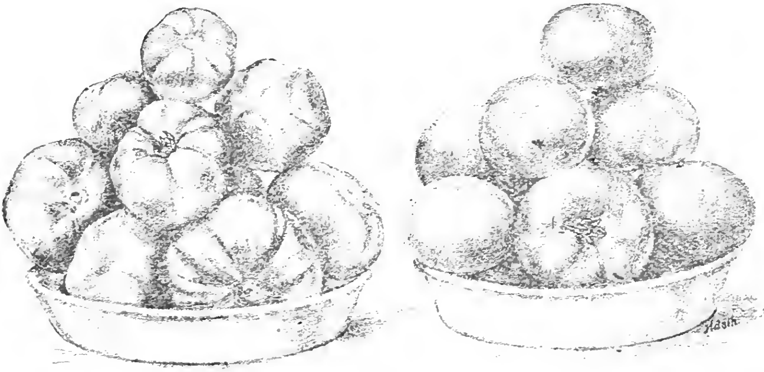
The demand in tomatoes now calls for fruits which are regular in shape, solid, large, and plants which are productive. The old angular sorts are rapidly disappearing in commercial practice. There has been no gain in earliness, for the species, for many years if at all, and little, if any, need be expected. The cherry and plum sorts, with a few of the angular-fruited and wrinkled-leaved varieties, are still our earliest sorts. Yet comparative earliness between commercial varieties is an important consideration. There is also no gain in capability to resist rot: the cherry, plum, and angular sorts are still most exempt, the cherry and plum varieties entirely so. The scale of points for a perfect tomato will probably run about as follows:

Vigor of plant, ...	5
Earliness, ...	10
Color of fruit, ...	5
Solidity of fruit, ...	20
Shape of fruit, ...	20
Size of fruit, ...	10
Flavor	5
Cooking qualities, ...	5
Productiveness, ...	20
	100

To measure varieties of tomatoes by a scale of points is an exceedingly difficult matter, however, from the fact that it is almost impossible to measure solidity, cooking qualities, and, to a less degree, flavor. Solidity is perhaps the most important point in market varieties, yet it cannot be definitely expressed either in figures or words. An attempt was made to find a measure for it, and at the same time to make a comparison in this respect of a few leading varieties. For this test, five representative fruits of a variety were selected, weighed, and then placed in a graduated beaker filled with water. The displacement which occurred, that is, the amount of water which flowed over the beaker when the tomato was inserted, gave an accurate measure of the volume of the fruit. By dividing the volume by the weight, a ratio is constructed. The following table is a record of such tests, and the third column of figures affords a means of comparison:

PLATE II.

Fig. 1.—U[illegible]



[illegible]—F[illegible]

WEIGHT OF FRUITS.

VARIETY.	SEEDSMAN. 1889.	Weights.	Volume. Fluid Ounces.	Ratio of Volume to Weight.
Ignotum . . .	Michigan Agr'l	9.5 oz.	7.75 oz.	
	College.	9. "	6.5 "	
		14. "	10 75 "	
		12. "	10. "	
		8. "	6.5 "	.790
Optimus, . . .	Ferry.	7. "	5.25 "	
		8. "	6.75 "	
		6. "	4.5 "	
		6. "	4.5 "	
		6. "	4.25 "	.765
Optimus, . . .	Thorburn.	5. "	3.5 "	
		9. "	7. "	
		7.5 "	5.5 "	
		7. "	4.75 "	
		6.5 "	4.25 "	.714
Queen, ...	Henderson.	8. "	6.75 "	
		7.5 "	6. "	
		8. "	6.5 "	
		4. "	2.75 "	
		5.25 "	4. "	.793
Puritan, ...	Thorburn.	4.5 "	3. "	
		9. "	7. "	
		8.5 "	6.75 "	
		4. "	2.75 "	
		4. "	3. "	.75
Volunteer, . . .	Burpee.	5. "	3.5 "	
		4.5 "	3.25 "	
		6. "	4. "	
		4.5 "	3. "	
		4. "	2.25 "	.666
Favorite, . . .	Livingston.	6. "	4.5 "	
		5. "	4. "	
		4.5 "	4.5 "	
		4.5 "	3.5 "	
		4. "	3.25 "	.823
Favorite, . . .	Thorburn.	9.5 "	8.4 "	
		7. "	5.5 "	
		6.5 "	5. "	
		5. "	3.75 "	
		4.5 "	3. "	.789
Paragon, . . .	Thorburn.	10.5 "	8.5 "	
		12. "	10.5 "	
		7.5 "	6. "	
		5.5 "	4.75 "	
		5. "	4. "	.833
Perfection, . .	Livingston.	5. "	3.25 "	
		8. "	5.75 "	
		8.5 "	7. "	
		9. "	6. "	
		9 5 "	7.5 "	.737

VARIETY.	SEEDSMAN. 1889.	Weights.	Volume. Fluid Ounces.	Ratio of Volume to Weight.
Beauty, ...	Thorburn.	10. oz.	7.5 oz.	
		12.5 "	10. "	
		8. "	4.5 "	
		8. "	6.75 "	
		7.5 "	5.75 "	.75
Haines, ...	Vaughan.	6. "	4. "	
(No. 64.)		6. "	4. "	
		5.5 "	4.25 "	
		5.5 "	3.5 "	
		5. "	3. "	.679
Haines, ...	Northrup,	7.5 "	6. "	
(No. 64.)	Braslan &	6. "	4.5 "	
	Goodwin Co.	5. "	3.5 "	
		5. "	4.25 "	
		8. "	6. "	.769
*McCullum, . .	Vick.	9. "	7.5 "	
(McCullum's		11. "	8.5 "	
Hybrid.)		8.5 "	6.5 "	
		6.5 "	5. "	
		5.5 "	3.5 "	.765
Jones' XXX, .	Cornish.	5.5 "	3.5 "	
		5.5 "	3.5 "	
		4. "	2.25 "	
		8.5 "	6. "	
		8.5 "	5.75 "	.656
Alpha, ...	Thorburn.	10. "	8. "	
		8. "	5.5 "	
		6.5 "	4. "	
		6. "	4. "	
		5.5 "	3.5 "	.694
Prelude, ...	Vaughan.	3.5 "	2.5 "	
		3.5 "	2.25 "	
		3. "	2.25 "	
		3. "	2.25 "	
		3. "	1.5 "	.672
Conqueror, . .	Thorburn.	4.5 "	3.5 "	
		4. "	3.5 "	
		6.5 "	5. "	
		8. "	6. "	
		5. "	3.75 "	.776
General Grant,	Henderson.	12. "	10.5 "	
		9. "	7.5 "	
		8.5 "	7. "	
		7.5 "	6.5 "	
		7. "	5.5 "	.840
Hathaway's	Henderson.	4. "	3. "	
Excelsior, .		5.5 "	4. "	
		3.5 "	2.75 "	
		3.5 "	2.5 "	
		3. "	2.5 "	.746

* The writer has modified various new names in conformity with the rules of nomenclature adopted by the horticulturists of experiment stations.

These figures express merely the ratio between weight and volume ; or, in other words, they give an accurate measure of the absolute weight of different fruits. For purposes of comparison, this method presents some advantages over mere specific gravity. The lowest ratios are evidently the measures of greatest weight. The heaviest tomatoes, size for size, in the above test are, therefore, Jones' XXX, Volunteer, Prelude, and Alpha, while the lightest are General Grant, Paragon, and Favorite. But the figures are nevertheless not a measure of solidity, for which they were made, inasmuch as solidity depends somewhat upon the strength of the fleshy portions of the fruit: two tomatoes, exactly alike in weight and volume, may differ in solidity.

An experiment was undertaken to determine if keeping qualities are correlated with solidity. Representative samples of many varieties, taken so far as possible in the same stage of maturity, were placed together upon a forcing-house table and the fruits were removed as soon as they began to decay. It was found that some of the frailest varieties kept the longest. It appears, therefore, that solidity must be measured by a general judgment rather than by any definite expression. This conclusion is quite at variance with common opinion.

Much has been said concerning the superiority of certain varieties for cooking purposes, aside from quality of fruit. There is said to be characteristic differences between varieties in time of cooking and amount of shrinkage. A painstaking cooking test was made with a few varieties, but the results are so variable as to appear to be merely accidental or characteristic of individual fruits. The fruits were cut into thin slices and placed in boiling water. The shrinkages in weight and bulk do not appear to be correlated. In some instances shrinkage was slight, while in other varieties, equally as solid and good, it was great. The test indicates, so far as it goes, that judgments founded upon the manner in which varieties cook, are unreliable. The results are given for what they are worth :

TESTS IN COOKING.

VARIETY.	No. of fruits.	Color before Cooking.	Color after Cooking.	Time required to cook.	Weight Before and After Cooking.*		Shrinkage in Weight.	Volume Before and After Cooking.—Third Ounces.		Shrinkage in volume.	REMARKS.
Jones' XXX	10	Bright red.	Medium.	23 min.	3 lb. 15½ oz.	3 lb. 2 oz.	13½ oz.	——	1 qt.	——	
Optimus . .	10	Dark "	"	17 "	3 " 14½ "	3 " 12 "	2½ "	3 pts. 9½ oz.	3 pts.	9½ oz.	
Prelude. . .	10	Purple.	Light red.	12 "	1 " 12½ "	1 " 12 "	½ "	1 " 10½ "	1 pt. 8 oz.	2½ "	Fruits very small
Volunteer .	10	Dark red.	Dark "	22 "	3 " 8 "	2 " 2½ "	1 lb. 5½ "	1 qt. 12½ "	1 qt. 1 "	11½ "	
Conqueror. .	8	" "	" "	17 "	3 " 14½ "	3 " 12 "	2½ "	——	1 pt. 8 "	——	Cooked down remarkably thick.
Perfection .	8	Bright "	" "	15 "	3 " 15 "	3 " 8½ "	6½ "	2 qts.	3 " 4 "	12 "	
Haines . . .	8	" "	Medium.	25 "	3 "	2 " 3½ "	12½ "	1 qt. 13½ "	1 " 14 "	15½ "	
Alpha . . .	8	Dark "	Dark.	22 "	3 " 3 "	2 " 5 "	14 "	1 " 12½ "	2 " 2½ "	10 "	
McCullum .	8	Bright "	"	20 "	4 " 1½ "	3 " 1½ "	1 lb.	3 pts. 12 "	2 " 12 "	1 pt.	
Ignotum . .	8	" "	Light.	46 "	5 " 11 "	5 " 5 "	6 oz.	5 " 9½ "	5 "	9½ oz.	Fruits large and very solid.
Beauty. . .	7	Purple.	"	23 "	3 " 13 "	3 " 6 "	7 "	3 " 11½ "	3 "	11½ "	
Golden Queen . .	8	Yellow.	Yellow.	35 "	3 " 15 "	3 " 9 "	6 "	3 " 10½ "	——	——	The solid parts very hard and slow to disintegrate. Aside from these hard pieces, the fruits cooked down very thin.

* The weights and volumes in this table include, in each instance, a pint of water which was added in order to cook the fruits The evaporation of this water was not calculated, but it may be assumed to be the same for equal times of cooking. The test was intended to imitate common methods of cooking.

Four-fifths of the varieties of tomatoes now offered by dealers possess no points of superiority for general culture. It should be borne in mind that a variety which is simply good is not worth introducing. It must present some point of decided superiority over the best kinds at present known in order to possess merit. This fact appears to be commonly overlooked in all classes of vegetables, and every year the grower is bewildered with the display of novelties. Nearly eighty varieties were grown this year, which is less than half the number grown last year ; yet from these numbers, comprising in all some two hundred sorts, six could be selected which, for profit, would combine the merits of them all : Ignotum, Beauty (or Acme), Mikado, Perfection, Favorite, Potato Leaf; or for very early, perhaps Advance, or Salzer, or Prelude may be added.

IMPRESSIONS OF SOME OF THE NEWER VARIETIES.

Unless otherwise stated, the measure of value in any variety is based upon its merit for market culture. A variety may be good in itself and yet possess no points of superiority over old sorts, and may be characterized as possessing no promise.

Amber Gem. (Morehouse & Annis).—A small tomato closely resembling the old Large Yellow. Tends to become irregular. Of no promise.

Atlantic. (*Atlantic Prize.* Johnson & Stokes).—A large tomato of good color, but too irregular, and late in the season it is inclined to crack. Medium in season, and productive. One of the earliest large sorts. Worthy of further trial.

Bay State. (Bragg).—A large and good late variety, regular or becoming rough only late in the season, firm, very productive. It runs very even in size. One of the best recent introductions.

Brandywine. (Johnson and Stokes).—Much like the last, but averaging smaller and inclined to be irregular, Worthy of trial.

Dwarf Champion. (Henderson. Burpee. Thorburn).—A distinct type of tomato, very dwarf and compact in habit. It is evidently an off-shoot of the French Upright, or is at least a variation towards it. It is handsome in fruit and very prolific. The fruits are small, however, and they ripen slowly, a characteristic of all the upright sorts. At the close of the season the vines are still headed with green and nearly full-grown fruits, to a greater extent than are the common varieties. As an amateur fruit it is an acquisition, but for market our experience indicates that it is not valuable. We shall force it during the winter. We had the same thing under the name of *Tree Tomato of New Jersey.*

Golden Queen. (Thorburn), and *Sunrise Yellow* (Henderson) are indistinguishable. Fruits medium in size, regular and handsome, but the variety is less productive than *Jubilee*, although the fruit is more regular in shape.

Haines. (*Haines' No. 64.* Vaughan. Northrup, Braslan and Goodwin Co.)—Fruits medium to large, firm, mid-season, but too irregular. Suggests the type of the old Large Red.

Ignotum. Plate I.—This variety, which originated with the writer, is a sport from Eiformige Dauer, a German variety. It appeared in a very large tomato test made in 1887. It was sent to several parties the following year, and a plantation of 500 plants was made by the writer. * Last year it showed some tendency to revert, but careful selection has been practiced and our plants this year, 422 in number, were all true to type, with the exception of the variation due to culture, as discussed on page 116 of this bulletin. The Ignotum is without question by far the finest market tomato which we have ever grown. Its particular points of superiority are large size, regularity of shape, solidity, productiveness, and uniformity throughout the season. It is the largest and heaviest of the perfectly regular tomatoes, and the most solid of any of the market sorts. The pickings from our patches this year were usually fit for market as they came from the vines; and the last picking, October 10th, after a long season, was scarcely inferior to the best picking of the season. Plate I is made from a photograph of an average cluster which weighed 3¼ lbs.

The following letters have been received from two well-known gardeners to whom Ignotum was sent for trial:

From John G. Gardner, Jobstown, N. J.—"I am very much pleased with the Ignotum so far as my experience has gone. I had eighteen plants, and planted them in a tomato house, and they did remarkably well under the circumstances. The season was getting late to plant under glass and the soil had grown a crop of tomatoes before, and only a small amount of manure was added and forked up before the variety was planted. But under these unfavorable conditions we gathered some fine, good-sized and well-formed fruits, good in color, but a little soft, and when cut as good as any tomato I have seen, and flavor grand. The softness I think is due to the soil. I think enough of it, that I shall have young plants ready in ten days to plant a 50 ft. house for trial."

From N. Hallock, Creedmoor, Long Island, who has made extensive tomato tests this season.—"I am greatly pleased with the Ignotum, and the more I see of it the better I like it. I have twenty-three plants, and have picked ten crates and have more to come. It was the second to have ripe fruits (*Station* first), but at the end of ten days the quantity was greatly ahead of the Station. The quality is A 1; solidity, ditto. It has picked longer than almost any other variety. I have had no wrinkled ones."

Jones. (*Jones' Early Hybrid.* Cornish).—This and Jones' XXX, also from Cornish, appear to be the same. Fair size to rather large, regular, prolific. A good variety, but possessing no points of superiority over several old varieties.

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* For a fuller history of the variety, see *American Garden*, March, 1889, 84.

Jubilee. (*Childs' Golden Jubilee.* Childs).—Large, bright yellow, very prolific and perhaps the most regular of the American large yellow sorts, although it becomes irregular late in the season. It is very like, if not identical with the French *Jaune grosse lisse* (Large smooth yellow). A good sort.

King of the Earlies. (Johnson & Stokes).—A cornered variety of medium size. A few fruits ripened very early, but the bulk of the crop came in with the mid-season varieties. Evidently the same as some of the old varieties of the Orangefield type.

Lorillard. (John G. Gardner. Henderson).—Fruit medium in size, apple-like, very regular, or rarely a little corrugated about the stem, firm and handsome. It is productive, and the fruits are uniform. Aside from its great uniformity, it does not appear to possess superior merits for field market culture. It is introduced as a forcing variety, however, and in this capacity we are now growing it.

Matchless. (Burpee).—Fruits large and firm, a little inclined to be cornered or angled but never becoming rough. Much like fine strains of the old Trophy. Mid-season to late. A good variety.

McCullom. (*McCullom's Hybrid.* Vick.)—Fruits medium to under-sized, angled or even wrinkled, second early. Appears to possess no superiority for market.

Peach. (Thorburn).—A distinct type of tomato, to be classed with the cherry sorts (*Lycopersicum esculentum* var. *cerasiforme*). It has a peculiar roughness of skin, which, with the shape, size, and purple color, makes its resemblance to a small early peach very close. It has a tendency to become many-celled. The structure of the fruit recalls the oblong tomatoes, of which the Criterion is the type. The flavor is very mild or even almost sweet. The fruit is soft, yet in tests of keeping qualities it was found to remain sound remarkably long. The foliage resembles that of the Cherry tomato except that it is lighter in color. The vine has an upright tendency of growth. An acquisition for amateur culture and as a curiosity.

Prelude. (Vaughan).—Fruits small and handsome, uniform in size and shape, regular or somewhat cornered, purplish. It is a short remove from the cherry tomatoes. In shape and size the fruit suggests the old Hathaway. It is very early and very productive. May prove valuable for first crop.

Salzer. (*Salzer's Earliest of All.* Salzer).—Fruits small, uniform, somewhat angular. One of the earliest varieties. The fruits were practically all ripe before frost. Very similar to various old sorts of the Hundred Day type. May prove valuable for first crop.

Shah. (Henderson).—A distinct variety, being the first yellow tomato with foliage of the Mikado type. The fruits are too irregular to be valuable, however.

Volunteer. (Hallock. Thorburn. Burpee).—Fruits medium in size, regular, uniform, and solid. It is a good and reliable variety, but possesses no points of superiority over other similar sorts.

SUMMARY.

1. Frequent transplanting of the young plant, and good tillage, are necessary to best results in tomato culture.

2. Plants started under glass about ten weeks before transplanting into field gave fruits from a week to ten days earlier than those started two or three weeks later, while there was a much greater difference when the plants wers started six weeks later. Productiveness was greatly increased by the early planting.

3. Liberal and even heavy manuring, during the present season, gave great increase in yield over no fertilizing, although the common notion is quite to the contrary. Heavy manuring does not appear, therefore, to produce vine at the expense of fruit.

4. The tests indicate that poor soil may tend to render fruits more angular.

5. Varieties of tomatoes run out, and ten years may perhaps be considered the average life of a variety.

6. The particular points at present in demand in tomatoes are these: regularity in shape, solidity, large size, productiveness of plant.

7. The ideal tomato would probably conform closely to the following scale of points: Vigor of plant, 5; earliness, 10; color of fruit, 5; solidity of fruit, 20; shape of fruit, 20; size, 10; flavor, 5; cooking qualities, 5; productiveness, 20.

8. Solidity of fruit cannot be accurately measured either by weight or keeping qualities.

9. Cooking qualities appear to be largely individual rather than varietal characteristics.

10. The following varieties appear, from the season's work, to be among the best market tomatoes: Ignotum, Beauty, Mikado, Perfection, Favorite, Potato Leaf.

11. The following recent introductions appear to possess merits for market: Bay State, Atlantic, Brandywine, Jubilee, Matchless, and perhaps Lorillard, Prelude and Salzer.

12. The following recent introductions are particularly valuable for amateur cultivation: Dwarf Champion, Lorillard, Peach, Prelude.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

ENTOMOLOGICAL DEPARTMENT.

XI.

NOVEMBER, 1889.

On a Saw-Fly Borer in Wheat.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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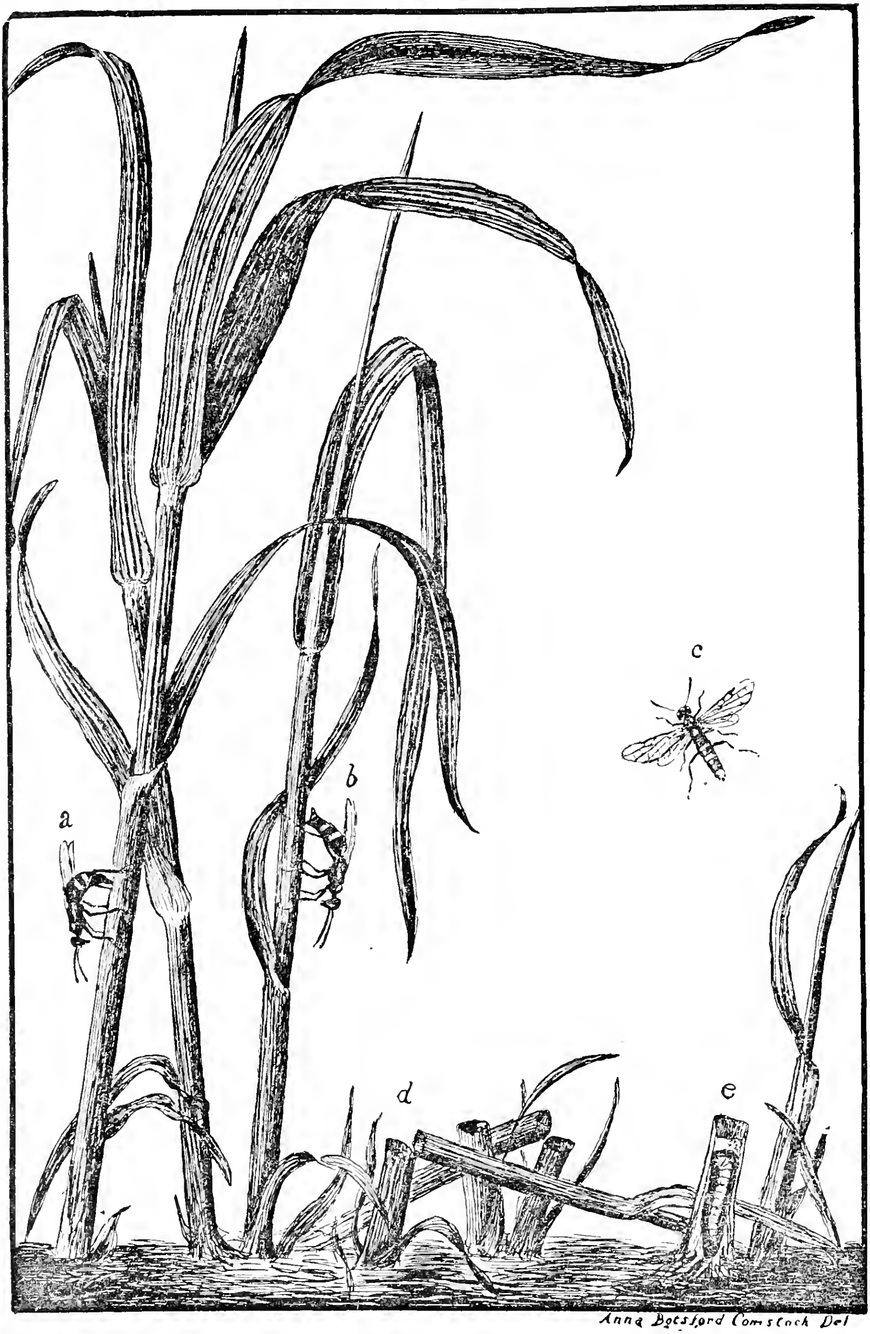

A SAW-FLY BORER IN WHEAT.

Cephus pygmaeus.

a, female beginning to oviposit; *b*, female with ovipositor inserted in straw; *c*, insect with wings expanded; *d*, straws cut by the larva; *e*, larva in cell at base of straw.

A SAW-FLY BORER IN WHEAT.

CEPHUS PYGMAEUS.

Order HYMENOPTERA; Family TENTHREDINIDAE.

AN insect destructive to wheat, but previously unknown in this country, has appeared in considerable numbers on the Cornell University Farm. I do not know of its occurrence anywhere else in this State; but as it is extremely abundant here, it is doubtless spread over a considerable area. It was first observed in this locality two years ago, by one of our students, the late Mr. S. H. Crossman, while making an investigation of wheat insects. Mr. Crossman's studies, however, were sadly terminated before he had carried his investigations of this species very far; and it has fallen to me to continue the work begun by him.

On examining the stalks of wheat at harvest time by splitting them throughout their length, it was found that some of them had been tunnelled by an insect larva. This larva had eaten a passage through each of the joints so that it could pass freely from one end of the cavity of the straw to the other. In addition to tunnelling the joints they had also fed more or less on the inner surface of the straw between the joints; and, scattered throughout the entire length of the cavity of the straw, except the smaller part near the head, were to be seen yellowish particles, the excrement of the insect.

If infested straws be examined a week or ten days before the ripening of the wheat, the cause of this injury can be found at work within them. It is at that time a yellowish, milky-white worm, varying in size from $\frac{1}{5}$ inch (5 mm.) to $\frac{1}{2}$ inch (12 mm.) in length. The smaller ones may not have bored through a single joint; while the larger ones will have tunnelled all of them, except, perhaps, the one next to the ground.*

As the grain becomes ripe the larva works its way toward the ground; and at the time of the harvest the greater number of them have penetrated to the root.† Here in the lowest part of the cavity

*For a detailed description of this larva see note 2.

†For further details see note 4.

of the straw they make preparations for passing the winter, and even for their escape from the straw the following year. This last is done by cutting the straw circularly on the inside nearly severing it a short distance, varying from one half inch to one inch from the ground. Fig. 1, c. If the wheat were growing wild, the winter winds would cause the stalk to break off at this point; and thus the insect after it had reached the adult stage in the following year could easily escape; while but for this cut, it would be very liable to be imprisoned within the straw. But under ordinary circumstances the straw is cut by the reaper before it is broken off at this point, and consequently that breaking off does not occur. If, however, there is a strong wind just before the harvest and after the straws have been cut in this manner by the insects, they are very liable to break off; the lodging of the grain may, therefore, be largely due to the injuries of this insect. In one field just before the harvest I observed a large number of isolated straws lying in a horizontal position, there was not the general breaking down of the grain characteristic of wind and rain; but distributed through the grain that was standing there were a large number of isolated straws that were lodged. A careful examination showed that this breaking down of the grain, in 45 per cent of the cases, was directly due to the injuries of this insect. In many cases the straws had been broken off a considerable distance above the ground, and before the larva had made the characteristeric circular cut near the root. An examination of these straws showed that the larva had eaten all or nearly all of the softer inner part of the straw for a short distance, thus making a weak place which was easily broken. As a rule, however, the larva obtains the greater part of its nourishment by tunnelling the joints of the straw and does not eat enough of the straw in any place to cause it to break until they make the circular cut near the ground described above.

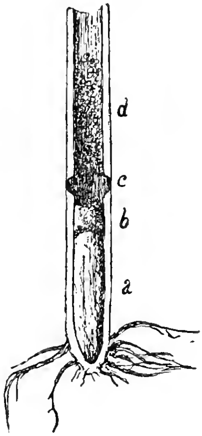

FIG. 1.—Base of an infested straw. *a*, cocoon; *b*, plug of borings; *c*, circular cut *d*, scattered borings.

After the circular cut has been made, the larva fills the cavity of the straw just below it for a short distance with a plug of borings. Fig. 1, b. Between this plug and the lower end of the cavity of the straw there is a place, measuring about one half inch in length (10 mm. to 15 mm.) Plate, *e*. It is here that the insect passes the winter. Immediately after cutting the straw and making this plug the larva makes a cocoon by lining the walls of this space with a layer of silk. Fig. 1, a. This layer is thin but very firm and more or less parchment-like; it can, however, be broken with slight difficulty, being somewhat brittle.

Within this cocoon, which remains in the stubble after the grain is cut, the insect passes the winter, in the larval state. It changes to a pupa during March or April*; and sometime during the month of May the adult insect appears.

The exact date of the appearance of the insect depends upon the nature of the weather. This year from pupae collected on the 23d of April and brought into the Insectary, the adults emerged from the 8th to the 10th of May; while the insects left in the fields were ten days later in emerging.

The adult insect is a four-winged fly belonging to the order *Hymenoptera*, the order that includes the bees, wasps, and ants; and it is a member of the family *Tenthredinidae* of this order, a family comprising the insects commonly known as Saw-flies. This popular name refers to the fact that in this family the female insects are furnished with a more or less saw-like organ. This arises near the caudal end of the body, and is the ovipositor. By means of it the insects are able to make incisions in the tissues of plants for the reception of their eggs.

The Saw-fly Borer of Wheat, is known to entomologists as *Cephus pygmaeus*. The form and appearance of the adult are represented on the accompaning plate. In this stage it is of a shining black color, banded and spotted with yellow. The male measures one-third inch (8 mm.) in length; the female two-fifths inch (10 mm.)†

Soon after the adults emerge from the stubble, they pair and the females begin to oviposit. Thus in our breeding-cages, the adults which emerged from the 8th to the 10th of May, began to pair on the 10th and the females were ovipositing on the 13th.

The appearance of the insects in large numbers in the field took place four or five days before the heads of wheat began to appear, *i. e.*, before they began to project from the sheath formed by the

*See note 5. †For a detailed description see note 1.

upper leaf. But it was not until the latter date that the flies had migrated to the wheat fields in considerable numbers. It will be noted that as the insect winters in the stubble of wheat, and that as in this region one crop of wheat rarely follows another, it is necessary for the adults, when they emerge, to migrate a greater or less distance in search of a wheat field, in which to oviposit. We found that the female migrated to the wheat fields first; but they were soon followed by the males.

The specimens which I reared in breeding-cages in which wheat was growing laid their eggs at various distances from the ground. Many observations, both in the Insectary and in the field, convinced me that these insects oviposit anywhere along the larger part of the straw where it is hollow; but chiefly in the upper portion. (See Table 1.) In each case that I observed, the female stood with her head towards the ground in the position indicated in the Plate, at *a* and *b*. The making of the slit through the straw, and the laying of the egg occupy about one minute of time. The slit made by the insect's ovipositor is so small that it can be detected only with difficulty. By carefully marking the point on a straw, at which a female was seen to oviposit, and then examining this point with a microscope, I was enabled to find the puncture. It is about one one-hundreth inch (¼ mm.) in length, slightly enlarged at the upper end as shown in Fig. 2, a. The egg is pushed entirely through the wall of the straw and is left adhering loosely to the inside. It is of a milky white color, one twenty-fifth inch (1 mm.) in length, and one seventy-fifth inch (⅓ mm.) in width at its widest place. It is oblong, and slightly curved, as shown in Fig. 2, b.

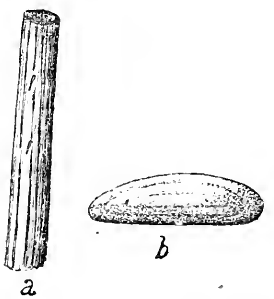

FIG. 2.—*a*, section of straw showing form of slits made by the ovipositor; *b*, egg, greatly enlarged.

In our breeding-cages the females laid many eggs in the same stalk. This was to be expected, owing to the large number of insects confined with a small amount of grain; but I was surprised to frequently observe a female lay an egg and then move down the same stalk two or three inches and repeat the operation without an effort to seek a fresh stalk.

Although many eggs were laid in some of the stalks in our breeding cages, in no instance did more than one larva become fully grown ; and no trace of the other larvae could be found. I have found in the fields stalks containing two larvae, but these larvae were separated by a joint of the straw. In no instance, after all the joints of a straw had been tunnelled, have I found more than a single larva. It is probable that where more than one egg is laid in a stalk, the stronger larva destroys the others.

The eggs hatch soon after they are laid, and the larvae may develope quite rapidly. A larva which hatched from an egg laid on May 13th was on May 24th about one-quarter inch (6 mm.) in length, and had bored through the principal joint of the straw, and had also penetrated the upper solid part of the stalk. Four days later another larva, which also hatched from an egg laid May 13th, was found to have tunnelled the entire length of the stalk in which it was.*

In no case did I find any external indication of the presence of a larva in a wheat stalk until the larva was nearly fully grown, and had tunnelled the stalk down to the first joint. At this time there is frequently a discoloration of the stalks just below the injured joints. This was observed during the first week in July. The wheat had then reached its full height and the grain was in the milk.

At this time there was observed scattered through the field heads of wheat which were yellow and contained no grain. These dead heads corresponded in appearance exactly with those described by Herpin in the extract quoted below. I carefully examined many of these stalks ; and found that in no case was the injury due to *Cephus pygmaeus*. In most cases the heads had been killed by a species of Thrips which sucks the juice from the stalk, in the tender portion, within the sheat of the upper leaf, just above the upper joint. This causes the stalk to shrivel at this point, and all above the injury to die. This disease of the wheat is similar to the common one of grass ; but the Thrips which produces it is larger than that infesting grass and is further distinguished by having its antennae marked by dark rings.

Although this saw-fly borer has not been previously observed in this country, it is a well known European species. It has been described by both English and Continental writers ; and in France especially it has been considered a very serious pest. One writer†

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* See note 4.

† J. Ch. Herpin, quoted by Curtis in Farm Insects, p. 253.

says "If you traverse a field of wheat or rye a week or a fortnight before harvest you may observe a greater or less considerable number of the stems the straight and whitened ears of which elevate themselves above the others, and appear to have attained their perfect maturity. They form a striking contrast with the neighboring plants which are still very green; and the heavy ears filled with grains are inflexed and bent towards the earth whilst the others are entirely empty, or contain only a very small number of grains, which are for the most part shrunk and horny." The same writer in referring to the circular cut made by the larva before spinning its cocoon states that: "In consequence of this section, the straw, having no more sustenance, breaks off at the foot and falls to the ground when the wind becomes a little strong; the field then presents the same appearance as if it had been traversed in every direction by sportsmen or by animals."

In this country, according to my observations, the injury to the wheat by this insect produces results somewhat different from those just described. I found the same lodging of the wheat caused by the circular cut near the root; but this lodging of the grain appears to be the chief injury here.

I did not find that the presence of a larva in a stalk caused the complete destruction of the seed described by European writers. In fact, in most cases, the grain shelled from a certain number of infested heads weighed more than the grain shelled from the same number of non-infested heads taken from the same bundle in regular order after the infested ones had been removed.*

This was at first very puzzling. It seemed to point to the absurd conclusion that the presence of this borer within a stalk increased the amount of grain produced by that stalk. It was noted, however, that the infested stalks were almost invariably large, healthy ones, with good well filled heads. When we recall the fact that the laying of the eggs takes place while the wheat is still small, and that a stalk must be large enough to contain a hollow of considerable size before it is suitable for the development of a larva, it will be seen that the stalks infested will naturally be those that are the largest early in the season; while the stalks that are backward in their development, and consequently will produce smaller heads, will escape the attack of the insect. Therefore, a comparison of heads from infested stalks

* See note 7.

with heads from stalks of average size will not indicate the results of the presence of the insect. Still, as I have already said, it appears that with us the chief injury caused by the insect is the lodging of the grain.

Some observations were made to determine how abundant this insect is at Ithaca. It was found that the proportion of straws infested varied from $\frac{7}{10}$ of one per cent to 11 per cent., with an average of $4\frac{6}{10}$ per cent.*

It is stated by European writers that this Saw-fly infests both wheat and rye. I had no opportunity to study the last named grain, but made some observations to determine the range of food-plants of the insect here. There was a field of oats on the University Farm adjoining a clover field that was in wheat last year. These oats were sowed very early so that at the time the Saw-flies were ovipositing the stalks were large enough to receive the eggs. I found Saw-flies on the plants; but a careful examination of a large number of oat straws made at harvest time, failed to reveal a single infested straw.

I confined fifty Saw-flies, thirty males, and twenty females, in a cage with growing orchard grass, which was large enough to receive the eggs. In a short time the females began to oviposit freely in the grass; but although many eggs were laid in the grass, I was unable later to find a single larva, or any indications of their having fed upon the interior of the stalk. Neither could larvae be found in orchard grass growing in a field where there was wheat last year.

Curtis describes a parasite that infests this Saw-fly in England. It is the Ichneumon-fly, *Pachymerus calcitrator*. But although I have bred many hundreds of the Saw-fly and have examined thousands of infested straws, in only two instances have I found any indications of parasites.† We must, therefore, depend on artificial means for checking the increase of this species.

The most obvious method of combating the insect is to attack it while it is in the stubble, that is to say, sometime between the wheat harvest and the first of the following May. If the stubble can be burned in the autumn the larvae in it can be destroyed. The same thing could be accomplished by ploughing the stubble under, which would prevent the escape of the adult flies. But as it is customary in this region to sow grass seed with wheat I fear

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* See note 6. † See note 8.

that the ploughing under of infested stubble would rarely be practicable; and it is also questionable if the burning of the stubble could be thoroughly done without destroying the young grass.

It seems probable, therefore, that if this insect becomes a very serious pest it will be necessary, in badly infested regions, either to sow grass seed with oats and burn or plough under all wheat stubble; or to suspend the raising of wheat for one year, in order to destroy the insects by starvation. I purpose to continue my experiments in the direction of ascertaining in what plants, other than wheat, the insect can develope, as bearing on the starvation method of combating it.

JOHN HENRY COMSTOCK.

NOTES.

Under this head are included the more technical descriptions, and the details of certain observations that I desire to put on record, but which would not interest the general reader.

NOTE I. *Description of the adult of Cephus pygmaeus.*—The adult is of a shining black color, banded and spotted with yellow; the male measures 8 mm. in length, the female 10 mm. The body and appendages are clothed with numerous microscopic hairs. these are somewhat longer and denser, especially in the male, on the ventral aspect of the abdomen and at the caudal end of the body. The head is large with prominent eyes. There are three ocelli, forming a triangle near the summit of the head. The antennae are inserted on the front nearly opposite the middle of the compound eyes. They are about 5 mm. in length, slightly clavate, and are composed of nineteen or twenty segments. The two antennae of the same insect sometimes differ as to the number of segments. The first segment is ovate with a well marked bulb at the base, which appears like a distinct globular segment. The second segment is short, being only about as long as broad. The three succeeding segments are elongated; after which the segments become successively shorter until the middle of the club is reached; where their length is less than their width. Beyond this there is but slight variation in the length of the segments. The last, however, is somewhat longer than those immediately preceding it ; or is divided, thus forming the supernumary segment. The four wings are transparent and irridescent but somewhat smoky. The costal margin of the wing is yellow towards the base ; the sub-costal vein, however, which is closely united to the costa is, like the other veins, dark, pitchy-brown. There is a more or less well marked smoky spot in the third discoidal cell extending from the origin of the posterior vein. The venation of the wings is represented in Fig. 3. In the male the yellow markings are much more extended than in the other sex, the following named parts being of that color : The mouth parts, except the tips of the mandables, which are dark-brown ; a spot on the clypeus ; a narrow margin between the compound eyes and the mouth parts ; the ventral aspect of the thorax ; the legs, excepting a dark band on the caudal aspect of the coxae and femora (the tibiae and tarsi are sometimes brown or smoky instead of yellow) ; the membrane at the base of the abdomen ; on the ventral side of the abdomen the caudal margin of each segment ; on the dorsal side of the abdomen a more or less well marked spot on each side of the first and second abdominal segments ; a broad band occupying the caudal three-fourths of the third and fifth segments ; a narrow band on the caudal margin of the sixth segment ; which may be more or less interrupted, forming spots on the back and sides ; and the latero-caudal angles of the seventh segment.

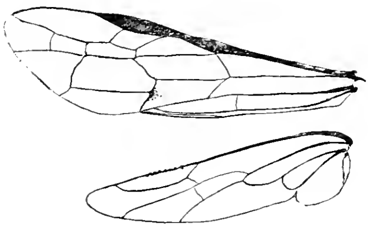


FIG. 3.—Venation of wings of Cephus.

In the female there is a yellow spot at the base of the mandibles ; the maxillary palpi, except the terminal portions, are yellow ; the tibiae and tarsi vary from light yellowish-brown to dark smoky-brown ; those of the hinder pair of legs usually being darker the markings of the abdomen are the same as in the male, except that the yellow spots and bands are usually smaller, and are sometimes entirely wanting on the ventral aspect.

NOTE 2 : *Description of the Larva of Cephus pygmaeus.*—The larva is of a yellowish milky-white color, with the head brownish, the tips of the mandibles and the eyes black. When fully grown it measures from 9 mm. to 14 mm. in length ; but in spinning the cocoon the body becomes shortened, measuring after that operation from 5 mm. to 9 mm. The body is nearly cylindrical in outline. The head is of medium size, being much smaller than either of the thoracic segments. The thoracic segments are somewhat swollen; and the abdomen tapers gradually from the thorax to the caudal-end. The antennae are four jointed, and taper strongly. A short distance ventro-caudad of each antenna is a single black ocellus. The labrum is prominent and slightly emarginate. The mandibles are strongly toothed. The maxillary palpi are four jointed. The labium is slightly emarginate. The labial palpi are three jointed. There are ten pairs of spiracles, two thoracic and eight abdominal. The prothoracic spiracles are much larger than the others and are greatly elongated. The second spiracles open in the fold between the mesothorax and metathorax. The remaining spiracles are borne by the abdominal segments one to eight. The thoracic legs are represented by very short tubercles. There is at the caudal end of the body on the middle line dorsad of the vent a prominent tubercle. This is terminated by a chitinous ferrule-like ring; and is doubtless an organ of locomotion, aiding the insect in pushing itself up the cavity of the straw. On each side of the ventral lobe at the caudal end of the body there is also a stout spine. These spines probably have the same function as the tubercle just described. The body is naked except the head and caudal extremity. There are a few slender scattered hairs upon the head, and a like quantity of stronger more spine-like hairs at the caudal end.

NOTE 3: *On the Position in which the Egg is laid.*—"This insect" says M. Dugaigneau "after pairing pierces the stalk of the rye, below the first knot, to deposit an egg in its interior, which hatches so much earlier, being warmed by the sun's rays concentrated close to the earth, amongst all the straw of the rye." (Curtis Farm Insects, p. 252.) My observations do not confirm this statement. The insect appears to oviposit anywhere along the larger part of the straw where it is hollow; if any preference is shown it is for the upper portion of the straw not for the lower. Table, I. will serve to illustrate this point. In this table the space between the horizontal lines represent the sections of a straw of wheat. The vertical lines represent the portion bored by the larvae of Cephus, in thirty straws taken from a single square yard on the 29th of June. Obviously in each case the egg was laid somewhere within the burrowed parts ; in the majority of cases this must have been above the third joint ; it may have been so in all cases excepting Nos. 13, 18, and 20, counting from the left.

NOTE 4 : *On the Development of the Larvae.*—I made observations to determine the rate of development of the larvae and the date of their maturing. Especial pains was taken to determine if any considerable proportion of the larvae failed to mature in time to descend to the ground before the grain was cut, as bearing on the artificial dissemination of the species.

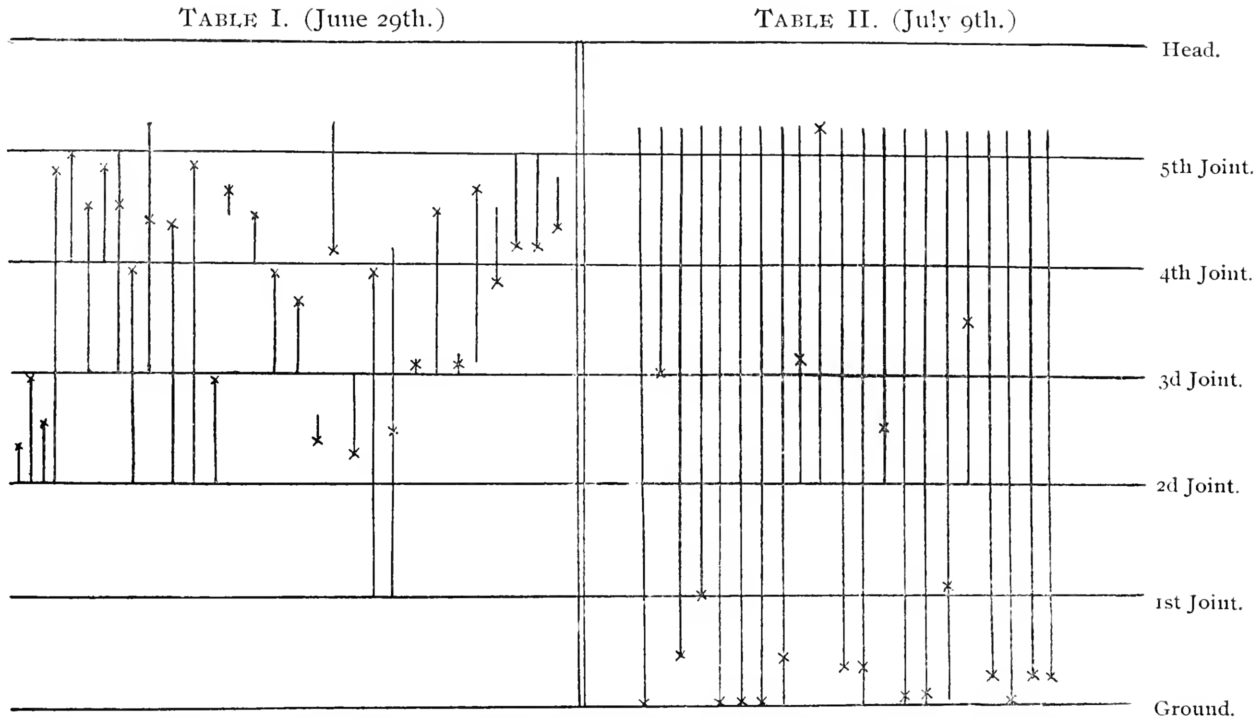
The data given on page 131 indicates a short duration of the egg state and a rapid development of the larvae. It should be borne in mind, however, that those observations were made in the Insectary upon specimens whose development had been accelerated by the heat of the greenhouse. In the field the corresponding changes took place much later.

After the appearance of the adult flies in the Insectary, I made frequent observations in the field. The following are the more important results :

Careful searching in the fields failed to reveal the presence of any adults till May 25th. Then they were found to be quite common in a field of young clover which was last year's wheat field. The insects had passed the winter in the wheat stubble in this field and had not yet migrated from it. Although I took fifty specimens in twenty minutes by sweeping in this field I could not find a single specimen in the nearest wheat field.

On May 29th the Saw-flies were found for the first time common in the wheat field. Both sexes were found, but the females were much more abundant. The specimens were found especially in that part of the field nearest the clover field. At that time the heads of wheat were just beginning to project from the sheath formed by the upper leaf. This was true of probably 4 per cent. or 5 per cent. of the stalks.

On June 29th the wheat was beginning to turn brown. On that date all of the wheat stalks were gathered from one square yard of the field and each stalk examined. Thirty of the stalks were found to be infested. Careful notes were taken of the position of each larva and the extent it had bored. The results are represented graphically in Table I. A study of this table shows that the greater part of the larvae were in the upper part of the stalks ;



Graphical representation of the positions of larvae and extent of their borings. The spaces between the horizontal lines represent the sections of the straws; each vertical line indicates the extent of the boring of a larva; and the x the position of the larva when found.

and most of them were boring towards the head of the stalks. Several larvae had just begun to tunnel the stalk and had not yet perforated a single joint.

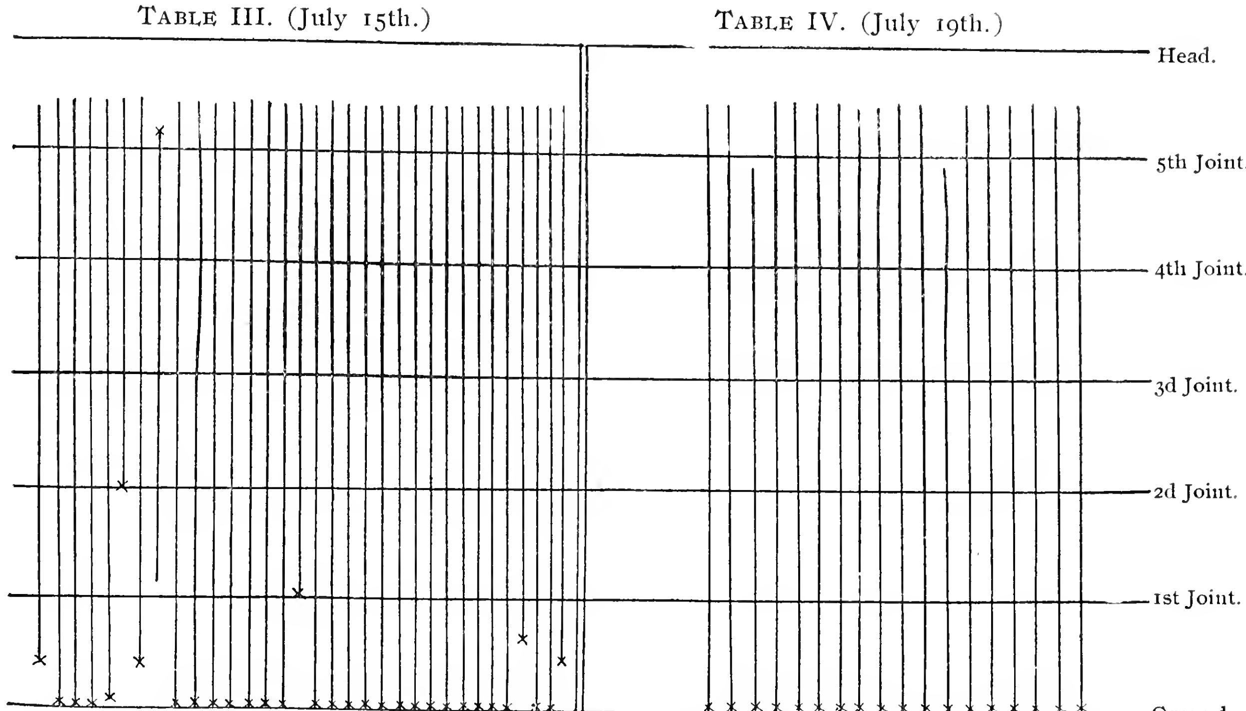
On the 9th of July the wheat was ready to harvest. At this time the stalks from another square yard were examined; and the results are shown in Table II. It will be seen that a very marked change had taken place in the ten days intervening between this time and the previous examination. In each case every joint above the larva had been tunnelled; with one exception the larvae had started downward; and sixteen of the twenty-one larvae had penetrated the lower joint Had the wheat been cut with a reaper that day only five of the larvae would have been removed with the straw. The average length of the larvae was 11 mm. In only two cases had the larvae begun to make the circular cut near the ground.

The wheat was left standing in a portion of the field and examinations were made on the 13th, 15th, 17th and 19th of July.

On the 13th, nineteen infested stalks were found in one square yard of the field. In these only one larva was above the second joint; five were at the first joint; and thirteen were at the root. All were below the reach of the reaper, as the one above the second joint was only two inches from the ground; in fact it was making its cocoon at this point. Ten of the specimens had made the circular cut; and three, had spun their cocoons.

The results of the observations of July 15th are indicated in Table III. Twenty-five of the thirty-three specimens had made the circular cut, and thirteen had spun their cocoons. One specimen, the sixth from the left in the table, had made its cocoon above the second joint, eight inches from the ground. Another specimen was at the top of its burrow. These two were all that were not below the reach of the reaper; the only other specimen above the first joint being only one and one-half inches from the ground.

The square yard of wheat examined July 17th contained fifteen infested straws. All but two of the larvae were at the surface of the ground; of these, one was five inches from the ground, above the first joint; and the other, six inches from the ground, and above the second joint.



Graphical representation of the positions of larvae and extent of their borings. The spaces between the horizontal lines represent the sections of the straws; each vertical line indicates the extent of the boring of a larva; and the x the position of the larva when found.

Table IV. shows the results of the examination of July 19th. Eighteen infested straws were found. All larvae had penetrated to the ground. All had made the circular cut and partition below it, and all but four had spun their cocoons.

From these observations it is evident that a small proportion of the insects are probably removed from the wheat fields in the straw; and consequently there is danger of the spreading of the species in this way. It is probable that the species was introduced into this country in straw used as packing; and it may be further distributed here in the same way.

Note 5. On the Date of Pupation.—Owing to my absence from Ithaca during the winter, the date at which the larvae changed to pupae was not definitely ascertained. On the 23d of April I was able to find in the field only pupae; but larvae which had been kept cool in the hibernating-room of the Insectary had not yet changed to pupae.

Note 6. On the Abundance of Cephus pygmaeus at Ithaca.—The following observation will serve to indicate the abundance of the species in this locality:

In 1887 four examinations were made to determine the proportion of wheat straws infested with the following results:

In a lot of	110	straws	10	were	infested.
" "	86	"	6	"	"
" "	46	"	6	"	"
" "	34	"	4	"	"

The following observations were made in 1889:

In one square yard containing	380	straws	30	were	infested.
" " " "	300	"	21	"	"
" " " "	380	"	19	"	"
" " " "	300	"	33	"	"
" " " "	360	"	15	"	"
" " " "	365	"	18	"	"
" bundle containing	2325	"	99	"	"
" " " "	2376	"	16	"	"
" " " "	2373	"	173	"	"

The three bundles were taken from widely different parts of the field. The six square yards examined were all situated on the side of the field nearest the clover field from which the Saw-flies spread. They therefore, doubtless indicate an unusually large proportion of infested straws. At the time these six examinations were made I was unable to remove the grain from other parts of the field, on account of other experiments which were being conducted upon it.

Note 7. On the Effect of the Boring of Cephus pygmaeus upon the Quantity of Grain Developed.—In 1887 only a single observation was made. It was found that ten infested stalks produced 273 kernals which weighed 10 grams; while ten stalks not infested produced 261 kernels which weighed a little more than 11 grams. This indicates that the kernels from the infested stalks were not so well filled as those from the non-infested stalks; for although there were a greater number of the former, they did not weigh as much as the latter. In fact the average weight of the kernals from the infested stalks was 13 per cent less than those from the other lot.

In 1889, unfortunately, a comparison was not made in the weight of the kernels from infested and non-infested stalks. The importance of this was not appreciated till I undertook to digest the results of the experiments. Comparisons were made between the weight of the grain from the infested straws in each bundle, and the weight of the grain from three lots of non-infested straws from the same bundle. The following are the results obtained. A possible explanation of these results has been suggested on page 132.

In bundle No. 1:

The grain from	99	infested heads weighed			85 grams.
" "	99	non-infested heads weighed			70 grams.
" "	99	"	"	"	77 "
" "	99	"	"	"	67 "

In bundle No. 2:

The grain from	16	infested heads weighed			12.3 grams.
" "	16	non-infested heads weighed			11.3 grams.
" "	16	"	"	"	13.6* "
" "	16	"	"	"	11.9 "

In bundle No. 3:

The grain from	173	infested heads weighed			165 grams.
" "	173	non-infested heads weighed			140 grams.
" "	173	"	"	"	130 "
" "	173	"	"	"	120 "

Note 8: Parasites of Cephus pygmaeus.—On the 23d of April a crippled Ichneumon-fly was found emerging from a cocoon of Cephus pygmaeus. Unfortunately, the specimen is in too poor a condition to admit of determining the species.

On the 20th of July a parasitic larva was found in the cell of a Cephus larva at the base of a wheat stalk. The parasite was outside of the body of the Cephus. The latter was soon destroyed; and the parasite spun a cocoon, from which it has not yet emerged.

* This lot was composed of large, selected heads.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

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CHEMICAL DEPARTMENT.

XII.

DECEMBER, 1889.

A New Apparatus for Drying Substances in Hydrogen and for the Extraction of the Fat.

This Bulletin is published in limited numbers for special distribution among Experiment Station Workers and Chemists.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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Agricultural Experiment Station.

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CORNELL UNIVERSITY EXPERIMENT STATION,

Ithaca, N. Y.

FIG. 1.

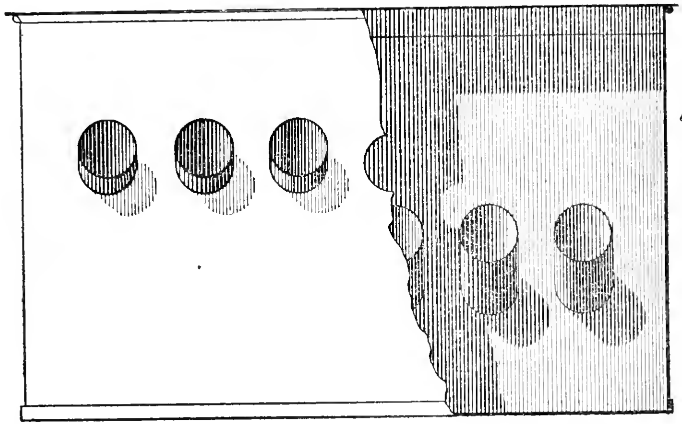


FIG. 2.

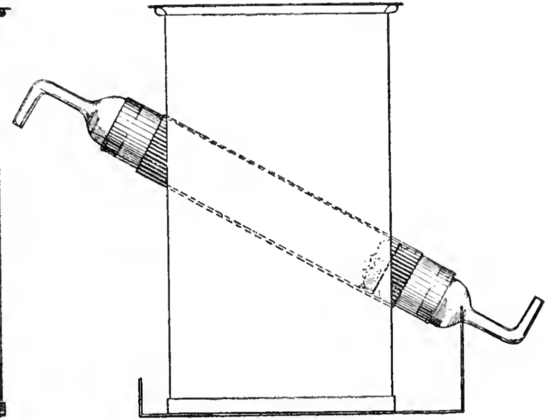


FIG. 3.

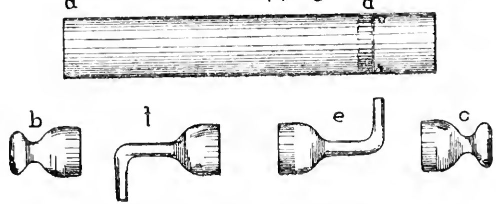
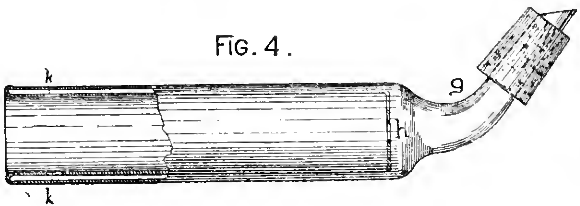


FIG. 4.



A NEW APPARATUS FOR DRYING SUBSTANCES IN HYDROGEN AND FOR THE EXTRACTION OF THE FAT.

AT the last meeting of the Association of Official Agricultural Chemists, it was voted that in the analysis of cattle foods the substance should be dried, for the determination of moisture and ether-extract, in a current of dried hydrogen, at the temperature of boiling water, and that the glass containing the substance should not come in contact with the water. It seemed to me at first well nigh impossible to fulfill this last condition; and it may be that this precaution is unnecessary; but if it can in any way easily be observed, it is certainly well enough to do so.

The form of drying bath and tube shown in the adjoining figures seems to meet the requirement fully, while at the same time it makes it also possible to carry the hydrogen directly through the substance instead of over it as usually done, thus securing more rapid drying, to weigh the substance before and after drying in a perfectly tight tube, and to use one and the same portion of the substance for the three determinations, moisture, ether-extract and fibre, without inconvenience, and without any danger of loss of substance in the single transfer from one vessel to another that is necessary.

It is also easy to heat the hydrogen to the temperature of the boiling water before conducting it through the substance, a modification that seemed desirable to some members of the Association. My own bath has a coil of about four feet of eighth-inch tin pipe in the bottom; one free end of this passes up inside one end of the bath, and out, to connect with the hydrogen-drying apparatus; the other end of the pipe passes up at the other end of the bath to near the top, where it is connected with a piece of quarter-inch pipe, running back as far as the other end of the bath, and from which arms of the smaller pipe pass out along the side, and then down to connect by rubber tube with the drying tubes. This addition was put in for the purpose of making a thorough test of the efficiency of previously heating the hydrogen, which test we have not yet had time to make. I seriously doubt, however, whether encouraging results will be obtained.

The construction of the copper bath is made plain by the figures 1 and 2; it is 24 cm. long, 15 high, and 8½ broad; it can be made at any respectable tin shop. This bath stands in a piece of sheet copper bent up at right angles along the sides, as shown in the end view, fig. 2; on one side, this vertical part need not be over 1 cm. high, just enough to project a little up the side of the bath which rests snugly against it, *not* as shown in the figure; along the other side it projects upward, at a little distance from the side of the bath, about 15 mm. and to about the height of 4 cm.; opposite each of the tubes of the bath a slot is cut in this vertical part, which serves then as a shoulder against which the glass tube rests when in place, to keep it from slipping down and out of position.

The tube, fig. 3, for containing the substance has at the zone *a* three small projections on the inner surface, which support a perforated platinum disk of rather heavy platinum foil carrying the asbestos filter. This tube is 13 cm. long and 23 mm. inner diameter, and weighs, with its close stoppers, about 30 gms.

The filter is readily made in the same manner as the Gooch filter, the tube being first fitted to a suction flask by an enlargement of one of the holes of the rubber cork, or, better still, by slipping a short piece of rubber tube over it, of such thickness that it will fit tightly in the mouth of one of the new suction flasks with lateral tube for connection with the suction. A very thin welt of asbestos is sufficient; if it is too thick the gas and ether will not flow through with suitable ease.

About two gms. of the substance are put in this tube, previously weighed with the stoppers *b* and *c*, and the weight of the substance accurately determined by weighing tube and contents. The stoppers are removed, a band of thin asbestos paper is wound around the end *d* of the tube, a little behind the slight shoulder at the rim, as many times as may be necessary to make a snug fit when this tube is slid down into the copper tube in the bath; thus the circulation of air between the glass and the copper tubes is prevented that would retard the heating of the former; the stopper *e* is put in the lower end of the tube, for connection with the hydrogen supply, and the stopper *f* in the upper end; this latter stopper is connected by rubber tube with a glass tube slipping easily through one of the holes of a rubber cork closing a small flask, containing a little sulphuric acid, into which this tube just dips ; when as many tubes as are to be charged are thus arranged in place and the hydrogen is turned on, the even flow of the current through the whole number is secured by raising or lowering, a very little, the several tubes through which the outflow passes, so as to get a little more back pressure for one, or a little less for another, as may be found necessary. When the drying is supposed to be completed, the tubes are weighed again with their close stoppers, and so on.

Then, for the extraction of the fat, the unstoppered tube with contents is put directly into a Soxhlet extractor, or into a continuous extractor, for the treatment with ether, in the usual manner. Fig. 4 is a representation of the form of a continuous extractor which has been used in my laboratory for many years with perfect success ; it was described in the second annual report of the Cornell University Experiment Station, 1882–3 ; as slightly modified, it is reproduced here simply in order to make the set of apparatus complete for the work in hand. The bottom of the inner tube is perforated at *h* to allow the ether that has entered through the lateral openings *k k* and passed through the substance to flow back into the flask connected with the tube *g*. By the bending to one side of this tube, the droplets of ether that may be projected upwards in the boiling are less likely to come in contact with the cork, a matter of some little consequence when the liquid becomes pretty well saturated with fat.

When the extraction is completed there seems to be no reason why the amount extracted cannot be determined by weighing the dried contents of the tube, as well as by weighing the substance extracted ; and the drying in hydrogen is much more easily managed in the former case than in the latter ; but I have not yet had time to test this variation of the method.

The ether-extract being estimated, it is evident that the contents of the tube, now in the proper condition for the determination of the fibre, can be transferred without any difficulty to the digestion flask, with the aid of a wash-bottle containing the required quantity of boiling sulphuric acid ; that the platinum disk and small quantity of asbestos must accompany the substance of course does no harm.

It now remains to be demonstrated that this apparatus serves its intended purpose. The following observations made by the assistant chemist of the Station, Mr. W. P. Cutter, furnish this demonstration, proving that the substance in the glass tube is heated to the temperature of the boiling water in the bath, although the tube itself is not in contact with the water, just as fully as when the vessel containing the substance *is* in direct contact with the water. The same thermometer was used in all the experiments.

1. Temperature of water boiling in covered beaker, ... 100°
2. Temperature of water boiling in the drying apparatus, ... 100°
3. Temperature of substance [bran] in a test tube immersed in boiling water, the bulb of the thermometer imbedded in the substance, . 101°
4. Temperature of the substance in the drying tube in the apparatus, taken in the same manner as in 3, ... 101°
5. Temperature of the substance in the drying tube in the apparatus, with hydrogen circulating through instead of air, ... 100°

The observation made in test three, and confirmed in the next succeeding test, in both of which cases the air was not displaced by hydrogen, is interesting as indicating oxidation of the substance when heated under such conditions, and thus still further enforcing the necessity of using hydrogen.

After these tests had been made, two samples of the bran sent out in 1887–8 were carried through the drying operation and the extraction by ether. A perfectly clear extract was obtained, yielding 4.61 and 4.63 per cent. of residue dried in hydrogen. The transfer to the flask for the treatment for fibre was then made without any difficulty.

The cost of the apparatus, for six tubes, was as follows:

The copper bath, ...	$3.30
Each glass tube, with the four stoppers, ...	1.00
Each extractor (fig. 4), ...	1.00
Each platinum disk, ...	.70

The tubes and extractors were made by E. Greiner, 76 Nassau St., New York, who has the full directions for them; the tubes were furnished under the name of "double-stoppered drying tubes."

PROF. G. C. CALDWELL.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

AGRICULTURAL DEPARTMENT.

XIII.

DECEMBER, 1889.

I. On the Deterioration of Farm Yard Manure by Leaching and Fermentation.

II. On the Effect of a Grain Ration for Cows at Pasture.

Bulletin XII was entirely devoted to the description of a new piece of chemical apparatus, and was not issued for general dristribution.

" That art on which a thousand millions of men are dependent for their sus tenance, and two hundred millions of men expeud their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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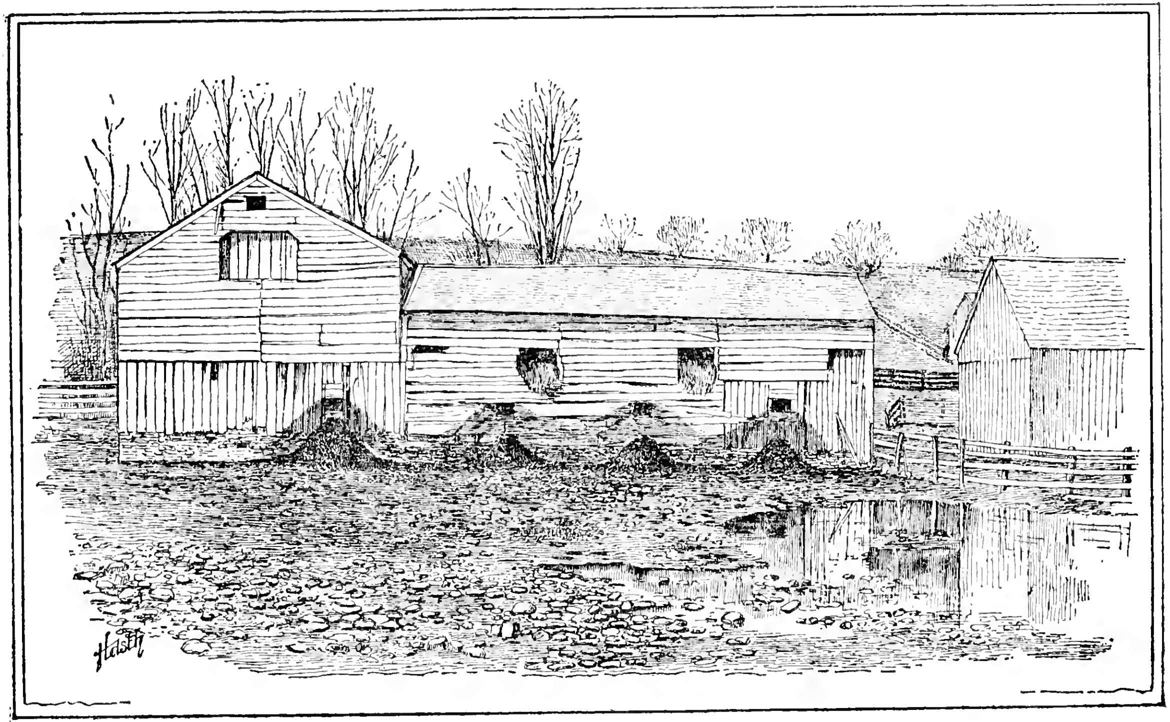
CORNELL UNIVERSITY.

Agricultural Experiment Station.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin for friends, will send us the names of the parties

CORNELL UNIVERSITY EXPERIMENT STATION,
Ithaca, N. Y.



THE WASTE OF MANURE. (*From a Photograph.*)

ON THE DETERIORATION OF FARM YARD MANURE BY LEACHING AND FERMENTATION.

During the past summer investigations have been made in this general subject in three main directions, viz :

I. What loss does horse manure suffer when thrown out in a pile unsheltered from the weather?

II. What loss does mixed farm yard manure suffer when piled in a close pile so that fermentation is very slow ; but without protection from rainfall ?

III. Is there an appreciable loss of valuable matter when manure simply dries without fermentation ?

Losses of Horse Manure in a Loose Pile.

For this experiment all the manure made in our horse stable for one day was used. The stables were cleaned out on Saturday night, March 30th, at 6 p. m. They were then littered with 38½ pounds of straw, and on Sunday night, March 31st, the accumulated manure and straw were gathered together and weighed. There were in the stable during this time nine horses and the floors were tight so that nothing was lost. The total excretion was as follows :

Total weight, manure and bedding	529.5
Weight of bedding	38.5
Total weight of excrement, solid and liquid	491.
Av. excreted per horse per day	54.4

The manure so obtained was placed, without especial care to pack it down in a wooden box that was not water tight but from which water did not easily escape. This box was placed out of doors and surrounded with similar manure so that the whole pile might heat up. The object being to place the box and its contents in the same conditions, as nearly as possible, that prevail when horse manure is thrown out in a loose pile from the stable door. The box was allowed to remain in this position until Sept. 30th, when the contents were weighed, thoroughly mixed and duplicate samples sent to the chemist for analysis.

In order to obtain a sample of manure for analysis to compare with that put in the wooden box, the horse manure for a day was collected in the same manner on the succeeding Sunday. These trials were made on Sunday, because on that day the horses were in the stable all day, and the whole amount of excrement could be obtained. The amount obtained in the second trial was as follows:

Total weight, manure and bedding	496.
Weight of bedding	30.
Total weight of excrement, solid and liquid	466.
Av. excreted per horse per day	58.25

There were but eight horses this time, one being absent, the others were the same and were fed the same. It is fair to assume that the composition of the manure was the same, it being very nearly the same in quantity. The manure was run through a straw cutter to cut up the bedding and then thoroughly mixed and duplicate samples sent to the laboratory.

Incidentally it is interesting to note the amount of solid and liquid excrement voided in twenty-four hours by a horse. The average for the two trials is a little less than fifty-six and one third pounds. Two of the horses were light driving horses, the remainder were grade Percheron farm horses of from 1200 to 1400 pounds weight and were fed liberally on oats and hay.

The composition of the fresh manure and the manure after being exposed as described for six months is given below:

	Analysis of Fresh Horse Manure. Per cent.	Analysis of Horse Manure after having been exposed six months. Per cent.
Water	70.79	81.74
Nitrogen	.51	.46
Phosphoric Acid	.21	.15
Potash	.53	.31
Total Weight of Manure . . .	529.5	372.

The losses therefore were threefold; first, a considerable loss in the total weight; second, a gain in the percentage of water; and third, a loss in the percentage of valuable fertilizing elements.

Let us now compute these losses in dollars and cents. A ton of fresh horse manure would be worth at the present prices of commercial fertilizers, $2.45 as follows:

Nitrogen	.51 per cent . . .	10.2 lbs.	at .17	$1.73
Phosphoric acid	.21 per cent . . .	4.2 "	.07	.29
Potash	.53 per cent . . .	10.7 "	.04	.43
Total				$2.45

The manure that weighed at the beginning 529.5 pounds had shrunk during the six months exposure to 372 pounds or 29.74 per cent. A ton diminished by this amount would leave 1404.2 pounds. This would contain fertilizing materials to the amount of $1.42 as follows:

Nitrogen	.46 per cent . . .	6.5 lbs.,	at .17	$1.10
Phosphoric acid	.15 per cent . . .	2.1 "	.07.	.15
Potash	.31 per cent . . .	4.4 "	.04	.17
Total				$1.42

RECAPITULATION.

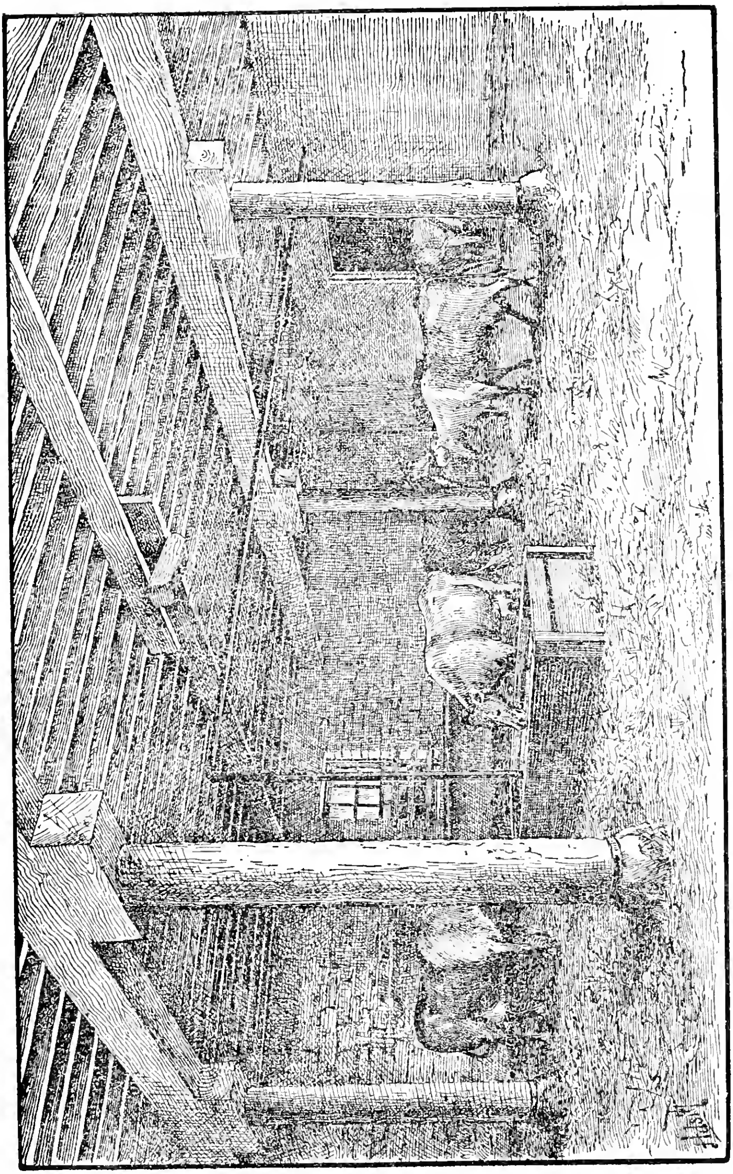
Value of one ton of fresh horse manure	$2.45
Value of same after exposure for six months	1.42

Loss $1.03 per ton or 42 per cent.

Loss of Mixed Manure by Leaching.

For this experiment there was provided a galvanized iron box about two feet square and a little more than one foot deep. It was furnished with a perforated bottom so arranged that the leachings could be caught below in a pail.

Our manure is ordinarily kept in a covered barn yard. A cut of which is herewith shown. The drawing is made to represent the covered yard with one side cut away. The temperature in this yard seldom falls below the freezing point. The horse manure is dropped down from above and spread evenly, the cow manure is wheeled out from the side and likewise spread evenly. Both are mixed with sufficient absorbents of some kind to take up all the liquid. The whole becomes firmly packed by the tramping of the animals. From this mass there was cut a block that would just fit into the box above described. The manure was put into the box without breaking it up, so that it remained in the same condition as to compactness as it had been while in



THE COVERED BARNYARD OF THE CORNELL UNIVERSITY BARN. (*From a Photograph.*)

the covered barn yard. It was then weighed and exposed to the weather from March 29th to Sept. 30th, or two days more than six months.

Into the pail in which the leachings were caught was put a small amount of oxalic acid that any free ammonia in the leachings might be fixed and not escape into the atmosphere. The leachings, as often as the pail became full, were weighed and a sample analyzed. At the end of the experiment the manure was weighed again, thoroughly mixed and a sample analyzed.

During the course of the experiment the rainfall was very abundant, moreover it came in very large quantities at a time. For this reason the leaching for the most part was very rapid and at times there was very little solid matter found in the leachings.

The manure weighed 226 pounds at the beginning of the experiment and 222 pounds at the end. The amounts of the valuable constituents found at the end together with the amount recovered in the leachings with the percentage of loss is given in the following table. The percentage of the valuable constituents in the leachings to the total amount of valuable constituents, as found in the leachings and in the manure at the end of the experiment, is taken as the percentage of loss.

	Amount in Manure at end of expt. Lbs.	Amount in leachings. Lbs.	**Loss. Per cent.**
Nitrogen, ...	1.0101	.0337	**3.2**
Phosphoric Acid, ...	.5839	.0293	**4.7**
Potash, ...	.7992	.4367	**35.0**

If we reduce these figures to the money value per ton, the real lesson of the experiment may perhaps be more readily seen. In the first column is given the money value of a ton of the fresh manure after being leached for six months, in the second the money value of the leachings provided a ton had been exposed in a compact pile one foot thick.

	In Manure at end of expt.	In leachings.
Nitrogen @ .17, ...	$1.52	$ .05
Phosphoric Acid @ .07, ...	.36	.02
Potash @ .04, ...	.28	.15
Total, ...	$2.16	$ .22

RECAPITULATION.

Value of one ton of well tramped mixed manure	$2.38
Value of same after leaching for six months	2.16

Loss $.22 per ton or 9.2 per cent.

It will be noticed that much the largest loss in both amount and value, falls on the potash. While potash is not the most valuable constituent of manure, it is still of so much importance that its loss cannot be ignored. It is usually supposed that the nitrogen is very easily lost from manure, the small amount lost in this case may be, and very likely is, due to the fact that the nitrogen was still largely in an organic and for that reason insoluble form, and decomposition being checked, by the close packing of the mass and by the large amounts of water, very little of the nitrogen was lost.

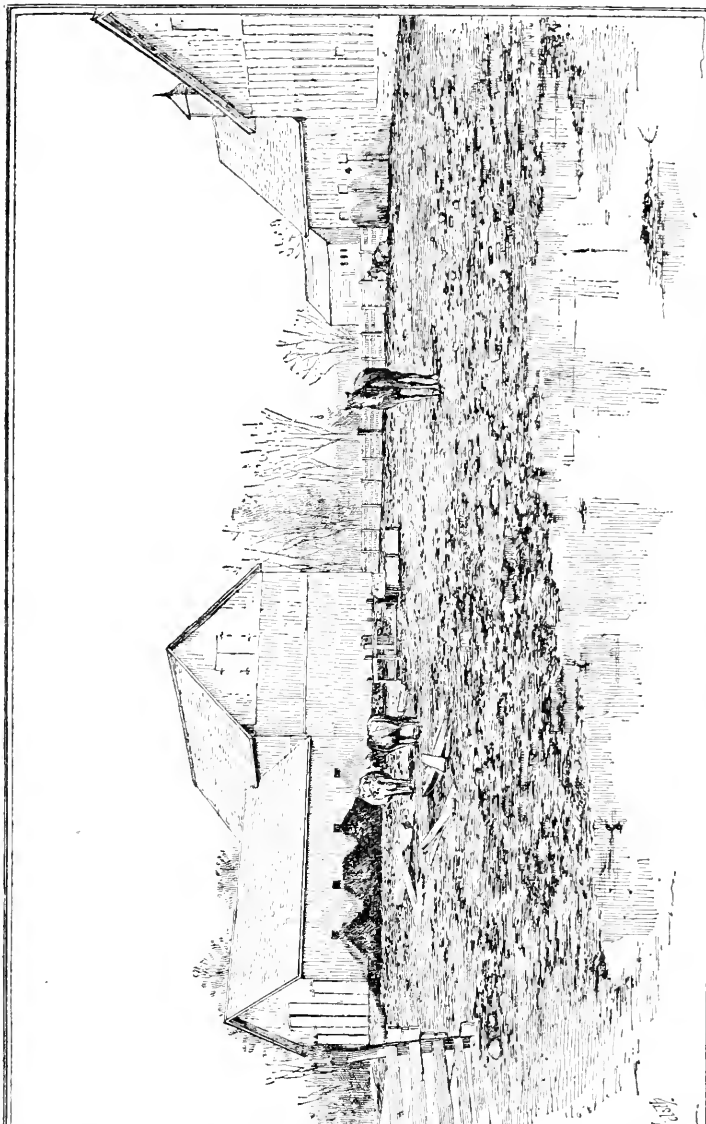
Attention is called to the fact that in this experiment all the conditions favoring loss were less than would ordinarily occur in farm practice with the single exception of the rainfall.

Loss of Manure in Drying,

In this experiment two samples of the same manure as that used in the leaching experiment were spread out thinly in galvanized iron pans. They were exposed to the air all the time and on pleasant days were exposed to the sunshine ; but care was taken not to allow any rain to fall upon them. The result was that they slowly dried out without fermentation. Owing to circumstances over which we had no control, we do not feel justified in publishing any figures of results at present ; but so far as we have any indication at all it is that under these circumstances no appreciable loss of fertilizing constituents takes place.

Summary.

The results of one season's trial seem to show that horse manure thrown in a loose pile and subjected to the action of the elements will lose nearly one half of its valuable fertilizing constituents in the course of six months ; that mixed horse and cow manure in a compact mass and so placed that all water falling upon it quickly runs through and off is subjected to a considerable, though not so great a loss, and that no appreciable loss takes place when manure simply dries.



THE WASTE OF MANURE, *(From a Photograph.)*

Professor Shelton from the results of somewhat similar experiments carried on at the Kansas Agricultural Experiment Station concludes as follows :

"The moral which the experiment plainly emphasizes is, that farm yard manures must be hauled to the field in the spring; otherwise the loss of manure is sure to be very great, the waste in the course of six months amounting to fully one half the gross manure and nearly forty per cent of the nitrogen that it contained."

To show that a large number of the farmers in the state are uninformed in this matter, or at least not sufficiently alive to its importance to take proper care of their manure, we have had engravings made of photographs of two actual "farm steadings" as they were found to exist, early last spring. Attention is particularly directed to the watery, miry condition of the yards and to the heaps of manure under the eaves.

These are not isolated cases, but are fairly representative of a large number of similar views that were taken in one day in the course of a not very extended walk in a single locality, and that a dairy district. From what we have seen from car windows in our journeys through the state, much the same condition of things prevails generally.

I. P. ROBERTS.
HENRY H. WING.

ON THE EFFECT OF A GRAIN RATION FOR COWS AT PASTURE.

It is generally recommended that cows at pasture in the summer should have a supplementary grain ration, and a large number of the more progressive farmers pursue this practice with an evident belief that it is profitable. In the absence of data as to the value of this practice it was deemed worth while to conduct as carefully as might be a somewhat extended experiment intended to afford, if possible, some light on the point in question. To this end the following trial was instituted :

The Cows.

From the University herd there were selected six cows making two lots mated in pairs as nearly alike as was possible in age, breeding, time since calving, yield of milk, and time to next calving, the details were as follows :

Lot I. Fed no grain.

No. 1. Sadie, high grade Jersey, about six years old, dropped last calf Jan. 21, 1889, bred May 10th, 1889.

No. 2. Glista, thoroughbred Holstein, two years old, dropped last calf Jan. 3, 1889, bred July 17th, 1889.

No. 3. Aggie, ⅞ blood Holstein, six years old, dropped last calf July 17, 1888, bred Dec. 23, 1888.

Lot II. Fed grain.

No. 1. Gem of Spring Brook, thoroughbred Jersey, five years old, dropped last calf Jan. 4, 1889, bred May 31, 1889.

No. 2. Dora, ⅞ blood Holstein, two years old, dropped last calf Jan. 6, 1889, bred June 30, 1889.

No. 3. Ruth, ⅞ blood Holstein, four years old, dropped last calf Sept. 1, 1888, bred Nov. 24, 1888.

That the two lots were fairly uniform is shown by the fact that there was only five pounds difference in the total milk yield of each lot for the month of May and the first eight days of June (the time of beginning the experiment); while the average analysis of the mixed milked of each lot for the three days immediately preceding the experiment was almost identical both in total solids and fat. The average number of days in milk was for lot I 188; for lot II, 197. The average number of days in calf was for lot I, 60; for lot II, 62.

At the end of the first period of four weeks, it became evident that the cows No. 3 in each lot were so far advanced in gestation that the results would be materially affected if the experiment were continued and as it seemed desirable to carry on the course of feeding for a considerable time longer, these two cows were dropped and the experiment continued with two in each lot.

The Method of the Experiment.

As has already been said Lot I received only the grass in the pasture, Lot II beside the pasture received a grain ration consisting of two pounds of cotton seed meal and two pounds of wheat bran per cow per day. It was fed in two equal feeds morning and night when the cows were brought into the stable to be milked.

The pasture was almost entirely blue grass on a dry gravelly upland soil and because of the frequent and heavy rains remained plentiful and luxuriant during the whole course of the experiment.

The cows were milked at about half past four in the morning, and about half past three in the afternoon, and the milk weighed as it came from the cow. For three days in each week the milk was analyzed. As soon as milked and weighed, the milk of cows in the same lot was mixed and a sample taken. The evening sample was kept on ice until morning and with the morning sample taken to the laboratory where the two were thoroughly mixed and the fat determined by "Short's Method" and the solids in the ordinary way.

The experiment was begun by sampling and analyzing the milk for three days to give data as to the exact condition of the milk at the time of beginning. As the whole herd were receiving a grain ration of about the same amount and character as the one fed, the effect was rather that of taking away a grain ration than adding it to the grass got in the pasture.

The Results.

The period of feeding extended from June 8th to Sept. 21st, 1889, or fifteen weeks. For convenience of tabulation and reference the time is divided into periods of four weeks each, except the last and the average of each period given in bold faced type.

In the column of yield is given the average number of pounds per cow per day for the whole week ending on the date given, except in the case of the yield given at the beginning of the experiment, which represents the average yield per cow per day for the whole month of May and the first eight days of June.

In the columns of "total solids" and "fats" are given the average analyses for the last three days of the week ending on the date given, except on a few occasions when a sample was lost and the average is then for two days only.

TABLE I.

	Lot I. Pasture only.			Lot II. Pasture and Grain.		
	Yield of Milk. Av. lbs. per cow per day for whole week.	Per cent. Total solids. Av. of last 3 days of week.	Per ct Fat. Av. of last 3 days of week.	Yield of Milk. Av. lbs. per cow per day for whole week.	Per cent. Total solids. Av. of last 3 days of week.	Per ct. Fat. Av. of last 3 days of week.
At the beginning, June 8	**20.60**	**13.95**	**4.19**	**20.55**	**13.82**	**4.18**
Week ending June 15 .	19.17	13.98	4.13	18.75	13.78	4.36
" " June 22 .	19.19	13.14	3.99	17.62	13.39	4.41
" " June 29 .	19.95	12.62	4.08	17.17	12.88	4.38
" " July 6 .	19.90	13.42	3.91	16.66	13.70	4.39
Average 1st Period . .	**19.55**	**13.26**	**4.03**	**17.58**	**13.44**	**4.39**
Week ending July 13 .	19.25	13.21	4.30	17.52	13.75	4.73
" " July 20 .	19.32	13.79	4.44	18.21	14.02	4.84
" " July 27 .	18.64	13.78	4.41	16.64	13.93	4.82
" " August 3	17.95	13.48	4.37	16.11	13.53	4.82
Average 2d Period . .	**18.79**	**13.57**	**4.38**	**17.12**	**13.81**	**4.80**
Week ending August 10	18.29	13.59	4.09	16.29	13.98	5.12
" " August 17	18.07	13.75	4.41	14.84	14.07	5.18
" " August 24	17.54	13.43	4.48	14.00	13.82	5.72
" " August 31	18.05	13.59	4.61	14.64	13.79	5.65
Average 3d Period . .	**17.99**	**13.59**	**4.40**	**14.94**	**13.92**	**5.42**
Week ending Sept. 7 .	18.96	13.61	4.47	13.66	13.82	5.77
" " Sept. 14 .	17.52	13.31	4.30	13.18	13.30	4.28
" " Sept. 21 .	17.16	13.12	4.10	12.43	13.20	4.61
Average 4th Period . .	**17.88**	**13.35**	**4.29**	**13.09**	**13.44**	**4.95**

Study of the Results.

It will at once be seen from the table that there was a steady and constant diminishing in the flow of milk of both lots but that lot II fell away in their milk yield much more rapidly that lot I. At the same time, if we except the last two weeks (of which mention will be made later) the milk of lot II showed a constant and considerable increase in percentage of fats, while that of lot I remained very nearly stationary. For this reason there was very little difference in the total amount of fat produced by the two lots as will be seen by the following summary.

TABLE II.

	Lot I.			Lot II.		
	Av. Milk yield per day per cow. lbs.	Average per cent. fat.	Av. fat produced per day per cow. lbs.	Av. Milk yield per day per cow. lbs.	Average per cent. fat.	Av. fat produced per day per cow. lbs.
At beginning, June 8 .	20.60	4.19	**.86**	20.55	4.18	**.86**
1st Period, June 9–July 6	19.55	4.03	**.79**	17.58	4.39	**.77**
2d Period, July 7–Aug. 3	18.79	4.38	**.82**	17.12	4.80	**.82**
3d Period, Aug. 4–31 . .	17.99	4.40	**.79**	14.94	5.42	**.81**
4th Period, Sept. 1–21 .	17.88	4.29	**.77**	13.09	4.95	**.65**

In this trial we certainly obtained no return in milk or butter for the extra grain fed; but we should want to repeat the trial with other and larger numbers of cows, in other seasons and on other pastures before we should consider the matter as at all settled. At present all the other data we have on the question is found in the report of an experiment made at the Kansas Argicultural Experiment Station in the summer of 1888 * and the results so far as they go are in accordance with ours.

In this experiment two lots of two cows each were fed alternately on rations consisting of pasture alone, pasture and bran, pasture and corn meal, and pasture and ground oats, for periods of seven days each. Professor Shelton from a most careful study of the milk and butter product obtained from these rations extending over a considerable period of time concludes:

"The lesson taught plainly is, that the grain in the case, of corn meal, bran and oats, was fed at a considerable loss. The

* First Annual Report of the Kansas Experiment Station for the year 1888, p. 69.

grain feed added materially to the milk yield, corn meal showing the greatest increase; but this gain did not nearly pay expenses.''

It seemed to us that the weak point in these experiments was in the extreme shortness of the feeding periods, only one week, and for this reason we determined to make our period so long that the effect of continued grain feeding would be shown. Still our final results were scarcely so favorable to the grain ration as Professor Shelton's.

While we received no return in milk and butter for the extra grain fed, we should scarcely want to say that the grain was fed at a loss for two reasons, first, there must have been a considerable saving in pasture, in other words we would have been able to keep a larger number of cows in the same pasture. For we know that a cow of 1000 pounds weight, and this was about the average weight of our cows, will consume when in full milk about twenty-four pounds of dry matter per day, the four pounds of bran and cotton-seed meal would furnish three and one half pounds of this dry matter or fifteen per cent. That is if our pasture would have maintained eight cows without grain feed, nine could have been carried as well with the grain. Second the manurial value of the grain at present prices of fodders and fertilizers, would go far toward balancing its cost. Reckoning that eighty per cent of the fertilizing value of the grain would be returned in the manure, and in this case there would be no danger of loss from leaching or fermentation, the fertilizing value of the two pounds of cotton-seed meal and the two pounds of bran would be 3.2 cents and the cost at 25 and 18 dollars per ton respectively would be 4.3 cents leaving 1.1 cents per cow per day to be accounted for in saving of pasture or increase of product.

Conclusion.

While all the data that we have so far go to show that it did not pay us to give cows on good pasture a supplementary grain ration, yet we do not feel that we have as yet sufficient data to warrant us in recommending those who follow this practice to give it up. So far as our results in butter are concerned, they are so close as to be almost identical. It is quite possible that the milk yield may have been more influenced by the "milking habit" of the cows than by the grain fed. By milking habit we mean the tendency that different cows have to milk for a longer or shorter period after calving. All the cows used in the experiment had been in milk for a considerable period, four of them about five months and the other two considerably longer. It is not only possible but quite probable that these last two (the ones that were dropped at the end of the first four weeks) were more influenced by the individual tendency to "run dry" than by the extra grain feed in the ration. We shall certainly repeat our investigations as soon as opportunity offers.

Supplementary Considerations.

Several conditions arose during the course of the experiment entirely without our control, that may or may not have influenced our results; and while in a certain sense they might be considered as foreign to the real discussion of the result, it seems worth while to mention them in this connection.

1. The rain fall at Ithaca in the growing season of 1889 was phenomenal, especially in the months of June and July, the amounts in inches being as follows: June, 6.74; July, 6.73; Aug. 3.32; Sept., 2.57, while the average for the past 11 years has been June, 3.52; July, 3.95; Aug., 3.02; Sept., 2.44, and during the time of the experiment June 8 to Sept. 21, rain fell on forty-nine days.* Our pastures remained green fresh and luxuriant throughout the whole season. The grass, almost entirely blue grass, grew continuously; but owing to the gravelly character of the soil the grass did not become soft and watery as often happens in soils that are naturally more moist. We cannot help thinking that had there been the usual midsummer drought with its accompaniment of parched pastures the results from our supplementary grain ration would have been more marked.

2. A striking feature of the experiment is the large increase in the percentage of fat in the milk of lot II during the period from Aug. 4 to Sept. 7 inclusive and a similar slight increase in the milk of lot I for the same period. This period coincided almost exactly with the period of least rainfall and highest temperature of the whole summer. From Aug. 5th to Sept. 5th inclusive, there was but one rain (Aug. 14) of any considerable amount, with some half dozen light showers on various intervening dates.

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* For these figures we are indebted to the Central Office of the New York State Weather Service, located at Ithaca.

Thus in the only time during the whole course of the experiment in which the conditions approached those of an ordinary season, we seem to see the greatest effect from our grain ration.

3. Another peculiarity that seems to be traced to climatic conditions is seen in the last two weeks of the experiment. Beginning on Sept. 6, more or less rain fell on every day but one till the close of the experiment on the 21st. During this period the weather was almost continually cloudy and what may be expressively termed "raw." From Sept. 7th to 21st, the percentage of fat in the milk of lot I fell from 4.47 to 4.10, or nine per cent while the fat in the milk of Lot II in the same period, decreased from 5.77 to 4.61, or twenty per cent.

4. In view of the fact that a citizen of a neighboring state has been imprisoned for selling milk that was below the legal standard of twelve per cent of solids, it seems worth while to state that while when the average analysis for three days is taken into account our milk was far above the required standard, (the average for both lots for the whole period was 13.56 per cent total solids and 4.58 per cent fats) yet there was one day when the milk from one lot fell below the legal requirement of 12% total solids, and several others on which the percentage of total solids came dangerously near the "dead line." Had a sample been taken on that day by the State authorities we should have been liable to conviction under the law and to a fine of not more than two hundred dollars and to imprisonment for not more than six months. It seems to us that no law can be just that fixes an arbitrary standard for the purity of milk which may depend upon the results of a single analysis.

I. P. ROBERTS.
HENRY H. WING.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

BOTANICAL DEPARTMENT.

XIV.

DECEMBER, 1889.

I. On the Strawberry Leaf-Blight.

II. On Another Disease of the Strawberry.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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CORNELL UNIVERSITY.

Agricultural Experiment Station.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends, will please send us the names of the parties.

CORNELL UNIVERSITY EXPERIMENT STATION,

Ithaca, N. Y.

THE STRAWBERRY LEAF-BLIGHT.

Sphaerella Fragariæ.—SACCARDO.

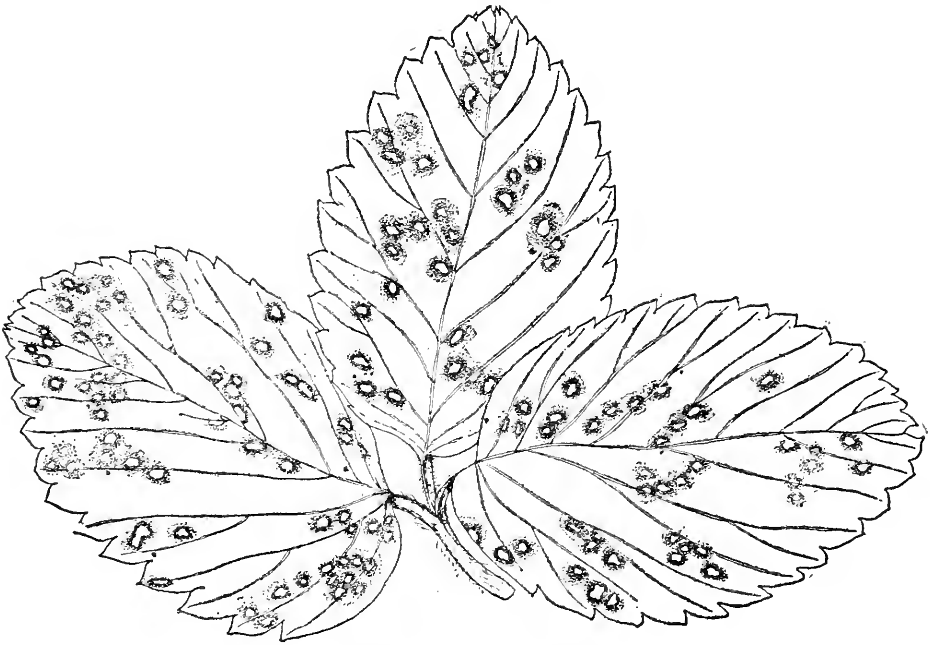

FIG. 1.—Leaf of Strawberry, marked by *Sphaerella Fragariæ.*

DURING the season of 1888 the Strawberry Leaf-blight was unusually abundant. This disease has long been recognized as due to the attack of a parasitic fungus, believed by some to appear in several different but genetically connected forms on the host-plant, by others to be limited to one form only. Finding it extremely prevalent about Ithaca in September and October, it was resolved to observe its habits during the winter and succeeding spring; and, if possible, add something to our incomplete knowledge of its life-history. The general lines of the work were then mapped out, and the very numerous details were placed in the hands of a competent observer in our laboratory.*

GENERAL CHARACTERS.

We adopt the name "Leaf-blight" for the malady in question, as it is a name not only frequently heard, but is appropriate considering the origin and the effects of the disease. Of the various other names found in various publications, the most descriptive is the "spot disease," given on account of the appearance of the blighted areas on the leaf. The names "sun-burn," "sun-scald," "strawberry rust," are also frequently applied, and the enumeration of the above will recall to the mind of any strawberry grower this troublesome disease.

In all sections, it is generally conceded that this blight appears on the new leaves about the time the fruit sets, and if it goes on unchecked is at its worst during the hot weather prevailing just after the crop is gathered. If continuous cloudy and rainy weather in May and June, causing a rank growth of leaves, is succeeded by hot, dry weather in July and August, the strawberry suffers a great check; and if it has also been exhausted by a large crop, it is, in this state of weakened vitality, usually attacked with great severity by the fungus, *Sphaerella Fragariæ.*

The latter, like many of the flowering plants, has various stages of development, each of which taken by itself exhibits characteristics very different from any of the others. The observations and experiments made last winter and spring showed the following stages of growth and reproduction, all proven to be connected: first, the *vegetative* stage, or that of the mycelium; second, the *early conidial* stage; third, the *sclerotium* stage,—a winter conidial stage; fourth, the *perithecium* stage. The spores or reproductive bodies of the second and third are extremely abundant, but short-lived; those of the fourth stage, being "resting" spores, are few but of comparatively long duration.

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* Miss J. W. Snow, holder of one of the University Fellowships during 1888–1889, desiring to inform herself concerning methods in work of this nature, undertook and carried on from October, 1888, till June, 1889, the observations, artificial cultures and infections. While the writer watched the course of the work, and made some of the later experiments, most of the new matter here given is drawn from Miss Snow's observations and records; and the figures after Fig. 2 are from original ones made by her. A long series of experiments on the possible development of sexual organs and pycnidia, and on the growth of the perithecium, are omitted here, as they are not yet complete, and it is Miss Snow's intention to continue this investigation.

There are several other spore-like growths on the strawberry which some writers believe to be yet other forms of *Sphaerella Fragariæ*, but which our experiments thus far have either not dealt with or else given no proof of such connection. These are the "stylospores" and the "spermatia" of Tulasne.* Besides the above there are ten or more species of fungi, all presumably distinct from *Sphaerella*, found parasitic on the Strawberry, none of which, excepting *Ascochyta Fragariæ*, Sacc., are known to produce any serious disease of the host.

When a "spot" first appears on a young leaf in June it is brownish, or more usually red or red-purple, and rapidly assumes the character it has at maturity. When fully developed it has a center nearly circular, dead-white, and usually from 3–6 millimeters (1/8–1/4 of an inch) in diameter. This white center is surrounded by a distinctly red or purple border 1–3 millimeters wide, which shades into dark purple-brown next to the white center (Fig. 1). These spots often join, when the leaf is badly diseased, so as to form a single large discolored area.

THE MYCELIUM OR VEGETATIVE PORTION.

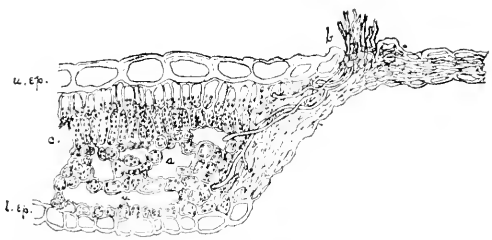

FIG. 2.—Transection of a strawberry leaf in autumn, showing a healthy portion on the left, and on the right the margin of a "spot." The tissue of the leaf is exhausted by the mycelium and shrivelled to one-fifth the original thickness. (u. ep.) the upper epidermis; (l. ep.) the lower epidermis; (c.) cells with chlorophyll; (a.) air spaces of leaf; (b.) basidia of the fallen conidia.

The discolorations above mentioned are caused by the mycelial stage of the fungus, which, with the summer conidia immediately connected with it, are the chief sources of injury to the host-plant. The mycelium (Fig. 2) consists of slender, branched, colorless filaments, the parts of which, whether for vegetative purposes or not, are often called the *hyphæ*. These filaments are narrower than the conidial spores which they bear, varying from .001–.003 of a millimeter in breadth. They push their way between the cells of the interior of the leaf, by contact disorganize the contents of such cells, and absorb their fluids. During this process a red fluid appears in the

* See "Selecta Fungorum Carpologia," II, p. 288, Pl. XXXI f. 1–9; and Ann. d. Sci. Nat., Series IV, Vol. 5, p. 112.

cells in place of disorganized chlorophyll and protoplasm,—a sure sign of lowered vitality,—and gives the reddish appearance seen from without. The mycelium continues to ramify from the center of the spot, where it has begun its work, attacking and destroying other cells, all those within reach of the denser growth of filaments, shrivelling, drying, and finally filling with air. It is this last change which gives the dead-white appearance to the center of the spot. It will be seen from the figures that the white area is only about one-fifth the thickness of the healthy portion of the old leaf, and of course its cells have completely lost their vitality. If these centers of the disease are numerous and coalesce, it will be seen that the whole leaf must succumb and die, an event of frequent occurrence in seasons favoring the fungus. If a second crop of leaves is put out in August, these may in turn be infected from the diseased ones, and either much injured or destroyed, in which case the plants should be plowed up, as no crop can be expected from them the following year.

Especial attention was directed to the hibernation of the ordinary mycelium. Leaves were brought in repeatedly during periods when they were not covered with snow, and placed in a warm, moist chamber. It was found that basidia invariably developed from the borders of the white spots in less than twenty-four hours and produced conidia exactly like the summer conidia. This demonstrated the presence of active mycelium about the disease centers. In the early spring it was found that wholly new spots would appear on diseased leaves, in so short a time after they were brought into the laboratory that no infection

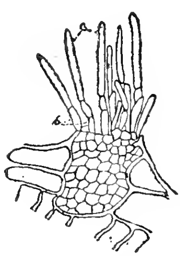

FIG. 3.—Cross section of the upper epidermis of a leaf showing the basidia (*b*) and conidia (*c*) of *Sphaerella Fragariae*.

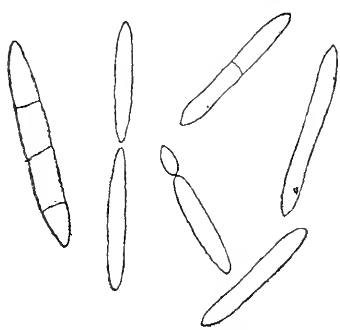

FIG. 4.—The conidia enlarged from Fig. 3.

could have taken place from newly formed conidia. Probably these diseased areas arose from a fresh growth of mycelium that had hibernated in the leaf. The mycelium in the leaf does not descend in the winter through the petiole to the stem and roots, to reascend through the new petioles in the spring. At least in the considerable number of sections made in the spring, no trace of it was discovered in the petioles.

THE REPRODUCTIVE ORGANS.

The mycelium is densest in growth just beneath the epidermis of the white area or at its borders, and from this region certain branches break through the upper epidermis of the leaf. (Figs. 2 and 3.) The ends thus exposed to the air undergo a simple segmentation, the lower cells forming the so-called *basidia*, the upper being the *conidia*, the reproductive organs of this stage. As conidia fall new growths and segmentation of the basidia form new conidia, and this continued production may go on throughout the life of the host. The chief development of the hyphae and basidia is from the upper surface rather than through the stomates or breathing pores of the lower epidermis.

The conidia are oblong or cylindrical, and are .026–.042 millimetres long by about .0035 m.m. broad.* If they fall on or are blown to a fresh leaf-surface and lodged in a little dew or moisture, they send out in a few hours white germ-tubes (Fig. 5). These bore their way through the epidermis of the leaf, and produce new centers of the disease, *i. e.*, new spots.

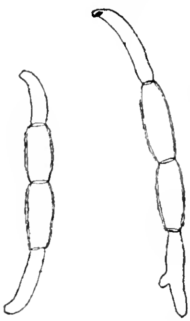

FIG. 5.—Conida germinating.

In the latter part of the season the mycelium becomes compact in certain places (Fig. 3). Toward winter masses of the mycelium, either ovoid or columnar in form, made up of polygonal cells, the outer brown or black-walled, force their way through the broken epidermis anywhere in the diseased part of the leaf, and may be seen as blackish specks, by the naked eye. These are very numerous on our plants and have been termed by Trelease† "*sclerotia*." If the leaves supporting them are brought, in the winter season, into a warm room, and kept in moist atmosphere, hyphal filaments will develop from the surface

* One millimeter = $\frac{1}{25}$ of an inch, nearly.

† Second Ann. Report of the Wisc. Agr. Exper. Sta. (1885) p. 52.

cells of the the sclerotia in from twelve to thirty hours, and immediately produce basidia and conidia like the summer form, (Fig. 6). As Miss Snow has remarked, "there is a striking resemblance between the sclerotia bodies bearing conidia and the later stages of the ordinary conidia growths," as seen in Fig. 3. Indeed, during the autumn we have seen all stages between the two; and although we have termed the hyphal, conidia-bearing filaments of summer, the *early* or *summer stage*, nevertheless this passes so imperceptibly into that seen in Fig. 3, and the latter into the *sclerotium*, or winter conidial stage, that the early stage and the sclerotia must be regarded as extreme states of the same phase of life, resulting almost wholly perhaps, from climatic conditions. When any fungus forms such sclerotium masses, the purpose is usually protection against cold or dessication; and this state takes the place of a "resting spore," in the case of a parasite, tiding the fungus over to the next growing season of its host. As the sections of the United States where these sclerotia have been noticed and reported as abundant, namely, in Wisconsin, by Professor Trelease, and in Central New York, are in regions of rigorous winters, it would be interesting to know whether they were as abundant in the south. Certainly in this region the sclerotia furnished one of the important and effective modes of carrying the fungus over the winter.

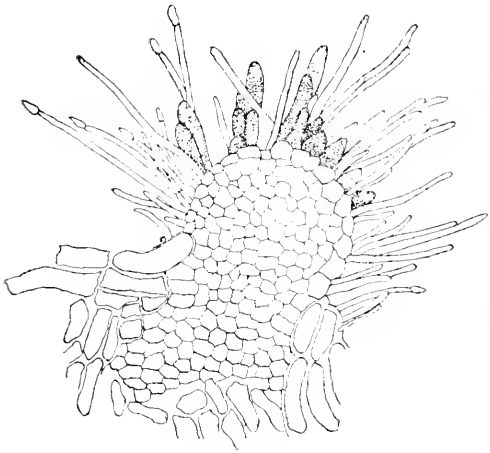

FIG. 6.—Section of a sclerotium producing new hyphal filaments and spores; from a mid-winter experiment.

The *perithecia*, constituting the fourth state mentioned, begin their development in late autumn, but are not mature in our latitude until March or April. They are found about, or occasionally upon the white center of a spot on an old, apparently dead leaf. They can be seen with the naked eye, as minute black points. Externally the wall is nearly black, and composed of large cells. The cavity of the perithecium is lined with delicate, white cells. At the apex is a circular opening in the wall called the ostiolum, and from the bottom arise a series of club-shaped, thin-walled sacs called *asci*. The asci contain eight spores, each of which is oblong and two-celled. These ascospores are capable of a much longer life than the conidia.

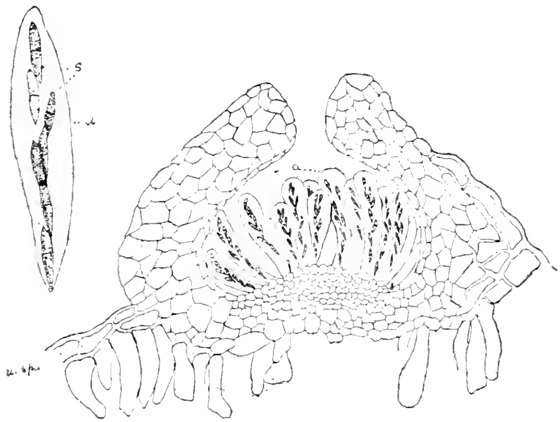

FIG. 7.—Section of a perithecium, with asci (a), and spores (b); an enlarged ascus with spores on the left.

Various opinions have been held concerning the real connection of the conidia and perithecia above described. In 1863, the Tulasne brothers published elaborate figures* of both, as well as another, called the stylosporic stage, asserting them to be forms of a single species, which they called *Stigmatea* (now *Sphaerella*) *Fragariæ*. Saccardo, however, in 1879, separated the summer stage from the perithecial, describing the former as *Ramularia Tulasnei*.† Recently Scribner‡ has asserted his belief, based on direct observation, in the correctness of Tulasne's view; but none of the authorities who have written on this subject, have shown us that they were able to propagate one form from the spores of the other, in artificial cultures, and thus actually demonstrate a genetic relationship. To accomplish this demonstration was one of the objects of the present investigation.

THE CULTURES AND ARTIFICIAL INFECTIONS.

Artificial cultures of the *conidia* were repeatedly made during the autumn and winter. The spores germinated more readily in

* Selecta Fungorum Carpologia, II., p. 286, pl. 31.

† See Sylloge Fungorum, I, p. 508; and Michelia, I, p. 536.

‡ See Report of the Chief of the Section of Veg. Pathology, (1887), Wn. p. 334.

a decoction of strawberry leaves than in any other of half-a-dozen fluids used, and begun to develop in about six hours from the time of sowing. The general result of the artificial cultures in the autumn was the production of a mycelium bearing certain spherical sac-like bodies of highly organized structure. The winter sowings produced mycelium and outgrowths of an entirely different character, and failed to develop the sac-like bodies of the autumn cultures. Both of these are subjects which Miss Snow hopes to further investigate, and no conclusions concerning them will now be published.

The sowings of conidia in the spring, obtained from the basidia on the old leaves, produced for the first time mycelium and conidia, like those from which they were derived ; but none of the growths obtained in the autumn or winter appeared on the mycelium grown in the spring.

Numerous infections were made in April and May, by placing both germinated and ungerminated conidia on the upper and the under surface of young strawberry leaves, which we believed to be previously uncontaminated by the fungus. It was found that the germ-tubes bored their way between epidermal cells of the upper surface, but they were not observed to enter by the stomates of the under surface, although infections took place readily from that surface. Entrance by the stomates was certainly not the usual mode of attack. In about ten days spots, brownish instead of red, appeared on the leaf, and in fourteen days all the places infected usually showed well-defined spots from which conidia were growing. In some cases one leaflet only, in other cases two were infected, and the disease always appeared *only* on the leaflets and in the places infected ; excepting in a few cases where from our control plants, or by other tests we ascertained our plants to be already contaminated.

The *perithecia* were diligently sought for, as it was evident that any proof to be obtained in the spring, of their connection with the conidal stage must lie in the artificial cultures of the ascospores. They were found with mature asci in April ; and on placing an ascus in a hanging-drop, the spores were observed to germinate in about six hours, *within* the ascus. The germ-tube developed from one end of the spore, passing, in case of four of the spores, to one end of the ascus, perforating it, while the germ-tubes from the remaining four perforated the opposite end, (Fig. 8). The mycelium formed by these germ-tubes, was larger than that from the conidia, grew more vigorously, soon producing at the surfaee of the culture-drop conidia, like those already described and figured as the summer conidia.

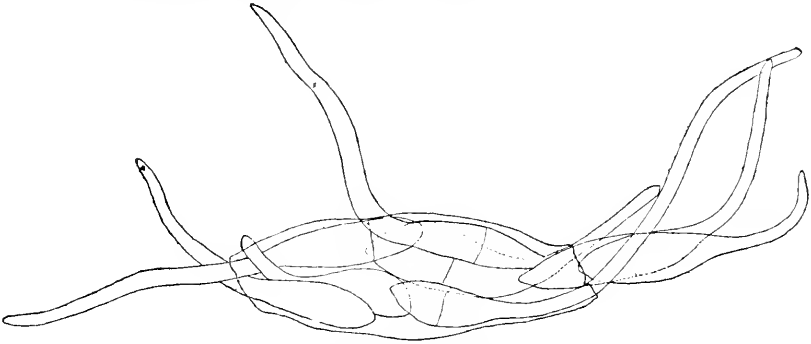

FIG. 8.—An ascus, with spores germinating within.

Asci within the perithecium were now examined and the spores were found to be germinating, not only within the asci, but while the asci were in the perithecium, and the mycelial filaments thus produced were crowding out through the ostiolum, (Fig. 9.)

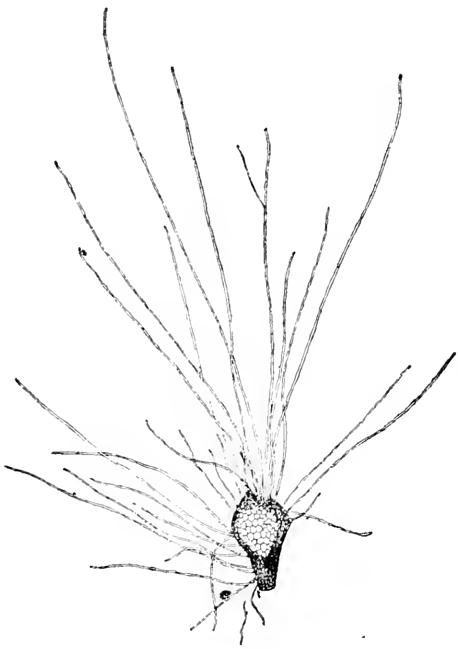

FIG. 9.—A perithecium removed from the leaf and showing the projecting filaments from the germinating ascospores.

The interesting discovery of the production of conidia directly from the ascosporic mycelium, immediately suggested the idea that the ascospore did not ordinarily directly infect the host-plant, but accomplished this only through the conidia it produced. Ascospores were then sown upon the leaves of rapidly-growing plants and in four days the mycelium was observed ramifying over the epidermis, but in no case could it be found penetrating it. Furthermore none of the plants on which ascospores were sown became spotted, with a single exception, and this was proven to have been diseased before the ascospores were placed upon it. The evidence, therefore, is in favor of the above hypothesis ; and as numerous conidia are produced from the mycelium growing from one ascospore, the fungus is enabled to increase many fold the effectiveness of its attack.

Several authors have indicated by figures and descriptions the development of mycelia and basidia from the surface-cells of the perithecium, particularly about the ostiolum. These were said to bear conidia, indistinguishable from the summer or the sclerotium conidia. Although especially sought for, no such out-growths were observed arising from the walls of the perithecium. The fact that the ascospores naturally germinate within the perithecium, and the mycelial filaments grow not only out of the ostiolum, but burst the wall of the perithecium, and grow through its rents, led to the conclusion that observers may have been, in some cases, deceived by the out-growth, supposing it to be directly from the wall-cells of the perithecium itself.

CONDITIONS AFFECTING THE DEVELOPMENT OF THE BLIGHT.

It has been intimated in the early part of this discussion, that a wet May or June succeeded by a hot, perhaps dry, summer causes the parasite to develop rapidly ; that the production of a large crop of berries has frequently been followed by heavy, perhaps fatal attacks of the Blight.* It might be added, that wet, undrained soil greatly favors it.† All these favoring conditions may be reduced to, or result in a single one, namely, an unhealthy or weakened plant. On the other hand a season either prevailingly dry or with abundant moisture throughout, is quite unfavorable to the development of the disease. There was an enormous amount of the fungus in many fields in 1888, and therefore an abundant supply of mycelium and spores, both of which in the spring of 1889 developed vigorously on the old leaves. But the leaves of this season's growth have been conspicuously free from the spots. This is true not only of plants reasonably healthy last year, but of beds where the leaves of last year still bear witness of the great ravages at that time. The Wilson very susceptible to the disease, and the Sharpless supposed to resist it more or less successfully, are both quite free from it in this vicinity. The season has had an abundant rainfall,

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* J. M. Smith, Second Ann. Report Wisc. Agr. Exper. Sta., p. 56, says : "Four-fifths of the plants (in a certain field) were dead from rust ; and that, just as far as they had borne heavily but no farther."

† Scribner, l. c., p. 335.

no drought, and a comparatively even temperature, all of which have favored the normal growth of the foliage. As a consequence the fungus has failed to obtain as strong a foot-hold as usual.

Anything promoting health in the strawberry plant and normal conditions about it is pretty sure to fortify it against its enemy. Its likes and dislikes in regard to soil, mulching, drainage and cultivation ought to be studied as carefully as a grower of choice flowers studies these things. To forestall the unfavorable influences of weather, fungicides must be resorted to.

REMEDIES.

The efficiency of Sulphide of Potassium ("Liver of Sulphur") has been questioned by growers with whom we have spoken; but Professor Scribner recommends a solution of it in the proportions of one ounce to eight gallons of water. Apply this by spraying once a week, from the beginning of the growing season till the berries begin to ripen. He also suggests the use of the copper solutions, and recommends, "three ounces of carbonate of copper dissolved in one quart of water, which should be diluted to twenty gallons."

The copper solutions have the advantage of adhering strongly to the foliage so that rain does not wash them off readily. It would be wise to apply such solutions after the crop is gathered, at intervals of two weeks until September.

The purpose of the above is to *prevent* the germination of conidia and the infection of the new leaves. Should these leaves become more or less infected in spite of the treatment suggested, and should the plants otherwise appear in fair condition, lightly raking up the dry mulch in the spring is advised,* and burning it, together with the leaves of the strawberry. The treatment seems harsh, but if there is not too much of the mulch the plants will send up afterward even a finer growth, and the source of infection is almost wholly destroyed.

SUMMARY.

1. *Sphaerella Fragariae*, Saccardo, passes the winter in this region in at least three different conditions; 1, as *mycelium* in the leaves near the spots; 2, in the so-called *sclerotia*; 3, as *ascospores* in perithecia.

2. Reproduction is provided for through *conidia* and *ascospores*; the former ephemeral, the latter long-lived.

* Trelease, l. c., p. 55.

3. The *ascospores* germinate within the ascus and perithecium, and their mycelium, growing through the mouth of the perithecium, rapidly produces numerous conidia capable of infecting the strawberry. There seems to be proof that no infections take place *directly* from the germinating ascospore.

4. The only mode now known of infecting the new leaves of the host-plant, is through the *conidia*, which grow from the mycelium about the white spots, from that of the sclerotia and from that produced by the ascospore. Consequently the conidia, or the spotted leaves themselves, must be destroyed in order to insure immunity against the disease.

5. The mycelium does not descend to the stem or roots through the leaf-stalks and pass the winter there. Therefore destruction of the *leaves*, in the fall or spring, destroys the fungus.

6. Aside from care in the selection of soil and in good cultivation, two modes of treatment will be found to repay the fruit-grower. First, if the season opens unfavorably, the regular use of the fungicides recommended ; second, if the fungus persists till autumn, destruction, in the following spring, of all old leaves by burning over.

W. R. DUDLEY.

ANOTHER DISEASE OF THE STRAWBERRY.

Ascochyta Fragariæ.—Sacc.

In June, 1889, Mr. Charles M. Booth, of Rochester, forwarded leaves of the Manchester strawberry, badly diseased. He says in a letter : "The leaves were taken from Manchesters set this spring. The other varieties particularly affected are the President Wilder and the Charles Downing, though all kinds show some spots on the leaves. . . . I would like to find some cure for it, and, indeed, must do so or give up raising strawberries."

The only fungus on these leaves, and the one occasioning the disease, was *Ascochyta Fragariæ*, Saccardo, the spores of which are shown in the accompanying figure. Certain leaves were from one-third to one-half discolored and killed by this parasite. Its presence is first manifested in May or June by the appearance of red spots, which enlarge, turn brown, and soon coalesce with neighboring ones, forming a brown patch which often retains the reddish tint. This discoloration is due to precisely the same causes as operate in producing a similar appearance in the Leaf-blight described in the preceding pages. The *mycelium* grows among the cells in the interior of the strawberry leaf, disorganizes and discolors their contents and absorbs their juices. Partly sunk in the diseased tissue of the leaves, and arising from the *mycelium* in the interior of these specimens, appeared small blackish fruiting organs, the *perithecia*, about $\frac{1}{8}-\frac{1}{10}$ of a millimeter ($\frac{1}{200}-\frac{1}{250}$ of an inch) in diameter. The spores arising from the bottom of the perithecia were fusiform or cylindrical, (Fig. 10), two-celled, slightly constricted at the middle, either straight or usually with one or both cells curved, .014–.027 mm. long by .004–.0056 mm. wide. The spores are larger than those in the Saccardoan species, but without expressing here a final opinion, there are reasons for thinking that the forms of *Ascochyta* on the strawberry leaves, described by Saccardo, by Peck* and in this note, belong to one species, *A. Fragariæ*, Sacc.

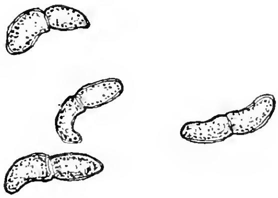

FIG. 10.—Spores of *Ascochyta Fragariæ*.—Sacc.

A considerable number of artificial cultures of the spores were made, but they did not germinate readily, and at that time no conidia were formed on the mycelium. We have not found it about Ithaca, and would solicit more material another season from correspondents, if it reappears on the strawberry. Hitherto *Ascochyta* has never been reported as destructive of this host, so far as we are aware.

As this is endophyllous, (*i. e.* lives within the leaf), it is necessary to spray the leaves before the time of the plant's blooming, with a fungicide, in order to prevent any possible entrance of a germinating spore into the tissues. The spores are killed by the Bordeaux mixture; but this mixture may be too strong for the young leaves, and the weaker Bordeaux mixture, (see next page), is advised. As this fungus is so similar to the Leaf-blight in its habits, we urge those troubled with the disease occasioned by the *Ascochyta* to experiment also with the remedies suggested for the Leaf-blight and to report the results.

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* *Ascochyta colorata*, Pk., 38th Report N. Y. S. Museum of N. H., p. 94. Pl. II, f. 9 and 10.

W. R. DUDLEY.

THE BORDEAUX MIXTURE.

The importance of copper solutions as fungicides having been proved beyond doubt, we append two formulæ for the Bordeaux Mixture, (or Copper Mixture of Gironde), which, in some of its modifications, is used more often than any other.

THE ORIGINAL FORMULA.

(1.) Sulphate of copper, 16 lbs., dissolved in 22 gallons of water.
(2.) Lime, 30 lbs., " in 6 " "

When (2) is cool, mix the solution slowly and thoroughly with solution (1).

A MODIFIED FORMULA.

(1.) Sulphate of copper, 6 lbs., dissolved in 4 gallons of hot water.
(2.) Lime, 4 lbs., " in 4 " cold water.

Mix the two solutions as above, and when desired for use dilute to 22 gallons with cold water. The latter mixture is applied (by means of a "sprayer") more readily than the former, is cheaper, and does not endanger young leaves.

CORNELL UNIVERSITY,

COLLEGE OF AGRICULTURE.

BULLETIN

OF THE

Agricultural Experiment Station.

ALL DEPARTMENTS.

XV.

DECEMBER, 1889.

Sundry Investigations made during the Year.

"That art on which a thousand millions of men are dependent for their sustenance, and two hundred millions of men expend their daily toil, must be the most important of all; the parent and precursor of all other arts. In every country, then, and at every period, the investigation of the principles on which the rational practice of this art is founded, ought to have commanded the principal attention of the greatest minds."—JAMES F. W. JOHNSTON.

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CORNELL UNIVERSITY.

Agricultural Experiment Station.

Offices of the Director and Deputy Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends, will please send us the names of the parties.

CORNELL UNIVERSITY EXPERIMENT STATION,
Ithaca, N. Y.

CHEMICAL DEPARTMENT.

MISCELLANEOUS ANALYSES,—1889.

ASHES.

I. From Melrose Acetate Works, Melrose, Pa., sent on by Hon. J. C. Latimer, Tioga Centre.

II. Cotton Seed Hull Ashes, from Union Oil Co., Providence, R.I.

	I.	II.
Potash soluble in water	3.52	26.24
Total Phosphoric Acid	2.05	7.90
Valuation	$6.01	$32.34
Cost	——	27.00

FODDERS.

I. Malt Sprouts, from C. L. Norton, Rochester. Cost $10 per ton.

II. Cotton Seed Hulls, from Mississippi. Cost $3 to $4 per ton in that state.

III. "Corn Germ" from J. P. Corbin, Whitney's Point.

	I.	II.	III.
Moisture	9.80	9.70	7.39
Ash	7.09	2.49	3.49
Crude Fat	1.67	2.38	10.41
Crude Protein	22.82	4.37	12.10
Crude Fibre	9.70	49.66	5.49
N. free Extract	48.92	31.40	61.12
	100.00	100.00	100.00

Remarks :

I. Is a fair example of malt sprouts, of average composition. It is one of the cheapest concentrated foods. The nitrogen, valued at 15 cents per pound, is worth as a fertilizer $10.95.

II. This food is used to quite an extent in the South. This sample consisted of about half lint and half hulls. I am informed that, by a machine now in operation, the hulls are cleaned from lint, much more perfectly. This would increase the value of the hulls as a feeding material. The chief use, however, to which these hulls are put at present, is for fuel under the boilers in the cotton-ginning establishments. The ashes thus formed are a commercial article, and are particularly valuable as a source of potash.

III. This food is the refuse from a starch manufactory, and compares favorably with corn meal.

IV. Wheat Bran (new process) from spring wheat, sent on by H. M. Jaques, Wright's Corners.

V. "Condimental Cattle Food" from the Condimental Food Co., Philadelphia, Pa.

	IV.	V.	Wheat Bran (83 analyses)
Moisture	12.37	12.22	12.28
Ash	4.26	5.42	3.78
Crude Fat	3.73	4.40	5.70
Crude Protein	11.31	13.81	15.07
Crude Fibre	8.44	7.38	8.71
N. free Extract	59 89	56.77	54.26
	100.00	100.00	100.00
Cost	$10.00	$80.00	——
Valuation	14.10	15.00	$16.35

(The above valuation is calculated by taking three-fourths of the German values established by Wolff. It is to be understood that these values are only comparative, and do not represent the market price or feeding value.)

Remarks :

IV. This bran is of fair quality, and is low in cost.

V. This is one of the many foods which claim to improve the digestion, increase appetite, etc. It is composed of wheat bran, or shorts, mixed with a little salt, and a small quantity of some aromatic plant. Whether it is economical to use this food, depends largely on the scarcity of wheat bran and salt. These are much cheaper unmixed in this locality. No experiments proving the value of fenugreek, anise, etc., have been tried, to my knowledge, and the small amount mixed with the bran can be purchased separately and mixed with the food, if deemed advisable. I have never seen any patented food of this character which has proved economical for cattle feeding.

SOOT.

A sample of soot, sent to the station for analysis, contained 1.13 per cent. of nitrogen. The value of soot as a top-dressing depends not so much on its value as a fertilizer, as on the fact that it helps the soil to absorb heat.

Persons sending samples for analysis to this Experiment Station are advised to send a letter, giving such data in regard to the sample as will help decide whether the matter is one of public utility or not. Unless this is done, it will be classed as work for private parties, and no analysis for private parties will be made by the Station. Analyses having a value for the public will be made free of charge, but, with the present working force, no analysis of any commercial fertilizer can be made, except those fertilizers used by the Station.

W. P. CUTTER.

BOTANICAL DEPARTMENT.

NOTES ON THE MEADOW-GRASSES.

The term meadow-grass as here used is a general one and is intended to include the various species of the botanical genus *Poa*, of which the best known representative is the Kentucky Blue Grass, or June Grass.

The genus Poa is one of the largest genera of grasses, the most conservative authorities making out at least from 80 to 100 species. These are widely dispersed over the northern temperate regions, but are infrequently met with in warmer latitudes. Within the limits of the State of New York about twelve meadow-grasses are found growing wild as native or introduced plants, while the number in the United States is not far from forty-five.

Of all this large number only a very few are regarded as possessing any agricultural value ; but it is probable that other forms if subjected to cultivation might prove valuable for certain soils or certain purposes.

The notes here given on a few meadow-grasses are derived from experiments now in progress on a considerable number of grasses which are commonly regarded as possessing greater or less value as cultivated plants. The experiments include the cultivation of the grasses in question both in pots and in the open ground, and are intended to afford opportunities for a somewhat close economic, structural, and comparative study of the species in question.

The part of the experiment here referred to consists of the sowing of the seeds of some thirty agricultural grasses in adjacent plats in the garden, where the soil and all conditions of cultivation are as nearly uniform as possible. The plats are each two by six feet in size, and were sown in May 1889, the seeds being obtained in the open market from a commercial dealer. The experiments are under the immediate charge of Mr. W. W. Rowlee. The notes here given are made Nov. 20, 1889.

1. Kentucky Blue-grass. June-grass. Spear-grass. (*Poa pratensis.*) Three plats were sown, the seeds being obtained from different sources,—*a*, an extra quality of seed, direct from Kentucky,

obtained through a seed house in Ithaca; *b*, from a seed house in New York City, which furnished also samples of all the kinds of seeds used in the experiment; *c*, common commercial seed obtained in Ithaca. Plats *a* and *b* are completely covered with an abundant growth of grass, from which a considerable cutting could now be made. Plat *c* is only about half covered. None of the plats have seeded except very sparingly.

2. Wire-grass. Blue-grass. (*Poa compressa.*) Only about half the ground is covered, and the plants are growing in rather large separate stools. The plants blossomed and fruited freely. Old seed stalks are still abundant.

3. Fowl Meadow-grass. False Red-top. (*Poa serotina.*) The plot is well seeded, fully ninety per cent of the ground being covered. Flowered and seeded freely, the old stalks being still abundant, as in the last.

4. Rough Meadow grass. (*Poa trivialis.*) The plat is poorly seeded, not more than half covered. The seed was poor and obviously in part untrue to name.

5. Wood Meadow-grass. (*Poa nemoralis.*) A few plants, apparently true to name.

6. Water Meadow-grass. (*Poa aquatica.*) Only a few plants, and these of uncertain identity.

The notes here given indicate the great difficulty of obtaining a satisfactory seeding with commercial grass seed, especially as regards those kinds less generally in use. The field experiments here noted correspond in all important respects with pot experiments in the green house; but the results of the whole series of experiments will be hereafter more carefully and fully elaborated.

ON ROOT-PROPAGATION OF CANADA THISTLE.

A considerable study of the Canada thistle has been made during the past season with reference to its power of propagating itself both by seeds and by under-ground roots. The study is still in progress, but it may be worth while to note at this time some of the results of experiments on root-propagation.

A number of plants were dug from a field of sandy soil, April 11, 1889. At this time the young plants had begun to grow, the leaves being from one to two inches in length. From the roots two sets of cuttings were made, the first, marked A in the table, from the smallest thread-like roots which could be found ; the other marked B, from stouter roots from one-eight to one-fourth of an inch in diameter.

The length of the cuttings varied from one-sixteenth to one inch in length. They were planted in pots and placed in the cool house April 12. The results of the experiment are in part indicated in the following table :

Experiment Number.	Size of Cutting.	Length of Cutting in Inches.	No. of Cuttings Sown.	Number of Plants.
1.	A	$\frac{1}{16}$	72	0
3.	A	¼	72	0
6.	A	1	24	1
7.	B	$\frac{1}{16}$	36	0
9.	B	¼	36	5
10.	B	½	24	24

As a general result of the experiments it may be inferred that minute fragments of the roots of Canada thistle, when left in the soil are not likely to grow, while very small portions of roots of a somewhat larger size are pretty sure to produce new plants freely. It should be noted, however, that the soil in which the cuttings were placed was almost constantly too damp—a condi.ion which could not well be avoided for reasons not necessary to mention here ; so that the inference may fairly be drawn that the results above recorded do not show the full power of the Canada thistle to multiply itself by root-propagation.

ON THE VITALITY OF WEED SEEDS.

During the season of 1879 a considerable collection of seeds of various weed plants were made for the Botanical Department, the special purpose of which was to aid in naming such seeds or plants as might be sent for identification. As a part of a general study during the past season of the physiology of weed plants, a number of these seeds were tested as to their vitality. The collection was kept in the Botanical Museum, the seeds being corked up in small bottles. The conditions were not favorable to the preservation of the vitality of the seeds, as the museum was almost always hot and dry, especially in the winter, when constantly steam heated.

Thirty-two kinds of seeds, (or in the case of the wild carrot, the seed-like fruits) were chosen for the experiment. These were sown in boxes in the green house, April 13, 1889, and as noted above were all ten years old. Out of the thirty-two kinds sown, only ten germinated up to the end of the experiment, May 30, as shown in the following table :

Department Number.	KIND OF SEED.	No. of Seeds Sown.	Date of Harvest.	Number of Plants.
3	Pigweed. Green Amaranth. (Amaranthus albus). .	50	Apr. 22	24
10	Thyme-leaved Sandwort. (Arenaria serpyllifolia) .	50	Apr. 22	26
13	Purslane. (Portulaca oleracea).	50	Apr. 22	15
15	Carrot. (Daucus carota)	40	May 30	15
23	Narrow-leaved Plantain. (Plantago lanceolata) . .	50	Apr. 22	23
29	Pigweed. (Chenopodium album).	50	May 30	25
30	Red-root. Pigweed. (Amaranthus retroflexus). . .	50	Apr. 22	25
31	Dock. (Rumex—species not known)	50	Apr. 22	16

It should be noted that the conditions for germination in the green house were probably not so favorable as in an out-door seed bed, as the atmosphere was constantly near the point of saturation and the soil for the most part too moist.

In the following table the kinds of seeds of which no germination took place are given :

Tall Buttercup. (Ranunculus acris.)
Wild Parsnip. (Pastinaca sativa.)
Alyssum. (Alyssum calycinum.)
Shepherd's-purse. (Capsella Bursa-pastoris.)
St. John's-wort. (Hypericum perforatum.)
Soapwort. (Saponaria officinalis.)
Catchfly. (Silene noctiflora.)
Cockle. (Lychnis Githago.)
Chickweed. (Stellaria media,)
Mouse-ear Chickweed. (Cerastium viscosum.)
Sweet Clover. (Melilotus alba.)
Caraway. (Carum carui.)
Cone-flower. (Rudbeckia hirta.)
Dandelion. (Taraxacum dens-leonis.)
Salsify. (Tragopogon porrifolius.)
Plantain. (Plantago major.)
Toad-flax. (Linaria vulgaris.)
Speedwell. (Veronica arvensis.)
Wheat-thief. Red-root. (Lithospermum arvenss.)
Gromwell. (Lithospermum officinale.)
Hound's-Tongue. (Cynoglossum officinale.)
Sheep sorrel. (Rumex acetosella.)

The plants indicated in table I were allowed to grow until they were from two to four inches in height. All appeared strong and vigorous as though quite capable of asserting their rights had they begun their career in field or garden.

A. N. PRENTISS.

CRYPTOGAMIC BOTANY.

[The following notes on subjects now under investigation in the Cryptogamic Laboratory, are contributed chiefly for the purpose of soliciting information from those practically acquainted with them in the field or garden. Any facts relative to the extent of the disease, the history of its appearance, favoring conditions for its development, its treatment, successful or unsuccessful, will be welcomed.—W. R. DUDLEY, Dec. 1889.]

I.—THE ONION MOLD.

Peronospora Schleideniana, De Bary.

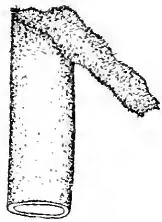

Fig. I.—Leaf of Onion, (natural size,) showing the mold (*Peronospora Schleideniana*) on the upper part.

So far as we can certainly ascertain this destructive disease was observed in New York last year, for the first time. It was forwarded to us from Madison, N. Y. by Mr. R. A. Goodrich, on July 29, who writes, * * * "It is very destructive. I have a bed of onions in my garden the tops of which are now all dead and dry from the effects of this parasite. It first appeared last year but has not become general in this section. The plant is killed by the time the bulbs are from one-half to one inch in diameter. In setting out this spring the small onions saved from last year's crops I found several of the bulbs completely covered by this mold and threw them away. It shows that the mold can be kept over winter." On August 6th, he writes: "very little of it can be found at present. The season of its growth seems to be the months of June and July."

About this time it was observed by ourselves on the onions in the gardens on the University farm, where it was not particularly destructive, rarely causing half a leaf to wither, or attacking all the leaves. Several small fields of the crop were noticed in Ithaca, all of which were unaffected by the mold.

It is common and greatly dreaded in Europe; but was not noticed in America till 1883, when observed by Professor Trelease* in Wisconsin. Since then it has not often been mentioned and seems to have been largely confined to the West. Even in the Connecticut River Valley, the only disease of the Onion attracting attention appears to be the "Onion Smut" (*Urocystis Cepulae*, Frost.)

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*In the "First Ann. Rep. of the Agr. Exper. Sta. of the Univ. of Wisc." (1883) this author summarizes what was known concerning the Onion Mold or "Onion Rust," and gives the best account of it, available to American gardeners.

The mold first appears on the upper part of a leaf as a velvety grayish outgrowth, being visible to the unaided eye, (Fig. 1). This pilose appearance is due to the fruiting branches, or conidiophores, growing out of the stomates, (Fig. 2) from the mycelium in the interior of the leaf. The stomates are numerous and in many plants each one is occupied by a fruiting branch, hence the velvet-like aspect of the diseased part. The gray or smoky tint is due to the lavender color in the cell-wall of the conidial spore, (Fig. 2, co.) The direct effect of the fungus is to cause the upper part of the leaf to become pallid, slowly shrivel, and finally in the autumn to become nearly white.

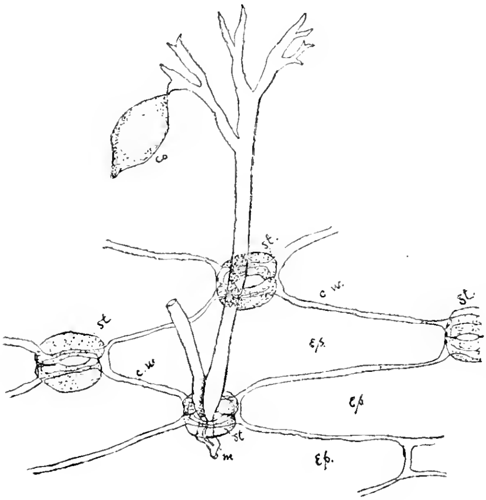

Fig. 2.—A few epidermal cells (ep.), and Stomates (st.) of the Onion. A conidiophore of the Mold growing through a stomate from the mycelium (m.) bears a conidium (co.) The cell-walls (c. w.)

This *Peronospora* is nearly related botanically to several destructive forms of fungi such as the Downy Mildew of the Grape, the Lettuce Mold and the more destructive Potato Rot fungus. Its habit is similar. Its conidial spores germinate within a few hours after maturity if they fall on the surface of the onion-leaf and find it moist. The germ tube enters a "breathing-pore" or stomate when it forms an extensively branching and ramifying mycelium, running among and preying upon the leaf-cells. A few days suffice for its maturity when its conidiophores, already mentioned, grow through the stomates and immediately develop the conidia on the ends of the ultimate branches as shown in the figure. The rapid maturing of these conidia furnish another crop of spores for fresh infections.

The rapid and the fatal progress of the disease as indicated in the letter from Mr. Goodrich, is thus accounted for. If it has not already, in many quarters, been as severe as at Madison, where it destroyed the crop, it is likely to develop at any time into a dangerous enemy, if we may judge from the experience in England and France.

An important link in its history, its mode of passing the winter, has not been definitely ascertained. Beside the conidial spores, which are ephemeral, it produces rarely "oospores," or spores which will live over winter in the dead tissues of the onion-leaf. But these are probably not the active propagators of the disease. They rather ensure the species against complete extinction at any time.

Mr. Goodrich and others have found the onion bulbs in the spring affected, apparently by this fungus. We have examined the tissue of fresh leaves growing on diseased plants in October and November, and found vigorous mycelium among the cells, although there was no external sign of the fungus, nor was there any disposition to send out fruiting branches when the onion plant was brought into a warm room. If the mycelium hibernates in the leaves or bulbs and begins to fruit in the spring from this source, it is possible our future observations may ascertain the fact.

No remedy has been tried. But the success in France of the copper fungicides in the treatment of a related parasite, the Potato-rot,—(see repetition of this important experiment, appended below), justify us in hoping they will protect the onion also. No bulbs from a crop diseased the previous year should be set out; and the English are in the habit of sowing the onion seed in the fall, thus enabling the young plant to get a good start before the possible advent of the fungus in the spring.

Note: The Prevention of Potato Rot.

Col. A. W. Pearson of Vineland, N. J., in "Garden and Forest" Dec. 4, 1889, reports almost completely successful experiments during 1889, against the common Potato Rot (*Phytophthora infestans*) by the use of either of the following copper solutions:

(1). *The Bordeaux Mixture.* The particular formula employed was as follows: (a) Sulphate of copper (pulv.), 6 pounds, in 4 gallons of hot water, (b) Fresh Lime, 4 pounds in 4 gallons of cold water. Mix (a) and (b) slowly and thoroughly and dilute to 22 gallons.

(2). *Ammonia Solution of Copper.* (a) Carbonate of copper, 3 oz, (b) Ammonia liq., 1 quart. Dissolve (a) in (b) and dilute to 22 gallons.

He reports experimenting on two plats of Peach-blow Potatoes, growing side by side, under the same conditions, and equal in area. The fungus and consequently the disease appeared on the unsprayed plat. He obtained only 164 pounds of small unmarketable tubers of poor flavor. The disease did not appear on the sprayed plat on leaves or tubers; and 346 pounds of large tubers of fine flavor were produced.

II.—*ANTHRACNOSE OF CURRANTS.

**Gloeosporium Ribis*, (Lib.), Mont. and Desm.

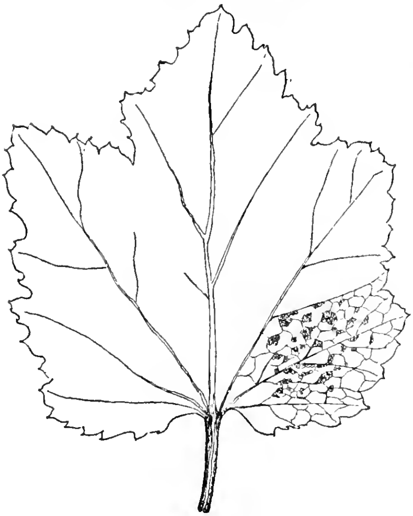

Fig. 3.—Leaf (reduced ½) from the White Dutch Currant. The venation shown in detail on the right hand together with the Leaf-blight, (*Gloeosporium Ribis*).

This note is published, on what is apparently a comparatively new trouble in the garden, to call attention to it, and afford information that would seem important at the present time, although it will appear that our knowledge is meager enough. Investigations on it begun last summer, will be continued during the coming season.

The spots appear (Fig. 3) chiefly on the upper surface but within the tissues of the leaves of certain species of the wild currant, and certain varieties of cultivated species. It was first reported from America by the Rev. M. J. Berkeley in "Notices of North Amer. Fungi" Grevillea II, p. 83, (Dec., 1873). It is there given as occurring in Connecticut on leaves of *Ribes nigrum*,—a cultivated currant,—collected by Charles Wright, and in "New England, by Russell." Since then it has been found by Dr. C. H. Peck, on leaves of the Wild Fetid Currant (*R. prostratum.*) It was found abundantly the past season on the leaves of the White Dutch currant growing in the University garden, while the Black Naples and the Crandall (*Ribes aureum*) growing next the White

*The common spotting of bean-pods, a disease of the Grape, one of Raspberry and Blackberry leaves and other diseases are caused by various species of *Gloeosporium*. Mycologists are adopting the name Anthracnose for all *Gloeosporium* diseases, hence the above name.

Dutch were free. Mr. C. M. Booth of Rochester reported it as severely attacking the Red Dutch Currant. Dr. C. H. Peck the State Botanist, reports it as abundant on and injurious to cultivated currants near Albany. All agree as to its effects. It appears in June or the early part of July, as small dark brown or blackish spots from ¼—1 millimeter in diameter. (Fig. 3). These may increase rapidly; and as the epidermis is raised by the spores beneath these spots, it becomes whitish, and a small pore appears in this raised surface through which the spores (Fig. 4) held together by a mucilage, escape in a little tendril. On account of the whitened epidermis the spots incline to a rustier or grayer tint than they possess at an earlier date. The general color that part of the leaf infested by the fungus at this stage is a dull brown. The leaves soon turn yellow, begin falling before the middle of July, and by the first or second week in August, if not earlier, the bushes are as bare as in November. Mr. Booth says that "under such circumstances the currants do not fully ripen but shrivel and fall off."

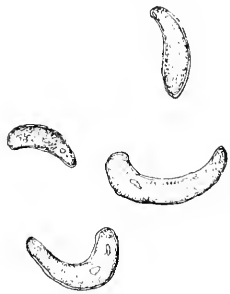
Fig. 4.—Spores of *Glœosporium Ribis.*

The spores (Fig. 4) are one-celled, curved, somewhat enlarged at one end, and, in all North American forms reported, from 1½–2 times the length of the European forms described by Saccardo. The measurements given by Berkeley, Peck and those made by ourselves practically agree, being from .015—.025 millimeters in length. Specimens from France in Roumeguere's *Fungi Gallici* No. 1873 are from .012—.016 millimeters long, and M. C. Cooke sent Ellis* specimens from Europe which were mostly .015 m. m. long, while Saccardo in his great work† gives only .010 of a m.m. as the length. There seems little doubt therefore of the identity of the American and the European forms, nevertheless the disease seems to have done little injury in Europe, and until this year, not to have attracted any attention whatever in America.

It is to be hoped that the peculiarly moist summer gave it an advantage it will not soon have in succeeding years, but it may be necessary to carefully watch the varieties susceptible to it, next June, and to apply occasionally by means of a fine sprayer, like the Eureka Sprayer, one of the copper solutions; for the entrance

*Ellis and Everhart, *Journal of Mycology* I, p. 110.
‡Sylloge Fungorum III, p. 706.

of the spores into the leaf must be *prevented* if the crop is to be protected. It is fair to suppose the copper solutions will be as efficacious in this as in Strawberry Leaf-blight.

The biological investigation of this presents peculiar difficulties, for we have little doubt that it hibernates elsewhere than on the fallen leaves of the previous season.

III. LEAF-BLIGHT OF QUINCE AND PEAR.

Entomosporium maculatum, Lev.

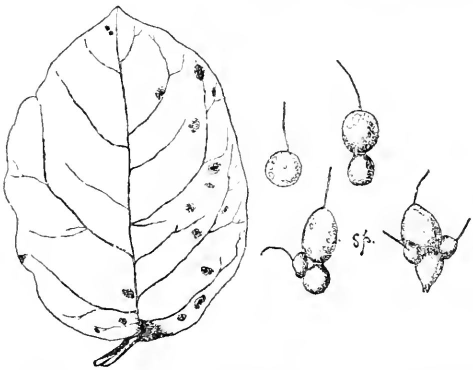

Fig. 5.—Leaf of Quince with spots of *Entomosporium maculatum*; also the spores (sp), of the latter much magnified. E. PORTER, Del.

Five years ago Mr. G. F. Wilcox of Fairport, N. Y., sent to the University, Quince leaves and fruits very much diseased by the above. The leaves were affected by circular brown spots from 1–3 millimeters in diameter, and the fruits had many brown patches from 3–7 millimeters in diameter on the surface. At the centre of the diseased areas in both cases were small perithecia (or pseudo-perithecia) containing the insect-like spores (fig. 5, sp.) of this fungus, and arising from the mycelium growing among the cells. These areas on the fruit were slightly sunken as if a finger had been pressed on them. Many of the fruits badly affected had cracked and all were unmarketable. We reported it as *Morthiera Mespilii*, Fuckel; *var. Cydoniae*, Cooke and Ellis, the name by which it was usually known at that time. Saccardo has revived the earlier name *Entomosporium maculatum*, Lev., which is given in his *Sylloge Fungorum*, III, p. 657, and by which it is now usually mentioned.

For some years it has been scarce on the Quince although it was abundant this year in some localities in New York.

It affects the Pear in precisely the same way, causing the leaves to fall and the fruit to crack. The greatest injury, however, is caused by its attack on seedling pears or quinces in the nursery. By causing the fall of the leaf the parasite so weakens the standard that grafting will not succeed.

Fortunately experiments during the past two years have proven—so we are assured on good authority, that this disease in all its phases, can be entirely controlled by the use of the copper solutions.* No nurseryman or fruit-grower need suffer further loss therefore, if he sprays the leaves once in two or three weeks in the early part of the growing season, and is careful to renew the spraying after heavy showers.

Considerable has been written concerning the habits of this parasite. It is believed to be chiefly reproduced through its conidia, (the spores figured in this paper), but Sorauer † claims to have discovered perithecia with ascospores or resting spores, on old leaves late in the autumn ; such, however, have not been reported in America. Indeed there are many hidden facts connected with the hibernation of this fungus, and the sources of its infection in the spring, which if known may lead to precautionary care such as may save time and money to the fruit-grower. One of the students in this laboratory is now at work on this question, has contributed the drawing (No. 5) would be glad to correspond on the subject, and will publish the results of the work if new facts are developed.

The CLOVER RUST [*Uromyces Trifolii*, (Alb. and Schwein.) Wint.] is another recent arrival from the Old World, and has destroyed a great amount of the host-plant this season. If correspondents can furnish us with well-considered estimates of the injuries caused in different localities or the history of its appearance, such facts may prove of value to us in investigations now going on.

W. R. DUDLEY.

ENTOMOLOGICAL DEPARTMENT.

THE APPLE TREE TENT CATERPILLAR.

Clisiocampa americana.

During the last few years the orchards in many parts of this State have become overrun by the Apple-tree Tent-caterpillar. In certain sections this insect has increased to so great an extent that it has destroyed every leaf in the orchards. Although the habits of this insect have been well known to entomologists for

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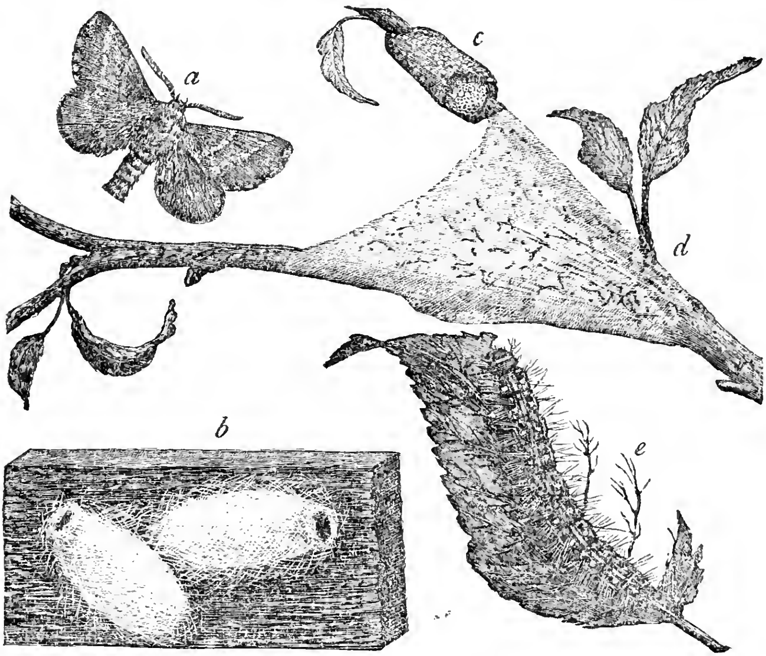
* See *Garden and Forest* Dec. 4, 1889, p. 582.

† Pflanzenkrankheiten Ed. II., Vol. II, p. 371. Plate XVI.

many years, it is evidently worth while to give a brief account of it in this place ; for it is rapidly assuming the importance of a first class pest. This, however, is unnecessary as it is one of the easiest of insects to combat.

We have two very common insects that build their webs in fruit and forests trees. One of these makes its webs early in the spring chiefly in apple and wild cherry trees ; the other occurs in the latter part of the summer, and infests a much wider range of trees ; frequently occurring in large numbers upon ash, oak, and other forest trees, as well as fruit trees. The former of these is the Apple-tree Tent-caterpillar (*Clisiocampa americana*) ; the latter, the Fall Web-worm (*Hyphantria cunea*) I do not care to speak further in this place of the latter. I merely mention it in order that the Apple-tree Tent-caterpillar shall not be confounded with it.



The accompanying figure illustrates the transformations of the Apple-tree Tent-caterpillar. The eggs are shown at c ; these are laid in a ring-like cluster about a small twig, and are covered with a substance, which protects them from the weather. These eggs are laid in mid-summer, and remain upon the trees until the following spring. They may, therefore, be found at any time during the winter months. This fact indicates an excellent method of combating this pest. If the trees are carefully searched during that part of the year when they are bare of foliage, the clusters of eggs can be easily found and destroyed. The little machine resembling a pair of shears, attached to the end of a long pole which is used for picking apples, will be found very useful in collecting these clusters of eggs. By the use of it one will be saved the necessity of climbing the trees. All wild cherry trees occurring in the vicinity of the orchard should also be cleared of eggs or destroyed ; as these usually serve as breeding places for this pest.

Early in the spring just as the buds are beginning to open the eggs hatch. In many cases this happens before the buds open ; and the young caterpillars are forced to gnaw into the buds in order to get food. In this way there is frequently much injury done before the webs appear. For this reason, I earnestly advocate the destruction of the egg clusters in preference to fighting the insects at a later stage.

As soon as the caterpillars hatch they move down the twig until they reach another branch ; and here in the fork they begin their web. The beginning of such a web is represented at d, in the figure just below the cluster of eggs. Ordinarily, however, the caterpillars move a much greater distance than that represented, making their web in a much larger fork. This web serves as a nest for the entire colony of worms hatched from the cluster of eggs. As the worms increase in size they add successive layers to the outside of the nest, making it larger and larger, until it becomes one or two feet or more in length.

A point to be remembered is that this web serves merely as a residence, and that the worms must leave it in order to get their food. Thus during a portion of the day comparatively few caterpillars will be found in the nest, the majority of them being scattered over the tree, feeding upon the foliage. It is a curious fact that this caterpillar spins a silken thread wherever it goes. As a result of this, there may be found upon the limbs over which the caterpillars pass in going to and from their nest, little bands of silk, extending from their nest to the various parts of the tree where the insects have fed.

As these webs are very conspicuous, the ordinary method of fighting this insect is by the destruction of it in the webs. This can be easily done by means of a torch attached to the end of a long pole. Care should be taken to do this when the insects are in the web, and not while they are scattered over the tree feeding. Ordinarily the best time will be early in the morning, or late in the afternoon, or during a stormy day. This work should also be done early in the season very soon after the appearance of the leaves; in fact as soon as the webs can be seen. It is a good deal like locking the stable after the horse is stolen, to delay the destruction of these insects until they are nearly or quite fully grown, as is usually done, if done at all. The caterpillars reach maturity about the middle of June. A single mature caterpillar is represented at e, in the figure. At this time they leave the trees in search of a place in which to spin their cocoons; they may then be seen crawling in all directions upon fences and over the ground. They choose some secluded place as the lower side of a stone or other object, where each makes for itself a dense silken cocoon. Two of these cocoons are represented attached to a piece of wood at b, in the figure. These cocoons may be easily recognized by their having a yellowish-white powder mixed with the silk.

Within the cocoon the insect changes to a pupa, and remains in this state about three weeks; it then emerges as a brownish moth whose wings are crossed by two oblique whitish lines. This moth is represented at a, in the figure. Soon after the adults appear the females lay their eggs, thus completing the circle of transformations.

There remains to be mentioned one other method of fighting this insect; that is by spraying the trees, as soon as the leaves appear, with Paris-green water. In this way the caterpillars will be poisoned while feeding upon the leaves. If the Apple-tree Tent-caterpillar is the only insect to be fought in the orchard, I do not think the spraying of the trees will be found as cheap a method as the destruction of the webs, except in those cases where the insect is very abundant. Ordinarily there will not be more than one or two webs upon a tree; and those can be destroyed much more quickly and cheaply than the tree can be sprayed. But if the trees are to be sprayed for the Codlin-moth or the Canker-worm, the same application will serve to destroy the Tent-caterpillar.

JOHN HENRY COMSTOCK.

AGRICULTURAL DEPARTMENT.

FIELD TRIALS WITH FERTILIZERS.

Ever since the Station was established in 1879, more or less work has been done in the way of field trials with commercial fertilizers and the almost universal experience has been that no marked results have immediately followed the application of such manures especially phosphates. As the result of these trials and the common experience of farmers in the locality, it seems reasonable to assume that some peculiarity of the soil in a certain limited district renders the soluble phosphoric acid almost immediately inert so that the plant can not use it. That this phosphate is finally available to the plant seems almost as certain to us as that the plant cannot use it immediately.

In the season of 1888 three separate trials with fertilizers other than phosphates were made on widely different localities of the farm and on different crops. The results in general were much the same as previous experience had led us to expect with phosphates and are given herewith, simply for what they are worth with no attempt at generalization.

The crops were ensilage corn, clover and timothy mixed, and oats. In all cases four h undred pounds per acre of the fertilizer was used broadcasted, in the case of the corn and oats befere seeding and in the case of the grass, on the sod early in the spring. The plots were in all cases one-tenth acre in area and ranged side by side.

Fertilizer Used.	Ensilage Corn. Pounds per acre.	Clover and Timothy Hay—lbs. per acre.	Oats.	
			Grain. Bushels per acre.	Straw. Pounds per acre.
1. Nothing	†20610	*5445	*42 3/8	*1945
2. Ground Bone	17100	*6010	42 3/16	1750
3. Cotton Seed Meal	15450	*5450	46 7/8	2000
4. Cotton Seed Hull Ashes . . .	13900	*5255	46	2030
5. Star Bone Phosphate			48 3/4	2040
6. Equal parts of 3 and 4 . . .	13600			
7. " " 2 and 3 . . .	13200			
8. " " 2 and 4 . . .	14730			
9. " " 2, 3, and 4 . . .		5690		
10. " " 2, 3, 4, and 5.			41	1990

* Average of Duplicate plots.

† Yield probably greater from moister situation of plot.

If we rearrange this table so that the yield of the unfertilized plot is in each case represented by 100 and the yields of the other plots changed in the same proportion it is easier to compare the effect of the fertilizers on the different crops. This we have done in the table below.

Fertilizer Used.	Ensilage Corn.	Clover and Timothy Hay	Oats. Grain.	Oats. Straw.	Average
1. Nothing	100.	100.	100.	100.	100.
2. Ground Bone	83.	110.4	99.6	90.	96.1
3. Cotton Seed Meal	75.	100.1	110.7	102.8	94.
4. Cotton Seed Hull Ashes	67.4	97.	108.5	104.4	90.3
5. Star Bone Phosphate			115.1	104.8	
6. Equal parts of 3 and 4	66.				
7. " " 2 and 3	64.				
8. " " 2 and 4	71.4				
9. " " 2, 3, and 4		104.5			
10. " " 2, 3, 4, and 5			96.7	102.3	

It will be seen that the average results obtained from those fertilizers that were used on all the crops is slightly below the crops obtained without the use of fertilizer. Even if we eliminate the effect of the moister situation of the unfertilized corn plot it could scarcely be claimed that there was an appreciable advantage gained by the use of the fertilizers.

A POINT IN THE CULTIVATION OF ROOT CROPS.

That roots form a very desirable adjunct to the winter ration of almost all kinds of domestic animals few who have raised them will question. At the same time from the large amount of water they contain, it is imperative that they be raised at the smallest possible cost in order to make their use profitable as a food for animals.

Two things make the growth of mangels expensive. First, germination is imperfect, in the second place, beside being imperfect, germination is often slow to start and being slow the weeds get the start of the young beets thus necessitating much hand weeding and a large increase in expense. These two things deter many who would otherwise raise considerable quantities from attempting their culture at all.

The mistake that is commonly made and to which we especially desire to call attention in this note is that beets are usually planted entirely too late. The common practice being to fit and plant the root ground after the corn is out of the way. As the result of experience we have come to the conclusion that this is not the best practice. The beet is a plant native to much colder latitudes than is corn and will germinate and grow in temperatures where corn would do nothing. The root ground should be plowed and fitted as early in the spring as the land can be brought into proper condition for the seed ; that is deep, rich, mellow and finely pulverized. At this time there is seldom a lack of sufficient moisture in the soil to insure rapid and even germination of the seed, while if planting is delayed till the latter part of May an incipient drought is often responsible for the slow start of the beets.

By planting early (about the middle of April), by the use of plenty of seed that is known to be good, and with the least possible amount of hand cultivation, we have succeeded in raising roots at a cost so low that we believe they can be fed at a profit.

The results of the past season's crop are fairly typical of our usual success and are given herewith not as representing anything unusual in the way of yield but as illustrative of what may be expected with ordinary careful practice.

The land was clover sod and had received a coat of farm yard manure in its regular rotation. It was plowed and fitted with harrow and cultivator till there was a seed bed such as the one described. The beets were planted April 18th. The season was very wet and the weeds were unusually numerous thus necessitating more than the usual amount of hand weeding. The plot contained 36,853 square feet or a little more than three-fourths of an acre. The yield and labor expended were as follows :

361.75 hours labor, man at 15 cents	$54.26
76 hours labor, team at 20 cents	15.20
Seed 3 pounds at 50 cents	1.50
Total	$70.96
Yield from 36,853 sq. ft., pounds	60705
Yield per acre, pounds	71753
Yield per acre, bushels	1196
Yield per acre, tons	35.75
Cost per bushel for seed and labor	$.07

Good authorities, (*i. e.*, practical dairymen) consider roots to be worth ten cents per bushel for feeding purposes, when fed in small quantities as an adjunct, digester, or appetizer.

It will be noticed that we have charged for labor of man and team nearly double what they can be procured for on ordinary farms. Even at these prices we have succeeded in more favorable years in raising roots at a cost of five cents per bushel for seed and labor.

I. P. ROBERTS.

HORTICULTURAL DEPARTMENT.

THE ORANGE MELON.

The fruit to which I have given the name Orange Melon has been offered by several seedsmen and others during the last two or three years under a variety of names, as Vine Peach, Mango Melon, Vegetable Orange and Melon App'e. The descriptions of it are always more or less indefinite, and the cuts are such as to convey little idea of its relationships. The following description is a sample: "One of the most beautiful vegetables grown. They grow on vines same as melons, are a beautiful golden yellow, almost exactly resembling oranges in color, shape and size. The flesh is snow white. Fried as egg plant, when green, they are delicious, and most excellent for mangoes. They will keep in good condition two months after being picked."

This vegetable is a variety of the musk-melon species, *Cucumis Melo*. Several similar varieties of the melon are grown in Europe. and it will probably not be difficult to identify our plant with some European variety during the coming season. The introduction of the Orange Melon into this country appears to have been recent. It was evidently first offered to the trade by Frank Finch, of Clyde, N. Y., probably four or five years ago. Mr. Finch writes, "I first obtained a sample of the vegetable orange from one of my customers. * * * I offered it to the trade, and now most of the seedsmen have it. I do not know how it originated." W. W. Tracy, of Detroit, informs me that "the vine peach and its nearly related Queen Ann's Pocket Melon are grown quite commonly by the Swedes, Norwegians and Danes in the northwest, and I think that the plants have been distributed from this source."

The Orange Melon is somewhat variable in size and shape. It is commonly nearly spherical, if one may judge from descriptions, but plants from one source gave us oblong fruits. The fruits range from two to three inches in diameter. They possess none of the common characteristics of the musk-melon fruit, but are suggestive, rather, of a cucumber. The variety presents some desirable features, but it is over praised.

THE CRANDALL CURRANT.

The Crandall currant was introduced but a couple of years ago, yet it has attracted general notice from the fact that it represents a species practically new to the fruit garden. The originator supposed it to be a hybrid between the Buffalo or Missouri currant and the common red currant.

Fifty plants were set upon the Experiment Station grounds in the spring of 1888. The plants have grown vigorously and all bore fruit last season. Plants have been observed in other places, also, and full notes and careful tests have been made.*

The Crandall is a simple variation of the Buffalo or Missouri currant (*Ribes aureum*), known in yards as the "flowering currant." It gives no indication of hybridity. The species is well known to be a variable one, and bushes occassionly appear which

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*The writer published a full account of the variety in the American Garden, Sept. 1889, 309.

produce edible and attractive fruits. It does not appear to be a well "fixed" variety. Some of our bushes produce berries little larger than those of the red currant, while others give fruits five-eighths of an inch in diameter. It is also variable in period of ripening on our plants, although the soil is uniform throughout the row.

Our bushes were fairly productive, but a heavy crop could not be expected from young plants. Bearing canes and photographs from Frank Ford & Son, the introducers, show remarkable productiveness. The habit of the plants indicate probable high productiveness.

The plant is hardy and vigorous and so far our specimens have been free from insect attacks, although the currant worm was very abundant upon adjacent rows of common sorts. The bushes attain to a large size, and need more room than other currants.

The fruits are large and fair, bluish-black and polished. They separate from the stem and are therefore picked and sold singly, like gooseberries and cherries. The flavor is sweet and agreeable, though not pronounced. There is none of the grossness of flavor characteristic of common black currants. It makes good stews, pies, and jellies, whether used green or ripe. In jelly we prefer it to other currants.

The variety is wholly distinct from every other. It represents a new type of small fruit, which, when further selected and improved, must come to be a staple.

INFLUENCE OF SOIL UPON PEAS.

It is well known that peas are quickly influenced by certain soils. The fact was incidentally well illustrated in our garden the past season in a planting of the Golden Gem. The rows began in a good rich loam and ran into a stiff and strong clay. A good sod had been turned under a few days before the peas were sown. The ends of the rows were so dissimilar at picking time that they appeared to be planted with different varieties. Twelve average plants were selected from each end of the patch, and they gave the following data :

Plants on loam.—Average height of plant, 18 inches; average number of pods per plant, 5.4; all the pods, except sometimes the very uppermost ones, were ripe and there were no flowers.

Plants on clay.—Vines larger, deeper green, more glaucous (more "bloom"), with a tendency, not apparent in the other case, to produce two pods on a peduncle; average number of pods per plant, 7; only about two-thirds of the pods were ripe, and there were still some flowers.

THE INFLUENCE OF DEPTH OF TRANSPLANTING UPON THE HEADING OF CABBAGES.

It is a common practice among gardeners to set cabbage plants to the depth of the first leaf, upon the supposition that deeply set plants give better heads than others. The experience and observation of the writer, during several seasons, have lead him to doubt the greater efficiency of deep-planting, beyond some influence it may exert by preventing injury from very dry weather. The following tests were made during the past season, the soil, particularly in the case of the late cabbages, being poor or in poor condition. Heavy rains may have interfered with the experiments with the early sorts by packing the earth or washing it away from the stems. But the tests were carefully made, and the late plantings did not suffer from rains. The early cabbages were started in a forcing-house March 15th. The late ones were sown July 2nd. The deeply set cabbages were planted up to the seed-leaves, while the others were set at the same depth at which they stood in the seed-bed. The column marked "Ratio" is designed to show, graphically, the ratios between the average weights of head in each lot; the lightest average weight in every couplet is called 1, and the heaviest average weight is divided by it.

VARIETIES. *Early Sowing.*	Number of Heads.	Heaviest Head. Lbs.	Lightest Head. Lbs.	Average Weight. Lbs.	No. of Immature Heads	Ratio.
Vandergaw—Shallow.	22	8.5	1.2	4.8	3	**1.4**
Deep . .	20	6.	.4	3.3	6	**1.**
Salzer—*S's Lightning*						
Shallow. . .	26	5.5	1.	2.9	2	**1.**
Deep.	21	6.	1.5	3.9	0	**1.3**
Early Etampes—						
Shallow. . . .	19	4.5	.7	2.6	1	**1.**
Deep.	19	5.5	1.2	3.3		**1.3**
Early Jersey Wakefl'd						
Shallow. . . .	16	7.	.4	4.1	1	**1.4**
Deep.	12	4.	.9	3.	4	**1.**
Extra Early Express.						
Shallow. . . .	15	4.5	1.7	2.6	. .	**1.**
Deep.	15	4.5	2.3	3.3	. .	**1.2**
Early Winningstadt—						
Shallow. . . .	13	5.9	1.8	4.	. .	. .
Deep.	19	5.	2.2	3.9	. .	. .
All Seasons—						
Shallow. . . .	13	. .	. .	5.9	. .	**1.1**
Deep.	13	. .	. .	5.1	. .	**1.**
Hard Heading Red—						
Shallow. . . .	20	5.5	1.6	4.	0	**1.1**
Deep.	24	8.	2.6	3.7		**1.**
"Imp. Stone-Head Heavy Red Dutch."						
Shallow. . . .	20	10 5	3.7	7.	. .	**1.06**
Deep.	17	9.	4.	6.6	. .	**1.**
Wick's Long Isl. Red.						
Shallow. . . .	21	7.5	2 6	4 6	. .	**1.**
Deep.	11	7.5	3 9	5.6	. .	**1.2**
Late Sowing.						
Marblehead Mamm'th						
Shallow. . . .	24	7.	.5	2.2	18	**1.**
Deep.	26	5.	.5	2 9	8	**1.3**
Flat Dutch—Shallow.	30	9.	1.7	4.9	2	**1.**
Deep. .	34	10 5	.7	6.4	1	**1.3**
All Seasons—Shallow.	31	8.5	1.4	4.3	4	**1.4**
Deep. .	24	6.	.8	3.1	5	**1.**

Summary.—Of the twelve lots, one-half did best from each treatment. The comparative ratios are 13.46 to 13.6, in favor of deep plantings. In other words, in 565 heads, those from the deep plantings averaged about two ounces per head heavier. 270 cabbages gave better results in shallow planting, and 295 better in deep planting. The differences is the two cases are so slight as appear to be indifferent.

INFLUENCE OF DEPTH OF SOWING UPON SEED TESTS.

Extremes in depth of planting are known to greatly affect germination. The investigation here recorded was undertaken for the purpose of determining if minor variations in depth of planting exert any influence upon results of seed tests. Seventy-two tests were made upon tomatoes, one-half of the seeds in each test being sown one-fourth inch deep, and half one-half inch deep. They were all sown in the house during March and April, in potting soil in 22-inch flats. The figures of these tests are too extended for presentation here. The average total germination from the samples sown one-half inch deep was 87.07%, and from those sown one-fourth inch, 86.92%. The difference is only three-twentieths of one per cent. As a rule, plants appeared sooner from the ¼ inch samples, as might be expected. In some cases, however, the ½ inch samples gave the earliest visible results, probably because the soil, in these instances, was more uniformly moist at the greater depth. The general behavior of seeds at these depths, as regards rapidity of appearing, is shown in the following test of cauliflower seeds:

CAULIFLOWER; *Thorburn's Gilt-Edge Snowball.*—Thorburn.

125 seeds in potting soil in 22-inch flat.

No. 1, ¼ inch deep. No. 2, ½ inch deep.

SOWN APR. 4.

Samples.	Sproutings.								Total.	Per Cent.
	Apr. 8	9	10	11	12	13	14	15		
No. 1, ¼-inch . . .	**36**	37	12	4	1	1	. .	1	92	73.6
No. 2, ½-inch . . .	**7**	61	11	8	3	3	1	1	95	76.

Essentially the same results were observed in the case of the Green Flageolet Beans.

From the foregoing figures and remarks we may conclude as follows:

1. In tomatoes, there is no evidence that per cent. of germination is influenced by variations from one-fourth to one-half inch in total depth of planting; and there is indication that the same may be said of other plants.

2. The greater rapidity of appearing of the plants in ¼ inch plantings as compared with ½ inch plantings, is only such as is due to the fact that in the shallower plantings there is less soil for the plantlet to push through.

DO OLD SEEDS OF CUCURBITS GIVE SHORTER VINES THAN RECENT SEEDS?

There is a belief that new or fresh seeds of squashes, pumpkins, and melons produce plants which "run to vine" more that those from old seeds; and this supposed redundance of vegetation is considered to exist at the expense of fruitfulness. An extensive test was made upon this point last season. The following species and varieties were grown: Squashes: White Bush Scallop, 3 ages, Summer Crookneck, 2 ages. Watermelons: Peerless, 2 ages, Mountain Sprout, 4 ages, Black Spanish, 3 ages. Muskmelons: Nutmeg, 3 ages, Improved Canteloupe, 2 ages. Cucumbers: Long Green, 4 ages, Short Green, 3 ages, Early Chester, 2 ages. The age of the seeds ranged from one to six years. About 450 plants were grown, all of which were measured, including the laterals, and records were made of the numbers and weights of fruits. The plantation occupied a poor piece of land, with no other enrichment than a thin sod which was plowed under. The land had not been cropped for some years, and was therefore uniform in character, and well adapted to the experiment. The figures are much too extended to be presented here.

There was no evidence whatever that older seeds give shorter and more productive vines. In fact, there was no uniformity of behavior between seeds of like ages. The largest vines in some instances came from oldest seeds, in others from the newest, and in others from those of intermediate ages. All this variation is evidently due to heredity of the individual seeds, or to conditions of growth of the immediate parents, rather than to age of seeds. The following summary of figures obtained from cucumbers may be taken as an indication of results in other species :

Variety.	Year when the Seeds were grown.	No. of Plants Raised.	Average Length of Vine, with Branches.	Ratios.
Long Green	1883	20	10.1	1.11
	1884	15	9.1	1.
	1886	13	17.1	1.88
	1888	13	14.1	1.55
Short Green	1884	3	25.7	1.52
	1886	4	17.5	1.03
	1888	14	16.9	1.
Early Cluster.	1882	10	8.7	1.
	1888	12	13.8	1.58

The ratios in the last column are obtained by taking the shortest average growth as 1, and dividing the other averages in the same variety by this number. In the first variety, Long Green, the shortest vines grew from 1884 seed and the longest from 1886 seed. In the Short Green, the shortest growth was from the most recent seed and the longest from the oldest seed, while in the Early Cluster the result is reversed.

TESTS OF A PATENT GERMINATOR.

A "New Preserver and Germinator of Cereals and Seeds of All Kinds," through the use of which there are to be "no more short crops" and which gives "absolute assurance of perfect and complete germination and an increase in yield of more than twenty-five per cent.," is sent out by F. P. Dimpfel, 60 Broadway, New York. The compound is evidently organic. It is apparently designed primarily for use upon cereals, but in virtue of the fact that it is adapted to "seeds of all kinds," it was tried upon various garden seeds. The material is dissolved in water and used as follows:

"Pour the liquid on the seed 24 hours before using, stirring occasionally to assure the uniform saturation.

"It can also be used by immersion. Let the seed soak for 12 hours in the liquid and then take it out and allow it to dry."

This appears to mean that 24 hours treatment is required if the liquid is poured upon the seeds, while but 12 hours is required when the seeds are dropped into the liquid.

The following tests were made:

1. TURNIP, *Red Top Strap-Leaf.*—Thorburn.

No. 1, 100 seeds soaked in germinator 24 hours.
No. 2, same, in water 24 hours.

SOWN APR. 30.

SAMPLES.	May. 2	May. 3	May. 4	May. 5	May. 6	May. 7	May. 8	May. 9	Total.
1. In Germinator, 24 hours.	. .	20	33	13	5	3	2	4	**80**
2. In Water, 24 hours.	1	63	14	3	3	1	. .	. .	**85**

Epitome.—The sample treated with the compound gave slightly lower results than the other, and the germination was less rapid.

2. RADISH, *Early Scarlet Globe.*—Henderson.

100 seeds of each number.
No. 1, soaked in germinator 12 hours.
No. 2, soaked in water 12 hours.
No. 3, soaked in germinator 24 hours.
No. 4, soaked in water 24 hours.

SOWN APR. 27.

SAMPLES.	APR.		MAY.													Total.
	29	30	1	2	3	4	5	6	7	8	9	10	11	12	17	
1. Germinator, 12 hours	.	.	2	1	.	2	1	4	8	3	1	.	2	.	.	**24**
2. Water, 12 hours	9	40	22	5	1	1	1	1	.	.	.	.	.	.	.	**80**
3. Germinator, 24 hours	.	.	.	.	.	.	1	.	.	.	.	1	2	.	3	**7**
4. Water, 24 hours	.	13	44	11	4	5	2	1	.	.	1	.	1	.	.	**82**

Epitome.—The germinator so far weakened the seeds as to practically destroy their value, particularly in the sample soaked

24 hours, according to directions. The test was repeated, the seeds being soaked 6 hours :—

3. Radish, *Early Scarlet Globe.*—Henderson.

No. 1, soaked in germinator 6 hours.
No. 2, soaked in water 6 hours.
No. 3, untreated.

SOWN MAY 3.

Samples.	May.											Total.
	6	7	8	9	10	11	12	13	14	15	16	
1. Germinator, 6 hours	.	4	4	15	3	5	5	2	4	2	5	**49**
2. Water, 6 hours	2	58	4	7	.	.	1	.	.	.	.	**72**
3. Untreated	5	56	3	5	.	1	1	.	.	.	.	**71**

Epitome.—The seeds treated to germinator still gave poor results, yet they did much better than the samples soaked twice and four times as long ; they also germinated more slowly than the other samples.

4. Onion, *Red Wethersfield.*—Thorburn.

No. 1, 100 seeds soaked in germinator 24 hours.
No. 2, 100 seeds soaked in water 24 hours.

SOWN APR. 30.

Samples.	May.								Total.
	3	4	5	6	7	8	9	10	
1. Germinator, 24 hours	2	7	46	7	4	.	.	.	**66**
2. Water, 24 hours	3	21	30	11	2	2	1	1	**71**

Epitome.—Seeds treated to germinator fell slightly below the other in per cent. of sprouting.

5. Tomato, *Bell.*—Cornish.

No. 1, 100 seeds soaked in germinator 24 hours.
No. 2, 100 seeds soaked in water 24 hours.

SOWN MAY 2.

Samples.	May.					Total.
	7	8	9	10	11	
1. Germinator, 24 hours	.	55	33	4	2	**94**
2. Water, 24 hours	15	73	4	1	.	**93**

Epitome.—The results are essentially the same in both samples. The test was repeated, giving 98 per cent. for the germinator and 89 per cent. for those soaked in water.

Conclusion.—With the exception of an indication of a trifling advantage in the tomato seed tests, in which the results may have been wholly accidental to the treatments, the germinator gave no results in germination superior to those obtained from soaking the same length of time in water; while in radishes the damage done by the material was marked. In radishes and turnips it also lessened the rapidity of germination.

L. H. BAILEY.

APPENDIX II.

Detailed statement of the receipts and expenditures of the Cornell University Agricultural Experiment Station for the fiscal year ending June 30, 1889.

RECEIPTS.

FROM AGRICULTURAL DEPARTMENT.

1888.		
Nov. 6.	Wool sold,	$ 10 60
1889.		
Feb. 23.	Sheep Carcasses and Pelts,	5 40
Apr. 1.	1 Dorset Ram Lamb,	15 00
" 8.	1 " " "	15 00
" 15.	1 Dorset Lamb, dressed,	5 75
" 29.	1 Dorset Ram Lamb,	12 00
May 16.	Wool sold,	15 12
June 7.	2 Dorset Ewes, 1 Ram Lamb,	112 00
	Total from Agritultural Department,	$190 87

FROM HORTICULTURAL DEPARTMENT.

1889.		
Feb. 28.	Hauling Fuel,	$ 22 41
" 11.	Overcharge on Feed Bill,	1 00
Apr. 1.	Hauling Fuel,	45 17
" 15.	" "	34 80
	Total from Horticultural Department,	$103 38

EXPENDITURES.

FOR SALARIES.

1888.		
Oct. 1.	I. P. Roberts, Director, 1 qr.,	$ 375 00
" 1.	H. H. Wing, Deputy Director, 1 qr.,	500 00
" 1.	L. H. Bailey, Horticulturist, ½ qr.,	250 00
" 1.	James M. Drew, Asst. Agr., 1 qr.,	187 50
" 1.	Wm. P. Cutter, Asst. Chemist, 1 qr.,	187 50
" 1.	J. M. Stedman, Asst. Entomologist, 1 qr.,	187 50
" 1.	W. W. Rowlee, Asst. Botanist, 6 days,	12 50
1889.		
Jan. 1.	I. P. Roberts, Director, 1 qr.,	375 00
" 1.	H. H. Wing, Deputy Director, 1 qr.,	500 00
" 1.	L. H. Bailey, Horticulturist, 1 qr.,	500 00
" 1.	James M. Drew, Asst. Agr., 1 qr.,	187 50
" 1.	Wm. P. Cutter, Asst. Chemist, 1 qr.,	187 50
" 1.	J. M. Stedman, Asst. Entomologist, 1 qr.,	187 50
" 1.	W. R. Dudley, Crypto. Botanist, 1 qr.,	187 50
	Amount carried forward,	$3,825 00

		Amount brought forward,	$3,825 00
Apr.	1.	I. P. Roberts, Director, 1 qr.,	375 00
"	1.	H. H. Wing, Deputy Director, 1 qr.,	500 00
"	1.	L. H. Bailey, Horticulturist, 1 qr.,	500 00
"	1.	James M. Drew, Asst. Agr., 2⅔ months,	166 67
"	1.	Wm. P. Cutter, Asst. Chemist, 1 qr.,	187 50
"	1.	J. M. Stedman, Asst. Entomologist, 1 qr.,	187 50
"	1.	W. M. Munson, Asst. Horticulturist, 1 qr.,	187 50
"	1.	W. R. Dudley, Crypto. Botanist, 1 qr.,	187 50
July	1.	I. P. Roberts, Director, 1 qr.,	375 00
"	1.	H. H. Wing, Deputy Director, 1 qr.,	500 00
"	1.	L. H. Bailey, Horticulturist, 1 qr.,	500 00
"	1.	Ed Tarbell, Asst. Agr., 1 qr.,	93 75
"	1.	Wm. P. Cutter, Asst. Chemist, 1 qr.,	187 50
"	1.	J. M. Stedman, Asst. Entomologist, 1 qr.,	187 50
"	1.	W. M. Munson, Asst. Horticulturist, 1 qr.,	187 50
"	1.	W. R. Dudley, Crypto. Botanist, 1 qr.,	187 50
		Total for Salaries,	$8,335 42

FOR BUILDINGS.

1889.			
Jan.	11.	Martin Gibbons, Labor,	$ 4 57
"	11.	John Mullehey, Labor,	4 99
"	11.	Wm. Cunningham, Labor,	2 47
"	11.	John Gaherty, Labor,	1 42
"	11.	Martin Solon, Labor,	4 57
"	12.	John Hennessey, Labor,	2 70
"	21.	Thomas Quilk, Labor,	11 25
"	21.	Dennis Connor, Labor,	9 19
"	28.	Jamieson & McKinney, Iron pipe,	9 16
Feb.	4.	Patrick Higgins, Labor,	1 50
Jan.	30.	George Small, Lumber,	59 72
Feb.	15.	Adams Express Co., Expressage,	25
"	26.	Thomas Quilk, Labor,	2 70
"	26.	Patrick Higgins, Labor,	1 42
Mar.	2.	D. S. Slaight, Labor,	8 40
Feb.	18.	Pay Roll,	72 75
Mar.	26.	D. S. Slaight, Labor,	10 20
"	26.	H. W. Smith, Labor,	1 35
Feb.	19.	George Small, Lumber,	39 89
Mar.	28.	Treman, King & Co., Paint,	5 77
Feb.	14.	" " Paint and hardware,	42 39
"	1.	" " Sash and hardware,	106 22
Apr.	1.	Herendeen Mfg. Co., Steam heating contract,	300 00
June	26.	Driscoll Bros., Mason work,	35 00
"	28.	Jamieson & McKinney, Repairs, Insectary,	12 12
		Total for Buildings,	$750 00

FOR PRINTING.

1888.			
July	12.	U. S. Express Co., Expressage on plates, Bull. II.,	$ 1 15
Aug.	1.	Adams Express Co., Expressage on plates, Bull. II.,	4 65
"	17.	Andrus & Church, Erratum slips and postals,	7 75
Nov.	12.	U. S. Express Co., Expressage Bull. III.,	25
"	23.	Crosscup & West, Eng. Co., Plate, Bull. III.,	19 00
		Amount carried forward,	$ 32 80

		Amount brought forward,	$ 32 80
Nov.	26.	Adams Express Co., Expressage, ...	35
Dec.	11.	Anna B. Comstock, Drawings, Bull. III., ...	52 50
1889.			
Jan.	3.	E. C. & N. Railroad, Freight on Bull. III., ...	2 30
"	10.	Crosscup & West Eng. Co., Plate, Bull. IV., ...	22 00
"	12.	Adams Express Co., Expressage on plate, ...	35
1888.			
Dec.	28.	Theodore L. DeVinne & Co., Press work, Bull. III., . .	103 00
1889.			
Jan.	26.	Andrus & Church, Eratum Slips Bulletin IV., ...	3 50
1888.			
Dec.	18.	The Lovejoy Co., Electrotyping Bulletin III., ...	37 36
"	18.	" " " Extra Electros, ...	3 39
1889.			
Feb.	4.	U. S. Express Co., Expressage Bulletin III., ...	50
"	15.	Andrus & Church, 10,000 copies Bulletin IV., ...	165 00
"	18.	Andrus & Church, 625 copies Annual Report, ...	183 27
"	28.	Andrus & Church, 2,000 copies Bulletin III., 2d Ed., . .	45 46
Mar.	28.	W. O. Kerr, Negative Shipping Case, ...	50
Apr.	13.	Crosscup & West Eng. Co., Plates Bulletin V., ...	64 00
May	13.	Andrus & Church, 10,000 copies Bulletin V., ...	157 60
June	22.	Andrus & Church, 7,000 copies Bulletin VI., ...	69 40
"	5.	Lewis Eng. Co., 5 Plates Bulletin VII., ...	6 50
"	24.	" " 5 " " "	4 50
"	15.	Anna B. Comstock, Drawings Bulletin VII., ...	20 35
"	28.	Andrus & Church, 8,000 copies Bulletin VII., ...	275 00
"	29.	Tennessee Agr. Exp. Station, 2,000 copies Bulletin II., .	30 00
"	27.	Anna B. Comstock, Drawings Bulletin IX., ...	27 00
		Total for Printing, ...	$1,306 63

FOR OFFICE EXPENSES.

1888.			
July	23.	I. P. Roberts, Ink, ...	$ 65
"	23.	Andrus & Church, 100 Sheets Carbon Paper, ...	4 00
"	9.	Andrus & Church, 5,000 Bristol Slips, ...	9 25
"	6.	Andrus & Church, Mem. Books, ...	25
Oct.	1.	A. E. Moore, 67 hrs. work, ...	10 05
"	8.	U. S. Express Co., Expressage, ...	. 25
"	6.	Ithaca Gas Light Co., Gas, July, ...	19
"	13.	U. S. Express Co., Expressage, ...	25
Sept.	26.	R. Friedlaender & Sohn, Landw. Kalendar, ...	83
Oct.	12.	E. & H. T. Anthony & Co., 5 Boxes Sentz. Paper, . . .	4 50
"	20.	Andrus & Church, 500 Bill Heads, ...	1 95
"	29.	A. Blakeslee, Office Signs, ...	4 25
Nov.	7.	Ithaca Gas Light Co., Gas, Oct.	19
"	30.	Raynor & Martin, 20,000 Manilla Envelopes, ...	63 00
"	9.	Andrus & Church, 1,000 Order Slips, ...	2 00
Oct.	31.	D. L. & W. R. R. Co., Freight on Envelopes, ...	1 82
Nov.	22.	Bush & Dean, 15 yds. Ribbon, ...	1 00
"	24.	Andrus & Church, Special Ruled Paper, ...	1 00
"	26.	Western Union Telegraph, 2 Messages, ...	50
"	27.	U. S. Express Co., Expressage, ...	55
Dec.	4.	Naughton Bros., Matches, ...	50
"	7.	Ithaca Gas Light Co., Gas, Nov., ...	60
		Amount carried forward,	$ 107 58

		Amount brought forward,	$ 107 58
Dec.	6.	Andrus & Church, 300 Circulars,	6 50
Oct.	19.	I. P. Roberts, Delivery of Telegram,	15
Dec.	20.	National Express Co., Expressage,	25
1889.			
Jan.	4.	Ithaca Gas Light Co., Gas, Dec.,	19
"	7.	U. S. Express Co., Expressage,	25
"	1.	Andrus & Church, Rubber Stamps,	2 50
"	14.	Andrus & Church, Letter Heads and Postals,	6 55
"	19.	Postmaster, 500 2ct. Stamps,	10 00
"	21.	Andrus & Church, Mem. Pads,	1 50
"	25.	Andrus & Church, Waste Basket,	80
Feb.	1.	A. E. Moore, Labor,	3 97
"	1.	H. N. Reid, Labor,	5 90
Jan.	31.	National Express Co., Expressage,	40
Feb.	5.	Ithaca Gas Light Co., Gas, Jan.	40
"	6.	Andrus & Church, 100 Circulars,	1 50
Jan.	5.	I. P. Roberts, Expenses to Knoxville Convention,	65 00
Feb.	9.	James M. Drew, Expenses to Geneva,	2 70
"	15.	Andrus & Church, Paid Expressage,	75
"	16.	Andrus & Church, Paid Expressage,	45
"	21.	National Express Co., Expressage,	50
"	22.	Andrus & Church, Letter Copying Book and Twine,	2 10
"	23.	Andrus & Church, 1,000 Printed Slips,	1 25
Mar.	1.	H. N. Reid, Labor,	2 25
"	5.	Ithaca Gas Light Co., Gas, Feb.,	57
"	2.	Andrus & Church, Bookbinding,	1 65
"	4.	U. S. Express Co., Expressage,	25
"	7.	W. O. Wyckoff, Typewriter Ribbon,	50
"	10.	U. S. Express Co., Expressage,	40
"	14.	Postmaster, Stamps,	25 00
"	13.	Andrus & Church, 5,000 Bristol Slips,	8 00
"	18.	T. R. Fife, Labor,	11 85
"	26.	U. S. Express Co , Expressage,	25
"	18.	George Bradley, Labor,	2 70
"	18.	Charles Moore, Labor,	4 20
"	29.	A. E. Moore, Labor,	2 03
Feb.	27.	W. U. Telegraph Co., Message,	25
Apr.	5.	Ithaca Gas Light Co., Gas, March,	38
"	11.	Andrus & Church, 2,500 Mem. Slips,	4 00
"	13.	Andrus & Church, 20,000 Manilla Envelopes,	62 00
"	16.	Edwin M. Hall, Matting,	6 51
"	18.	Adams Express Co., Expressage	95
May	1.	James Seaman, Carpenter Work and Material,	13 72
"	4.	Andrus & Church, 50 Circulars,	2 00
May	7.	Ithaca Gas Light Co., Gas, April,	76
"	11.	Andrus & Church, Two Bill Files,	12
"	20.	T. R. Fife, Labor,	11 63
"	21.	National Express Co., Expressage,	60
"	23.	U. S. Express Co., Expressage,	30
"	18.	A. B. Dick Co., Edison Mineograph,	20 00
"	22.	Andrus & Church, Paper,	1 75
"	29.	U. S. Express Co., Expressage,	30
"	31.	A. B. Dick Co., ½ ream Spec. Ruled Paper,	6 50
June	3.	C. W. Matthews, Labor,	75
"	1.	H. N. Reid, labor,	1 65
		Amount carried forward,	$ 415 01

		Amount brought forward,	$ 415 01
June	5.	Ithaca Gas Light Co., Gas, May,	57
"	7.	Andrus & Church, 5,000 Envelopes,	12 50
"	7.	E. C. Cleaves, Photographs,	2 00
"	10.	Andrus & Church, Paper Fasteners,	50
"	11.	George Bradley, Labor,	22
"	22.	A. E. Moore, Labor,	90
"	11.	Treman, King & Co., Shears,	1 50
"	28.	W. U. Telegraph Co., 2 Messages,	89
"	29.	H. N. Reid, Labor,	2 25
		Total for Office Expenses,	$436 34

FOR AGRICULTURAL DEPARTMENT.

1888.			
July	17.	I. P. Roberts, 6 samples Paris Green,	$ 92
Aug.	3.	I. P. Roberts, Telegram,	54
"	4.	D. L. W. R. R. Co., Freight on Holsteins,	17 50
"	6.	I. P. Roberts, Telegram,	50
"	14.	National Express Co., Expressage,	45
"	27.	I. P. Roberts, Expenses to Brentwood, L. I.,	23 96
"	27.	" " Cleveland, O.,	29 44
"	31.	" " Montezuma, N. Y.,	10 50
"	31.	U. S. Express Co., Expressage,	35
Sept.	1.	C. U. Farm, Labor,	56 15
July	11.	Jameison & McKinney, Plumbing,	2 55
Aug.	14.	Smiths, Powell & Lamb, Attendant's Expenses,	6 79
Sept.	1.	Treman, King & Co , Plow Point,	50
"	4.	Washington Glass Co., 2 Shades,	2 00
"	15.	W. E. Martin, 2 Hogs,	21 50
"	22.	U. S. Express Co., Expressage,	50
"	18.	National " "	50
Sept.	19.	R. H. Brown, 5 Sheep,	13 75
"	28.	E. & H. T. Anthony & Co., Photo. Developer,	3 10
"	29.	U. S. Express Co., Expressage,	75
"	29.	James E. Rice, Labor,	5 70
Oct.	1.	C. U. Farm, Labor,	7 30
Sept.	3.	Treman, King & Co., Hardware Sundries,	4 75
May	16.	C. B. Strong, Labor,	3 26
Oct.	3.	Treman, King & Co., Hardware Sundries,	6 50
"	27.	Dennis Letts, Shearing Sheep,	1 50
Nov.	1.	C. U. Farm, Labor,	1 75
"	16.	F. B. Fargo &. Co., Short's Milk Tester,	12 80
"	19.	Adams Express Co., Expressage,	1 80
"	27.	W. J. Ellis, 12 Young Sheep,	34 00
Dec.	3.	D. L. & W. R R. Co., Freight,	2 20
"	8.	Jamieson & McKinney, Plumbing,	34 18
1889.			
Jan.	8.	W. J. Ellis, 3 Sheep,	14 00
"	12.	Condimental Food Co., 25 lbs. Cond. Food,	1 25
Feb.	1.	C. U. Farm, Labor,	2 75
Jan.	19.	E. C. & N. R. R., Freight,	40
Feb.	8.	Charles Moore, Labor,	8 25
"	14.	U. S. Express Co., Expressage,	60
"	13.	National Express Co., Expressage,	30
Mar.	1.	C. U. Farm, Labor,	2 50
Apr.	1.	C. U. Farm, Labor,	10 80
		Amount brought forward,	$ 348 84

		Amount brought forward,	$ 348 84
Apr.	6.	I. P. Roberts, Expenses to Truxton,	5 00
Mar.	1.	Jamieson & McKinney, Plumbing,	4 46
Apr.	12.	Ed Tarbell, Labor,	10 80
"	12.	Adams Express Co., Expressage,	35
"	11.	U. S. Express Co., Expressage,	95
"	16.	National Express Co., Expressage,	65
"	18.	U. S. Express Co., Expressage,	30
"	18.	National Express Co., Expressage,	30
"	8.	A. D. Perry & Co., Seed Corn,	25
"	5.	Z. DeForest Ely & Co., Seed Corn,	55
Mar.	8.	Treman, King & Co., Hardware Sundries,	27 37
Apr.	26.	E. C. & N. R. R. Co., Freight,	55
"	26.	H. H. Wing, Photo. Materials,	25
"	30.	U. S. Express Co., Expressage,	45
May	1.	James Seaman, Carpenter Work and Material,	16 30
Mar.	19.	Edward G. Allen, Subscription to Periodicals,	1 25
Apr.	29.	Jos. Breck & Sons, Seed Corn,	70
May	1.	C. U. Farm, Labor,	12 92
"	6.	Rothschild Bros., Cheese Cloth,	50
"	11.	D. L. & W. R R. Co., Freight,	40
May	23.	E. & H. T Anthony & Co., Ground Glass,	33
"	21.	Symmes Hay Cap Co., 40 Hay Caps,	9 34
June	1.	C. U. Farm, Labor,	18 74
"	15.	" " Feed for Sheep,	87 03
May	2.	Geo. Rankin & Son, Dishes,	1 50
"	3.	Treman, King & Co., Galvanized oven,	10 25
June	30.	C. U. Farm, Labor,	4 73
"	29.	Jas. Seaman, Carpenter work,	60
"	29.	C. U. Farm, Cotton Seed Meal and Bran,	40 56
		Total for Agricultural Department,	$606 22

FOR HORTICULTURAL DEPARTMENT.

1888.			
July	27.	E. W. Solies, 1 load Manure,	$ 40
Aug.	1.	H. D. Frear, 9 " "	3 15
"	6.	John Sincebaugh, 8 loads Manure,	3 20
"	6.	E. C. & N. R. R., Freight on Books,	12 58
"	21.	National Express Co., Expressage,	1 05
June	30.	E. & H. T. Anthony & Co., Photograph outfit,	96 32
Aug.	4.	L. H. Bailey, Fruit Seeds,	40 05
"	1.	C. U. Farm, Labor,	59 13
Sept.	1.	" " "	16 63
July	30.	Dunn & Hill, 2 Locks,	7 00
May	24.	Fairbanks & Co., Scales,	10 85
Sept.	1.	Treman, King & Co., 6 Plow Points,	2 50
June	29.	Gustav E. Stechert, Books,	110 00
Oct.	3.	B. W. Ross & Co., 9 loads Manure,	3 15
Aug.	24.	J. Carbutt, Negatives,	35 35
Sept.	29.	Gustav E. Stechert, Subs't to Jour.,	5 20
Oct.	3.	I. H. Dallmeyer, Photo Lens,	39 20
"	22.	National Express Co., Expressage,	2 60
Sept.	27.	John Wheldon, Books,	133 88
"	21.	J. F. Moore, Horse-blankets, etc.,	13 05
Oct.	31.	Cornell University, Cultivating,	9 00
Nov.	1.	Tice & Lynch, Custom House Brokerage,	12 28
		Amount carried forward,	$ 616 57

		Amount brought forward,	$ 616 57
Oct.	12.	Gustav E. Stechert, Books,	2 00
"	26.	Chas. H. Hillick, Book Binding,	28 31
"	31.	G. B. Bracket, Iowa Hort. Rep.,	5 00
Nov.	15.	D. L. & W. R. R., Freight,	1 30
"	15.	Chas. H. Hillick, Book Binding,	18 27
"	16.	Adams Exp. Co., Expressing Custom House Brokerage,	4 00
Oct.	16.	H. E. Van Deman, 200 Juneberry Plants,	12 00
1889.			
Mar.	1.	Pay Roll, Labor,	28 14
1888.			
Dec.	15.	Cornell University, Cultivating Nursery,	10 00
"	12.	Charles H. Hillick, Binding Books,	5 72
Aug.	20.	C. M. Chapman, 6 Loads Manure,	2 40
Dec.	31.	L. H. Bailey, Stationery,	10 13
1889.			
Jan.	11.	Martin Gibbons, Labor,	2 14
"	11.	John Mullehey, Labor,	2 14
"	11.	Martin Solon, Labor,	72
"	11.	Wm. Cunningham, Labor,	2 55
"	11.	John Gaherty, Labor,	2 22
"	12.	John Hennessey, Labor,	4 42
"	19.	U. S. Express Co., Expressage,	30
"	1.	C. U. Farm, Labor,	2 62
"	19.	National Express Co., Expressage,	40
"	21.	Thomas Quilk, Labor,	12 30
"	21.	Dennis Connor, Labor,	13 62
"	19.	Patrick Higgins, Labor,	7 13
"	21.	Martin Gibbons, Labor,	6 15
"	29.	J. W. Cline, 104¾ bu. Oats,	41 90
"	10.	H. Bool, Office Furniture,	24 98
"	10.	W. Atlee Burpee & Co., Seeds,	3 83
"	31.	J. R. Comings, 14 Loads Manure,	5 60
Feb.	1.	Frank Knettles, Labor,	22 88
"	1.	L. H. Bailey. Sundries,	10 30
Jan.	28.	U. S. Express Co., Expressage,	45
Feb.	4.	D. L. & W. R. R., Freight,	5 10
Jan.	30.	George Small, Lumber,	40 00
"	12.	A. M. Hull, 1,000 lbs. Feed,	11 00
"	14.	J. E. Van Natta, 50 bu. Oats,	20 00
"	15.	Haskin & Todd, 2 gals. Astral Oil,	44
"	14.	C. S. Wattles, 1 bbl, Salt,	1 25
"	14.	Joseph Fowles, 165 2-inch Tile,	3 30
Feb.	6.	Andrus & Church, Stationery,	21 08
"	9.	Henry Smith, 5 Loads Manure,	2 00
"	8.	Andrus & Church, 200 Circulars and Envelopes,	3 50
"	7.	National Express Co., Expressage,	2 95
Jan.	31.	Atkins & Durbrow, 1 ton Peat Moss,	14 00
Feb.	14.	Andrus & Church, Labels,	2 56
"	19.	A. I. Root, Transplanting Tubes,	50
"	19.	Z. K. Jewett, 5 bales Sphagnum,	8 00
"	19.	Andrus & Church, Ink,	56
Jan.	5.	James F. Moore, Repairing Harness,	75
Feb.	28.	L. H. Bailey, Postage,	4 25
"	26.	Thomas Quilk, Labor,	5 10
Mar.	4.	J. Reed, 1 Load Manure,	40
		Amount carried forward,	$ 1,057 23

		Amount brought forward,	$ 1,057	23
Feb.	13.	Peter Henderson & Co., Seed, ...	1	00
"	12.	Eimer & Amend, Apparatus, ...	4	60
"	28.	D. L. & W. R. R. Co., Freight, ...	5	22
Mar.	5.	F. W. Smith, 2 Portfolios, ...	3	00
"	5.	National Express Co., Expressage, ...		40
"	6.	J. C. Vaughan, Seeds, ...	5	00
Feb.	18.	Pay Roll, labor, ...	12	50
Mar.	6.	L. H. Bailey, Expressage, ...	4	05
"	6.	U. S. Express Co. Expressage, ...	2	15
"	6.	National Express Co., Expressage, ...		70
"	8.	L. H. Bailey, Expressage, ...		30
"	9.	National Express Co., Expressage, ...		30
"	11.	U. S. Express Co., Expressage, ...		30
"	8.	Dennison Manufacturing Co., Fish Glue, ...		70
"	6.	Judson & Co., 5 lbs. Raffia, ...		75
"	11.	T. V. Munson, Plants, ...	15	00
"	11.	National Express Co., Expressage, ...		40
Jan.	26.	Vilmorin, Andrieux & Co., Seeds, ...	14	68
"	26.	Becker Bros., Balance, ...	11	44
Mar.	14.	National Express Co., Expressage, ...		60
"	8.	Gould's Manufacturing Co., 2 Rubber Nozzles, ...		78
"	13.	J. M. Thorburn & Co., Seeds, ...	6	24
"	11.	Peter Henderson & Co., Seeds, ...	5	85
"	11.	National Express Co., Expressage, ...		50
"	21.	" " " "		25
"	18.	Andrus & Church, Stationery, ...		27
Feb.	6.	J. C. Vaughan, Seeds, ...	5	64
Mar.	26.	W. M. Munson, Sundries, ...	1	27
"	18.	National Express Co., Expressage, ...		60
"	26.	D. S. Slaight, Labor, ...	3	00
Feb.	21.	George Small, Lumber, ...	3	45
Mar.	1.	Treman, King & Co., Hardware Sundries, ...	1	65
Feb.	14.	" " " " "	10	33
"	1.	" " " " "	36	73
Mar.	1.	Jamieson & McKinney, 12 ft. Hose, ...	12	50
"	4.	J. M. Thorburn & Co., Seeds, ...		53
"	16.	Automatic Electric Co., Repairs to Incubator, ...	8	20
Feb.	11.	J. C. Vaughan, Seeds, ...	1	38
Mar.	25.	U. S. Express Co., Expressage, ...		30
"	18.	A. M. Hull, 1,000 lbs. Feed, ...	9	50
"	15.	Green's Nursery Co., Plants, ...	6	00
"	27.	Andrus & Church, Tracing Linen, ...		80
"	12.	Treman, King & Co., Hardware Sundries, ...	4	39
"	25.	John Lewis Childs, Plants, ...	4	00
Apr.	1.	U. S. Express Co., Expressage, ...		65
Mar.	28.	Andrus & Church, Pens and Pencils, ...		40
Apr.	1.	Wm. Wescott, Labor, ...	35	00
Mar.	12.	Burns Bros., Blacksmithing, ...	12	25
"	20.	H. Hill, Coal, ...	25	62
Apr.	1.	Ithaca Glass Works, 2050 lbs. Sand, ...	3	23
Mar.	30.	H. W. Smith, Labor, ...	7	50
Apr.	3.	National Express Co., Expressage, ...	1	15
Mar.	26.	" " " "		35
Apr.	5.	W. M. Munson, Sundries	6	45
"	2.	Andrus & Church, Mounting Paper, ...	4	50
		Amount carried forward,	$ 1,361	58

		Amount brought forward,	$ 1,361 58
Apr.	6.	Andrus & Church, Circulars,	6 96
"	6.	Andrus & Church, Stationery,	78
"	6.	L. H. Bailey, Sundries,	3 65
"	6.	Charles Cleveland, Labor,	7 50
"	3.	DeLandreth & Sons, Seeds,	1 25
"	5.	Jamieson & McKinney, Plumbing,	23 79
"	6.	Judson & Co., 2,000 Pot Labels,	92
"	9.	National Express Co., Expressage,	30
"	12.	Adams Express Co., Expressage,	50
"	12.	L. H. Bailey, Postage,	8 00
"	12.	Johnson & Stokes, Seeds,	1 78
"	12.	C. Rich, Huckleberry Plants,	5 50
"	1.	D. S. Slaight, Making Shades,	1 00
"	11.	T. H. Hoskins, Seeds,	1 75
"	11.	D. Bogue, Trees,	17 20
"	15.	National Express Co., Expressage,	1 80
"	13.	Barr Bros., 6 Plow Points,	3 00
"	15.	L. V. R. R., Freight,	75
"	22.	National Express Co., Expressage,	60
"	18.	U. S. Express Co., Expressage,	2 05
"	18.	Adams Express Co., Expressage,	2 30
"	18.	Mecke & Co., Custom House Brokerage,	6 04
"	15.	E. & H. T. Anthony & Co., Photo. Apparatus,	47 65
"	17.	" " " " " "	3 53
"	19.	" " " " " "	1 42
"	23.	Treman, King & Co , Hot-bed Sash,	6 08
"	20.	Burns Bros., Blacksmithing,	6 30
"	24.	E. C. & N. R. R., Freight,	1 47
"	26.	H. W. Smith, Labor,	7 05
"	25.	U. S. Express Co., Expressage,	50
"	25.	I. Brewer, Trees,	22 00
"	16.	Lewis Roesch, Grapevines,	10 00
"	11.	H. Bool, Table,	7 00
Apr.	24.	Andrus & Church, Circulars and Envelopes,	2 31
"	27.	L. H. Bailey, Trees and Expenses,	67 78
"	27.	A. Tompkins, 6 Loads Manure,	2 40
"	25.	Jamieson & McKinney, Sewer Pipe,	3 24
"	27.	T. R. Fife, Labor,	7 88
"	25.	Andrus & Church. Envelopes,	90
"	20.	George Small, 500 Pickets,	2 50
"	24.	J. M. Thorburn & Co., Seeds,	90
"	24.	Duane H. Nash, Repairs to Harrow,	1 35
1888.			
Aug.	23.	E. & H. T. Anthony & Co., Photo Material,	8 33
1889.			
Apr.	29.	George Small, 500 Brick,	5 00
May	1.	James Seaman, Carpenter Work and Material,	8 98
Apr.	29.	Johnson & Stokes, Peach Pits,	2 00
"	20.	Harmon Hill, Coal,	20 33
"	2.	Jamieson & McKinney, Sewer Pipe,	1 00
"	20.	Eimer & Amend, Bell Glass,	2 40
"	27.	Eimer & Amend, Rubber Tubing,	57
"	29.	Andrus & Church, 300 Postal Cards and Printing,	3 75
May	1.	Pay Roll, Labor,	78 30
"	1.	Gustav E. Stechert, Books,	5 94
		Amount carried forward,	$ 1,797 86

		Amount brought forward,	$ 1,797 86
Mar.	29.	Gustav E. Stechert, Books,	9 75
"	19.	Edward G. Allen, Books,	58 68
May	1.	C. U. Farm, Labor,	2 28
Apr.	20.	G. D. Howe, Seed Potatoes,	1 00
"	15.	J. Carbutt, Photo. Negatives,	5 40
May	6.	National Express Co., Expressage,	40
"	10.	Simon Maloney, Labor,	2 50
"	9.	Adams Express Co., Expressage,	1 00
"	9.	National Express Co., Expressage,	65
"	27.	U. S. Express Co., Expressage,	1 50
"	3.	Eimer & Amend, Thermometers,	5 00
"	6.	Andrus & Church, Paper,	2 00
"	6.	James W. Queen & Co., Camera Lucida,	3 38
"	25.	W. M. Munson, Sundries,	2 05
"	31.	Pay Roll, Labor,	119 22
"	20.	Burns Bros., Blacksmithing,	6 45
"	31.	National Express Co., Expressage,	1 80
June	1.	T. R. Fife, Labor,	6 90
"	15.	H. W. Smith, Labor,	7 50
"	21.	A. E. Moore, Labor,	4 05
"	15.	National Express Co., Expressage,	90
May	14.	W. H. Cornish & Co., Seeds,	2 95
Apr.	17.	G. H. & J. H. Hale, Strawberry Plants,	28 13
"	13.	J. F. Moore, Harness Repairs,	7 50
"	27.	Ellwanger & Barry, Plants,	17 16
May	8.	A. M. Hull, 1,000 lbs. Feed,	10 00
"	28.	J. M. Thorburn & Co., Seeds,	1 62
"	28.	Judson & Co , 500 pkg. Labels,	63
"	23.	Farmers' Fertilizer Co., Fertilizer,	20 00
"	13.	T. J. Wilson, 1 Case,	6 00
Apr.	25.	D. Laughton, Ground Bone,	4 58
May	8.	Straiton & Storms, Tobacco stems,	4 00
June	17.	C. H. Howes, Printing Photographs,	1 84
May	6.	J. M. Thorburn & Co., Grass Seed,	2 68
June	30.	Pay Roll, Labor,	75 69
"	1.	Jamieson & McKinney, Plumbing,	7 28
"	21.	Andrus & Church, Tablets,	25
"	28.	W. M. Munson, Sundries,	85
"	10.	Treman, King & Co., Hardware Sundries,	40 24
May	28.	Edward G. Allen, Books,	119 30
"	24.	Gustav E. Stechert, Books,	5 20
"	28.	" " " "	10 92
June	12.	L. H. Bailey, Traveling Expenses,	39 90
"	12.	H. Bool, Curtain Fixtures,	15 44
"	29.	Andrus & Church, Stationery,	2 75
"	28.	J. M. Thorburn & Co., Seeds,	35
"	29.	H. S. Williams, Lumber,	5 00
"	29.	S. B. Buck, 2,300 lbs. Feed,	23 00
		Total for Horticultural Department,	$2,493 53

FOR ENTOMOLOGICAL DEPARTMENT.

1888.			
July	2.	National Express Co., Expressage,	$ 30
"	2.	" " " "	65
Sept.	15.	D. L. & W. R. R., Freight,	1 35
		Amount carried forward,	$ 2 30

	Amount brought forward,	$ 2 30
Aug. 30.	E. & H. T. Anthony & Co., Photo. Material,	50
July 11.	C. T. Stephens, Seeds,	2 45
Sept. 1.	Treman, King & Co., Sundries,	3 45
Aug. 22.	National Express Co., Expressage,	25
" 28.	Peter Henderson & Co., Plants,	1 84
" 8.	Bausch & Lomb Opt. Co., Microscopic Sund.,	15 28
" 29.	J. H. Comstock, Traveling Expenses to L. I.,	23 87
" 29.	" " " " " Rochester,	13 66
" 29.	" " Sundries,	5 26
Sept. 25.	James E. Rice, Labor,	17 70
" 5.	U. S. Express Co., Expressage,	70
Aug. 21.	" " " "	25
Sept. 28.	Treman, King & Co., Door Springs,	1 45
" 28.	E. & H. T. Anthony & Co., Photo. Material,	3 10
July 16.	E. S. Becker, Sundries,	2 03
" 13.	George E. Meigs, Telephone,	30 00
June 7.	White & Burdick, Ether,	1 20
Oct. 9.	H. Bool, Curtain Fixtures,	12 80
Nov. 22.	James Osborn, Cartage,	50
June 12.	E. C. & N. R. R., Freight,	1 75
Oct. 15.	Treman, King & Co , Sundries,	2 25
Dec. 10.	National Express Co., Expressage,	40
1889.		
Jan. 1.	C. U. Farm, Labor,	1 75
Feb. 1.	M. V Slingerland, Labor,	7 00
Mar. 2.	U. S. Express Co., Expressage,	2 25
" 13.	M. V. Slingerland, Labor,	4 00
Apr. 1.	" " "	5 50
" 19.	White & Burdick, 15 gr. Chlor. Gold,	50
" 11.	Andrus & Church, Printing 200 Cards,	1 25
May 1.	James Seaman, Carpenter Work and Material,	4 81
Apr. 27.	Gauntlet & Brooks, Chemicals,	1 00
" 27.	Andrus & Church, Ink,	1 45
" 20.	Andrus & Church, Letter Heads,	2 15
May 1.	M. V. Slingerland, Labor,	13 95
" 3.	National Express Co., Expressage,	25
" 15.	W. J. Ellis 40 Hop Poles,	4 00
" 27.	U. S. Express Co., Expressage,	40
" 16.	W. O. Kerr, Carpenter Work and Material,	10 58
June 6.	Frost & Brown, Kerosene Oil,	5 09
" 5.	J. H. Comstock, Sundries,	9 95
" 18.	Frost & Brown, Kerosene Oil,	63
May 21.	Treman, King & Co., Hardware Sundries,	11 86
June 21.	J. C. Stowell & Son. Kerosene Oil,	6 90
" 27.	M. J. Holmes, Labor,	7 20
" 27.	Jennie Fleming, labor,	15 00
	Total for Entomological Department,	$260 46

FOR BOTANICAL DEPARTMENT.

Sept. 28.	Adams Express Co., Expressage,	$ 70
June 30.	Eimer & Amend, 1 Platinum Dish,	5 08
Nov. 8.	Andrus & Church, 500 Circulars and Envelopes,	7 05
" 13.	A. N. Prentiss, Postage,	18 00
" 15.	Charles H. Hillick, Bookbinding,	52 48
	Amount carried forward,	$ 83 31

	Amount brought forward,	$ 83 31
Nov. 28.	Bausch & Lomb Opt. Co., Microscope material,	5 04
1889.		
Jan. 28.	Eimer & Amend, Thermometers,	7 72
Feb. 18.	D. L. & W. R. R., Freight,	2 22
Mar. 7.	W. O. Kerr, Case and Table,	100 00
" 28.	" Carpenter work and Material,	121 11
Apr. 18.	U. S. Express, Expressage,	1 85
1888.		
Nov. 13.	W. A. Kellerman, Specimens,	1 92
1889.		
Apr. 15.	Ellwanger & Barry, Strawberry Plants,	80
" 29.	W. R. Dudley, Postage,	5 00
1888.		
Dec. 22.	Ithaca Democrat, Envelopes and Blanks,	10 75
1889.		
Apr. 24.	H. Bool, Office Furniture,	9 86
May 1.	W. O. Kerr, Carpenter work and Material,	90 85
" 24.	" Book and Herbarum case,	55 00
" 16.	E. D. Baright, Labor,	56 70
" 30.	Andrus & Church, Mounting Paper,	31 80
June 18.	W. O. Kerr, 12 Cabinet Boxes,	13 20
	Total for Botanical Department,	$597 13

FOR CHEMICAL DEPARTMENT.

July 4.	U. S. Express Co., Expressage,	$ 35
" 26.	National " "	55
Sept. 21.	Andrus & Church, Blank Books,	4 00
1889.		
Jan. 16.	Eimer & Amend, Apparatus,	1 50
Feb. 5.	U. S. Express Co.,	35
Jan. 19.	C. Carmody, Labor,	3 75
Feb. 8.	G. C. Caldwell, Postage,	3 00
" 4.	Emil Greiner, Apparatus,	5 25
Jan. 28.	Eimer & Amend, Glass wool,	9 60
Feb. 18.	National Express, Expressage,	25
" 19.	Eimer & Amend, Apparatus,	1 25
" 20.	Andrus & Church, Blanks,	3 25
" 27.	Eimer & Amend, 2 Bunsen Burners,	80
Apr. 12.	Adams Express,	25
Jan. 28.	Treman, King & Co., Labor and Material,	6 75
May 1.	Jas. Seaman, Carpenter work and Material,	5 57
" 15.	D. W. Colby, Assistant in Laboratory,	60 00
May 10.	Eimer & Amend, Platinum wire,	18 92
" 10.	Andrus & Church, Gum Labels,	1 00
" 27.	W. P. Cutter, Expenses to Geneva,	2 44
" 31.	National Express, Expressage,	55
" 28.	Emil Greiner, Short's Milk tester,	13 00
June 4.	D. W. Colby, Assistant in Laboratory,	60 00
Feb. 15.	White & Burdick, Pepsin,	1 25
June 6.	Andrus & Church, Blank Book,	1 50
" 7.	Eimer & Amend, Caustic soda,	22
" 8.	Baker & Adamson, Sulphuric acid,	8 92
	Total for Chemical Department,	$214 27
	Total expenditures,	$15,000 00