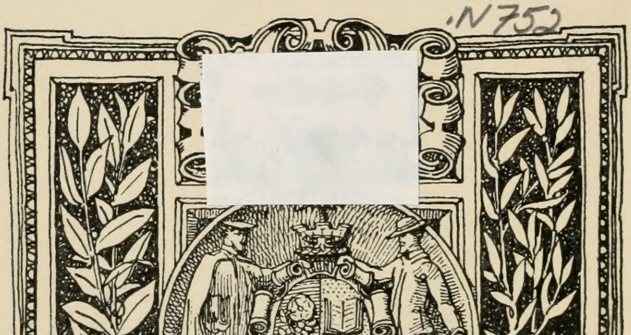
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Cornell University — Agricultural Experiment Station.

SIXTH ANNUAL REPORT

OF THE

Agricultural Experiment Station.

ITHACA, N. Y.

1893.

TRANSMITTED TO THE LEGISLATURE FEBRUARY 16, 1894.

ALBANY:
JAMES B. LYON, STATE PRINTER.
1894.

STATE OF NEW YORK.

No. 22.

IN SENATE,

FEBRUARY 16, 1894.

SIXTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION OF CORNELL UNIVERSITY.

STATE OF NEW YORK:

EXECUTIVE CHAMBER,
ALBANY, *February* 16, 1894.

To the Legislature:

I have the honor to transmit herewith the sixth annual report of the Agricultural Experiment Station of Cornell University.

ROSWELL P. FLOWER.

LETTER OF TRANSMITTAL.

Cornell University, President's Rooms,
Ithaca, N. Y., *February* 12, 1894.

To His Excellency Roswell P. Flower,
Governor of the State of New York:

Sir.— I have the honor to transmit to Your Excellency the sixth annual report of the Agricultural Experiment Station of Cornell University, conformably to the requirement of the act of Congress of March 2, 1887, establishing the station.

I have the honor to be your obedient servant.

J. G. SCHURMAN,
President of Cornell University.

ORGANIZATION.

Board of Control.—The Trustees of the University.

STATION COUNCIL.

President—JACOB GOULD SCHURMAN.

HON. A. D. WHITE	*Trustee of the University.*
HON. JOHN B. DUTCHER	*President State Agricultural Society.*
I. P. ROBERTS	*Professor of Agriculture.*
G. C. CALDWELL	*Professor of Chemistry.*
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A. N. PRENTISS	*Professor of Botany.*
J. H. COMSTOCK	*Professor of Entomology.*
L. H. BAILEY	*Professor of Horticulture.*
H. H. WING	*Assistant Professor of Dairy Husbandry.*
G. F. ATKINSON	*Assistant Professor of Cryptogamic Botany*

OFFICERS OF THE STATION.

I. P. ROBERTS	*Director.*
HENRY H. WING	*Deputy Director and Secretary.*
E. L. WILLIAMS	*Treasurer.*

ASSISTANTS.

M. V. SLINGERLAND	*Entomology.*
GEORGE C. WATSON	*Agriculture.*
G. W. CAVANAUGH	*Chemistry.*
E. G. LODEMAN	*Horticulture.*

Office of the Director, 20 Morrill hall.

Report of the Director.

To the President of Cornell University:

SIR.—I have the honor to transmit herewith my sixth annual report, with those of the treasurer and chemist, the botanist and arboriculturist, the cryptogamic botanist and plant pathologist, the entomologist, agriculturist and horticulturist, together with a detailed statement of receipts and expenditures for the year and an appendix of twelve bulletins. The matter contained in these bulletins is of such prime importance that I deem it not only a privilege but a duty to call your special attention to the published investigations of the year. While the funds of the station remain so limited it is impossible to publish all that we would like to; hence many experiments begun as early as 1888 have not been written up, though they have been continued and probably will be for some considerable time to come, as the longer experiments are carried on, especially those by the "plot system" in the fields, the more valuable they become.

The year's investigations have embraced a large amount of both practical and scientific work, and I am pleased to say that the quality of the work is steadily improving. This year's publications have been not only of a high scientific character, but they will be found to be exceedingly useful to the farmers of the State.

Bulletin No. 50, the first one of the year, treats of the bud moth. This insect has done a large amount of damage to the apple crop, and I am certain that the careful investigation of the habits of this pest and the remedies discovered for preventing its ravages, will be highly appreciated by all fruit growers.

The second publication of the year is on "Four New Types of Fruit." These new fruits may not be superior to some of the old standard varieties, yet all additions to our fruit list add variety and create new demands. So, even though the new varieties may be somewhat inferior to standard old varieties, they often fill vacant places and become of considerable value in some localities. Then, too, experimenting with new varieties is always likely to lead to valuable facts concerning old established varieties.

Bulletin No. 52 is entirely devoted to the dairy interests of the State. It is in brief the results of a year's investigations into the cost of producing milk, and the variation in individual cows. No bulletin yet published by any agricultural experiment station, so far as I have been able to learn, has set forth so clearly and emphatically the fact of the wide variation in the cost of milk production due largely to a single cause, the individuality of the animal. Our dairy is largely composed of high grades, most of which were thought to be superior cows, yet the cost of producing 100 pounds of milk ranges all the way from one dollar and forty-eight cents to forty-four cents. Milk throughout the State wholesales at an average of about one dollar per hundred weight. It will be seen that two of the cows in the herd were producing milk at a loss, while many of them were producing at a profit of more than 100 per cent. What was true of the milk production was equally as true of the fat production. These investigations also emphasized the subject of feeding of cattle, the cost of the several kinds of food, and the amount of production in gross pounds of milk and in net pounds of butter fat. Since the animals experimented with were not of the expensive sort, but selected grades, the bulletin becomes a practical treatise on the production of milk and butter fats for the dairymen throughout the entire United States.

"The Œdema of the Tomato" was treated of in Bulletin No. 53. As the tomato is in universal cultivation, being in every garden and plantation throughout the State, any disease which affects this plant should of necessity receive immediate and careful attention. The cryptogamic botanist has made a very careful and extended study of this new form of plant disease; the summary contains instructions for its prevention.

No publication of the year has brought to us so many requests as the little bulletin of sixteen pages on "Dehorning." A few years since the practice was begun in Illinois, and it has spread far and wide throughout the herds in the northern States of the Union. Much discussion has been had as to whether stock-raisers were doing all they could to prevent loss and suffering caused by wounds inflicted by one animal upon another. All who have practiced dehorning agree that in the long run the removal of the horns from cattle prevents a large amount of suffering and loss. For several years the station has been experimenting not only as to the best method of dehorning, but also as to the best means of preventing the growth of horns.

Bulletin No. 55.—"Green-House Notes, 1892–93," is really the third report on electro-horticulture, and the second on steam and hot water heating of greenhouses. While the first subject treated of is not likely to aid the horticulturist in any large way, yet the investigations are likely to lead indirectly to valuable results. The second subject discussed is always of prime importance, as the chief cost in forcing plants is the heating of the house, any discoveries which will lead to more economical methods will be of value. This bulletin also treats of the winter raising of cauliflower.

Two publications have been issued in former years upon the "Production and Care of Farm Manures," and Bulletin No. 56 is a continuation of this subject which is of so great importance. That a vast waste of fertility takes place by present methods has been shown in these investigations, and it is believed that they have led to the practice of better methods in so many cases that the value of the plant food saved by the improved practices more than equals the entire cost of the station work since its beginning.

Bulletin No. 57 treats of "Raspberries and Blackberries," and gives instruction in setting and caring for plantations of small fruits and is valuable, especially to the beginner.

The second bulletin of the year from the entomological division of the station treats of the "four-lined leaf bug," which has been so disastrous to currant and gooseberry bushes in several localities of the State. The bug is somewhat difficult to exterminate, but the division has succeeded in discovering insecticides that promise good results.

Bulletins Nos. 59 and 60 are from the horticultural division. The first is an effort to discover whether "mulching retards the the maturing of fruit." The second is on the "Spraying of Orchards." The orchards treated were near the university, and I had the pleasure of seeing the results of the summer's work in this direction. No illustration or description can adequately show the difference between the fruit produced by trees treated and untreated. The fruit of the orchard, which contained less than two acres, sold upon the trees for $200, or probably 100 per cent more than it would have had the orchard been left to itself. Far more work should be done in this line than the station is able to do. Many millions of dollars are lost annually from neglect and from a want of knowledge as to the diseases of the orchards and the remedies which may be applied for preventing them. The State is certainly practicing a "penny wise and pound foolish" policy when it fails to come to the assistance of the horticulturists by methods sufficiently ample to give help to all. Many orchardists of the great fruit belt of the western counties are thinking of cutting down their fruit trees because they have not as yet the requisite knowledge for fighting the enemies which have become so common and so destructive to the apple and pear crops in recent years. If to the horticultural division, $25,000, could be appropriated for giving instruction in fields and orchards to owners of plantations, and for carrying on experiments in various parts of the State, it would immediately return to the people many times that amount.

Our Omnibus Bulletin, the last one of the year, treats of various investigations which have been conducted during the current year, as follows:

Œdema of apple trees.

Artificial culture of Melanconium fuligineum.

Jethro Tull or Lois-Weedon system of wheat culture.

Powdered mildew cruciferus.

Corn detasseling.

Pear-leaf blister.

A new food plant (Stachys Floridana).

The mole-plant.

Varieties of tomatoes.

A potato preserver.

Border carnations.

Potato-tomato grafts.

Orchard covers.

Edible garden docks.

Spraying barns and greenhouse roofs.

A shed for seeds.

Labels.

I. P. ROBERTS,
Director.

Report of the Treasurer.

THE AGRICULTURAL EXPERIMENT STATION OF CORNELL UNIVERSITY IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

Dr.

1893.	To receipts from treasurer of the United States, as per appropriation for year ending June 30, 1893, under act of Congress approved March 2, 1887......	$15,000 00

Cr.

June 30.	By salaries	$9,570 84
	By buildings	17 64
	By printing	2,491 14
	By office expense	673 95
	By equipment, labor and current expenses:	
	Agriculture	496 45
	Horticulture	996 06
	Entomology	248 86
	Botany	333 14
	Chemistry	6 14
	Columbian exposition	165 78
		$15,000 00

Receipts for produce sold:	
Balance from 1891–2..................	$299 11
Horticultural division	292 88
Agricultural division	291 95
	$883 94

By printing	$36 76
By balance to 1893–4..................	847 18
	$883 94

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, 1893; that we have found the same well kept, and correctly classified as above, and that the receipts from the treasurer of the United States for the time named are shown to have been $15,000 and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

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.

EMMONS L. WILLIAMS,
Treasurer.

STATE OF NEW YORK, } *ss.:*
COUNTY OF TOMPKINS. }

On this twenty-first day of December, 1893, 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.

[L. S.]

HORACE MACK,
Notary Public.

Report of the Chemist.

During the year 1893, as in the preceding year, practically all the work done in the chemical laboratory of the station was for the Divisions of agriculture and horticulture by the assistant chemist, Mr. G. W. Cavanaugh.

The most important part of this work consisted in the quantitative analysis of seventeen samples of manure and fertilizers, four of fodder, forty-four of milk and twenty-nine of sugar beets. The analysis of ten samples of Paris green is nearly completed at the time of the writing of this report.

G. C. CALDWELL,

Chemist.

Report of the Botanist.

The botanical work of the station, as heretofore, has been wholly devoted to the investigations of the diseases of plants. This has been carried on by Prof. Atkinson, whose report is inclosed. While there are other botanical questions, the consideration of which would come well within the scope and purpose of the station, the one referred to above is of such paramount importance at the present time that it seems wise to devote the entire efforts of this division to its study. A considerable number of letters of inquiry relating to general botanical subjects have reached the division, to all of which I have given due consideration and have sent appropriate replies.

A. N. PRENTISS,
Botanist.

Report of Cryptogamic Botanist and Plant Pathologist.

The most important investigation of the past year relating to the diseases of plants is that of a very mysterious disease of tomatoes grown in the forcing-house. It was at first supposed that the disease was due to the action of some specific micro-organism, and an extended series of cultural and inoculation-experiments were carried on to determine this question. The results were negative and at the same time indicated that the trouble might be a purely physiological one. Another series of experiments confirmed this view, and it was determined that the trouble was due to the unequal operation of two physiological processes, *i. e.*, root absorption was in excess of transpiration. This induced an abnormal increase of water in the plant tissues, which could not be gotten rid of by the plant by the ordinary processes, and resulted in the dropsical swelling of the succulent parts just behind the actively growing tissues. The full results of this study were published in Bulletin No. 53 under the caption — "Œdema of the Tomato."

This œdema or dropsy is probably of greater occurrence than is generally supposed in many plants. During the past summer I investigated a similar trouble of young orchard trees, the result of which is published in the annual bulletin under the title "Œdema of Apple Trees." Another case has also been recently investigated by me in violets grown in forcing-houses.

Two other articles have been prepared for the annual bulletin, viz., "Powdery Mildew of Crucifers" and "Artificial Cultures of Melanconium fuligineum."

A very extended study is in progress upon the anthracnoses, a group of fungi affecting a very great number of cultivated and indigenous plants, but from the breadth and scope which the work has at present assumed it is impossible to say when the matter will be ready for publication.

The equipment of the laboratory has been further increased by the purchase of needed photographic apparatus and the fitting up of a dark room for photographic work. It does not seem out of place to call attention to some very important needs which were mentioned in the last annual report. The need of a competent assistant who can take charge of the routine work of the experiments, and manage those of lesser importance is very pressing and would be a very profitable investment, since it would relieve me of much time-absorbing work which might better be devoted to problems of a more intricate nature which can not be conducted so successfully when harassed by so many minor details.

The provision of some cultural compartments mentioned last year is imperative before satisfactory experiments can be carried on in the investigation of the relation of supposed parasitic organisms to plant diseases.

Respectfully submitted.

GEO. F. ATKINSON.

Report of the Entomologist.

To the Director of the Cornell University Agricultural Experiment Station:

Sir.—I beg leave to submit the following report of the work of the entomological division of this station for the past year. The general plan of conducting the work has been the same as that outlined in preceding reports; but the work has been done almost entirely by the assistant entomologist, Mr. M. V. Slingerland.

The correspondence of the division has nearly if not quite doubled during the past year. This has been due in great part to more attention being drawn to our work through our bulletins and through the farmers' institutes. Two hundred letters of inquiry regarding insects and their injuries have been answered. Twenty of these answers were prepared for publication and have appeared in the columns of agricultural journals.

Three pests have been monographically treated in our bulletins during the year. These are the following:

The bud moth (*Tmetocera ocellana*), in Bulletin No. 50.

The four-lined leaf-bug (*Pœcildcapsus lineatus*), in Bulletin No. 58.

The pear-leaf blister-mite (*Phytoptus pyri*), in Bulletin No. 61.

Work is now in progress on a monographic account of the apple aphis (*A. mali*) and the apple-leaf aphis (*A. sorbi?*); the latter has heretofore been treated as a variety of *A. mali* in this country. Both species have been carefully traced on the apple tree and all the forms occurring there studied. Further, *A. mali* has been traced during the entire year from its emerging from the egg in early spring to the deposition of the eggs by the oviparous females in the fall. Experiments were carried on against the eggs during the winter also.

A series of experiments to test the effect of kerosene emulsion on white grubs on a lawn were carried on, but with only negative results.

Considerable work has been done on several species of cut-worms, notably two species of climbing cut-worms which did much damage to young peach trees, and one species which practically destroyed the second growth of clover over an area of eight or ten acres.

Tenebrioides mauritanica injuring stored wheat is under investigation, and its egg stage, which seems not to have been before observed, has been studied.

These details will serve to show the nature of the work in progress, although the species enumerated are merely the more important ones of those studied.

Very respectfully yours.

J. H. COMSTOCK.

Report of the Agriculturist.

To the Director of Cornell University Agricultural Experiment Station:

In general, the work of the agricultural division has been carried out in the same lines as indicated in previous reports.

Particular attention has been given during the past year to the study of questions concerning fertility; not only to the direct application of plant food, but also to the conserving and gathering of fertility by growing crops, and the importance of the plant food contained in the various commercial animal foods.

The raising of winter lambs from the leading breeds of mutton sheep has received especial attention. During the past year the equipment of the poultry department has been materially increased, which greatly increases the facilities for investigation in this line.

Heretofore the experiments in the breeding and management of poultry have necessarily been meager on account of insufficient number of fowls and the very limited equipment. Many letters of inquiry concerning poultry have been received during the past year, indicating a desire on the part of poultry keepers for more information in this line from experiment stations and agricultural colleges.

The study of better methods for the preservation of ensilage has been continued from last year. Experiments in seeding and cultivation of ensilage crops have been continued in the same lines as in previous years, and will be the subject of a bulletin in the near future.

G. C. WATSON.

Report of the Horticulturist.

To the Director of Cornell University Agricultural Experiment Station :

Sir.— The endeavors of the horticultural division of this station have always fallen into two general lines of work: First, a discussion of the methods of forcing plants, especially plants which bear edible parts; and second, the preparation of monographs of certain plants or types of plants which are adapted to field culture. There has never been any attempt to make a mere test of varieties, nor to make any general and miscellaneous experiments upon isolated and detached objects. The theory of the division has rather been that certain subjects should be well monographed, and that the study of this subject should be continuous; that is, that it should occupy the attention year after year, even after the publication of a certain amount of result had been made in bulletin form. It therefore occurs that we have at the present time many lines of inquiry which we hope to monograph in the future. The division has endeavored to appreciate the fact that the conditions, under which the horticulturists of the State and nation labor are exceedingly diverse, and, therefore, the first province of the Experiment Station is to discover or elucidate fundamental laws rather than simply to make records and observations.

In the pursuance of this plan the division is called upon to make somewhat extended reports of its various inquiries, and the funds at the disposition of the station are insufficient to allow of the publication of these results. The greatest need which this division feels at present is not facilities for doing more work, but means of diffusing more rapidly and more widely the results of its investigations. I believe that it is a legitimate province of the State to encourage a dissemination of information which we obtain through correspondence and experiment. This dissemination of the results of our work, it seems to me, should proceed along two lines: First, there should be more funds for the printing and mailing of bulletins and reports; second and chiefly, there should be some organization by means of which the horticultural interests of the State can be co-ordinated and banded together in a common bond or union. The horticultural interests of New York State are very great, but they are divided between three or four great geographical regions which are more or less separated and independent of each other. There is no State Horticultural Society. There should be some central organization which would have authority and power to carry the results of the latest scientific experiment and teaching into these various regions. The prosperity of the commonwealth could be greatly quickened, if, for instance, there could be what might be called "horticultural schools," fashioned somewhat after the plan of the itinerant dairy schools, and held in various parts of the State, and we should then have the means of giving to the people the information which I now feel is very largely withheld from them. The recommendation which I have to make at this time, therefore, is that you may consider the practicability of asking the State for funds by means of which we can increase our own usefulness and add decidedly to the material progress of the State.

Very respectfully submitted.

L. H. BAILEY,

Professor of Horticulture.

Appendix I.

BULLET IN PUBLISHED DURING THE YEAR.

50-61.

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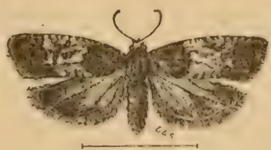
Cornell University—Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

BULLETIN 50—MARCH, 1893.



THE BUD MOTH.

By Mark Vernon Slingerland.

ORGANIZATION.

Board of Control.—The Trustees of the University.

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.

BULLETINS OF 1893.

The Bud Moth.

Tmetocera ocellana.

Order Lepidoptera ; family Grapholithidæ.

Nearly every year some injurious insect makes its appearance in sufficient numbers to alarm the fruit growers of this State. In 1891, not only did the pear growers suffer severely from the Pear Psylla,* but the apple growers also had much of their fruit destroyed while yet in the bud by an insect known as the Bud Moth.

During May and June, 1891, this Department of the Station received a large number of inquiries regarding the pest which was then at work in many counties of the State. The letters indicated that the pest was the most prominent apple pest of the season.

As the insect attacks the opening leaf and flower buds, the destruction wrought is often very great. The reports from some localities in the great fruit growing districts in the western portion of the State showed that nearly the whole crop on many trees was destroyed while yet in the bud. The pest was also especially destructive when it attacked recently budded or grafted trees and young nursery stock. The attack was not confined to the apple alone, but pear, plum, cherry, quince, and peach trees also suffered.

Thus the fruit growers have to fear, in the Bud Moth, a pest which is capable of literally "nipping in the bud" a prospective crop of fruit, a graft, or a budded stock.

The Past History of this Pest.

This insect had been known for more than half a century in Europe before it was recorded in this country. The Bud Moth, therefore, like many of our worst insect pests, was no doubt an importation from Europe. The insect is common in nearly all parts of Europe and there became of economic importance about 1840, or about the same time it was recorded here as injurious by Dr. Harris.

*This pest was discussed in Bulletin 44, Cornell University Agricultural Experiment Station.

Dr. Harris' account (1841) seems to be the first notice we have of the appearance of the pest in this country. It had probably been imported, while in hibernation, from Europe upon nursery stock some years before. After 1841, we have no record of the insect having been injurious until 1869. Then Dr. Packard (Rept. Mass. Bd. Agr. for 1869) found it to be "the most injurious enemy of the apple tree, next to the Canker worm, that we have in this (Mass.) State.' In the same year the pest did some damage in Pennsylvania (Am. Ent., I, 251). In 1870, the insect damaged plums in Ontario, Canada.

Although Dr. Fitch mentions the insect as an apple tree pest in his Third Report (1856), he does not record it as found in our State. And it is not until 1880 that we find any record of the occurrence of the pest in New York State. Then Prof. Comstock while U. S. Entomologist received the insect from nurserymen at Union Springs, N. Y. In the previous year, as the notes of the Department at Washington show, Prof. Comstock had found the pest at work on the Department grounds at Washington. By 1885, the pest had reached Nova Scotia, where Mr. Fletcher found it hibernating on the twigs (Rept. Dept. Agr. of Canada for 1885).

Dr. Lintner records the pest as quite injurious near Rochester, N. Y., in 1887. In 1888, Prof. Harvey (An. Rept. Maine Expt. Sta. for 1888, p. 169) found the pest doing considerable damage to apple buds in Maine; and in his Report for 1890, he records a very serious attack of the insect upon blackberry buds at Rockland, Me. Throughout Massachusetts, New York, and Canada, the pest appeared in increased numbers and was very destructive in 1891. Prof. Cook also records it as doing unusual harm in Michigan during 1892. (Fourth An. Rept. Mich. Agr. Expt. Station, 1891). December 17, 1892, Dr. Riley wrote us regarding the distribution of the pest as follows: "In the last two or three years I have received it from several localities in New England and the Middle States, and the labels upon the specimens in the National Museum show that it has also been received from Missouri."

It is thus seen that this pest, which seems to have first appeared in this country in Massachusetts about 1841, has now become widely distributed over the New England, Middle States and Canada; and it has spread southward to Washington, D. C., and westward into Missouri.

Its Classification.

This pest is one of the Micro-Lepidoptera and belongs to the group of moths known as the *Tortricina*. According to the latest systematic arrangement of the Lepidoptera, the insect is closely allied to the well known Codlin moth, *Carpocapsa pomonella;* and the adult insect does resemble the Codlin moth in size and form, but it differs from it in structure, in coloring, and in its habits and life history.

Its generic name *Tmetocera* (meaning cut-horned in the original Greek) was established in 1859 for the reception of this insect which still remains the only representative of the genus thus far known; the notched appearance of the base of the antenna* of the male moth (Fig. 3*c*) suggested the name, and seems to be the principal generic character. The specific name *ocellana* (from the Latin for eye-like) was given to the insect in Austria in 1776, more than a century ago; a spot somewhat eye-like in appearance on each front wing of the moth suggested the name. The Eye-Spotted Bud moth is a common name given to the pest by some entomologists. The moth has been described under five different names, and the species has been placed in six different genera. All of the names are now brought into the synonomy of *Tmetocera ocellana.*

INDICATIONS OF ITS PRESENCE.

The pest makes its presence known early in the spring as soon as the buds begin to open, usually about May first on early varieties and a week or ten days later on late varieties. Our correspondents reported that in 1891, Greenings, Baldwins and Kings suffered the most. The caterpillars work in opening fruit and leaf buds, often eating into the buds, especially the terminal ones, so that new growth is stopped. Such work in but a few buds on a nursery tree especially, soon checks and disfigures its symmetry of growth and often spoils the tree for marketing. This fact makes this insect one of the worst pests to be dreaded by nurserymen. On larger trees, unless the pest is very numerous, this disfigurement of the natural growth is not so noticeable.

More often the pest does not begin its work until the buds are nearly half opened. In this case the caterpillars feed upon the central portions of the buds, if a fruit bud, upon the unopened flowers. The central leaves and flowers are tied together with silken threads, and when the pest needs more food it draws in and fastens an outer leaf or flower. In a short time some of the partly eaten leaves in this nest turn brown and become detached from the branch, thus rendering the work of the pest quite conspicuous. So many of the leaf and flower clusters were thus webbed together, and so many of the leaves had turned brown in one instance, that a correspondent wrote May 25, 1891, that some of his trees looked as though a fire had been through

* The joints are not much notched, but a notched appearance is caused by the scanty clothing of the fifth joint, the peculiar arrangement of the scales on the third and fourth, and the spurs on the sixth and seventh joints.

them. This tying together of leaves and flowers and the brown appearance of many of the leaves are the most characteristic indications of the presence of the pest on large trees.

In some cases, especially on the tender shoots of young trees, the caterpillar, after destroying the bud, burrows down the center of the shoot, thus causing it to die back for several inches.

Later in the season, in July, the work of the recently hatched caterpillars may be seen on the under side of the leaves (Fig. 7). They feed upon the lower side of the leaf near the mid-rib, leaving the veins and upper epidermis of the leaf. As the area over which the caterpillar has fed soon turns brown, its work is quite easily seen. The number of leaves found thus affected in July and August will indicate whether the pest will be numerous the coming spring or not. The reason for this will appear when we treat of the life history of the pest.

There is nothing about the appearance of the tree itself in winter that would indicate whether the pest was present or not. As the caterpillars hibernate and are so securely hidden, it would be very difficult for an ordinary observer to find them and thus to determine whether the pest is present in alarming numbers.

THE APPEARANCE OF THE PEST.

The larva or caterpillar.---This is the stage of the insect which is the most familiar to fruit growers. When first hatched, the larvæ are about .04 of an inch (1 mm.) in length, slightly hairy, and of a light green color with a dark brown shield on the first thoracic segment; the head is nearly twice as wide as the body and of a shining dark brown color. In a few hours the larva changes to a light seal-brown color and the head and thoracic shield become nearly black. The larvæ go into hibernation when about half grown, and appear upon the opening buds in the spring as little light brown caterpillars, about .16 of an inch (4 mm.) long, with a black head and thoracic shield; the anal shield on the dorsum of the last segment is scarcely darker in color than the body.

In June when the larvæ are full grown (Fig. 1) they measure about

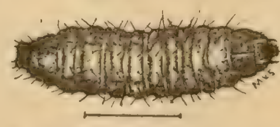


FIG. 1.—The larva, about three times natural size.

one half an inch (13 mm.) in length and are of a cinnamon brown color, with the head and thoracic shield shining black and the anal shield sometimes considerably darker than the body. Light colored hairs arising from minute dark spots on slight elevations sparsely clothe the body. The three pairs of true legs borne by the thoracic segments are black; the five pairs of pro-legs are of a fleshy nature and borne by the fourth, fifth, sixth, seventh, and last abdominal segments.

The pupa.—This is the quiescent stage through which the insect passes in changing from the larva to the adult. If the nests made by the larvæ be examined in the latter part of June the pupæ may be found in a tube of dead leaves. Fig. 2, *a* and *b* represent in outline the ventral and dorsal aspects of the pupa. It is about .27 of an inch (7 mm.) in length and of a light brown color. Each segment of the abdomen is provided on the dorsum with two rows of small tooth-like processes pointing caudad, and there are several hook-like bristles projecting from the caudal segment.

The moth or adult insect.— Dr. Fernald describes the moth (Fig. 3 *a*) thus: "The fore wings expand about three-fifths of an inch. The

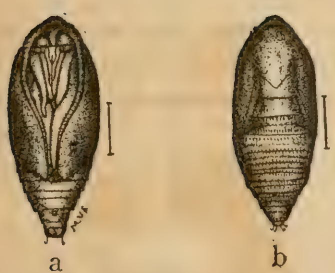


FIG. 2.—The pupa; *a*, ventral view; *b*, dorsal view.

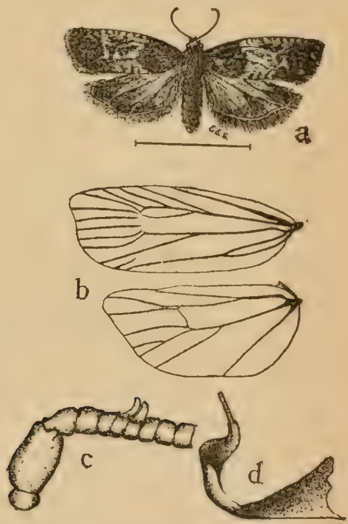


FIG. 3.—The adult; *a*, twice natural size; *b*, venation of the wings; *c*, basal joints of antenna of male, much enlarged; *d*, genitalia, one harpe much enlarged.

head, thorax, and basal third of the fore wings, and also the outer edge and fringe, are dark ashen gray, the middle of the fore wings is cream white, marked more or less with costal streaks of gray, and in some specimens this part is ashy gray, but little lighter than the base. Just before the anal angle are two short horizontal black dashes followed by a vertical streak of lead blue, and there are three or four similar black dashes before the apex, also followed by a streak of lead blue.

"The hind wings above and below and the abdomen are ashy gray. The under side of the fore wings is darker, and has a series of light costal streaks on the outer part." At *b*, figure 3, is shown the venation of the wings; *c*, represents the peculiar structure of the basal joints of the antennae of the male moth; *d*, represents one side of the genitalia of the adult male.

The Life History of the Insect.

The more one can learn about the habits and life history of an insect pest, the easier it will be to intelligently combat that insect. The minutest details of the where, how, and when the insect works are always of interest and oftentimes reveal the weak and vulnerable point in their defensive armor. In order to study with accuracy the habits of an insect it is necessary to place the insect under conditions, in the field if possible, and if not then in the laboratory, where it can be watched almost constantly and yet have the conditions as nearly natural as possible. The same insect may differ in its life history in different localities under the different climatic conditions. For instance, the Elm-Leaf Beetle (*Galeruca xanthomelæna*) develops two broods in the vicinity of Washington, D. C., while in its spread northward it has has become single brooded in Northern New Jersey. Again, the Squash-Vine Borer (*Melittia ceto*), according to the observations of Prof. J. B. Smith is single brooded in New Jersey, but Prof. D. S. Kellicut finds it to be double brooded in central Ohio. These instances show the need of supplementing the observations of others by a study of the insect in one's own locality. In fact were it not for just such complete studies of the habits and life histories of our worst insect pests, it would not be possible for farmers and fruit growers to be so successfully fighting these minute foes.

Our study of the life history of this Bud Moth has afforded a striking example of the importance of the above facts. It has been found necessary to watch the insect in its various stages almost constantly to learn its habits; and this detailed study has revealed what appears to be the only weak point in its armor. And again our observations show that the pest has quite different habits in this State from what it has in Massachusetts, if the recorded observations of one of our leading entomologists are correct; this difference will be seen to be of vital importance when we come to discuss the preventive measures to be used against the pest.

Although the larva and pupa of the Bud Moth were known more than eighty years ago, but little was recorded of its life history until

1840. Then Schmidberger recorded that in Austria the moth laid her eggs in June on the fruit and leaf buds, where they remained unhatched all winter, the larvæ emerging as soon as the bud began to swell in the spring. Although considerable was written later of the insect, nothing new was learned of its habits until 1885, when Mr. James Fletcher found what he believed to be the half grown larva hibernating under a silken covering on the twigs. In April, 1891, Dr. C. H. Fernald (Bull. No. 12, Mass. Hatch Agr. Expt. Sta.) recorded the results of several years of observation upon the pest. His observations were quite extensive and threw considerable new light upon the life history of the insect. It was not until 1892, however, that the life history of the Bud Moth as observed in New York State and in Canada was correctly, although very briefly, recorded (Mr. James Fletcher's Rept. as Entomologist for Dept. Agr. Canada 1891, p. 195).

Appearance and habits of the insect in the spring.—As the attention of fruit growers will be attracted to this pest by its appearance and methods of work upon the buds in the spring, it seems best to begin the discussion of its life history at this point.

The insect comes from its winter quarters and appears upon the buds in the form of a small dark brown larva about one-fourth of an inch in length, with a shining black head and thoracic shield. The dates of its appearance in this State varies considerably. In 1891 it appeared about April 15; but in 1892 it was about May 7 before any larva began work on the buds at Ithaca, N. Y., and on some late varieties of apples they had not all made their appearance by May 15. As a rule it may be said that they time their appearance by the date of the opening of the buds. Thus the earliness or lateness of the season or of the variety of the tree infested will vary the time from two to four weeks, ranging from April 15 to May 15.

In some cases the larva appears before the bud has opened sufficiently for it to readily enter. It is then forced to eat its way into the bud. Once within the bud it revels in the very tender growing leaves or flower buds, tying them together with its silken threads, and thus forming for itself a well protected nest, within which its destructive work goes on (Fig. 4). The larva does not confine its work to one or two leaves or flowers, but it seems to delight in devouring a part of a leaf here or one side of a developing flower there. So that nearly every leaf or flower in the opening bud is forced to contribute to the greed of the little larva, thus greatly increasing its destructiveness.

The larva does the most damaging work upon young trees or upon nursery stock when it attacks, as it often does, the terminal buds of twigs or shoots. Its work in the central portions of the opening bud is quite certain to check the growth of the shoot in that direction. Again, in some cases the larva not only feeds upon the leaves of the bud, but it begins, usually, near the base of the second or third young leaf, and works its way into the pith of the twig. A burrow is thus

FIG. 4.—Work of larvæ in opening buds.

formed which sometimes extends for two or three inches down the shoot. The entrance to this burrow is more or less concealed by some of the basal leaflets of the bud, which are dead and dry and fastened with silk to one side of the hole. When attacked in this manner, the whole tip of the shoot soon dies back as far as the burrow extends. Thus the symmetry of the growth of the tree is marred, and if in a nursery its market value greatly lessened.

Some larvæ do not leave their winter quarters until the buds are quite well opened. The manner of working of these larvæ, and the later steps in the work of those that appeared earlier, has been well described by Professor Comstock in the notes of the Department of Agriculture at Washington, taken May 14, 1879, while he was United States Entomologist. He says: "The larva settles on one of the more advanced leaves, of which it cuts the petiole half through, either near its base or close to the leaf so that it wilts. Of this half dead leaf it forms a sort of tube by rolling the edge of one side more or less down and fastening it with silken threads and then lining the inside sparsely with silk. If the leaf which it has selected as its final home should become too weak at the place where it has been cut, so that there may be danger of its falling to the ground, then the larva goes to work and either strengthens it with silk, which is fastened to the twig and petiole or ties the apical portion of the tube to another leaf, or cuts that part of the leaf which contains its tube from the rest of the leaf, so that either

FIG. 5.—Work of the larvæ among opening leaves.

the whole or only that portion which contains the tube hangs suspended from another leaf." The larva lives in this tube most of the time, only coming forth to feed; when disturbed it retreats into the tube out of sight. In feeding it draws other leaves, one after another, toward it and fastens them with threads of silk, thus forming a nest. (Fig. 5.) Some of these partially devoured leaves soon turn brown and die, thus rendering the nest quite conspicuous.

After their first appearance in the spring, the larvæ continue to feed, mostly at night, in the opening fruit and leaf and buds for six or seven weeks. During this time, they probably cast their skin three times, but no change takes place in their general appearance except the natural increase in size. The full grown larva is described on page 32. Soon after reaching maturity the larva begins to make preparation for its transformation to the quiescent stage of the insect — the pupa.

Pupation.— Within a tube, formed by rolling up one side of a leaf or by bringing together two or three half devoured leaves, and securely fastening everything with silken threads, the larva retreats and lines the interior with a thin closely woven layer of silk. This forms the cocoon of the larva, within which it is soon to undergo its wonderful change to a pupa. In some cases the cocoon is formed on a leaf or twig and covered on the outside with the fine wool taken from the leaves or petioles, thus giving it a close resemblance to its surroundings so that it is not easy to detect it. Those larvæ which emerge first on the earlier varieties of trees attain maturity and begin spinning their cocoons in the latter part of May. The date of pupation varies from June 1st to the 25th in this State. The pupa is described on page 33.

The pupa (Fig. 2, *a* and *b*) lies quietly in its silken chamber for about ten days. It then pushes its head through one end of the cocoon, and by the aid of the rows of the tooth-like processes on its dorsum it works itself along until the greater portion of its body projects from the end of the cocoon. The pupal skin then splits open over the head and along the back and sides, and the delicate little moth emerges.

Habits of the moth.— After crawling forth from the pupal skin and waiting a few minutes for its wings to expand and dry, the moth flies away and is soon ready to begin its mission of the perpetuation of the species. The moths begin to appear as early as June 5 in this State, and all have not emerged by July 10. They are the most active at night. During the day they remain quiet on the trunk and limbs of the tree with the wings folded roof-like over the body. In this position they so closely mimic the bark of the tree as not to be readily seen. The moths lived about two weeks in our cages.

Oviposition.— Three or four days after emerging, the moths copulate and egg-laying begins. Oviposition takes place mostly at night.

FIG. 6.— Egg showing embryonic larva within, greatly enlarged.

The eggs are usually laid singly on the under side of the leaves; some were found upon the upper surface and sometimes from two to seven occurred slightly overlapping each other in a cluster. The eggs (Fig. 6) are curious objects. They are disc-like, very much flattened, usually oval in outline, a few are circular, and measure .8 mm. by .7 mm. A flat outer rim .2 mm. wide adheres closely to the leaf leaving a central slightly elevated rounded disc in which the larva develops. The egg is so nearly transparent that it can be scarcely distinguished from the leaf unless it be held in the right light when the egg will reflect the prismatic colors like a drop of water. In fact the eggs so closely resemble minute drops of water or a fish scale on the leaf that a lens is necessary to determine the egg characters.

Although the eggs were closely watched, no visible changes in color or arrangement of the contents took place until about nine days after they were laid. Then the developing insect was plainly visible as a greenish larva with a dark brown head and thoracic shield. The larva was curled in the central portion of the egg as shown in the figure. Eggs which were laid July 1 and 4 hatched July 11, the egg state thus lasting from seven to ten days.*

Habits of the larva during the summer.— The larva emerge from the egg through a hole made by it near the edge of the central disc. The little greenish colored creature which emerges is scarcely 1 mm. in length ; the thoracle shield is dark brown and its similarly colored head is nearly twice as wide as the body which is sparsely clothed with hairs. It does not stop to eat the shell of its egg, but

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* These observations upon the eggs of the Bud Moth differ much from those of Dr. Fernald recorded in Bulletin 12, Mass. Hatch Agr. Expt. Station, April, 1891. Dr. Fernald says: "The female lays her eggs, when in confinement, in clusters of from four to ten or eleven, often overlapping each other. They are oval, flattened, four-fifths of a millimeter long, and half as wide, sordid white with a narrow border of clear and transparent white, while the centre of the eggs is one complete mass of minute granules. In about three days the center of the egg has grown darker, and the granules larger; and on either side there is a clear, white oval space about one-third the length of the egg. In about two days more the outer edge of the center is the same color as in the last stage, and inside this is a narrow, lighter band, while in the center is seen the form of a cylindrical larva larger at one end, and both ends slightly curved toward each other; and in one or two days more the whole form of the larva is visible, the head, thoracic and anal shields being black. The egg stage lasts from eight to eleven days."

Our eggs were obtained in large numbers from moths reared from the larvæ and confined in cages containing branches of apple which had been very carefully examined for any other eggs before they were placed in the cages. Dr. Lintner has also called attention to the fact (Can. Ent., XXIII, 231) that the eggs of the Bud Moth which he obtained were very different from those described by Dr. Fernald.

immediately begins to feed upon the outer layer of cells or epidermis of the leaf, usually upon the under side. A few hours later the larva makes for itself a tube, open at both ends, of silk in which pellets of excrement are intermingled. This tube is usually made alongside the mid-rib of the leaf, but sometimes near a large vein. These tubes are the homes of the larvæ from which they sally forth to feed upon the surrounding tissues and into which they retreat when disturbed. The larvæ further protect themselves by spinning, as they go, a thin layer of silk, in which the natural pubescence of the leaf is mixed, over their feeding grounds. This silken web extends over the tube also, and being gradually thickened as the larva grows, the tube is scarcely visible from without. As the larva increases in size and the area over which it feeds becomes larger, the tube is enlarged and lengthened along the mid-rib, sometimes becoming nearly one inch in length. The silken web under which the larva feeds covers the entire field of operations but is so thin near the edges where the larva has last fed as to be scarcely visible. The excrement of the larva being retained by the web appears as little black pellets scattered here and there over the feeding ground.

The larvæ feed almost entirely upon one epidermis and the inner tissues of the leaf, leaving the net-work of little veinlets and rarely

Fig. 7.—Leaf showing the work of a young larva during the summer. Natural size.

eating through the opposite epidermis which thus forms the floor of its feeding grounds. The veinlets and epidermis remaining soon turn brown and die; and as the epidermis is quite transparent the work of the larva is rendered conspicuous from either side of the leaf. Rarely more than one larva works on a leaf. Sometimes two leaves are fastened by the silk of the web, and the larva then works between the leaves, feeding mostly on the tissues of one.

The larvæ continue to feed in this manner during July and August, and some may be found feeding in September. The area over which a larva has fed is very irregular in outline and usually covers less than one-fifth the area of the leaf. It usually extends along both sides of the mid-rib and branches out along the large veins into irregular areas. (Fig. 7.)

From the time the larvæ emerged from the eggs in our cages (July 11) they received careful attention. Some were placed out-doors on a tree under a net; and the food in the cages was kept as fresh as possible and their habits of growth and feeding noted. And although the observations upon their feeding habits as recorded above agree in general with those of Dr. Fernald, there were no such changes took place in the size and appearance of the larvæ as he describes.*

Our observations show that the greenish color of the larva when it first emerges changes in a day or two to a dark brown, slightly lighter than that of the mature larva; and the larva then maintains this brown color throughout its whole existence. The head and thoracic shields change to black, but the anal shield in the early stages of the larva is scarcely to be distinguished from the body color; rarely does a mature larva have the anal shield blackish. The larvæ grow very slowly. Instead of attaining a length of 4 mm. in a week (as did Dr. Fernald's), they did not moult or cast their skin the first time until five days after emerging. They then measured 2.25 mm. in length, and the head was now but little wider than the body. The second moult occurred seven days after the first. There was no change in the appearance of the larvæ except in size, they then measuring 3 mm. in length. July 28, or five days after the second moult, the larvæ cast their skins for the third time and attained a length of 4 mm.†

*Dr. Fernald says: "When the young larva hatches it does not eat the shell of its egg, but goes on to the tenderest leaves and almost immediately begins spinning a microscopic layer of silk, under which it eats the outer layer or epidermis of the leaf. The larva is then about three millimeters in length, of a creamy white color, with head, thoracic and anal shields blackish brown, and a few minute pale hairs on the body; the head is very large for the rest of the body. In a week the larva is nearly four millimeters long, light yellowish brown, with the head, thoracic and anal shields dark brown, and it eats minute holes through the leaf, its silken web now being visible to the naked eye. The larva gradually becomes a trifle more brownish, increases in size and enlarges its web along the side of the mid-rib."

†It may be of interest to some to know how it was determined when the larva had moulted, working as it does mostly out of sight. The method employed was that used by Mr. H. G. Dyar, who has worked out the number of moults of many species of caterpillars. He found that the diameters of the head of a larva taken after each moult formed a geometrical series. The head being chitinous does not increase in size between the moults. So that by ascertaining the diameter of the head before and after a moult a ratio could be taken with which the terms of the series could be obtained; or, in other words, one could calculate what the diameter of the head of the larva was going to

After the third moult the larvæ fed but little; one or two moulted the fourth time. When this stage is reached, the larvæ seem to know instinctively that they have reached that point in their development when it is necessary for them to make preparations to go into winter quarters, even though it be several weeks yet before the leaves become unfit for food or fall from the trees.

Hibernation.— Previous to 1885 the Bud Moth was supposed to pass the winter in the egg state as recorded in 1840 by Schmidberger. In 1885, however, Mr. J. Fletcher, in his Report as Entomologist to the Department of Agriculture of Canada says: "I do not know for certain the life history of this little moth, but believe that it passes the winter on the branches of the apple trees, protected by a covering of silk. I have found small brown larvæ hibernating in this manner at Kentville, N. S. The size of the caterpillar in the spring when it attacks the buds also points to the probability of this view." Prof. Fernald says: "Late in the fall the silken web is quite heavy and thick, and the larva deposits its excrements in little pellets in the form of a tube, under the web, within which it hibernates during the winter." In August, 1891, Dr. Lintner stated (Can. Ent., XXIII, 231) that: "He had believed that eggs were deposited in the month of April by the parent moths, from some imperfect and denuded specimens that had been captured fluttering about the trees at this time, and which seemed to be that species. Some of the larvæ which he had hatched from the eggs in June had attained such size in early

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be after any future moult. This method has been found to work surprisingly well in practice here at the Insectary. Mr. Dyar has found but few exceptions in his work. It requires careful measurement with a compound microscope, however, and the real diameters frequently vary from the calculated, but rarely more than .05 mm.

The heads of the Bud Moth larvæ were found to measure .225 mm. when first hatched. In a few days a cast head was found under a web. The diameter of the head of the larva in the tube was .288 mm. From the ratio between these diameters calculations were made of what the diameters of the heads would be after the other moults. But what would be the last term of the series? It so happened that a larva which had spun its cocoon but had not yet changed to a pupa was available. The diameter of the head of this fully matured larva gave the last term. Surprising as it may seem, the calculated seventh term lacked only .06 mm. of the real diameter of the larva's head. The calculated diameters after the second moult were as follows: .368 mm.; .471 mm.; .603 mm.; .772 mm. and .99 mm. The real diameters thus far obtained from measuring the heads of the larvæ are: .363 mm.; .43 mm.; .56 mm. and 1.05 mm., leaving that after the fifth moult to be determined. The diameters after hatching and after the first moult are not included in these figures. They were obtained by measurement and formed the basis for the others; they were .225 mm. and .288 mm.

July when they died that they certainly should have attained full maturity during early autumn." Again, in 1892, Mr. Fletcher says in his Report for 1891: "In 1885 I found in Nova Scotia some small larvæ enclosed in silken cells, which they had spun in the roughness of the bark of fruit spurs upon apple trees. Upon one or two occasions last year the method of passing the winter of this insect was discussed at scientific meetings, but there seemed to be doubt about the matter. This winter I have made careful search upon apple trees and upon some twigs, which were sent to me by Dr. Young, bearing the larvæ of a small Coleophora. In every case I have been able to find the larvæ of this (Bud) moth enclosed in small silken cells, covered over with, apparently, the excrement of the caterpillar, so that I am convinced that for this part of Canada and Nova Scotia this is the usual mode of passing the winter."

From these extracts it will be readily seen that there is considerable difference of opinion in regard to the stage and manner in which this pest passes the winter. Especial attention has been given to this part of its life history here at the Insectary.

During 1891 many observations were made upon the larvæ working upon apple trees on the University grounds. The work of the larvæ in their early stages under their webs upon the leaves progressed as discussed under the habits of the larvæ during the summer. By September 15, however, it became apparent that the larvæ were feeding but little, if any, and several of the tubes under the webs did not contain larvæ. By November 1, not a larva could be found in nearly one hundred infested leaves taken from various parts of the trees. What had become of the larvæ? By very close scrutiny of the twigs which bore infested leaves, it was found that in almost every case there was a small brown larva snugly ensconced in a little silken cell made in some angular roughness of the bark. These larvæ could not be distinguished from those which had been in the tubes only a few days before.

To leave no room for doubt that these were the larvæ of the Bud Moth, several twigs were enclosed in nets. These larvæ did not leave their silken cases or hibernacula until about May 15, 1892. Their work during May and June was similar to that of Bud Moth larvæ on other trees. July 5, 1892, some of these larvæ had pupated, and the moths emerged July 15. They were typical *Tmetocera ocellana*, thus proving that the larvæ which were found in the silken hibernacula were those of the Bud Moth. These observations also go to show that the larvæ do not hibernate in their tubes upon the leaves where Dr. Fernald left them in the fall.

In 1891, we also had a similar experience to that recorded by Dr. Linter above. Larvæ which hatched in the latter part of June, attained such a growth by July 20, that it seemed as if they must become full grown before fall. All had disappeared, however, by August 1, and were supposed to have died.

Further observations were made upon this point in 1892. The eggs obtained from moths confined in cages hatched July 11; and the larvæ were given every chance to grow in our cages and on trees in the field. These larvæ had moulted the third time by July 28, after which they fed but very little. On August 2, one of the larvæ in the cage had left its tube and leaf. It was found in a minute, closely woven, silken case constructed in a slight groove by the larva in the bark of the twig; the bark presenting no angular places, the larva had cut one. The outside of the cocoon was completely covered with little particles of bark and dirt, thus rendering it a very inconspicuous object. These hibernacula are but little more than an eighth of an inch in length and just large enough to hold the somewhat contracted body of the little larva. They are always made on the twigs and smaller branches, and usually quite near a bud. Figure 8 represents a twig natural size bearing three hibernacula at *a* and *b*. By the middle of August most

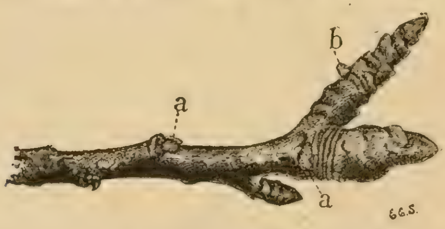

FIG. 8.—Twig showing the position of the winter homes of the larvæ at *a*, *a*, and *b*, natural size.

of the larvæ both in the cages and in the field had gone into hibernation. Frequenty the hibernacula were made under some convenient piece of dead leaf or bud scale (*b*, Fig. 9) which had happened to lodge on the bark of the tree. The bit of leaf or scale would be firmly fastened to the branch by the silken case underneath Some of the larvæ which were of the same brood as those which went into hibernation early in August, did not leave their tubes until September 1. But none remained in the tubes when the leaves fell in autumn.

These observations leave but little doubt that the larvæ cease feeding on the leaves soon after the third moult; a few may moult the fourth time, and some of them immediately go into hibernation while others wait until later, but none remain upon the leaves during the winter. Undoubtedly those larvæ which pass the third or fourth moult quite early in the season, go into hibernation, even though the leaves remain green and do not fall for two or three months afterward.

The little creatures seem to understand when they have reached the hibernating stage. And notwithstanding the temptation of plenty of food and weeks of mild weather, they do not believe in waiting for their comrades who from unforseen circumstances have not reached this eventful period in their lives; thus all can pass the winter under the same conditions and start equal in the spring.

In the light of these facts it seems very probable that the larvæ which we had under observation in 1891, and those upon which Dr. Lintner based his records as mentioned above, had reached their hibernating stage, and either escaped our observation in their hibernacula or they may have died in seeking a suitable place to hibernate.

Taking into consideration all of these observations, we can not escape the conclusion that the normal method of hibernation for the Bud Moth in New York State, Canada, and Nova Scotia is as a half-grown larva snugly hidden in a silken case on the twigs of the tree In this position it is right at hand to nip the bud upon its first showing signs of opening. Whereas, if the little larva fell to the ground with the leaf, it must of necessity proceed by a tortuous and very uncertain route over the ground and up the tree to the buds. It would seem that instinctively the little creature must choose the former method.

It has seemed best to discuss the hibernation of this insect in such detail not only because of the widely differing opinions held, but because it has a very practical bearing which will be discussed under the preventive methods to be used against this pest.

When spring opens, the little brown larvæ leave their winter homes and begin their destructive work upon the buds as described under the appearance and habits of the larvæ in the spring; and thus the yearly life cycle of the insect is completed.

Number of Broods.— The pest is normally single brooded in this and more northern latitudes. The moth appears and lays her eggs in June and July; the larvæ feed upon the leaves until half grown and then hibernate in that stage. Farther south in the vicinity of Washington, D. C., it is possible that there are two broods. Prof. Comstock's notes taken there in 1879, show that the larvæ pupated as early as May 19, and moths began emerging May 29. If there are two broods there it would be interesting to know the habits of the larvæ during the summer.

In his Seventh Report (1891), Dr. Lintner speaks of a second brood of larvæ working on the leaves during July. This is misleading, for these larvæ are simply the early stages of the same brood of larvæ which will appear upon the buds next spring. There is only one brood a year, but the larval period extending over a part of two years causes the larvæ of two different broods to appear during the same calendar year.

NATURAL ENEMIES OF THE PEST.

This pest, like many of our insect foes, has its natural enemies which help to hold it in check. There are several parasitic insects belonging to the Hymenoptera which prey upon the larvæ of the Bud Moth. They are all active wasp-like insects, scarcely one-fourth of an inch in length.

Taschenberg records the following five species of parasites as preying upon the insect in Europe: *Chelonus nigrinus* and *similis*, *Microdus rufipes*, *Mesochorus dilutus*, and *Lissonota culiciformis*.

In this country, but three species seem to be at work upon the pest. Dr. Fernald says (Bull. 12 Mass. Hatch Agr. Expt Sta., 1891): "Some years ago I found a most curious parasite attacking the larvæ of this species. It was a Hymenopterous insect of a pea-green color, and was attached to the top and across the second segment of the larva, on the outside and entirely out of the way of harm; there it grew fat at the expense of its host which died a lingering death. The parasite was determined for me by Mr. E. T. Cresson as *Phytodictus vulgaris* Cr." In July, 1892, we reared two species of these small Hymenoptera from the larvæ of the Bud Moth. Dr. Riley says of them: "One of them proves to be a *Pimpla* near *P. alboricta* Cr., the main difference being in the color of the clypeus. It is not likely that it is an undescribed species and may prove to be one of the forms described by Provancher. The other is *Microdus laticinctus* Cr. *Microdus laticinctus* seems to be quite a common parasite, as Dr. Riley bred it from larvæ received from Canada in 1870, and again in 1879, at Washington, D. C. Prof. A. J. Cook says (An. Rept. Mich. Agr. Expt. Sta., 1891): "We reared from the Bud Moth the parasite *Microdus laticinctus*, which is very common, and will surely do much to stay the ravages of this pest."

Besides these parasitic enemies, the Bud Moth has a predaceous insect foe in the form of one of the large wasps, *Odynerus catskillensis*. This wasp builds mud nests or cells in angular places about houses. In each cell it deposits an egg and then goes on a foraging expedition to get food with which to store the cell. This food often consists of caterpillars, which are paralyzed but not killed, by the wasp, and thus furnish a very delicious morsel for the grub when it hatches from the egg. In June, 1892, a cell of this wasp was found which contained six nearly full grown larvæ of the Bud Moth, and a smaller green larva. About the same time a correspondent wrote that he saw a wasp pick a brown larva out of a cluster of leaves on a quince tree; doubtless it was a Bud Moth larva.

Not only is this pest attacked by foes among its own kind but the birds also seem to take a part in its destruction. Mr. J. Fletcher in his Report for 1885, quotes from Rev. J. R. Hart, of Bridgetown, N. S., as follows: "Two years ago our apple trees were attacked by a large number of brown grubs which ate the young leaves and fruit buds just as they were opening. I tried to watch them developing, but the birds so industriously gathered them up that I could find none coming to maturity."

Doubtless all of these foes aid considerably in keeping the pest in check, but it has now become so numerous and wide spread that its enemies are insufficient and the devices of man must be called into action.

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

Previous to 1887, the principal method recommended to prevent the ravages of this pest was to hand-pick and destroy the nests containing the larvæ or pupæ in the spring. The nests are rendered quite conspicuous at this time by the dead brown leaves in them. This of course is the surest method to prevent the further increase of the pest. But by the time the work of the larvæ has progressed far enough to render its nest conspicuous, the insect has done its worst damage; the growth of the shoot has been checked, or if a fruit bud most of the flowers are destroyed. The most serious objection to this method, however, is that it is impracticable on a large scale. On a few small choice trees it could be done profitably. But the pest must not be allowed to get such a foothold upon the developing foliage and blossoms. Fruit growers can not afford to wait until after the developing and new growth are "nipped in the bud" before placing any obstacles in the way of the depredator.

The principal aim and end had in view in all the observations made upon the pest here at the Insectory during the past two years has been to find just what obstacle could be used to check the insect before its most destructive period was reached; and especially at just what period the obstacle could be presented the most effectively.

In the adult stage, as a moth, the pest does no damage to the fruit or trees. It feeds but little, if any, during its short lifetime of two or three weeks. But if it could be destroyed before it had performed its mission of laying eggs to perpetuate the species it would be then worth while to try. The principal method recommended to destroy moths is by trapping them with lights. Perhaps many of the moths could be thus attracted by placing lights in an orchard, but it has been our experience that the number taken would not repay for the trouble; and besides most of them that were caught would be males. Thus it is not practicable to combat the pest while in the adult stage.

The eggs laid in June and July are freely exposed upon the under surface of the leaves, and would seem to offer a good chance for the application of some insecticide. But what can one apply that would kill the egg and not the leaf? In 1891 (Can. Ent., xxiii, 231) Dr. Lintner said he thought the egg could be killed by kerosene emulsion. Our experience with the eggs of the Pear Psylla (*Psylla pyricola*) in 1892, and with those of the Apple Aphis (*Aphis mali*) in January, 1893, showing that eggs of some insects at least are almost impervious to any of the insecticides thus far employed — even undiluted kerosene was of no avail. If an effective insecticide was found, it would be hard to get it upon the eggs as they are usually scattered about upon the underside of the leaves. No experiments have been tried to destroy the eggs of the Bud Moth; but in the present state of our knowledge of the efficacy of insecticides against the eggs of insects, it will not be practicable to try to combat the pest in this stage.

Following the development of the insect, the next stage in its life history which presents itself is that of the young larva as it works upon the leaves in July and August. Preliminary observations upon the pest while feeding at this time apparently exposed upon the leaves, had led us to hope that it might be easily checked by the application of an arsenical spray. Further detailed observations, however, showed that the larva feeds over but a small portion of the leaf usually upon the under side; and it not only spends most of its time in its tube, but when it does sally forth to feed, it is protected by a layer of silk which it spins and underneath which it works. Owing to the protection afforded by the tube and web, the larva could not be readily reached by any insecticide which kills by contact, as kerosene emulsion. The only chance then to reach the pest in this stage seems to be to get some poisonous insecticide upon the leaves just about the time the larvæ are beginning their work; so that as they extend their feeding grounds they must get some of the poison. This will prove rather a difficult thing to do in practice for several reasons. The poison must be applied to the underside of the leaves.

It will need two or three applications to catch the earliest and latest larvæ which emerge. And on early varieties it is not advisable to spray the trees within at least a month of the time for picking the fruit. Thus it would seem to be hardly profitable to spray in July and August for this pest alone.

Undoubtedly some of the larvæ could be destroyed by the spray, using Paris Green at the rate of one pound to two hundred gallons of water, and if fruit growers are spraying for fungus diseases like the Apple Scab (*Fusicladium dendriticum*) or for a leaf eating insect like the Fall Web Worm (*Hyphantria cunea*), they should spray as late as July 15. And as Bordeaux Mixture, the fungicide most commonly used, can be readily combined with Paris Green without decreasing the effectiveness of either, it would be advisable and profitable under these conditions to spray the trees in July with this combination for fungi and the young larvæ of the Bud Moth. It would cost but little more, and the Paris Green could be used at the rate of one pound to one hundred and fifty gallons in connection with the lime in the Bordeaux Mixture. This plan is practicable and if given a fair trial we believe that it will so lessen the numbers of the pest that the application can be profitably made.

In Massachusetts, according to the observations of Dr. Fernald already quoted, the young larvæ fall to the ground with the leaves. Therefore he says: "To destroy these caterpillars it is desirable to gather all the leaves from under the infested trees in the fall and burn them." Other recent writers following Dr. Fernald, have advised the same treatment. Our observations here at the Insectary corroborated by those of Mr. Fletcher in Canada show that this gathering and burning of the leaves would be useless labor so far as combating the Bud Moth is concerned. For the larvæ are not on the leaves when they fall, but are snugly hidden on the twigs where they will be right at hand when the buds open. Of course, the burning of the leaves and other rubbish in an orchard is desirable under any circumstances, for these harbor many other injurious insects, but one cannot hope to check in the least the ravages of the Bud Moth by this means.

The next question which presents itself, as one follows the life history of the pest is, can it be reached under the silken covering on the twigs in the winter? No experiments have been tried here at the Insectary to reach the pest in this stage. Mr. James Fletcher, however, in his Report as Entomologist to the Department of Agriculture of Canada for 1891, says: "Kerosene emulsion sprayed three times over trees, upon the twigs of which they were in winter quarters inside their silken tubes, had no effect upon the larvæ, having failed apparently to penetrate through the silken covering." And judging from the closely woven and comparatively thick covering over the larva, no insecticide that would not injure the tree would penetrate the covering. Undiluted kerosene might, but we have found that it severely injures the previous year's growth on apple and peach trees. Thus there seems to be no hope of reaching the insect while it is in hibernation.

Thus far in the discussion of the preventive methods which can be used against this pest, the conclusions reached have not been as encouraging as we had hoped to be able to present when the study of the insect was begun. However, we have now reached that point in following the life history of the pest where we confidently believe it can be easily and successfully combated. This point is where the little half grown larva comes from its winter quarters and begins feeding in the spring upon the opening buds. We have only to manage it so that the little larva's first meal in the spring will be a poisonous one. This is the way the Codlin Moth is so successfully kept in check; the little larva which hatches in the blossom end of the developing apple finds a tiny bit of poison served up for its first meal by the deft hand of the spraying machine. In a similar manner, if one can manage to have a little poison on the opening buds when the larva of the Bud Moth appears, the little creature can be effectually destroyed before it can do much harm. This can be easily and cheaply accomplished by spraying the trees with an arsenite.

When and with what shall we spray? Fruit growers usually do not begin to spray their trees until the blossoms have fallen. Recent investigations, however, have shown that the best results are obtained in fighting fungus diseases when the spraying is begun earlier. So that fruit growers are now being advised to spray their trees once or twice before the flowers open with a fungicide for the Apple Scab and other kindred fungus diseases. Again, if fruit growers wait until the blossoms have fallen — the time to spray for the Codlin Moth — before spraying with an arsenite, the Bud Moth will have done the greater part of its damage. Thus fruit growers must begin to spray earlier than usual both for fungus diseases and for insect pests. And as the insecticide can be combined with the fungicide and applied at the same time, the extra expense of one or two sprayings before the blossoms open will be more than met by the extra vigor and growth of the tree and the increased numbers and selling qualities of the fruit. Experiments have shown that it pays to spray for the fungus diseases alone at this time, and we believe that this is the time when the Bud Moth can be the most easily, cheaply, and successfully combated.

The Bordeaux Mixture* is the best fungicide to use in combination with the arsenite. And Paris Green seems to work better than the London Purple or White Arsenic with the mixture. The Paris Green also has some fungicidal properties, and the effectiveness of either the insecticide or fungicide is not decreased by combining them. Therefore we would advise fruit growers to spray their trees with the Bordeaux Mixture and Paris Green combined, using the arsenite at the rate of one pound to two hundred gallons of the mixture.

If one think that he can not afford to apply but one of the substances, use the Paris Green; for it is primarily an insecticide and also has considerable fungicidal properties, while the Bordeaux Mixture is purely a fungicide and practically useless as an insecticide. In case the Paris Green were used alone, it would not be advisable to use it stronger than one pound to two hundred and fifty or three hundred gallons of water, as it would probably injure the tender opening buds if stronger. The lime in the Bordeaux Mixture forms an insoluble compound with the injurious soluble arsenic in the Paris Green and thus allows a much larger quantity of the arsenite to be used in connection with the mixture. It is not safe to mix the arsenites with a fungicide containing ammonia and no lime, as the ammonia dissolves the arsenic, thus making it very injurious to foliage.

The time to spray will depend upon the climatic conditions and upon the variety of the tree. The first application should be made just as the buds are opening in the spring. In 1892, the buds upon early varieties began to open about April fifteenth, and the larvæ appeared soon afterward. On later varieties the buds were ten days later in opening. So that ordinarily the first spraying should be done about April fifteenth in this latitude. It will no doubt vary a week or ten days in different sections of the State. A gallon of the mixture will

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*To make the Bordeaux Mixture, dissolve six pounds of sulphate of copper in four or five gallons of hot water. Slake four pounds of quick lime in sufficient water to form a thin whitewash and strain this through a gunny sack (burlap) into the copper sulphate solution. Dilute to forty gallons with water, and the mixture is ready for use. When using it, it must be kept thoroughly stirred to keep the lime in suspension. The preparation of the mixture in large quantities may be simplified by a test which obviates the necessity of weighing the lime. Keep the mixture thoroughly stirred when the thin whitewash of slaked lime is being poured through the burlap, and add from time to time a drop or two of the commercial potassium ferrocyanide to the mixture. If not enough lime has been added the drop of ferrocyanide will turn to a very dark color the moment it touches the mixture; when enough lime has been added, the ferrocyanide will not change color when it is dropped into the mixture.

spray a large tree at this time as there is but little foliage. A second spraying should be made about a week or ten days later or before the blossoms open. If these two applications be thoroughly made, we believe that the pest will be so greatly checked as to render any further spraying for it alone unnecessary.

Do not spray when the trees are in bloom. If the trees are not sprayed when the buds are opening and the pest thus allowed to get a start, it may pay to spray the trees later, even when the larvæ are protected in their nests. Mr. J. Fletcher says (Rept. for 1891): "Although like the Leaf-rollers they enclose themselves in cases made of leaves drawn together, they have to continually draw in fresh material, and I found last season that where an orchard was severely attacked at the same time by this insect, the Canker worm (*Anisopteryx pometaria*,) the Lesser Apple Leaf Roller (*Teras malivorana*), and the Oblique-banded Leaf-roller (*Cacaecia rosaceana*), all were much reduced in numbers by a single spraying with Paris Green."

We have not had an opportunity to try any extensive experiments in spraying for this pest early in the spring. However, in the spring of 1892, four trees on which there were several larvæ in hibernation were sprayed the first time April 15. Owing to frequent hard showers, it was almost impossible to keep any of the poison on the opening buds. By May 15, the trees had been sprayed five times, using one pound of Paris Green to from one hundred and fifty to two hundred gallons of water. This excessive spraying resulted in considerable injury to the leaves and flowers. But enough of the larvæ were killed to lead us to believe that in an ordinary season the treatment recommended above will prove sufficient to prevent the pest from doing serious damage. In spraying large trees it will be necessary to have one of the Barrel Spraying Machines. Use as fine a spray as possible.

To summarize, it is not practicable to try to check this pest in either the adult or egg stages, or while it is in hibernation as a half grown larva. Undoubtedly it can be checked somewhat by spraying in July when the larvæ are at work on the under side of the leaves. But the best time to combat the pest the most profitably and successfully is in spring when a little poison can be easily sprayed upon the opening buds; and thus the little larva, hungry from its long winter's fast, will be quite certain to get the fatal dose at its first meal.

MARK VERNON SLINGERLAND.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BULLETIN 51 — APRIL, 1893.

FOUR NEW TYPES OF FRUITS.

Prunus Simonii, Crandall Currant, Wineberry, Dwarf Juneberry.

By L. H. Bailey.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.

Four New Types of Fruits.

New types of fruits are nearly always misjudged. They are compared with the most similar type of well-known fruit, even though the two may be very unlike. It should be remembered that wholly new types of fruits are not to be measured by existing standards. They are not introduced, as a rule, for the purpose of supplanting other fruits but with the intent that they shall add variety to our fruit-lists, and occupy places which are now vacant. If they fill an unsupplied demand or if they create a new demand, then they may be counted successful. It is often said of the Crandall currant, for instance, that it can never supplant the common currants and is therefore worthless. It is true that it can not compete with our present currants, but it may fill a place in the market or in the home demand which no other fruit fills; if so, it is worthy, and we shall grow it at the same time that we increase the plantations of red and white currants. The following new types must ultimately stand or fall upon their own intrinsic characters.

It must also be said that new types of fruits and vegetables usually suffer from injudicious praise. Their merits are so much exaggerated that great disappointment results when the varieties come to be known, even though they really possess commendable features. Catalogue descriptions are so often overdrawn and colored beyond the point of belief, that they create a presumption against the novelty in question in the minds of intelligent persons. Novelties are often short-lived because of this disappointment which follows excessive praise; while if the same varieties had been introduced quietly and with candid descriptions, they might persist and eventually become acquisitions to our horticulture. Few fruits have suffered more from this unwise applause than the four which I am about to discuss, and I feel that I must create a wholly new basis of criticism before I can command the attention of careful men.

Simon or Apricot Plum.—Prunus Simonii.*

Something like a dozen years ago, this fruit began to be talked about in North America, although it did not gain any notoriety until

**Prunus Simonii*, Carrière, Rev. Hort. xliv. 111 (1872). *Persica Simonii*, Decaisne, Fruit. du Museum, vii. 43 (1872–5).

six or seven years ago.* It had been introduced from France, where it was first described under its present name and with an admirable colored plate in 1872, by Carriére, in the *Revue Horticole*. I do not know when the fruit reached Europe, but it could not have been introduced long prior to 1872. It was named for Eugene Simon, who sent pits to the Paris Museum while he was representing the French government in China. It is probably native to China, although Hemsley, in his recent Flora of China, does not mention it; but this author evidently adopts Maximowicz's opinion that it is indistinguishable from the nectarine and does not regard it worth distinct discussion. It was disseminated by Simon Brothers at Metz, in Alsace, and by Thibaut & Keteleer, at Sceaux, France.

Prunus Simonii began to fruit in this country about 1885 or 1886. I fruited it in 1886.† The fruit was also figured and described in *The Rural New-Yorker* in October, 1886. The fruit, which is shown about three-fourths size in the engraving, is flattened longitudinally, marked with a deep stem cavity and a very prominent suture, and is borne upon a very short stem. The color is very intense and striking, being a glowing dark red slightly mottled with lighter shades. The flesh is yellow, hard, and clings tightly to the somewhat apricot-like pit. The flavor in all the specimens which I have tested is very disagreeable, being mawkish bitter, and leaving a pronounced bitter almond taste in the mouth. I have never tried a specimen which I could say was edible, and this is an unwilling confession because the fruit is exceedingly attractive to look upon. Other persons appear to have had pleasanter experience with these fruits for I occasionally read of favorable or at least only indifferent comments upon their quality. But it is certainly true that *Prunus Simonii* is not a delectable fruit in New York. It is said that this bitterness passes away in cooking, although my experience in this direction has not been reassuring.

But there are other demerits in this plant besides its mawkish-bitter fruits. It is not a productive tree so far as I have observed, and I have seen it in many different plantations. It bears young, but the

* The first record which I find of *Prunus Simonii* in America is a statement in *Gardener's Monthly* in 1881 (Vol. xxiii, 314) that "under this name Professor Bessey has a peculiar peach-like species, which has been found quite hardy in the college grounds at Ames, Iowa." Both Professor Bessey and Professor Budd disclaim having had the tree at Ames at that date. Professor Budd writes me: "I first saw the tree in bearing in the valley of the Moselle in 1882. We introduced trees from Metz, Germany, in the spring of 1883. Its main defeat is its very early blossoming and the fragile character of the flower."

† See *Amer. Gard.* vii. 330.

fruiting is not profuse. Many of the fruits are borne upon spurs upon the old wood, and they are often found well down to the base of the leaf-bearing portions of the top.

The two transcendent merits of the fruit of *Prunus Simonii* are the very handsome shape and color, and its long keeping qualities consequent upon its hard flesh. Ripe fruits will ordinarily keep a week or ten days in good condition. And aside from these merits, the tree appears to be as hardy as the common plums. But it blooms early and is often caught by late frosts. Professor Budd recently speaks of it as follows in Iowa: "Fruit large to very large, red in color, and is shaped much like a smooth tomato. Its fault is in the way of too early blossoming. It will pay to grow this fine fruit by laying down in winter, as recommended for the peach. The tree is not fully hardy at Ames without winter protection.*

The fruit of *Prunus Simonii* ripens with the early peaches. In New York it ripens about with the Early Rivers peach. The specimens which are shown in the accompanying engraving were ripe August 24th, 1892. They grew upon heavy soil in western New York. The fruit often drops before it is fully ripe and it frequently rots on the tree. Although it is apparently less liable to attacks of curculio than peaches and plums, it is not exempt from such injury, as it is often said to be.

Prunus Simonii is a wholy distinct species from any other stone fruit. It is not a hybrid between the plum and apricot, as some have supposed. Botanically, it probably belongs in the peach section of the genus Prunus, although it is more plum than peach in character of fruit and habit of tree. Maximowicz, a renowned Russian botanist who has given much attention to the celestial floras, has said† that it is identical with the nectarine, but he certainly could not have had a personal acquaintance with the plant. The flowers are shown upon the title page of this bulletin. The two sprigs at the right show the flowers as they appear in Maryland, being sessile and coming out sometime ahead of the leaves. The left-hand sprigs show the stalked flowers opening with the starting of the leaves, as they appear in New York. The difference in behavior of flowers is di6erent latitudes has been mentioned in my plum bulletin (Bull. 38, pp. 22, 30, 31, 37) and it is now under investigation. *Prunus Simonii* grows well upon plum stocks, upon which it is probably oftenest worked in the north. It also takes upon the peach, and upon the Myrobalan and Marianna plums.

*Exp. with New Orchard Fruits, etc., 23, in Bull. 19, Iowa Exp. Sta. (1892).

†Bull. Acad. Sci. St. Petersburg, xi. 669 (1883).

After some years of study of this fruit, I am forced to conclude that it is worthless for orchard cultivation in New York.* It is possible that hybrids between this and the peach or other fruits may possess commercial merit. If hybrids could be obtained with the peach, they might be expected to be hardier than the peach. As an ornamental tree, *Prunus Simonii* has distinct merit, its erect poplar-like habit, interesting conduplicate leaves, early flowers and glowing fruits making it a conspicuous object.

WINEBERRY.— RUBUS PHŒNICOLASIUS.†

In 1887, Professor C. C. Georgeson, traveling in Japan, sent seeds of this raspberry, collected from wild bushes, to J. T. Lovett, Little Silver, N. J. In 1889, Mr. Lovett sold the resulting stock to John Lewis Childs who introduced the plant in 1890 as Japanese Wineberry.‡ Professor Georgeson describes the wild berries as "of good size, firm and handsome." "When the sepals (or burr) first open the berry is

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*The Simon plum appears to be successful in California. The *California Fruit Grower* (Aug. 27, 1892) comments upon its ready sale in the eastern markets and says it "has taken a leading position throughout the season." I. H. Thomas speaks of it in Wickson's *California Fruits* (p. 344) as "large, six and a quarter to seven inches in circumference; flesh firm, rich, sweet, aromatic, delicious, with marked pineapple and faint banana flavors." I find reports of auction sales of California plums to run per box (20 lbs.) as follows:

Chicago: July 2, 1892. Cherry plum, $2; Peach plum, $1.30 and $3.75; Simon, $5.50.

July 8. Cherry plum, $1.80; Peach plum, $2.50 and $3.30; Duane Purple, $3; Simon, $5.75.

July 12. Duane Purple, $2.05 and $2.65; Washington, $3.25; Cherry, $2.35; Peach, $1 and $3.15; Simon, $2 and $5.

New York: July 2. St. Catharine, $3; Peach plum, $3.45; Royal Hative, $2.05 and $2.55; St. Catharine, $2.65 and $2.70; Peach, $2.80 and $3.10; Simon $4.90.

July 5. Cherry plum, $1.10 and $1.15; Royal Hative, $2.05 and $2.55; St. Catharine, $2.65 and $2.70; Peach, $2.80 and $3.10; Simon, $4.90.

July 9. Japan plums, $2.85 and $2.95; Duane Purple, $2.10 to $2.40; Peach, $2.30 and $2.60; Simon, $4.

July 7. Cherry plum, $1.65 and $2.50; Peach plum, $3.80 and $4.15; Simon, $5.

Boston: July 2. St Catharine, $2.37½ and $5; Royal Hative, $2.50 and $3.75; Cherry, $2.75; Simon, $7.25.

Whether these remarkable sales are due to the mere novelty of the fruit and its taking appearance, or to its intrinsic merits, I am unable to say. It is said that *Prnnus Simonii* loves a dry hot climate, and this may account for its good behavior in California.

†*Rubus phœnicolasius*, Maximowicz, Bull. Acad. Sci. St. Petersburg, viii. 393 (1872). Bot. Mag. t. 6479 (1880).

‡See *Amer. Gard.* xii. 204 (1891).

white, but in two or three days it turns bright red, when it becomes sweet and delicious, with a flavor something between the common red raspberry and the black cap." "It is not cultivated by the Japanese, but they gather the berries wherever found." A berry which possesses such decided merits in a wild state may be expected to yield good varieties under cultivation, but one cannot expect that a miscellaneous batch of seedlings thrown upon the market will present uniform value. The current number of the *Mayflower*, published by John Lewis Childs, contains an unsigned article recommending propagation by seed as the best method of multiplying the Wineberry. Mr. Childs' 1893 catalogue contains the same advice, although it also says that the plant is propagated by means of "tips." If the plant is inclined to be variable, this advice is unsafe for the propagation of the plant for fruit; and if the plant is not variable, it has little value for fruit judging from our experience. This *Mayflower* article says that "there is probably no small fruit so eminently desirable and satisfactory for the family garden as the Wineberry." * The 1893 catalogue of Mr. Childs says that the Wineberry "is the most desirable, hardy and profitable small fruit for any climate or soil." The flavor is "very sprightly, sweet and juicy, having no disagreeable sour, but a delicate and luscious flavor peculiar to itself, and superior to other berries." "It is the most prolific berry known, the bushes being literally covered with its large clusters of luscious fruit which are very easily gathered. Owing to their novelty, superb flavor and great beauty they sell more readily and at far better prices than any other berry."

The accompanying illustration is from a photograph three-fourths natural size made from the wineberry on our grounds last summer. The plants were received from Mr. Childs in 1890. The photograph was taken August 25, although the fruit began to ripen sometime before this date. The fruits were very small -- as raspberries go -- and the pips were so little connected that the fruit crumbled when picked. The fruit was cherry red, acrid, with little pronounced flavor. It had little either in size, appearance or quality to recommend it. Whether all wineberries are like ours, I do not know. It is to be expected that considerable variation will be found among them, if they are grown from seeds, as I have already suggested.

H. E. Van Deman, United States Pomologist, reports as follows upon wineberry fruits received from Harper's Ferry, W. Va.: "Berry round, drupes small, deep red, glossy; seeds small, smooth, easily crushed; a handsome berry of medium size and fairly firm; flavor subacid, somewhat sprightly, pleasant. More ornamental than useful."

* *Mayflower*, ix. 81.

The plant has aroused considerable comment in England and a portrait of it was given in the *Gardeners' Chronicle*, September 18, 1886; but it is always recommended as an ornamental plant, and never for fruit, so far as I have seen.

If our wineberry gives little promise for fruit, the plants nevertheless possess decided merit for certain kinds of ornamental planting. The bristly red canes and rich leaves with felt-white color beneath, render the plant very striking; and the bright little fruits remind one of fragile coral beads sprinkled over the plant. These fruits are at first enclosed in the burr-like calyx, and this covering is thought to afford the plants a distinct value in keeping insects from the fruit. "The hairy, viscous calyx, which covers the berry till it is full grown, effectually repels all insects," Professor Georgeson writes. This may be true; but if the fruit were to develop to the point of commercial usefulness, burrowing insects would undoubtedly find this dense calyx to be an excellent protection from outside attacks. The plant is about as hardy as the common raspberries here, although it failed to endure the winter at Kew, England (near London).*

This interesting plant was first clearly described in 1872, by the Russian botanist, Maximowicz. He reported it as growing in Yezo and Nippon, Japan. A plant of it was sent to Kew in 1875, from the Jardin des Plantes, Paris, and from this Sir J. D. Hooker described the species, with an illustration, in the *Botanical Magazine*, in 1880. Hooker characterized it as "a singularly handsome bramble," and said that the fruit, "though eatable, is mawkish." It was early introduced into this country under its proper name of *Rubus phœnicolasius* (the specific name meaning "purple-red hairy"), and was sold by Ellwanger & Barry in 1881. I also received seeds of it from the orient four or five years ago. P. J. Berckmans, President of the American Pomological Society, speaking of the wineberry as having been figured in 1877, adds that it "was known in Holland for a generation before, and cultivated simply as a curiosity in many gardens, the fruit being devoid of any value. Still the new comer may be a form of the well-known sort with better fruit, and if so I will watch it with some interest, as I had known it for nearly fifty years." † I have grown the plants sold by Ellwanger & Barry by the side of the Wineberry from Childs, and they are both *Rubus phœnicolasius.* E. S. Carman has been able to cross this plant with "both the blackberry and the rose." ‡

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* W. Watson in *Garden and Forest*, v. 66 (1892).

† Quoted in *American Gardening*, xiv. 246 (Apr. 1893).

‡ Proc. 6th Conv. Soc. Am. Fl. 92 (1890).

Simon or Apricot Plum — Prunus Simonii.

Wineberry — Rubus phœnicolasius.

Although I find no fruit with commercial value in our wineberry plants, I am nevertheless ready to believe that the species may eventually give us fruit of considerale value; but for the present I should class it among the ornamentals rather than among the fruits.

CRANDALL CURRANT.— RIBES AUREUM.*

The Crandall currant was named for R. W. Crandall, of Newton, Kansas, who found it growing wild. It was introduced in the spring

Good and poor types of the Crandall Currant.

of 1888, by Frank Ford & Son, Ravenna, Ohio. We bought 50 plants of Mr. Ford in 1888, and set them in a continuous row upon high gravelly soil. I have given close attention to the plant since that time and have made two or three reports upon it.†

This type or species of currant undoubtedly has great promise as the parent of a new and valuable race of small fruit. The Crandall, however, is too variable to be reliable. I early noticed that comparatively few of our plants produce abundantly of large fruits, while many of them bear fruits little larger than occasional plants of the common flowering currant, to which species the Crandall belongs. When the crop

* *Ribes aureum*, Pursh, Fl. Am. Sept. 164 (1814). *R. fragrans*, Loddiges, Bot. Cat. t. 1533.

† See *Amer. Gard.* x. 309 (1889). Bull. xv. Cornell Exp. Sta. 207 (1889). Annals of Horticulture for 1891, 52.

was at its height last year (July 26, 1892) I made a record of the size of fruit upon each plant, classifying it into three categories — poor, fairly good and good. The poor fruit was such as appeared to be little larger than the fruit of the flowering currant, or such as is shown — five-eighths natural size — in the lower spray in the engraving, and it ran from five-eighths to three-fourths inch in diameter. The fairly good fruits were those of intermediate size. In order to show that soil did not cause these differences, I transfer the consecutive record of the plants beginning with the end of the row:

	Plants.
Poor	6
Good	1
Poor	7
Fairly good	2
Good	2
Poor	2
Good	1
Poor	2
Good	3
Poor	1
Fairly good	6
Poor	4
Fairly good	2
Poor	2
Good	1
Poor	1
Good	2
Fairly good	1
Poor	2
Good	2
	50

Twenty-seven poor; eleven fairly good; twelve good.

Only a dozen plants, or less than a fourth of the whole number, could be called profitable. There is every reason to expect that if cuttings were taken from these plants alone, the Crandall currant would soon rise in popular estimation. At its best, the Crandall has decided merits. The fruits are large and handsome, firm, of good culinary quality, and the plant is thrifty, hardy and productive. The fruits are borne in very short and open clusters, to be sure, but they are not picked by the cluster like the red and white currants, but singly like the gooseberries.

To some people the flavor of the fruit is disagreeable and it has been called a medicinal flavor; but there are others — the writer included — who are fond of them, even to eat from the hand. In pies and jellies we have found them to be useful. It is not to be expected, of course,

Flowers of Crandall Currant (Half Size).

that these fruits will find a ready market, because consumers are not acquainted with them; but if the stock were more uniform, I think that the Crandall could be recommended as a good fruit for home consumption. There are undoubtedly possibilities before this type of currant, and for this reason, if for no other, the introduction of the Crandall has been fortunate. The plant grows readily from seeds, and we now have several hundred seedlings.

The Crandall so far has been free from attacks of the currant worm, although our plants grow in a general currant and gooseberry plantation in which the worms are common. It has been seriously attacked by the spot disease of the leaves, however (*Septoria ribis*), especially late in the season when the crop is nearly off and from that time until the leaves drop. The leaves develop many brownish spots of a circular outline and which are an eighth of an inch or more across. As the tissue in these spots dies, the portion becomes more or less translucent. Finally the whole leaf yellows and drops. If the attack should be serious upon young leaves, they never attain their full growth. This disease has been successfully treated by Professor Pammel with sprays of Bordeaux mixture and ammoniacal carbonate of copper.*

Ribes aureum, to which species the Crandall belongs, is native to a large area from Missouri and Arkansas westward. It has long been cultivated in yards for the long sweet yellow flowers, which are shown half size in the engraving. It is also sold by some nurserymen as *Ribes fragrans*.

DWARF JUNEBERRY.—AMELANCHIER CANADENSIS VAR. OBLONGIFOLIA.†

Two or three forms of this interesting little food have been introduced to cultivation within the past few years, of which the best known is the variety called Success. This variety was brought to notice by H. E. VanDeman, United States Pomologist, who found the plants growing in a garden in Kansas in 1873.‡ The variety was named and put upon the market about 1878 by Mr. VanDeman. We procured 200 plants in the spring of 1888, and these have now given us three good crops. The plants have never been headed in but they do not stand more than three or four feet high at the present time, and they are upon strong soil. They were set three feet apart and the sprouts are now beginning to fill the row.

The fruit ripens here with the early currants and lasts nearly as long as the currants. Last year, the last fruits were picked July 18. The accompanying picture shows a good cluster, full size. The berries closely resemble huckleberries, as well in flavor as in appearance. They are more juicy and palatable than huckleberries, however. The plants are exceedingly productive and hardy. Professor Alwood, of the Virginia Experiment Station writes in the *Southern Planter*: § "The fruit which is now, June 16th, just ripening, is nearly as large as ordinary smooth peas, and has a pleasant sweet taste, accompanied by a not

* See Bull. 13, Iowa Exp. Sta.

† *Amelanchier Canadensis* var. *oblongifolia*, Torrey and Gray, Fl, N. Am. i. 473 (1838). *A. Canadensis* var. *obovalis*. Sargent, Silva N. Am. iv. 128 (1892)? This dwarf Juneberry is undoubtedly a distinct species from *A. Canadensis*.

‡ See Annals Hort. for 1891, 51, for a fuller history.

§ *Southern Planter*, liii. 400 (July, 1892).

easily described but pleasant aroma. In quality it is, to my taste, superior to the huckleberry, and ranks well with the strawberry. I venture to predict that this fruit will become very popular, and fill a real need for a first-class small fruit, ripening just at the close of a strawberry season." Professor Alwood reaffirms this opinion in a

Success Juneberry. (Natural size.)

recent bulletin.* I subscribe to the above encomium. The fruit is excellent whether eaten from the hand, dried in sugar, or otherwise prepared.

There is one serious difficulty in the cultivation of this fruit, however, which we have not been able to overcome — the incursions of the robins. There is no fruit on our plantation which is so irresistible to the birds as this, and nothing short of actual shooting will keep them away. The only way in which we can save a single fruit is to cover the branch with mosquito netting and tie or sew it on securely, and even then the birds often steal the fruit. It has ben suggested that if

* Bull. 22, Va. Exp. Sta., 109.

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we had an acre of Juneberries, there would be enough fruit for the birds and ourselves, too ; but the robins of the whole country-side seem

Flowers of Success Juneberry. (Half size.)

to know our Juneberry patch, and if we had more berries the only result would be, I fear, that we should have more robins.* But the birds bear me out in the statement that the Juneberries are good !

This dwarf Juneberry or service-berry grows wild over a large part of the northern states, always remaining a low bush so far as I have observed it. The natural variations of the Juneberry are perplexing, and this variety is no exception to the rule. But I am convinced that these dwarf forms are specifically distinct from the common tree-like Juneberry or Shad-bush (*Amelanchier Canadensis*). We are not yet ready to report upon other cultivated varieties of Juneberry, but the Success is an acquisition if the birds can be induced to avoid it.

L. H. BAILEY.

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* Professor Budd writes as follows upon this point in a recent number of *Rural Life* (Feb. 16, 1893, p. 12) : "The great drawback to the culture in a small way of the Dwarf Juneberry is the special fondness of the birds for the fruit. In plantations of an acre or more the fruit taken by the birds is hardly missed, but it is difficult to secure a perfect specimen from a half dozen or a dozen plants unless they are covered. In the near future the tanned bird-netting for covering such fruits as the Juneberry and cherry, which we now are compelled to import, will be manufactured in our country. The inquiries we now have lead us to hope that the manufacture will be commenced the coming year." This material can be had of George Robinson, Rye, Sussex, England, and can be delivered in America for about three cents per yard.

Bulletins of Cornell University Agricultural Experiment Station, 1888 to 1892, inclusive.

No. 1, Experimental Dairy House; No. 2, Feeding Lambs for Fat and Lean; No. 3, Insectary of Cornell University, Wireworms, Plum Curculio; No. 4, Growing Corn for Fodder and Ensilage; No. 5, Lean Meat in Mature Animals, Heating Milk before Setting; No. 6, Fodders and Feeding Stuffs; No. 7, Influences Affecting Sprouting of Seeds; No. 8, Different Rations for Fattening Lambs; No. 9, Windbreaks in their Relation to Fruit Growing; No. 10, Tomatoes; No. 11, Saw Fly Borer in Wheat; No. 12, Apparatus for Drying in Hydrogen and Extracting Fat; No. 13, Leaching of Farm Yard Manure, Grain for Cows at Pasture; No. 14, Strawberry Leaf Blight; No. 15, Sundry Investigations of 1889; No. 16, Growing Corn for Fodder and Ensilage; No. 17, Cochran's Method for Testing Milk; No. 18, Experience in Spraying; No. 19, Condition of Fruit Growing in Western New York; No. 20, Cream Raising by Dilution; No. 21, Tomatoes; No. 22, Grain for Cows at Pasture; No. 23, Insects Injurious to Fruit; No. 24, Clover Rust; No. 25, Sundry Investigations of 1890; No. 26, Egg Plants; No. 27, Farm Manures; No. 28, Forcing Tomatoes; No. 29, Cream Raising by Dilution; No. 30, Influence of Electric Light on Greenhouse Plants; No. 31, Forcing English Cucumbers; No. 32, Tomatoes; No. 33, Wireworms; No. 34, Dewberries; No. 35, Combination of Fungicides and Insecticides; No. 36, Grain for Cows at Pasture; No. 37, Sundry Investigations of 1891; No. 38, Native Plums and Cherries; No. 39, Creaming and Aerating Milk; No. 40, Removing Tassels from Corn; No. 41, Steam and Hot Water for Heating Green Houses; No. 42, Electro-Horticulture; No. 43, Trouble of Winter Tomatoes; No. 44, Pear Tree Psylla; No. 45, Tomatoes; No. 46, Mulberries; No. 47, Feeding Lambs and Pigs; No. 48, Spraying Apple Orchards; No. 49, Sundry Investigations of 1892.

Of these numbers, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 23, 25, 26, 27, 29, 32, 33, 34, 35, 36, 37, are out of print; the remainder will be sent to any desiring them.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

BULLETIN 52—MAY, 1893.

COST OF MILK PRODUCTION.

Variation in Individual Cows.

By Henry H. Wing.

ORGANIZATION.

Office 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.

Bulletins for 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.

Cost of Milk Production---Variation in Individual Cows.

So much has been said of late in Farmers' Institutes, in the Agricultural Press and in the Bulletins and Reports of Agricultural Experiment Stations, in regard to the yield of milk and butter that may be obtained from cows, and in regard to the improvement of herds, that it has seemed well to undertake a record which should if possible show not only what a fairly good herd can be made to produce, but what such production costs in dollars and cents and in the amount of dry matter consumed. In regard to these last two items there is comparatively little data at present accessible. Most of the large records that have been reported by our enterprising breeders of thoroughbred stock have not been accompanied with any statement of the amount or cost of the material consumed to produce these records. Some of our Experiment Stations have made reports of experiments covering these points, but in general they have been made with a few animals and covering a comparatively short period of time. In view of the general interest in these matters it has seemed to us worth while to keep a record as exact as might be not only of the milk and butter production, but of the amount and cost of the food consumed as well. Consequently, beginning January 15, 1892, and ending January 14, 1893, a record of the amound fed and the amount produced by each individual cow in the University herd has been kept. The food was weighed separately for each cow at each feeding and charged to the animal consuming it. The milk was weighed at each milking and credited to the animal producing it. Once each week a sample of an equal amount of night's and morning's milk was taken from each cow. The fat in these samples of mixed milk was determined by Dr. Babcock's centrifugal method, and this percentage multiplied by the number of pounds of milk given during the week was taken to represent the number of pounds of fat produced during that week. The University herd during the time of the experiment contained twenty cows. It has been developed from the ordinary stock of the neighborhood by the use of thoroughbred bulls and a rigid selection of the best heifer calves.

This course of breeding was established by Professor Roberts in 1875, and has been continued ever since. The year previous the yield of the cows upon the farm had been a little more than 3,000 pounds per cow. The descendants of these same cows, as will be seen in detail a little later on, produced in 1892 more than 7,000 pounds per cow. Special animals were not selected for this experiment; every cow in the herd without exception was taken. It was thought that by doing this, average results of more value would be obtained than though most of the better individuals were selected for the special purpose and a few of the poorer ones discarded.

In the table following (Table I) is given the pounds of milk and fat produced by each cow during the entire year and also the age of the cow at the beginning of the experiment. A large number of the cows were young; *four were three-year-olds and four heifers with their first calves; three of the latter were under two years old at the beginning of the experiment*. Four of the cows were not bred upon the farm and their ages were not definitely known, except that they were more than seven years old at the time of the beginning of the experiment. The column for age is left blank in the case of these cows. Two of these cows, Shadow and Sue, were of the common or mixed stock of the neighborhood and evidently carried considerable Short Horn blood. They were not bred and were sold for beef in the fall of 1892, so that their year extends from October 15, 1891, to October 14, 1892, in the case of Shadow, and from November 20, 1891, to November 19, 1892, in the case of Sue, instead of from January 15, 1892, to January 14, 1893, as in the case of all the others. No accidents or sickness interrupted the experiment with one exception; the cow May was farrow at the beginning of the experiment, having then been in milk more than a year. She dropped a heifer calf on November 20th and did very nicely, giving a large flow of milk till December 26th, when she was attacked with a violent chill followed by a fever and almost complete loss of appetite. She dried up rapidly and was removed from the experiment on January fifth. Inasmuch as the experiment was so nearly closed it was not thought worth while to take account of this and her record simply lacks the nine days of a complete year.

TABLE I — TOTAL YIELD IN ONE YEAR.

COW.	Age.		Milk.	Butter fat.
	Years.	Months.	Pounds.	Pounds.
Beauty	....	...	8,028.50	391.62
Belva	5	4	9,739.75	309.19
Bertha	3	5	4,743.25	233.63
Carrie	1	9	6,008.50	219.34
Cora	....	....	6,214.50	326.68
Daisy	1	10	2,829.75	159.02
Freddie	6	4	11,165.00	417.97
Gazelle	4	....	5,670.50	285.10
Gem Valentine	3	....	3,387.75	197.33
Glista	4	8	6,323.50	224.71
Glista 2d	1	9	5,136.00	160.79
Jennie	3	5	5,785.75	294.30
May	10	4	5,458.50	195.31
Mollie	2	4	7,757.25	260.34
Pearl	3	4	9,003.25	299.07
Pet	6	4	9,776.50	330.59
Puss	7	3	10,417.00	302.93
Ruby	3	4	7,955.00	282.35
Shadow	....	....	8,655.50	382.77
Sue	...	....	10,754.00	439.37
Total			114,809.75	5,712.41
Average			7,240.50	285.62

It will be seen that the average yield of milk was 7,240 pounds per cow and the average yield of fat 285 pounds, but it will be also seen that these averages are the averages of wide variations.

The least yield of milk was by Daisy, not quite 3,000 pounds; the largest by Freddie, something over 11,000 pounds, nearly four times as much. Similar variations are seen in the yield of fat and as to be expected the largest yields of fat were not in all cases from the cows giving the most milk though attention is called to the fact that the cow giving the largest yield of fat, 439 pounds, was second in milk production, 10,754 pounds, and the cow giving the largest yield of milk, 11,165 pounds, was second in fat production, 418 pounds. In tables II, III and IV are giving in detail for each month the total yield of milk, the average per cent of fat in the milk, and the total yield of fat. In these Tables and in all the follow-

TABLE II — YIELD OF MILK FOR EACH COW EACH MONTH.

COW.	1892.												1893.
	January 15-31.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January 1-14.
	Pounds	Pounds.	Pounds	Pounds.	Pounds	Pounds.	Pounds.	Pounds	Pounds.	Pounds.	Pounds.	Pounds	Pounds.
Beauty	469.	1033.	1021.50	887.	879.75	801.	627.	403.75	115.75	....	473.25	931.50	386.
Belva	695.	992.75	938.	874.75	969.	826.25	424.75	....	....	1170.	1184.75	1235.50	431.
Bertha	271.	435.	414.50	375.	393.	374.	77.	....	....	618.75	745.75	731.50	307.75
Carrie	339.50	569.25	601.60	573.50	557.	539.	469.	444.	462.50	424.75	372.	429.75	206.78
Cora	255.75	859.25	862.	807.25	838.25	781.50	697.	449.25	301.25	65.	....	....	298.
Daisy	134.75	228.25	239.75	232.25	240.75	240.75	48.50	....	81.75	476.75	359.	3[illegible]7.25	160.
Freddie	737.	1200.25	1231.50	1097.50	956.50	921.25	370.	....	497.50	1351.25	1126.75	1158.	517.50
Gazelle	....	393.50	771.75	712.75	705.	641.25	558.	477.50	353.25	114.50	....	662.	341.
Gem Valentine	39.25	....	108.75	542.25	541.50	510.	448.50	408.50	355.75	279.	154.25	....	....
Glista	405.75	677.50	700.50	615.70	639.	601.50	482.	370 50	....	327.25	553.75	642.25	307.75
Glista 2d	324.75	553.25	643.50	613.75	578 75	508.50	440.	411.	367.	56.75	38.	401.50	199.25
Jennie	....	....	505.	756.75	703.75	649.	576.	538.50	521.75	478.	410.	445.	202.
May	386.50	652.	651.50	596.75	608.75	581.75	419.75	129.50	....	....	210.50	1153.75	67.75
Mollie	478.50	754.50	808.	729.	862.	694.50	94.75	....	554 50	867.75	704.75	860.75	408.25
Pearl	611.25	1024.25	884.75	905.25	865.	589.75	45.	....	411.50	1173.25	924.	1080.25	489.
Pet	....	....	1019.75	1329.75	1411.	1291.75	1146.75	1060.25	1061.25	873.50	445.50	137.00	....
Puss	814.25	1291.50	1426.75	1210.50	1167.	1036.50	950.50	870.25	789.75	639.75	229.25	....	....
Ruby	476.25	7[illegible]8.	822.25	812.25	847.75	814.75	699.50	576.25	273.	....	258.25	1104.50	532.25
Shadow	1014.25	865.	814.50	730.75	716.50	637.	537.	463.75	367.	*593.50	*877.	*1039.25	....
Sue	1265.75	1074.75	1070.50	974.00	974.25	888.50	766.50	664.25	569.25	506.75	†654.50	*1345.	....

* 1891. † 1891 and 1892.

TABLE III — PERCENTAGE OF FAT IN THE MILK OF EACH COW EACH MONTH.

COW.	1892.												1893.
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.
	Per cent.	Per cent	Per cent.	Per cent.	Per cent	Per cent	Per cent.	Per cent.	Per cent	Per cent.	Per cent	Per cent.	Per cent.
Beauty	5.63	5.05	4.50	4.53	4.93	4.70	5.01	5.34	5.19	....	5 50	4.59	4.67
Belva	2.92	3.02	3.17	3 11	3.11	2.90	3.15	....	....	3.88	2.94	3.30	3.12
Bertha	5.16	5.05	5.30	5 22	5.23	4.95	4.95	....	....	4.64	4.59	5.21	3.98
Carrie	3.50	3.32	3.33	3.27	3.82	3.70	3.63	3.74	3.86	3.98	4.09	3.80	3.79
Cora	4.66	5.37	5.36	5.15	5.39	4.96	5.04	5.67	6.02	6.46	....	....	4.67
Daisy	3.80	5.84	6.06	6.15	6.48	5.76	5.55	....	5.20	5.21	5.07	5.20	5.83
Freddie	3.55	3.71	3.85	3.89	4.11	3.65	3.95	....	4.14	3.68	3.27	3.78	3.62
Gazelle	....	4.86	5.22	4.97	5.39	4.68	4.62	5.14	5.00	5.85	....	5.13	4.92
Gem Valentine	7.80	....	6.13	5.57	5.63	5.60	5.54	5.91	6.05	6.49	6.25	....	....
Gilista	3.47	3.24	3.31	3.22	3.66	3 56	3.63	4.10	....	4.01	3.70	3.58	3.75
Glista 2d	3.09	2.92	2.87	2.90	3.14	3.22	3.33	3.25	3.48	3.84	2.97	3.47	2.88
Jennie	....	....	5.30	5.27	4.97	4.58	4.62	5.11	5.23	5.16	5.34	5.41	5.41
May	3.49	3.33	3 17	3.07	3.30	2.99	3 40	3.37	....	....	6.08	4.32	3.50
Mollie	3.27	3.24	3.38	3.19	3.57	3.89	3.95	....	3.81	3.01	3.06	3.19	3.45
Pearl	3.06	3.19	3.77	3.39	3.51	3.61	4.80	....	3.60	3.18	2.88	3.16	3.21
Pet	....	....	3.40	3.23	3.25	3.01	3.27	3.41	3.50	3.50	4.04	5.57	....
Puss	2 84	2.67	3.12	3.16	2.61	2.62	2.75	2.80	3.18	3.34	4.00	....	....
Ruby	3.50	3.83	3.65	3.49	3.33	3.22	3.34	3.92	4 08	....	3.77	3.55	3.49
Shadow	4.28	4.58	4.76	4.61	4.16	3 76	4.24	4.44	4.27	4.57	4.66	4.48	....
Sue	3.94	3.94	4.33	4.28	4.45	3.72	3.71	3.70	4.04	4.10	4 30	4.30	....

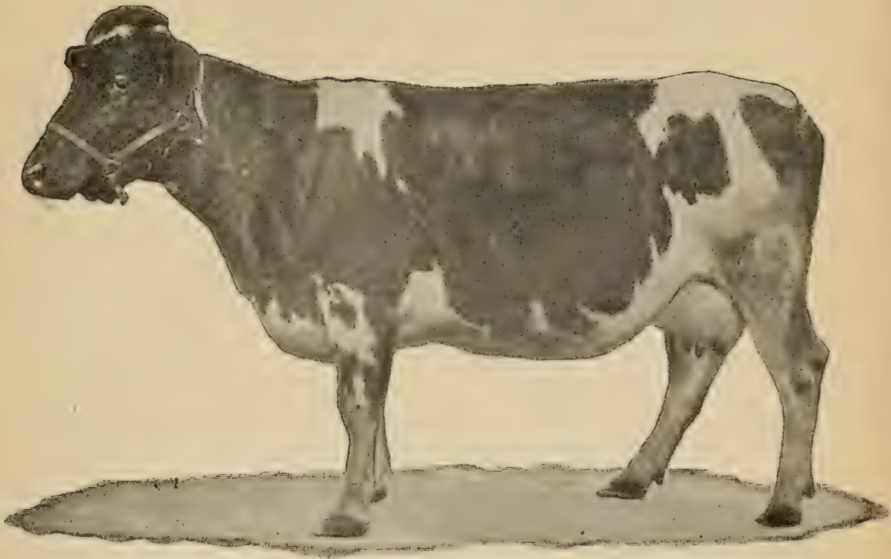
TABLE IV — YIELD OF FAT FOR EACH COW EACH MONTH.

COW.	1892.												1893.
	January 15-31.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January 1-14.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Beauty	26.41	52.18	46.01	40.21	43.36	37.66	31.44	21.56	6.01	....	26.04	42.71	18.03
Belva	20.32	30.	29.76	27.17	30.11	23.98	13.36	....	....	45.44	34.88	40.71	13.46
Bertha	13.99	21.96	21.98	19.56	20.54	18.51	3.81	....	....	28.74	34.21	38.08	12.25
Carrie	11.89	18.92	20.06	18.74	22.05	19.93	17.03	16.61	17.87	16.92	15.20	16.29	7.83
Cora	11.91	46.15	46.24	41.56	45.17	38.76	35.13	25.49	18 15	4.20	....	....	13.92
Daisy	7.82	13.34	14.53	14.29	15.59	13.87	2.69	....	4.25	24.99	18.19	20.13	9.33
Freddie	26.18	44.49	47.44	42.74	39.34	33.64	14.60	....	20.59	49.66	36.82	43.74	18.73
Gazelle	....	19.11	40.24	35.39	38.00	30.01	25.78	24.52	17.67	6.70	....	30.91	16.77
Gem Valentine	2.06	....	6.67	30.20	30.48	28.55	24.86	24.24	21.53	18.10	9.64	....	....
Glista	14.09	21.96	23.22	19.81	23.37	21.41	17.50	15.19	....	13.11	20.52	23.00	11.53
Glista 2d	10.02	16,17	18.45	17.82	18.17	16.38	14.67	13.36	12.77	2.18	1.13	13.93	5.73
Jennie	....	....	26.75	39.91	34.92	29.71	26.62	27.53	27.30	24.65	21.89	24.07	10.92
May	13.50	21.69	20.63	18.33	20.07	17.40	14.28	4.36	....	....	12.80	49.88	2.37
Mollie	15.64	24.45	27.21	23.27	28.60	27.05	3.74	....	21.15	26.08	21.54	27.42	14.09
Pearl	18.85	32.70	33.37	30.67	30.38	21.27	2.16	....	14.80	37.34	26.62	35 19	15.72
Pet	....	....	34.71	43.01	45.91	38.86	37.51	36.11	37.19	31.67	17.99	7.63	....
Puss	23.09	34.50	44.54	38.23	30.44	27.12	26.11	24.37	24.31	21.06	9.16	....	....
Ruby	16.66	28.28	30.04	28.32	28.23	26.26	23.38	22.59	11.13	....	9.73	39.17	18.56
Shadow	43.36	39 60	38.77	33.69	29.83	23.92	22.76	20.58	15.67	*27.12	*40.91	*46.56	....
Sue	49.82	42.34	46.38	41.66	43.31	35.07	28.45	24.58	22.97	20.76	†28.13	†57.90	....

* 1891. † 1891-1891.

Fig. 1.— Sue, First in Fat, Second in Milk.

Fig. 2.— Puss, Third in Milk.



[FIG. 3.— Freddie, First in Milk, Second in Fat.]

FIG. 4.— Beauty, Third in Fat.

ing discussions we have based our figures upon the actual fat produced by the cow as determined by the Babcock Test and not upon the amount of butter that such fat might be expected to make. We have done this because we believe it to more accurately measure the producing powers of the different cows. But since butter has to many a more significance than fat, we have made the following calculations:

The average yield of fat per cow was 285.62 lbs. If all this fat had been made into butter that contained 80 per cent of fat * we should have had a butter yield of 357 lbs. per cow. The best cow gave 439.37 lbs. of fat. On the same basis this would be equivalent to 549 pounds of butter.

But not all the fat can be made into butter, some is unavoidably lost in the skim-milk and in the butter-milk. Assuming that four-fifths of all the milk would be skim-milk and that it would contain .25 of one per cent of fat and that three-fourths of the cream would be butter-milk and it should contain .5 of one per cent of fat, we should lose in this way 398.23 lbs. of fat or 19.91 lbs. per cow, equivalent to 24.9 pounds of butter. This subtracted from 357 would leave the average yield of butter per cow 332 pounds after making due allowance for the losses in skim-milk and butter-milk.

The cows in general are fresh in the months of September and October of each year. In table No. V are shown the dates at which calves were dropped both before and during the experiment and also the number of days that each cow was actually milked from January 15, 1891, to January 14, 1893. It will be seen that one cow, May, was farrow at the time of the beginning of the experiment, that two others, Carrie and Jennie, went farrow during the experiment, and that Shadow and Sue were not bred. The general plan of treatment of the University herd is that the cows shall be milked ten months in the year, going dry about eight weeks before calving. On referring to the last column of table V it will be seen that this is very nearly practically carried out, and that the average number of days of milking was 304; almost exactly ten months.

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* This is the standard adopted by the judges of the Dairy Test at the World's Columbian Exposition.

TABLE V — DATES OF CALVING.

COW.	Dropped calf before or in early part of experiment.	Dropped calf during or at close of experiment.	Days in milk between Jan. 15, 1892, and Jan, 14, 1892
Beauty	January 15, 1992	November 9, 1893	304
Belva	October 2, 1891	September 26, 1892	295
Bertha	September 16, 1891	October 7, 1892	273
Carrie	October 28, 1891	*(August 8, 1893)	366
Cora	January 16, 1892	December 31, 1892	278
Daisy	September 20, 1891	September 22, 1892	287
Freddie	October 6, 1891	September 15, 1892	309
Gazelle	February 8, 1892	December 1, 1892	288
Gem Valentine	March 21, 1892	*(January 26, 1893)	252
Glista	September 21, 1891	October 9, 1892	324
Glista 2d	September 29, 1891	November 21, 1892	316
Jennie	March 5, 1892	*(September 7, 1893)	311
May	(December 27, 1890)	November 20, 1892	257
Mollie	September 25, 1891	September 10, 1892	298
Pearl	September 1, 1891	September 16, 1892	292
Pet	March 2, 1892	*(April 16, 1893)	285
Puss	December 10, 1891	*(February 2, 1893)	317
Ruby	September 11, 1891	November 14, 1892	302
Shadow	October 12, 1891	Not bred	352
Sue	November 16, 1891	Not bred	366
Average number of days in milk			304

The cows were weighed on the 15th of each month, except in a few cases where dry cows were at pasture and away from the barn. They were weighed in every case in the morning after milking and feeding and before watering. The weights of each cow each month are shown in table VI and also the average for the year.

It will be seen that the herd as a whole maintained about an even degree of flesh, only a few of the younger cows making a material increase in weight during the year. It will also be seen that the size of the cows varied considerably and that very few were under 1,000 pounds in average weight, so that the herd as a whole was made up of large cows.

It was the aim to feed a ration that would be eaten up fairly clean by all the cows. The foods used during the winter were hay, ensilage, roots, wheat bran, cotton-seed meal and corn meal. Only very slight variations were made from this list of foods. In the summer the cows had pasture of good quality and a grain

* Due to calve.

TABLE VI.— WEIGHT OF COWS EACH MONTH.

COWS.	1892.												1893.	
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	Average.
Beauty	....	830	875	885	830	805	865	865	890	....	880	820	845	858
Belva	1254	1244	1262	1325	1265	1350	1405	1400	1425	1290	1442	1300	1275	1326
Bertha	900	935	955	975	945	1050	970	970	970	925	895	895	915	946
Carrie	847	896	962	1000	925	970	945	945	940	1010	1050	1070	1070	972
Cora	1235	1088	1115	1135	1025	1070	1095	1090	1095	1185	1225	1210	1030	1123
Daisy	610	748	800	820	795	815	855	855	897	815	845	840	895	815
Freddie	1477	1485	1520	1492	1455	1500	1565	1545	1525	1375	1430	1430	1365	1474
Gazelle	1135	1094	1105	1110	1015	1055	1075	1040	1050	1080	1130	1005	1036	1071
Gem Valentine	807	849	900	835	765	800	815	800	805	840	845	865	850	829
Glista	1208	1255	1273	1305	1250	1300	1320	1345	1325	1225	1255	1250	1195	1270
Glista 2d	883	920	975	1015	980	970	965	1005	990	1095	1115	1025	1070	1001
Jennie	1076	1100	1020	1060	[illegible]	1030	1030	985	[illegible]	1010	[illegible]	1045	1065	1030
May	1252	1290	1290	1310	1230	1330	1365	1325	1330	....	1447	1195	1035	1283
Mollie	963	992	1026	1025	995	1060	1020	1040	940	960	1015	1025	1035	1007
Pearl	1095	1093	1128	1145	1080	1180	1260	1250	1295	1105	1155	1140	1155	1160
Pet	1430	1472	1270	1265	1200	1255	1275	1230	1185	1255	1448	1325	1360	1305
Puss	1482	1517	1510	1565	1425	1500	1525	1465	1475	1535	1600	1630	1525	1520
Ruby	1133	1148	1187	1215	1160	1245	1265	1255	1275	....	1180	1060	1070	1183
Shadow	1148	1192	1165	1245	1170	1245	1355	1245	1270	1350	....	....	....	1239
Sue	1094	1093	1105	1015	995	940	1030	1015	960	1065	1130	....	....	1040

ration, for the most of the time, of wheat bran and cotton-seed meal supplemented with soiling crops when the pastures become dry.

The hay used was clover hay of a fair quality grown upon a wheat stubble and having a considerable proportion of volunteer wheat mixed with it, which was not readily eaten by the cows. The silage was made from Pride of the North corn grown in hills having a fair crop of ears. It was well preserved and of good quality. The roots used were almost wholly Mangel Wurtzels of medium size and good quality. The grain ration in January, February, March and April, 1892, was made up of a mixture of 300 pounds of bran, 200 pounds of cotton-seed meal and 60 pounds of corn meal. The corn silage crop of 1892 had considerable more grain than that of 1891, consequently, in November and December, 1892, and the first half of January, 1893, the corn meal was left out of the grain ration and three parts of bran, and two parts of cotton-seed meal were fed. During the time the cows were at pasture the grain ration was made up of three parts bran and one part cotton-seed meal. The daily winter ration was as follows:

For the larger cows.	*For the smaller cows.*
15 pounds hay	10 lbs. hay.
50 to 55 lbs. silage.	40 to 45 lbs. silage.
10 lbs. roots.	10 lbs. roots.
8 lbs. grain.	8 lbs. grain.

The only exceptions made to this were that Freddie and Puss, during January, February and March, 1892, had ten pounds of grain instead of eight. The summer grain ration was four pounds per cow except during the month of June, when one-half of the cows received no grain whatever. The cows while dry were fed no grain at all, the remainder of the ration being unchanged. In the latter part of the summer, particularly in the months of August and October, the pastures became very short and were supplemented in August with second growth clover, cut and carried to the cows, and in October with corn stalks. These were in every case weighed and charged to the cows consuming them. In making up the cost of the food consumed the following scale of prices were used, based as far as possible upon the market prices in Ithaca:

Hay	$9 00 per ton.
Ensilage	1 75 per ton.
Roots	2 00 per ton.

Wheat bran	18 00 per ton.
Oats	35 per bushel.
Cotton-seed meal	25 00 per ton.
Corn meal	20 00 per ton.
Corn stalks	3 00 per ton.
Grass, cut and carried to cows	1 75 per ton.
Pasture, exclusive of grain and silage crops	30 per week.

It was somewhat difficult to estimate the value of the cornstalks and the second growth clover used for soiling, since the materials, particularly the cornstalks, varied widely in the amount of water contained in them. But as fair an estimate as could be made seemed to be the figures given. In order to estimate with some degree of accuracy the proper charge to be made for pasture, the following letter was sent to representative farmers in thirteen counties in those parts of the State where dairying is a leading industry:

"DEAR SIR.— Will you please tell me what you consider a fair estimate per week of the cost of pasturing a cow in milk during the whole season; not what people in villages pay for a cow or so, but what it costs dairymen keeping cows in large herds. Please base your estimates upon your own county."

To this thirteen replies were received from the counties of Broome, Cattaraugus, Chautauqua, Chemung, Cortland, Delaware, Dutchess, Lewis, Montgomery, Oneida, Orange, St. Lawrence and Tompkins. The average of the whole was 33 cents per week. Three of the replies were above 45 cents; eight between 25 and 35 cents, and two were below 25 cents. A discussion of the matter, by the various members of the Station Staff, had already decided upon 30 cents as a fair price, and that price had been used as the value of the pasture. The cows were charged with pasturage from May 9th to November 1st. During November they were turned in the pasture on pleasant days and ate more or less grass; but as they were on full winter rations, both of grain and coarse fodder during the month, it was not thought best to make any charge for the small amount of frosted grass they might have eaten.

In Table VII is given the cost of the food consumed by each animal; the total number of pounds of milk and fat produced and the cost of a hundred pounds of milk and one pound of fat for each individual and the average for the whole. The average cost of food consumed was $45.25; the highest for any one cow was $53.38 for the cow Shadow; the lowest, $36.24, for Gem Valentine. The average

TABLE VII — COST OF FOOD, MILK AND FAT.

COW.	Cost of food consumed during the year.	Pounds of milk produced.	Cost of 100 pounds of milk.	Pounds of fat produced.	Cost of one pound of fat.
Beauty	$44 24	8,028.50	$0.55	391.62	$0.115
Belva.........	47 65	9,739.75	.49	309.19	.155
Bertha........	42 00	4,743.25	.89	233.63	.18
Carrie	49 07	6,008.50	.82	219.34	.225
Cora	38 74	6,214.50	.62	326.68	.12
Daisy	41 24	2,829.75	1.48	159.02	.26
Freddie	52 06	11,165.00	.47	417.97	.125
Gazelle	39 96	5,670.50	.70	285.10	.14
Gem Valentine.	36 24	3,387.75	1.07	197.33	.185
Glista	46 51	6,323.50	.74	224.71	.21
Glista 2d......	43 80	5,136.00	.85	160.79	.27
Jennie........	43 66	5,785.75	.75	294.30	.15
May..........	44 34	5,458.50	.81	195.31	.225
Mollie	45 98	7,757.25	.59	260.34	.175
Pearl.........	47 44	9,003.25	.53	299.07	.16
Pet	43 12	9,776.50	.44	330.59	.13
Puss..........	47 87	10,417.00	.46	302.93	.16
Ruby.........	48 63	7,955.00	.61	282.35	.17
Shadow	53 38	8,655.50	.62	382.77	.14
Sue	49 08	10,754.00	.46	439.37	.11
Total	$905 01	144,809.75		5,712.41	
Average ..	45 25	7,240.50	$0.625	285.62	$0.158

cost of 100 pounds of milk was almost exactly 62½ cents; the highest for any one cow being $1.48 for Daisy; the lowest 44 cents for Pet. If we consider milk to be worth $1.00 per hundred weight at the barn two of the cows produced milk at a loss, Daisy and Gem Valentine. The average cost of butter fat was 15.8 cents; the highest 27 cents for Glista 2d; the lowest 11 cents for Sue. If we should consider fat to be worth 30 cents per pound, which is a little more than an equivalent of 25 cents a pound for butter, we should have no cows that produced fat at a loss for food consumed.

Of course, in making comparisons of cows in this way it is necessary that the individual history of the cows be taken into account. For instance, in our herd two cows, Daisy and Glista 2d, were under comparatively unfavorable conditions; because of an accident they had dropped their calves when about eighteen months old and after having run in a back pasture where they were overlooked until they had been seriously annoyed by the horn fly. They were retained in the herd for another year, and one of them, Daisy, showed marked improvement. The other, Glista 2d, did not, and, therefore, has already been sent to the butcher, while Daisy is retained for still further development. This is mentioned simply to show the principles upon which we base our selections. In the same way the cow May was under unfavorable conditions as she had already been milked more than a year when the experiment started, and in this year had given more than 13,000 pounds of milk, and it was not to be expected that in the second year she would do as well. On the other hand the cow Pet was fresh in March and in full flow of milk during the time that the pasture was at its best. Her cost of milk and fat in comparison with others of her age and weight is therefore probably quite a little reduced. But after taking into account

TABLE VIII.—COST OF 100 POUNDS OF MILK FOR EACH MONTH.

COW.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Jan.
	1892.												1893.
Beauty	.57	.49	.53	.58	.49	.31	.41	.87	....	....	....	.52	.54
Belva	.49	.56	.64	.66	.48	.17	....	....	....	.25	.41	.49	.63
Bertha	1.09	1.16	1.31	1.37	1.10	.38	....	....	....	....	.55	.66	.68
Carrie	.87	.89	.90	.90	.75	.46	.55	.82	.58	.72	1.23	1.16	1.04
Cora	....	.60	.63	.64	.52	.18	.30	.78	.88	....	....	....	.59
Daisy	2.20	2.21	2.27	2.22	1.80	.59	....	....	....	.60	.82	1.24	1.31
Freddie	.52	.54	.56	.54	.48	.27	....	....	....	.23	.43	.53	.52
Gazelle	....	...	.70	.72	.62	.22	.38	.74	.75	....	....	.71	.61
Gem Valentine	....	....	....	.95	.80	.49	.57	.86	.75	1.10	....	....	.....
Glista	.73	.74	.78	.84	.68	.24	.44	.99	....	....	.83	.86	.83
Glista 2d	.91	.91	.85	.84	.75	.28	.48	.89	.73	....	....	1.24	1.08
Jennie	....	....	....	.68	.62	.38	.44	.65	.51	.64	1.03	1.09	1.03
May	.88	.90	.96	.98	.77	.43	.61	....	....	....	....	.44	.58
Mollie	.62	.67	.67	.71	.54	.36	....	....	....	.35	.65	.64	.62
Pearl	.56	.58	.69	.65	.54	.24	....	....	....	.26	.49	.51	.52
Pet	....	....	....	.44	.33	.11	.18	.34	.25	.35	1.09	....	.....
Puss	.47	.50	.48	.51	.40	.24	.27	.42	.34	.49	....	....	.....
Ruby	.71	.79	.75	.72	.55	.30	.37	.63	....	....	...	.50	.48
Shadow	.61	.68	.77	.80	.65	.39	.48	.76	.66	.41	.56	.60	.....
Sue	.46	.51	.55	.59	.48	.16	.28	.55	.47	.61	.81	.43	.....
Average	.64	.68	.71	.71	.58	.28	.38	.65	.51	.41	.65	.63	.67

TABLE IX.—COST OF ONE POUND OF FAT FOR EACH MONTH.

COW.	Jan.	Feb.	March.	April.	May.	June.	July.	August	Sept.	Oct.	Nov.	Dec.	Jan.
	1892.												1893.
Beauty	.10	.095	.12	.13	.10	.065	.08	.165	....	....	....	.115	.115
Belva	.165	.185	.205	.215	.155	.06	....	....	...	.065	.14	.15	.20
Bertha	.21	.23	.25	.265	.21	.075	....	....	....	....	.125	.125	.17
Carrie	.25	.265	.27	.275	.195	.125	.15	.22	.15	.18	.30	.305	.275
Cora	....	.11	.12	.125	.095	.035	.06	.14	.145	....	....	....	.125
Daisy	.38	.38	.375	.36	.28	.10	....	....	....	.115	.16	.24	.225
Freddie	.145	.145	.145	.14	.12	.075	....	....	....	.06	.13	.14	.145
Gazelle	...	....	.135	.145	.115	.05	.08	.14	.15	....	....	.14	.125
Gem Valentine	....	....	....	.17	.14	.085	.105	.145	.125	.17	....	....	.....
Glista	.21	.23	.235	.26	.185	.065	.12	.24	....	....	.225	.24	.22
Glista 2d	.295	.31	.295	.29	.24	.085	.145	.275	.21	....	....	.36	.375
Jennie	....	....	....	.13	.125	.085	.095	.125	.095	.125	.195	.20	.19
May	.25	.27	.30	.32	.23	.14	.18	....	....	....	....	.105	.165
Mollie	.19	.205	.20	.22	.15	.09	....	....	...	.12	.21	.20	.18
Pearl	.18	.18	.185	.19	.155	.065	....	...	....	.08	.17	.16	.16
Pet	....	....	....	.135	.10	.035	.055	.10	.07	.095	.27	....	.....
Puss	.165	.19	.155	.16	.155	.09	.10	.15	.11	.145	....	...	.....
Ruby	.20	.205	.205	.205	.165	.095	.11	.16	....	....	....	.14	.135
Shadow	.145	.15	.16	.175	.16	.105	.11	.17	.155	.09	.12	.135	.....
Sue	.115	.13	.125	.14	.105	.045	.075	.15	.115	.15	.285	.10	....
Average	.17	.18	.18	.18	.145	.075	.095	.155	.125	.105	.175	.155	.17

these individual variations the larger number of the animals may be fairly judged by their records as made. For instance, Bertha produced milk at \$.85 a hundred weight and fat at \$.18 per pound; her twin sister, Jennie, under the same conditions produced milk at \$.75 a hundred weight and fat at \$.15 per pound. Both of them were surpassed by Beauty and Cora, cows of like age and breeding, and so the comparison of others might be made. A single one is perhaps striking enough to merit attention. Glista and Belva are cows in outward appearance very similar and of nearly the same age and weight; Glista required seventy-four cents worth of food to make 100 pounds of milk, Belva forty-nine; nearly 50 per cent less. Belva produced a pound of fat for fifteen and one-half cents, Glista for twenty-one cents; considerably more than one-third more. It is also of interest to note the varying cost of milk and fat in the different months of the year. This is shown in detail in Tables VIII and IX.

In Table VII the cost of milk is obtained by dividing the total cost of food for the year by the total number of pounds produced during the year. In tables VIII and IX the cost per month is obtained by dividing the value of the food consumed in any given month by the amount of milk and fat produced in that month and the figures are therefore relatively lower because the amount consumed in the months when the cows were dry or partially dry is not taken into account, and figures are given only in the months where the cows were milked during the whole month. These tables show what might have been expected, that milk produced upon pasture is produced at a lower cost for food or that it costs more to produce milk on dry food in the winter than in the summer on pasture, and in this case the larger number of cows were fresh in the winter. But some other generalizations of interest may be drawn from these tables. It will be seen that the highest cost both for milk and fat was in the months of March and April, the lowest in June. It will be seen too that in the month of August the cost was higher than in either July or September. November also was a month in which the cost was relatively high. We have found that in the three months of April, August and November we have the greatest difficulty in getting a satisfactory return for the amount of food used. The cost of individual cows is also worthy of notice. It will be seen that one cow, Pet, produced milk for eleven cents per hundred weight in June, and that two cows, Cora and Pet, produced fat for three and a half cents per pound in the same month, and it will be seen a little further on that in this month these cows had nothing but pasture.

As a sort of side issue a study was made of the effect of a grain ration upon the cost of production of milk and fat. The study was made during the month of June in this way. The cows were first turned to pasture on May ninth; the winter grain ration of eight pounds per day was reduced to the summer ration of four pounds per day on May twenty-six; on June third the cows were divided into two lots, evenly mated as nearly as possible in regard to the yield of milk, age, size, time of calving, etc. One lot received no grain during the remainder of the month of June; the other lot continued to receive the customary allowance of four pounds.

TABLE X.—EFFECT OF GRAIN WITH PASTURE ON COST OF MILK.

COW.	FED GRAIN IN JUNE.			COW.	FED NO GRAIN IN JUNE.		
	COST OF 100 POUNDS MILK.		Reduction of cost in June —per cent.		COST OF 100 POUNDS MILK.		Reduction of cost in June —per cent.
	May.	June.			May.	June.	
Beauty	$0.49	$0.31	58	Belva	$0.48	$0.17	182
Carrie	.75	.46	63	Bertha	1.10	.38	189
Freddie	.48	.27	78	Cora	.52	.18	189
Gem Valentine.	.80	.49	63	Daisy	1.80	.59	205
Jennie	.62	.38	63	Gazelle	.62	.22	182
May	.77	.43	79	Glista	.68	.24	183
Mollie	.54	.39	50	Glista 2d	.75	.28	168
Puss	.40	.24	67	Pearl	.54	.24	125
Ruby	.55	.30	83	Pet	.33	.11	200
Shadow	.65	.39	67	Sue	.48	.16	200
Average			67	Average			182

TABLE XI.— EFFECT OF GRAIN WITH PASTURE ON COST OF FAT.

COW.	FED GRAIN IN JUNE. Cost of 100 pounds of fat. May.	June.	Reduction of cost in June —per cent.	COW.	FED NO GRAIN IN JUNE. Cost of 100 pounds of fat. May.	June.	Reduction of cost in June —per cent.
Beauty	$0.10	$0.065	54	Belva	$0.155	$0.06	158
Carrie	.195	.125	56	Bertha	.21	.075	180
Freddie	.12	.075	60	Cora	.095	.035	171
Gem Valentine.	.14	.085	65	Daisy........	.28	.10	180
Jennie	.125	.085	47	Gazelle	.115	.05	130
May	.23	.14	64	Glista	.185	.065	185
Molly	.15	.09	67	Glista 2d	.24	.085	182
Puss	.155	.09	72	Pearl........	.155	.065	138
Ruby	.165	.095	74	Pet	.10	.035	186
Shadow	.16	.105	62	Sue	.105	.045	133
Average			62	Average			164

In tables X and XI is shown the relative cost of milk and fat in the two months of May and June. The cost of milk and fat was largely reduced in the month of June with all the cows, but the reduction was nearly three times as much with the lot that received no grain, and by a study of the column in tables X and XI showing the percentage of reduction in cost of milk and butter in June, it will be seen that the percentage of reduction was fairly uniform with all the cows in each lot. The percentage of reduction was quite as much with those producing a small amount of milk as with those producing a large amount of milk. In no case was the reduction in cost in a cow having grain as large as in a cow having no grain, and the average reduction for the lot having no grain was nearly three times as much as for those having grain. In general the milk was reduced in cost in June more than the fat, but this difference is not very marked. With the grain-fed lot the cost of milk was sixty-seven per cent, and the cost of fat sixty-two per cent less in June than in May; with the lot receiving no grain the cost of the milk was 182 per cent and the cost of the fat 164 per cent less in June than in May. It should be borne in mind that this reduction was effected in cows that were none of them fresh in milk and most of them well advanced in the period of lactation; it is interesting also to note that the four pounds of grain ration per day cost just as much as the pasture at thirty cents per week; in other words the addition of a grain ration doubled the cost of keeping the cows for that month.

In regard to the dry matter consumed, it was found impracticable to make any estimate of the dry matter consumed in the pasture, so that the figures of the dry matter consumed are based upon what the animals ate during the months of winter feeding, namely, November, December, January, February, March and April, and are given in Table XII. The percentages of dry matter in the various foods were taken from Jenkin's and Winton's Compilation of Analyses of American Feeding Stuffs (U. S. Dept. Agr., Experiment Station Bulletin No. 11) and are as follows:

	Per cent dry matter.
Clover hay	88.63
Corn silage	20.90
Mangels	9.10
Wheat bran	88.10
Corn meal	85.00
Cotton-seed meal	91.80
Corn stalks	59.90
Oats	89.00

In this table and in the averages computed from it those months have been omitted in which the cow was dry for the whole or part of the time, and the figures therefore relate only to the milk given and the food consumed during the time that the milk was given without reference to the food consumed when the animal was dry.

TABLE XII.— CONSUMPTION OF DRY MATTER IN WINTER MONTHS.

COW.	Nov.	Dec.	Jan. 1–14, '93.	Jan. 15–31, '92.	Feb.	March.	April.	Total.
Beauty	......	724	309	411	743	800	767	3754
Belva	828	973	434	533	867	967	910	5512
Bertha	664	724	309	440	743	800	767	4447
Carrie	767	752	323	439	743	800	767	4591
Cora	......	......	......	......	752	800	767	2319
Daisy	557	721	309	440	743	800	767	4337
Freddie	828	973	434	569	973	1024	922	5723
Gazelle	......	687	309	......	......	800	767	2563
Gem Valentine	......	......	......	......	....	.....	767	767
Glista	769	864	401	440	743	800	767	4784
Glista, 2d	......	752	323	440	743	800	767	3825
Jennie	681	724	309	......	.....	.....	767	2481
May	......	807	......	533	921	968	910	4139
Mollie	767	864	401	440	743	800	767	4782
Pearl	767	864	401	533	921	967	910	5363
Pet	828	......	......	......	.....	898	911	2636
Puss	......	......	......	569	973	1024	942	3508
Ruby	......	864	401	525	911	968	910	4579
Shadow	*828	*971	......	*970	921	969	910	5569
Sue	*587	*889	......	*892	844	886	892	4990

The averages of Table XII are summed up in Table XIII which gives the number of pounds of dry matter consumed for each pound of milk and fat yielded and also the pounds of dry matter consumed per 1,000 pounds live weight per day. The average number of pounds of dry matter required for 100 pounds of milk was 104. Freddie required the least, 81 pounds, Daisy the most, 249 pounds. The average number of pounds of dry matter required for 1 pound of fat was 27. Cora and Beauty required the least, 17 pounds; Glista 2d the most, 47 pounds. The average number of pounds of dry matter consumed per 1,000 pounds live weight per day was 24.7. The standard for milch cows as given by Armsby (Manual of Cattle Feeding, p. 432) is 24. The larger cows required less per 1,000 pounds live weight and the smaller cows more than the standard. Eleven cows, whose average weight was 1,004 pounds, ate more than 24 pounds of dry matter per 1,000 pounds live weight per day; 9 cows, whose average weight was 1,267 pounds, ate less than 24 pounds of dry matter per 1,000 pounds live weight per day, the extremes being 20.7 for Glista and 30.8 for Gem Valentine.

* Figures for these two cows are for November and December, 1891, and the whole of January, 1892.

TABLE XIII — DRY MATTER REQUIRED FOR 100 POUNDS MILK AND ONE POUND FAT.

COW.	Number of days.	Pounds dry matter consumed.	Pounds milk produced.	Pounds dry matter consumed for each 100 pounds milk.	Pounds fat produced.	Pounds dry matter consumed for each pound fat.	Live weight — Pounds.	Pounds dry matter consumed per 1,000 pounds live weight per day.
Beauty	152	3,754	4,728.00	79	225.55	17	858	28.8
Belva	182	5,512	6,349.75	87	196.30	28	1,326	22.8
Bertha	182	4,447	3,280.50	136	162.03	27	946	25.8
Carrie	182	4,591	3,092.25	148	108.93	42	972	25.9
Cora	90	2,319	2,528.50	92	133.95	17	1,123	22.9
Daisy	182	4,337	1,741.25	249	97.63	44	815	29.2
Freddie	182	5,723	7,068.50	81	260.14	22	1,474	21.3
Gazelle	106	2,563	2,427.50	106	123.31	21	1,071	22.6
Gem Valentine	30	767	542.25	141	30.20	25	829	30.8
Glista	182	4,784	3,903.25	123	134.13	36	1,270	20.7
Glista 2d	152	3,825	2,736.00	140	82.13	47	1,001	25.1
Jennie	105	2,481	1,813.75	137	96.79	26	1,030	22.9
May	138	4,139	3,440.50	120	124.03	33	1,283	23.4
Mollie	182	4,782	4,743.75	101	153.72	31	1,007	26.1
Pearl	182	5,363	5,918.75	91	193.12	28	1,160	25.4
Pet	91	2,636	2,795.00	94	95.71	28	1,305	22.2
Puss	107	3,508	4,743.00	74	140.36	25	1,520	21.6
Ruby	152	4,579	4,485.50	102	161.03	28	1,183	25.5
Shadow	182	5,569	5,340.75	104	242.89	23	1,239	24.7
Sue	182	4,990	5,983.75	83	266.23	19	1,040	26.4
Average	....	......	....	104	....	27	......	24.7

Heretofore no mention has been made of the breed of the various cows as it was preferred to discuss all the questions bearing upon age, weight, etc., before taking up a discussion of the breed. Of the 20 cows 9 were grade Holsteins; 2 thoroughbred Holsteins; 6 grade Jerseys; 1 thoroughbred Jersey, and 2 common grade cows bearing evidence of having considerable Short Horn blood. The cows are grouped below:

Holsteins and Holstein Grades.

Belva		$\frac{7}{8}$
Carrie		$\frac{3}{4}$
Freddie		$\frac{3}{4}$
Glista	H. F. H. B.	7,857
Glita 2d	H. F. H. B.	23,905
May		$\frac{3}{4}$
Mollie		$\frac{15}{16}$
Pearl		$\frac{7}{8}$
Pet		$\frac{7}{8}$
Puss		$\frac{7}{8}$
Ruby		$\frac{3}{4}$

Jerseys and Jersey Grades.

Beauty	at least	$\frac{3}{4}$
Bertha	at least	$\frac{7}{8}$
Cora	at least	$\frac{3}{4}$
Daisy	at least	$\frac{7}{8}$
Gazelle	at least	$\frac{7}{8}$
Gem Valentine	A. J. C. C. H. R.	57,881
Jennie	at least	$\frac{7}{8}$

Common Grades.

Shadow		0
Sue		0

The percentage of blood in the Jersey grades is not definitely known because the foundation of the Jersey part of the herd was secured by purchasing some graded Jerseys that were known to be at least three-fourths bred, thus making their descendants at least seven-eighth bred.

In Table XIV we have grouped together the cows according to their rank in milk and butter production, and according to their rank in the cost of milk and butter production, prefixing the name of each animal with the letter belonging to its breed. It will be seen that the Short Horn grades, particularly Sue, compared very favorably with the other breeds both in the amount and cost of production, but it is only fair to state that these two cows were the only two out of twenty of like breeding purchased at different times that it was thought advisable to keep in the herd for more than one year. It should also be stated in regard to them that they were farrow, and therefore undoubtedly continued to give a larger flow of milk for a longer time than though they had been due to drop calves again as the others did. As between the Jerseys and Holsteins it will be seen that they are pretty well sandwiched together as to relative rank. The Holsteins as a rule are better in the matter of the production of milk both as to amount and to cost, and the Jerseys stand better in regard to the production of fat both as to amount and cost; the order rank of the first ten being as follows:

TABLE XIV.— RELATIVE RANKS.

RANK.	Relative rank in amount of fat produced.	Relative rank in cost of fat.	Relative rank in amount of milk produced.	Relative rank in cost of milk.
1	S. Sue	S. Sue	H. Freddie ...	H. Pet.
2	H. Freddie ...	J. Beauty	S. Sue	S. Sue.
3	J. Beauty	J. Cora	H. Puss......	H. Puss.
4	S. Shadow....	H. Freddie ...	H. Pet.......	H. Freddie.
5	H. Pet.......	H. Pet.......	H. Belva.....	H. Belva.
6	J. Cora	S. Shadow....	H. Pearl	H. Pearl.
7	H. Belva.....	J. Gazelle....	S. Shadow....	J. Beauty.
8	H. Puss......	J. Jennie	J. Beauty....	H. Mollie.
9	H. Pearl	H. Belva.....	H. Ruby.....	H. Ruby.
10	J. Jennie.....	H. Puss......	H. Mollie	S. Shadow.
11	J. Gazelle	H. Pearl	H. Glista.....	J. Cora.
12	H. Ruby	H. Ruby.....	J. Cora	J. Gazelle.
13	H. Mollie	H. Mollie	H. Carrie	H. Glista.
14	J. Bertha	J. Bertha	J. Jennie.....	J. Jennie.
15	H. Glista	J. Gem Val...	J. Gazelle....	H. May.
16	H. Carrie	H. Glista.....	H. May	H. Carrie.
17	J. Gem Val ..	H. Carrie	H. Glista 2d..	H. Glista 2d.
18	H. May	H. May......	J. Bertha	J. Bertha.
19	H. Glista 2d..	J. Daisy	J. Gem Val...	J. Gem Val.
20	J. Daisy	H. Glista 2d..	J. Daisy	J. Daisy.

In cost of fat, a grade Short Horn first, then two Jerseys followed by two Holsteins, next the other grade Short Horn, followed by two Jerseys and then by two Holsteins.

In cost of milk, a grade Holstein first followed by a grade Short Horn, then four more grade Holsteins followed by a grade Jersey, then two grade Holsteins followed by the other grade Short Horn.

In Table XV the averages of the different groups and of the whole are shown. As between the Jerseys and Holsteins, the Jerseys were kept at a cost of about $6.00 per year or thirteen per cent less; they gave a little more than five-eighths as much milk and almost as much fat as the Holsteins; and produced the fat at a cost of two cents per pound less and the milk at twenty cents per hundred weight more than the Holsteins. The two grade Short Horns ate the most food, gave the most milk and fat, and produced milk and fat at the lowest cost, but for the reasons already shown they can not be considered as types of the common grade cows of the country; they simply illustrate the

TABLE XV.— AVERAGES BY BREED GROUPS FOR THE YEAR.

	Cost of food consumed.	Pounds of milk given.	Pounds of fat produced.	Cost of 100 pounds of milk.	Cost of one pound of fat.
Two grade Short Horns	$51.23	9,705	411.07	$0.53	$0.125
Seven grade Jerseys..	40.87	5,237	269.67	.78	.15
Eleven grade Holsteins	46.95	8,067	272.96	.58	.17
Average of all ...	$45.25	7,241	285.62	$0.625	$0.158

fact that has often already been noticed that among such cows are to be found here and there individuals that will respond to good care and improved feeding in a most remarkable way.

In order to give the reader some idea of the general appearance of the cows we have had plates prepared from photographs of four of the best. At figure one is shown Sue, a grade Short Horn; she produced the most fat and next to the largest amount of milk. At figure three is shown Freddie, a grade Holstein; she gave the largest amount of milk and the second largest amount of fat. At figure two is shown Puss, also a grade Holstein, third in milk production, and at figure four Beauty, a grade Jersey, third in fat production. It is rather a remarkable coincidence that Puss and Beauty, respectively, ranked eighth in fat and milk production. These figures illustrate very nicely the fact that the scale and the fat tester are immeasurably in advance of any outward indication of the producing powers of a cow. Particularly is this shown in the cases of Freddie and Puss. Visitors, and indeed the men about the stable, almost invariably esteem Puss a better cow than Freddie; but the scale and fat tester have shown us that while Puss is not far below in milk, she is a long distance below Freddie in fat. Attention is also called to figure one. The position seems to be an unnatural and distorted one, but it is extremely life-like. This cow invariably stood in this cramped sort of a position and gave very little outward indication of her good producing powers.

SUMMARY.

Our records of this herd for the year seem to us to warrant the following conclusions:

First. With a fairly good herd, carefully fed and kept, milk can be produced for sixty-five cents per hundred weight and fat for sixteen cents per pound for the cost of food consumed.

Second. That individuals of the same breed vary more widely in milk and butter production than do the breeds themselves.

Third. The larger animals consumed less pounds of dry matter per 1,000 pounds live weight per day than did the smaller animals.

Fourth. That in general the best yields of fat were obtained from cows that gave at least a fairly large flow of milk, particularly as seen in the cows Sue, Freddie and Beauty.

Fifth. In general, the cows consuming the most food produced both milk and fat at the lowest rate.

Sixth. For the production of milk and fat there is no food so cheap as good pasture grass.

Fertilizers.

A great number of letters of inquiry have been received at this office regarding the value and application of farm and commercial manures; as to their application for special purposes and also for some information regarding their profitable use on the various soils for the ordinary field crops. These letters not only show the interest the farmers of this State take in the questions of fertility and the appreciation of the importance of supplying plant food in some form but also a desire to become better informed as to the economical and profitable application of the plant food contained in the various farm manures or that purchased in the form of commercial fertilizers. An effort to explain some of the questions most frequently asked and to save the task of answering so many personal letters is the object of this short article.

Before we can make satisfactory comparisons of fertilizers, even though we have correct chemical analyses, it is necessary to adopt some uniform price for the various fertilizing constituents found in farm and commercial manures. The prices generally adopted for these purposes are those decided upon annually by experiment station chemists of certain New England and Middle States. The average prices that these ingredients were sold for at retail in our larger cities for the previous six months determine the prices adopted for the year. The following is a list of prices for 1892. These will not differ materially from the prices for 1893:

FERTILIZERS — TRADE VALUE FOR 1892.

Nitrogen in ammoniates	$ .175
Nitrogen in nitrates	.15
Organic nitrogen in dry and fine ground fish, meat and blood	.16
Organic nitrogen in cottonseed meal and castor pomace	.15
Organic nitrogen in fine ground bone and tankage	.15
Organic nitrogen in fine ground medium bone and tankage	.12
Organic nitrogen in medium bone and tankage	.095
Organic nitrogen in coarser bone and tankage	.075
Organic nitrogen in hair, horn, shavings and coarse fish scrape	.07
Phosphoric acid soluble in water	.075
Phosphoric acid soluble in ammonia citrate (reverted)	.07
Phosphoric acid in dry ground fish, fine bone and tankage	.07

Phosphoric acid in fine medium bone and tankage	$.055
Phosphoric acid in medium bone and tankage	.045
Phosphoric acid in coarser bone and tankage	.03
Phosphoric acid insoluble in complete fertilizers	.02
Potash as high grade sulphate and in forms free from muriates or chlorides	.055
Potash as kainit	.045
Potash as muriate	.045

Following is given the guaranteed analyses of a brand of fertilizer sold in this State to which the foregoing prices will be applied to ascertain the value of the plant food contained in this particular brand:

GUARANTEED ANALYSES.

Ammonia	1 to 2 per cent
Soluble phosphoric acid	8 to 10 per cent
Reverted phosphoric acid	2 to 3 per cent
Available phosphoric acid	10 to 12 per cent
Insoluble phosphoric acid	1 to 3 per cent
Total phosphoric acid	11 to 15 per cent
Sulphate of potash	2 to 4 per cent

Of these constituents, the nitrogen contained in the ammonia, the soluble, reverted and insoluble phosphoric acid, together with the potash, constitute the valuable plant food. As these constituents in analyses are given in per cent or by the hundred the number of pounds of each constituent in a ton may be ascertained by multiplying the per cent. by 20.

Ammonia is $\frac{14}{17}$ nitrogen.

Sulphate of potash is $\frac{47}{87}$ actual potash.

The following is an application of the prices given to the foregoing guaranteed analysis. The lowest per cent guaranteed is always taken for computation:

Ammonia 1 per cent. x 20 x 14 divided by 17 gives 16.47 lbs. of nitrogen in one ton; 16.47 multiplied by 16 cents gives	$2 64
Soluble phosphoric acid 8 per cent. x 20 x 7½ cents per lb. gives	12 00
Reverted phosphoric acid 2 per cent. x 20 x 7 cents per lb. gives	2 80
Insoluble phosphoric acid 1 per cent. x 20 x 2 cents per lb. gives	40
Sulphate of potash 2 per cent. x 20 x 47 divided by 87 and multiplied by 4½ cents per lb. gives	97
Total value per ton	$18 81

To this amount should be added something for freight, mixing and commissions.

The application of these prices is intended to afford a means for comparing the value of plant food derived from different sources rather than the producing value of any particular brand of commercial fertilizers.

In a general way the following rules may be of some aid in applying plant food under ordinary conditions:

Reclaimed lowland rich in vegetable matter is likely to be rich in nitrogen but deficient in phosphoric acid.

Well drained highland, particularly on exposed locations, is more likely to be deficient in nitrogen than phosphoric acid.

Where crops have made a small growth of leaf or stalk, under otherwise favorable conditions, nitrogen is likely to be deficient in the soil.

A large yield of plump, bright grain from a small or moderate growth of straw or stalks would indicate an abundance of phosphoric acid and potash and a deficient amount of nitrogen.

An abnormal growth of leaf or stalk with a small yield of light grain would indicate an abundance of nitrogen and an insufficient amount of phosphoric acid and potash.

As a rule, plants having the greatest leaf development require the most potash.

Farm manures that have been well cared for contain about twice as much nitrogen as phosphoric acid, and consequently land that has received recent liberal applications of barn manures is not likely to be deficient in nitrogen.

High grade fertilizers generally give more plant food for their cost than those of low grade.

Pure sodium nitrate (Chili saltpetre) in 100 lbs. contain 16.5 lbs. of nitrogen.

Pure ammonium sulphate in 100 lbs. contains 21.2 lbs. of nitrogen.

Pure chloride or muriate of potash in 100 lbs. contains 63.5 lbs. of actual potash.

Pure sulphate of potash in 100 lbs. contains 54 lbs. of actual potash.

Kainit should contain in 100 lbs. about 12.5 lbs. of potash.

The best results from sodium nitrate are secured by frequent applications of small amounts on the growing crop as a top dressing.

GEORGE C. WATSON.

Cornell University Agricultural Experiment Station.

BOTANICAL DIVISION.

BULLETIN 53—MAY, 1893.

ŒDEMA OF THE TOMATO.

By Geo. F. Atkinson.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

Bulletins of 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.— Variation in Individual Cows.
53. Œdema of the Tomato.

Œdema of the Tomato.

During the latter part of October, 1892, tomato plants, of a variety No. 18, grown in the forcing houses of the Horticultural Department, presented a very peculiar appearance. The plants were at some little distance from the main passage way in the tomato house through which I occasionally passed. For this reason, and also because no complaint was entered by the growers, the trouble escaped my notice. The plants presented to me the appearance of having been recently transplanted, many of the compound leaves having a curved pendent position, though the leaflets were usually curved strongly upward, showing the lighter color of the under surface. It was suggested at that time that this peculiar position of the leaf and curl of the leaflets was a peculiarity of the variety. Upon each of the several following visits to the forcing house, at intervals of four to six days, the peculiar appearance of these plants fastened my attention for a few minutes. Upon one visit I had occasion to pass the bench upon which they were growing, and I could not resist the impulse to look more closely at the character of the curled leaf.

It was at once apparent that this peculiar appearance was not normal to the plant. The veinlets as well as the midrib, petioles, and the surface of the stem presented numerous elevated areas of a frosty aspect as shown in figures 1 and 2, in Plate I. Their resemblance to the masses of conidia formed in the early stages of some of the *Erysipheæ* was very striking. Examined with a pocket lens a mass of minute rounded bodies could be seen which still bore resemblance to conidia of the powdery mildews. The rounded particles possessed a gleaming aspect and did not lie so loosely nor appear in chains as is the case with these mildews. A little further observation showed that great injury to the plant followed in the latter phases of the trouble.

It was quite natural before recourse to a microscopic examination to attribute the mildewed aspect of the leaves and the dying of the leaves in the later stages to the operation of some fungus. But a section through one of these areas revealed under the microscope a very different state of things. The affected areas had the appearance of a cushion similar to an erinoid or hypertrophied condition of the tissue. The epidermal cells were very much enlarged while the chlorophyll bearing cells just beneath as well as some of the more deeply seated cells were greatly elongated in a radial direction, and strongly clavate at their outer extremity where this extended beyond the lateral pressure from adjacent tissue. In many cases the epidermal cells quickly separate and slough off. The cells of the affected areas possess exceedingly delicate walls so that with little disturbance they would collapse. There was little protoplasm in proportion to the size of the cell and a corresponding amount of cell sap.

Several of the notable phenomena coincident with the development of these cushions of abnormally turgescent tissue are explained by this peculiar physical derangement of the normal cell structure. The frosted or whitened aspect of the cushions results from the small amount of chlorophyll in proportion to the leaf surface. The amount of chlorophyll in the individual cell remains the same while the grains are far separated in their distribution throughout the greatly enlarged cell. The curling upward of the leaves results from the greater lateral pressure which exists in the cells of the lower surface of the veins.

A comparison of the normal tissues with that of the cushions will serve to show the profound changes accompanying their development. From serial sections made through several of these cushions on the leaf veins two sections were selected from one series to illustrate the changes in this part of the leaf. Camera lucida drawings were made from these two sections magnified to the same scale. One of these represented in figure 4 was taken from the leaf vein just before the series of sections entered the cushion and practically represents the normal arrangement and form of the cells of the leaf vein. Figure 5 represents one of the serial sections of the same leaf vein, the section having been taken from the center of the cushion. Each end of the section at *a* represents relatively the normal condition of the cells of the leaf. The line of epidermal cells, *e*, *e*, is still adhering for some distance, but at the summit of the cushion they have fallen away. A comparison with the normal epidermal cells shows how much they have been enlarged. The sub epidermal cells have undergone the most profound change, being eight to ten times their normal size. Some of the deeper lying cells have also elong ted radially, while others have become abnormally enlarged. It will be observed that the distention of the cells has not only profoundly changed their normal form, but the crowding one upon another has displaced many others. A study of the series of sections from such a cushion, as well as the study of one in an early stage of development, shows that the epidermal cells nearly always first partake of the radial elongation. These are followed by the sub-epidermal layer and so on.

Serial sections through the cushions on the stem were also made. Three from a series through quite a young cushion on the stem are reproduced by camera lucida drawings in figures 9, 10 and 11.

Figure 9 represents a section taken from the edge of the cushion and shows the early stage in the elongation of a few epidermal cells. In this section is also shown a peculiarity in the early elongation of some of the more deeply seated cells. A few of the cells of the collenchyma have elongated radially before those lying immediately outside of them have changed their form. This rarely occurs, and by the time the sections approach the center of the cushion the successional changes of the layers of cells from the outside exists in the usual manner It is to be noted in connection with the elongation of the cells of the collenchyma, that while such thick-angled tissue offers support to the stem, little more resistance is offered to the radial elongation of the cells by this tissue than by parenchyma. The lateral walls being thin permit the cell membrane to be stretched. Figure 11 is one of the series from the center of this very young cushion. Figure 12 is from an older cushion on a much older part of the stem of the same variety. Here many of the epidermal cells have sloughed off and others are nearly free. The hypodermal layer, chlorophyll bearing layer, is remarkably elongated, while the first layer of the collenchyma is also changed. In the older cushions the radial elongation effects also deeper layers of the collenchyma, sometimes two or three layers. Usually by the time such changes occur to any marked degree in the deeper layers, the sub-epidermal portion of the cushion is in a state of collapse. This effect is partially shown in figures 13 and 15.

On the leaves of some plants there frequently is very little evidence to the unaided eye of the presence of these cushions. But here and there, upon close examination, can be seen very minute elevations. Magnified with a pocket lens they present the appearance shown in figure 6. They appear to be located entirely in the mesophyll of the leaf, or more properly speaking, at or near the terminations of some of the veinlets. This probably accounts for their small size. Being located in such delicate tissue they rapidly collapse and disappear from view.

Figures 7 and 8 represent sections selected from serial sections through one of these small mesophyll cushions. Figure 7 is taken from the edge and shows the remarkable enlargement of two of the epidermal cells. Near by can be seen the termination of a vascular bundle. Figure 8 is from the center of the same mesophyll cushion. Passing from each end of the section toward the center an idea can be formed of the progressive elongation of the different cell layers. The tissues at the summit of the cushion are in a state of collapse. This one is remarkable from the fact that the elongation has advanced from the epidermal layer of the under side of the leaf through the parenchyma until the palisade cells of the upper side of the leaf are concerned, and their elongation is in the same direction, *i. e.*, toward the lower side of the leaf. This results from the fact that the progressive elongaticn, beginning at the lower side of the leaf and advancing toward the upper, has relieved the pressure from adjacent cells on the lower side, and also that the primary enlargement of the cells of the under side caused the leaf, at this point, to arch downward, which in itself would make lower side of the cells the point of the least resistance. Figures 6, 7 and 8 are from plants sent by L. R. Jones, horticulturist of the Vermont station. Very rarely, I have noted in a few instances in the forcing-house, cushions are formed upon the upper side of the leaf.

The primary effects of this derangement of the tissue, farther than is pointed out above, relates to certain interferences with the life and nutrition of the plant which are manifestly attributable to it. When the cell walls have become so inordinately stretched that they suddenly collapse, as frequently happens, the changes brought about by the escape of water from this and adjacent tissues during the warmer part of the day may be so profound as to cause the leaf to wilt and die. In other cases the cushions when collapsed soon dry without great loss of water from adjacent tissues, but the injry is so deep it seriously disturbs the nutrition of that part of the leaf as shown by a yellowing of the upper surface at this point. Numerous points of attack on the venation of the lower surface of the leaf in such cases gives to the upper surface a spotted appearance, while the dried cushion immediately below presents a tomentose appearance. Although in such cases the entire leaf is usually curled upward, the points of injury are more strongly arched, which produces upon the upper surface of the leaf a depressed area within the yellow spots.

The secondary effects of the trouble relate to profound changes which sometimes follow, but which are not so manifestly attributable in all cases, at first examination, to this derangement of the tissues. Frequently, when the leaf does not wilt after the collapse of the cushion, the broken and dying tissues encourage the development of putrefactive germs which set up fermentations that affect adjoining tissues and the leaf is slowly disorganized. Discoloration of the tissue accompanies these morbid phenomena, and while they proceed also through the very succulent parenchymatous tissue of the petiole and down the stem, there appear elongated, depressed, blackened areas, which eventually reach the vascular tissue of the stem.

Frequently such morbid changes originate from cushions developed on the stem, and there is reason to believe that sometimes quite extenive areas of hypodermal tissue of the stem are stretched enormously and induce similar destructive metabolism when the epidermis has become too firm for its individual cells to participate in such change.

When the development of the cushions is confined mainly to the mesophyll areas of the leaf, or to the very small veinlets, or at their terminations, they rapidly collapse and the morbid changes succeeding in the mesophyll extend over areas of various sizes, which in the early stages are yellowish in color. In these secondary effects many of the very small young leaves are affected at the apex, frequently the entire apex being involved, and on the somewhat larger leaves it may be confined chiefly to the base of the leaf, or the severity of the attack is located there. The progress of this yellow color indicates failing nutrition which is augmented by the interference produced from the diseased areas in the stem. It terminates in the death of the tissues involved, which then change to a dirty grayish brown color. The veinlets involved become much darker in color, being nearly black, so that viewed through a pocket lens the greyish brown patches show frequently cross lines of black or borders of the same color.

Inquiry into the governing cause. Having observed the external aspect and progress of development of these cushions, as well as their minute anatomy and relation to the well being of the plant, the inquiry into their cause presents itself. The existence of any fungus of ordinary dimensions standing in causal relation was easily disposed of. Their superficial resemblance to the erineum developed on the leaves of various species of birch, maple, alder, etc., through the stimulus induced by irritation from phytoptid mites, suggested a similar symbiont upon the tomato plant. But careful examination proved this suspicion to be groundless.

By this process of elimination of suspected causes, the inquiry was gradually removed from the region of the possible symbiosis of some one of the more prominent and easily recognizable microscopic forms to that of a possible relation of some form of bacteria which, by its presence within or upon the affected organs, excited them to this abnormal development.

Two lines of investigation were carried out, having in view the discovery of the causal germ. One of these proceeded upon the more customary, but less scientific, lines of inquiry usually adopted in the study of the bacteria of plant diseases, viz.: The inoculation with diseased material; the other proceeded upon the more rational line of inquiry chiefly adopted in the study of the bacteria of animal diseases, viz.: The separation of the germs present and inoculations with pure cultures to determine the specific germ.

Inoculation of healthy plants with diseased material. Experiment No. 1, December 3, 1892. Macerated tissue from freshly developed cushions was gently rubbed between the thumb and finger upon the leaves and stem of a healthy plant. Portions of the affected plant were also left pendent upon the healthy one. *No result*.

Experiment No. 2, December 3, 1892. Macerated tissue from a plant in the later stages of disorganization was gently rubbed between the thumb and finger upon the leaves and stem of a healthy plant. A portion also of the diseased plant was left pendent upon the healthy one. *No result.*

Experiment No. 3, December 3, 1892. Twenty very young plants freshly potted, just developing the plumule, were treated as follows: There were four rows, five plants in each row. To one plant in each row was applied some of the macerated tissue from freshly developed cushions. Likewise to one plant in each row was applied some of the macerated tissue from a plant in the later stage of the disease. *No result.*

Experiment No. 4, December 3, 1892. In a potted plant were made several slit wounds with a scalpel, parallel with the axis of the stem and petiole. Into these were introduced thin longitudinal slices of tissue from freshly developed cushions. The wounds were then wrapped with fresh tomato leaves and tied loosely to prevent too great evaporation from the wound. The plant was thoroughly sprayed with water also. *No result.*

Experiment No. 5, December 3, 1892. In like manner a potted plant was inoculated with longitudinal slices from a stem in the later stages of the disease. *No result.*

Separation of bacteria from affected plants. By the use of sterilized instruments and with precautions against contamination from the outside, portions of the interior of freshly developed cushions were transferred to nutrient agar which contained an infusion of tomato plant. *No growth appeared.*

Portions of the cushions including the external parts were then macerated in sterilized distilled water, and the dilution was farther diluted in the usual way in three tubes of liquid nutrient agar containing tomato plant infusion. Esmarch rolls and cultures in Petrie dishes were made of these, and several different bacteria were isolated.

In like manner leaves of plants in the later stages of the disease were macerated and carried through dilutions to isolate bacteria. Also tissue from the internal parts of petioles and stems in the later stages of the disease were used for dilution cultures. From several such dilution cultures there were obtained fifteen different species of bacteria which were grown in pure cultures and used for inoculations. Of these there were three species of *Bacillus*, three of *Micrococcus* and the remainder probably species of *Bacterium*. One *Micrococcus* and four species of *Bacterium* were chromogenous forms. The chromogenous forms and one species of *Bacillus* (*B. figurans*) were not considered suspicious, but it was very little additional trouble to carry on cultures of these.

When the organisms were isolated they were grown in quantity in a liquid culture consisting of equal parts of bouillon and tomato plant infusion.

Experiment No. 6, December 19, 1892. Inoculations were made with liquid cultures of the bacteria as follows: The liquid containing the cultures was gently rubbed between the thumb and finger upon the surface of the stem and leaves. Also with a needle abrasions were made of the surface tissue of petioles and stems introducing in this manner into the superficial tissues some of the organisms. *No result.*

The entire series of inoculations was made in such a way that several duplicate inoculations were made of all the germs present which could possibly bear any relation to the trouble. The negative results point to the possibility that there is some disturbance of the equilibrium of the natural forces and physiological processes in the plant. This suspicion is strengthened by the fact that the cushion is not formed by ordinary hypertrophy which is accompanied by increase of nutriment at that point, and multiplication of cells. Ordinarily, there is no increase in the number of the cells. When this does occur it takes place in the deeply seated cells which do not suffer collapse while the more superficial ones break down. The increase in the number of cells in such cases occurs simply by the formation of transverse walls in the elongated cells.

Is the trouble a physiological one? The abnormal stretching of groups of cells to eight to ten times their normal size would then be sought for in the excessive activity of one or more of the physiological processes which contribute to tugescence and in the lesser activity of of those processes which relieve it.

The most important of these seems to be the excess of root pressure over transpiration. It will be instructive to consider the conditions of environment which have united to disturb the desirable stability of equilibrium of these two forces in the plant.

The close confinement of the plants in the forcing house where there is little agitation of the air, must necessarily lessen the rapidity and amount of transpiration compared with what would take place in the open. The water vapor freed through transpiration from plants grown in the open under such natural conditions is quickly carried away by currents of air* which are to a greater or less extent in almost constant action. This permits then a more active transpiration than could take place should the water vapor remain undisturbed near the foliar organs. Even should the water vapor escape from the neighborhood of the transpiring surfaces only through the law of diffusion plants in the open would be at a greater advantage than those grown in the confined quarters of the forcing house. That transpiration is obstructed by the humidity of the atmosphere has been abundantly shown.†

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* Sachs Physiology, p. 554.

Höhnel, Ueber den Geng d. Wassergehaltes und Transpiration bei Entwicklung d. Blattes, 1878. Cited by Pfeffer, p. 144.

Wiesner, Grundversuche ueber den Einfluss per Luftbewegung auf die Transpiration. Bot. Centralb, viii, pp. 382–383.

Wind according to Wiesner in most cases accelerates transpiration. In some cases (*Saxifraga sarmentosa*) it closes the stomates and therefore retards transpiration. See same title in P. A. Wein, Abth, i, Bd. xcvi, pp. 182–214. Cited in Just's Bot. Jahrbücher, 1888, I, pp. 83–84.

† Unger, Sitzungsbericht d. Wiener Akademie, Bd. xliv, 2, 1861.

Sachs, Handbuch der Experimental-Physiologie, 1865. Sitzungsb. d. Wien, Akad. Bd. xxvi.

Déherain, Comptes Rendus, T, lxix.

Masure, Untersuchungen über die Verdunstung des freien Wassers, des im Ackerbodenenthalten Wasser, und über die transpiration der Pflanzen, Ann. Agronomiques, T, vi, fasc, iii, pp. 441–500.

Reinitzer, Ueber die physiologische Bedeutung der Transpiration der Pflanzen. Sitzungsberichte der K. K. Acad. d, Wissenschaft, 1881, I, Abth.

LeClerc, De la transpiration dans les végétaux, Ann. d. Sc. Nat. T, xvi, 1883, pp. 231–279.

Tschaplowitz, Giebt es ein Transpiration-Optimum? Beitrag zur Theoric der Vegetationsconstanten Bot. Zeit. Jahrg, 41, No. 22, S. 353–362.

Kohl, Die Transpiration der Pflanzen, etc., Braunschweig, 1886.

Eberdt, Die Transpiration d, Pflanzen und ihre Abhangigkeit von äusseren Bedingungen, Marburg, 1889.

Goodale, Physiological Botany.

Transpiration is less active during the night than in the day, not only because of the lower temperature of the air, but especially because of the absence of light.* During the winter season when plants are grown in the forcing houses the nights are much longer than the days and the total amount of transpiration in 24 hours, other things being equal, would be less than what wonld take place in the open during the summer months when the days are much longer than the nights. Add to this the marked number of cloudy days during the winter, with a low sun offering at best but a feeble light, and the conditions for transpiration are still more unfavorable.

Still another factor must be considered which deprives the plants of much light, the structure of the forcing house itself. The light is not so intense when it passes through glass, though the amount of light thus cut off may be very little. However, the frame work, walls and partitions do cut off an appreciable amount of light.

These considerations, showing a lessened amount of transpiration compared with what takes place under natural conditions when the plants are grown out doors, would place root pressure in excess of transpiration should the conditions for root pressure under both circumstances be the same.

With the comparatively small amount of light carbon assimilation is lessened, so that the plant under the forced conditions of growth, when it needs larger quantities of carbohydrates has to do with really a less quantity than is supplied in the open where conditions for rapid growth are not so favorable and those for assimilation are improved.

Soil temperature compared with that of the air. Some observations made upon the temperature of the soil and air in the tomato house indicate that the soil is maintained at a temperature only a few degrees below that of the air. A sufficient number of observations have not been made to show what bearing the difference in temperature between

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*Sach's Physiology.

Goodale, Physiological Botany.

Unger, Seitzungsb, Wien, Akad, Bd. xliv, 2, 1861.

Déherain, Compt. Rend. Paris. T. lxix.

Masure, Ann. Aronomique, T. vi, fasc, pp. 441–500.

Reinitzer, Sitzungsb, d. K. K. Acad. Wiss., 1881, I.

Leclerc, Ann. Sci. Nat. Bot. T. xvi, 1883, pp. 231–279.

Kohl, Die Transpiration der Pflanzen, Braunschweig, 1886.

Eberdt, Die Transp. d. Pfl. u. ihre Abhäng. v. aus Bed. Marburg, 1889.

Burgenstein, Material zu einer Monographie der Transpiration, Verhandlungen d. K. K. Zool Bot. Gesellsch, Zu Wein Vol. 37, 1887, pp. 691–782, and Vol. 39, 1889.

the two media has upon the relation of root pressure to transpiration. At the lower benches (those at the side of the house where the glass is quite close to the beds) the soil, from a few observations, possessed a temperature of 2° to 5° Fahr. lower than the air, while in the center of

TABLE OF COMPARATIVE SOIL AND AIR TEMPERATURES (FAHRENHEIT).

	Inches.	7 A. M.	1 P. M.	7 P. M.	Mean.
May, 1891	Air	47.04	61.75	53.30	54.04
	1 Soil	46.54	54.03	52.93	51.17
	3 Soil	54.31	53.73	52.87	53.63
	6 Soil	47.49	49.27	51.24	49.33
	9 Soil	47.83	48.22	49.36	48.80
	12 Soil	47.64	47.63	47.90	47.72
	24 Soil	45.00	45.14	45.20	45.10
	36 Soil	43.78	43.49	43.50	43.59
	Mean of soil	45.47	46.40	46.45	46.10
June, 1891	Air	58.28	72.42	65.38	65.36
	1 Soil	59.18	65.42	64.53	63.04
	3 Soil	59.10	64.80	64.21	62.70
	6 Soil	59.43	60.40	61.73	60.52
	9 Soil	59.23	58.96	59.67	59.28
	12 Soil	58.79	58.37	58.60	58.58
	24 Soil	54.00	54.12	54.11	54.07
	36 Soil	51.25	51.35	51.37	51.32
	Mean of soil	54.80	55.68	55.74	55.40
July, 1891	Air	64.08	76.05	68.81	69.65
	1 Soil	62.70	68.59	67.44	66.24
	3 Soil	62.78	67.56	67.10	65.81
	6 Soil	63.08	64.23	65.18	64.16
	9 Soil	63.17	63.18	62.85	63.07
	12 Soil	62.39	62.14	62.44	62.32
	24 Soil	58.16	58.25	58.26	58.22
	36 Soil	55.75	55.82	55.82	55.79
	Mean of soil	58.91	59.73	59.69	59.44

the house where there was an opportunity for the warm air to rise toward the ridge, the difference in soil and air temperature was greater, being more marked the higher the elevation at which the temperature was taken in the air.

In the absence of careful data covering a period of several weeks there could not be made any satisfactory comparison with the difference between soil and air temperature out doors during the growing months. However, it will be interesting to note such differences in this connection. For this reason there is appended here a table of soil and air temperatures adapted from data published by President Fernald of the Maine Agr. Exp. Station.*

The difference in the mean temperature of the soil (from 1–36 inches) and air for May, June and July is thus seen to be approximately 10° Fahr. Comparing the temperature of the soil from 1–12 inches, it is found to be from 5°–6° Fahr. below the mean temperature of the air. It is doubtful, however, if these temperatures taken only at the stated times of day, really give the information desired in relation to the bearing of soil and air temperatures on root pressure and transpiration. For through the day when the temperature is the highest that of the air is still higher and with the aid of light and agitation of the air transpiration is sufficient to relieve the plant. The early period of the night is the time when out doors the conditions for root pressure as indicated by temperature would be more favorable than they would for transpiration. But terrestrial radiation soon lowers the temperature of the soil so that the plants exist under this disadvantage a comparatively short time.

Here again it is necessary to bear in mind the very short nights during which transpiration is low in comparison with the long days when it is very active. The light conditions are reversed in the forcing house and frequently the light is very feeble with little agitation of the air while there is a continued maintenance of soil temperatures suitable for active root absorption. Thus while it can not be asserted positively that the temperatures of the forcing house are such as to add to the complex disturbance of the physiological processes, there are indications that such is the case.

Since turgescence is mainly dependent upon root absorption for the supply of water and a turgid condition of the plant soon follows strong root pressure unless transpiration is taking place rapidly, it has become customary to say that root pressure causes turgidity. Of course it is understood that this is not the immediate cause. Water cannot be pressed into a cell and cause turgescence. The cell wall is permeable and as rapidly as water could be driven in at one side it

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*Annual Report, Part IV., Maine State College Agr. Exp. Station, pp. 155–174.

would filter out at the other. The protoplasmic utricle* which lines the cell wall is not permeable, or at least only to a small degree. The water, then, which passes into the cell through the protoplasmic utricle, cannot filter out, and when it does not escape by evaporation or exosmose from the surface, it stretches the protoplasmic utricle, presses it against the elastic cell wall which then yields and the cell is turgid. The extent to which the cell wall is stretched depends upon the endosmatic activity which introduces water into the cell, the rate of transpiration and the firmness of the cell wall. The endosmatic activity within the cell is brought about by the presence of certain salts or organic acids in the cell sap, which have a strong affinity for water.†

By root absorption the plant is supplied with water, the permeable cell wall permitting it to flow from the vascular bundles into the fundamental and other tissues, where it comes in contact with the protoplasmic membrane lining the cell wall. When root absorption is active and transpiration is inactive or at a low ebb, the affinity which the vegetable acids possess for the water draws it within the cells. Root absorption practically being in operation continuously under the conditions of the forcing house, the transpiration being in operation for such a large part of the time, the cell walls are unduly stretched. This continues until a point is reached where normal tissue tension of the leaf or the cortical parenthyma of the stem is no longer held in longitudinal tension. The cell wall thus continuing to stretch yields at the point of least resistance which is at the surface of the congested tissue and the radial elongation of the cells is the result.

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*Mohl. Bot. Zeitung, 1846, p. 75.

Nægeli, Pflanzenphysiologische Untersuch, Heft I, 1855, p. I.

Pfeffer, Osmotische Untersuchungen. Leipsig 1877.

Sachs' Physiology.

Goodale, Physiological Botany.

†De Vries, Ueber die Ausdehnung wachsender Pflanzenzellen durch ihren Turgor, Vorlaufige Mittheilung; Bot. Zeit. 1877, S., 1–10.

Untersuchungen über die mechanischen Ursachen der Zellstreckung von der Einwirk von Salzlösungen auf den Turgor wachsenden Pflanzenzellen, Leipsig, 1877. See Justs Bot. Jahresb. 1877, I, p. 65–67.

Ueber die Beduetung der Pflanzensäuren für den Turgor der Zellen. Bot. Zeit. 1879, p. 847.

Palladin, Hthmung und Wachsthum, Berichte d. Deutsch. Bot. Gessellschaft, 1886, pp. 322–328.

Bildung der organischer Säuren in den Wachsenden Pflanzentheilen, Ber. d. Deuts. Bot. Gesellschaft, 1887, p. 325.

The organic acids increase most rapidly at a temperature ranging from 50 degrees to 57 degrees Fahr.* As the temperature rises above this point they are gradually decomposed. Darkness or weak light also favors their increase, and De Vries† has shown that a periodicity of increase or decrease of these acids exists corresponding to night and day. In fact anything which interferes with oxidation serves to permit their increase, while those conditions which promote oxidation serve to decrease them.‡ According to Warburg it is not the direct action of light which decomposes these organic acids, but the oxygen set free during carbon assimilation.‖

Another effect of the feeble light and its short duration is the proportionately small quantity of carbohydrates produced. Except in the case of some shade plants where direct solar light may be too intense for normal assimilation, other things being equal the activity of carbon assimilation increases nearly in proportion to intensity of solar light,¶ or as the plants exist under more favorable conditions of light.

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*De Vries, Ueber den Antheil der Pflanzensäuren an die Turgorkraft wachsender Organe. Bot. Zeit. 1883, S., 850.

Warburg, Untersuchungen aus d. Bot. Inst. 2. Tübingen, Vol. 2, Heft. I, 1886, p. 71.

†De Vries, Ueber die periodische Säurebildung der Fettplanzen, Vorlauifge Mittheilung, Bot. Zeit., 1884.

Ueber die Periodicität im Säuregehalt der Fettpflanzen, Verslagen en Mededeelingen der Koninkl. Akad. van Wetenschapen, Afd. Naturkunde, R. P. Amsterdam, 1884.

‡Ward. On some relations between Host and Parasite. Proceedings Royal Society, Vol. 47.

‖ Warburg, Untersuchungen, etc,, pp. 77–92.

¶ Wolkoff. Einige Untersuchugen über die Wirkungen des Lichtes von verschiedener Intensität auf die Ausscheidung der Gase durch Wasserpflanzen. Pringsheim's Jahrbücher, Bd, 5, S. 1–30.

Van Tieghem, Respiration des plantes submergées à la lumière d. une bougii, lieu de formation des gaz. Comptes Rendus, herbd. 1869, p. 482.

Famintzin, Die Wirkung des Intensitat des Lichtes auf pie Kohlensäurerzersetzung durch Pflanzen, Bulletin de l'Acad. d. St. Petersburg, Vol. 26, 1880, column 296–314.

Pringsheim, Zur Kritik der bisherigen Grundlagen der Assimilationstheorie der Pflanzen, Monatsberichte der Berliner Academie, vom Feb., 1881, S. 15 und 16, cited by Reinke, Bot. Zeitung, 1883, No. 42, 43 and 44.

Ward, Proceedings Royal Society, Vol. 47.

Sachs' Physiology.

Pfeffer Pflanzenphysiologie.

Detmer Lehrbuch der Pflanzenphysiologie.

Wollney shows that the water content* is less and the quantity of carbohydrates greater the better the plants are lighted.

One reason why shade plants when exposed to the direct light of the sun may be injured is because the form and structure of the leaves developed in the shade is different from that of plants in sunny places as shown by Stahl.† Grosglick ‡ has proved experimentally that such difference is a natural adaptation to environment.

Obstructed transpiration in conjunction with strong root pressure produces much the same condition of tissues as is found in etiolated plants. Ward says,‖ "we may look on a shoot growing in a saturated atmosphere as presenting all the chief features of one growing in darkness. Its cells are extremely turgid, with watery, soft, thin walls,¶ and acid cell-sap; its vascular bundles freely developed and hardly lignified; and as before it is ill adapted to withstand the exigences of the ordinary environment."

Thus obstructed transpiration in the forcing houses through feebleness and short duration of light, and an atmosphere more humid than the average in the open during the summer months favors watery tissue, thin cell walls which are easily stretched and rapid growth in size. The weakness of the cell walls is increased through lack of sufficient building material, a result of the low degree of assimilation.

During certain processes of destructive metabolism, brought about by respiration, nitrogenous compounds like asparagin, leucin, etc., are built up. When an abundance of carbohydrates are present in the protoplasm the amides are worked up into more complex bodies.

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* Wollney, Beiträge zur Frage des Einfluss des Lichtes auf die Stoff — und Form-buildung der Pflzen. Forsch. Agr. Bd. vii, 1884, pp. 351–375, cited in Just's Bot. Johresbericht, 1884, i, pp. 30–31.

† Ueber den Einfluss sonnigen oder Schattigen Standfortes auf die Ausbildung der Laubblattes, Zeitchrift für Naturw. xvi, n. f. ix, 1, 2. Cited in Bot. Zeitung, 1883, s 330, and Just's Bot Jahresbericht, 1883, ii, pp. 425–426.

‡ Bot. Centralb, 1884, No. 51, pp. 374–378. Just's Bot. Jahresb. 1884, i, p. 28.

‖ On some Relations between Host and Parasite. Proceedings Royal Society, Vol. 47, pp. 393–443.

See also Vesque et Viet. Influence du Milieu sur les végétaux, Ann. de Sci. Nat. 6th Series, Bot. Vol. 12, 1881, p. 167.

¶ Similar results have been obtained by students in Physiological Botany at Cornell University. Bean plants grown with lessened degrees of diffused light show corresponding grades of approach to etiolated plants and also corresponding degrees of frail, succulent tissue.

When there is a lack of carbohydrates the amides increase and the protoplasm suffers from farther decomposition.*

The simultaneous increase of the organic acids tends to overcome the tension of the protoplasm which should hold them in bounds, and they gradually diffuse through it. This may continue until the protoplasm is killed by the increase and diffusion of these substances.

This study of the environment of the plants under these conditions of forced culture and the operation of the natural forces and physiological processes leads irresistibly to the conclusion that this affection of the tomato plants in a physiological one.

Confirmed by Experiment. In order to test the effect of the injection of excessive amounts of water into the plant the following experiment was carried out.

On Monday, December 5th, cuttings, including eight to twelve inches of the top of four tomato plants, were connected with the hydrant as follows: A cork, bored to receive glass tubing sufficient to give four delivery tubes, was inserted in a rubber hose and connected with the hydrant. The cork was then covered with resin and beeswax to prevent leakage. Small rubber tubing was then used to connect the delivery tubes with the tomato cuttings which were supported by being tied to stakes. In turning on the water it was found that the union at the cork was not water tight and it was necessary to leave the experiment until the morning of the 6th.

By this time the cuttings were badly wilted so that they drooped, and the edges of the leaves on one plant were dry. More of the resin and beeswax was brushed over the cork, melted paraffine was run over this and finally it was wrapped with a strip of cloth saturated with melted paraffine which made the union practically water tight. It was also found necessary to wire the rubber tubing to the end of the cuttings to prevent them from being thrown out by the force of the water pressure.

In turning on the water the pressure was so great it was necessary to wrap the larger rubber tube to prevent its bursting. In a few hours, the plants, though they had drooped and wilted so badly, were turgid and upright, only a few leaves of one plant which had dried at the edges not fully opening. On the 7th and 8th, during the middle of the

* Schulze, Landwirtschaftliche, Jahrbücher, 1876, Bd. 5, p. 848,

Bonordin, Bot. Zeitung, 1878, p. 801, cited by Ward, Proceed. Royal Soc., Vol. 47, pp. 343–443.

Palladin, Ueber Eiweisszersetzung in der Pflanzen, Ber. d. Deustchen Bot. Gesellsch, 1888, p. 205.

Pfeffer, Pflanzenphysiologie, p. 301.

day, transpiration being greater, the leaves were somewhat flabby though later in the day and during the night they were turgid.* By the 8th two large cushions of turgescent tissue had formed on one of the cuttings of the No. 18 variety, one on the stem about 2½ *cm* long and extending about one-fourth the distance around the stem; the other one on the under side of a petiole about 3 *cm* long. At noon on the 8th the experiment was changed by placing a glass cage over the plants to lessen transpiration. The plants and the inside of the cage soon became so wet that water streamed slowly down. The cage remained on until the 10th. During this time the plants remained so wet no observations could be made on the development of the cushions.

During the preceding night the tissue of the No. 18 variety, being much more tender than the others, collapsed where the rubber tube was wired to the stem and permitted water to spurt through the delivery tube over the other plants. The cage was then removed at 8:45 A. M., and two plants were replaced with fresh ones, those being removed were the No. 18 variety and the plant the leaves of which had partially dried at the time the experiment was set up. Both of the fresh plants introduced were of the Lorillard variety. At the time of the mid-day observations on the 10th it was noted that the two other plants which had been connected four days, two days of the time under the moist cage, were drooped. They were left for another day with the hope that lessened transpiration during the night might revive them. On both of these plants, which were of the Lorillard variety, quite extended cushions were developed on the stem. On one plant were two cushions each about 3 *cm* long, on the other was one cushion 2½ *cm* long. The elevated, shining mass of cells could readily be seen so soon as they had dried after removal of the cage. December 11th these two plants were still drooped, probably not having revived during the night. They must have been near dissolution, for some of the leaves easily fell away from the stem. While there probably had been sufficient pressure on during the past 24 hours, the faucet was but a little way open and much iron rust had formed and clogged the vascular ducts at the point of union with the delivery tubes so that one of the fresh plants introduced the previous day had drooped. The three drooping plants were then replaced with fresh ones, one cutting being of the No. 18 variety and possessing quite a firm stem at the base. The water was turned on full pressure.† It

*It was latter found that iron rust accumulated slowly in the larger rubber tubes and partially clogged the vascular ducts, which accounted for the flabby condition during the middle of the day.

†The pressure of the water was about 20 to 30 lbs.

was so great that within five minutes the fresh plants had been injected and water stood out in great drops at the ends of the veinlets on the edges of the leaves. This same phenomenon was observed in all the plants when freshly connected with the delivery tubes.

The exudation of drops from the edges of leaves through artificial injection of the plants has been observed by other experimenters, the water being forced into the cut end of the stem by the weight of a column of mercury.* Sachs also has produced the same effects in plants, by simply warming their roots, thus increasing root pressure.†

Some of the lower leaves had been cut from each of the last three plants connected with the tubes and from the cut surfaces a steady stream of water flowed slowly down the stem.

December 12th at 12:15 P. M., three of the plants were turgid while one was a little drooped. The epidermis of the stem and petioles of this one presented numerous longitudinal slits which perhaps offered opportunity for freer evaporation, and during mid-day when the air was comparatively dry and warm it became limp, while toward evening (4:30 P. M.) it became turgid. In one of the turgid plants several of the leaves presented quite extensive areas where the intercellular spaces were injected so that these portions of the leaf exhibited a water-soaked appearance, and drops of water stood out upon the lower surface of such areas. In all of the plants a small amount was expelled from the axils of some of the leaves, collecting in drops which flowed away at intervals.

One of the delivery tubes broke during the night of December 12th, and on the morning of the 13th the water pressure was turned off. The tube was repaired at 9 A. M. The temperature was quite low in the house during the night of the 12th, owing to an accident in the boiler room. Probably for this reason, coupled with the fact that the plants were partly covered, little transpiration took place and the plants were quite turgid. On December 14th there were no points of interest to note.

During the night of December 14th one of the delivery tubes broke again and at the time on the morning of the 15th the pressure being off, the plants had drooped. It was not deemed necessary to carry the

* Moll, J. W. Ueber Tropfenausscheidung bei Blättern. Bot. Zeit., 1880, p. 49. Moll, J. W. Untersuchungen über Tropfenaus-scheidung und Injection bei Blättern, verslagen en Mededeelingen d. k. Acad. van Wetenschappen, 2, R, xv. Deel. Amsterdam, 1880. See Just's Bot. Jahrb., 1880. i, p. 239. See also Bot. Zeitung, 1880, p. 49.

† Sach's Physiology, p, 278.

experiment farther, but in order to photograph the experiment fresh plants were introduced and the photograph was taken ten minutes after the pressure had been turned on. The photograph is reproduced in Plate I, to show the plan of the experiment and also the numerous drops which exuded from the leaves of the injected plants, and which can be seen running down on some of the stems.

The experience had during the trial has suggested that, should it ever be repeated, it would be well to place a filter in the large rubber hose in order to remove all particles of sediment, since considerable interference arises from the clogging of the vascular ducts of the cuttings.

It demonstrates, however, the relation which excessive root pressure* bears to the development of the cushions. Their appearance on the stem of the No. 18 variety through the agency of artificial pressure may not seem so convincing perhaps, since this variety was very susceptible to the trouble, and it was quite difficult to obtain a cutting for the experiment which was free from it.

Their appearance on the stems of the Lorillard variety, the stems of which are much more resistant to the trouble, is quiet convincing that the lack of a proper equilibrium between root and pressure and transpiration is an important factor in the cause.

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*It matters little for the present discussion of excessive turgidity whether "root-pressure" or the laws governing the lifting of water in the stems of plants is the real cause of the elevation of the water in the tomato plants beyond the point of the root absorption. It is well known that root pressure cannot lift water to the height attained by some plants and that the transpiration current is not the only factor concerned, for it goes on sometimes independently of transpiration. See the following literature:

Jamin Comptes Rendus, 1860, 1, pp. 172, 311, 385.

Unger, Sitzungsb. d. Akad. d. Wiss. z. Wien. lvii, 1, 1868.

Sachs, Vorlesungen über Pflanzen physiologie. Ueber die Porosität des Holze, cited by Ward. Timer and some of its diseases, 1889.

Boehm. De la cause du movement de l'eau Ann. d. Sci, Nat. 6th ser., T, xii, 1881.

Elfving, Ueber die, Wasserleitung im Holz. Bot. Zeit. 1882, Oct.

Hartig, Ueber die Vertheilung der organischen Substanz, des Wassers und Luftraumes in den Bäumen. Unters. a. d. Forst. Bot. Inst. München, 1882. Ueber die Ursache der Wasserbewegung in Transpirirenden Pflanzen, Ibid, 1883.

Dufour; Ueber den Transpirationsstrom in Holz-pflanzen, Aarb.d, Bot. Inst. Würzburg, 1883.

Hartig, Die Gasdrucktheorie und die Sachs' che Imbibitionstheorie, Berlin 1883. Cited by Ward, l. c.

To be certain that the anatomical characters of the cushions developed artificially comported with those developed under the prevailing conditions in the forcing house, portions of the stems of the No. 18 and Lorillard varieties used in the experiment, on which the cushions appeared, were hardened, sectioned and prepared for study by the same method used in the preparation of the former material. The plants having been kept under the moist cage so long, their surfaces were very wet and the superficial portions of the cushions were broken down.

Plate VII represents four sections from the preparations. The two upper figures, 13 and 14, are from the stem of the No. 18 variety, while the two lower figures, 15 and 16, are from the stem of a Lorrillard. Each one of the figures includes the same depth structurally of the stem, the portion represented including the epidermis, layer of chlorophyll bearing cells, the collenchyma and cortical parenchyma. In each of the varieties the left hand figure in the Plate shows the anatomical structure of the cushion, while the right hand figure shows that of the opposite side of the stem where the tissue possesses its normal form, the drawing both of the left and right hand figures being made from the same section. In both varieties the epidermis, the layer of chlorophyll bearing cells, and two layers of the cells of the collenchyma participate in the radial elongation. The remainder of the

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Zimmerman, Zur kritik per Böhm-Hartigschen Theorie der Wasserbewegung in der Pflanze, Ber. d. Deutsch, Bot. Gessellsch, Bd. i, p. 183. Ueber die Jamin'ische Kette, Ibid. p. 384.

Westermaier, Zur Kenntniss der osmotischen Leistungen des lebenden Parenchym's. Ber. d, Deut. Bot. Gessellsch. Bd. i, 1883, p. 371.

Elfving, Ueber den Transpirationsstrom in den Pflanzen, Acta Societatis Scientiarum Fenuicæ, T, xiv, 1884, cited by Ward, 1. c.

Scheit, Die Wasserbewegung im Holze, Bot. Zeit, 1884, p. 177.

Godlewski, Zur Theorie der Wasserbewegung in den Pflanzen, Pringsheims Jahrb für wissensch. Bot. Bd. xv. Heft 4, 1884, p. 569.

Kohl, Zur Wasserleitungsfrage, Bot. Zeit, 1885, p. 522.

Errera, Eun Transpiration Versuch. Ber. d. Deut. Bot. Gessellsch., 1886, p. 16.

Zimmerman, Zur Godlewskischen Theorie der Wasserbewegung in der Pflanzen Ber. d. Deut. Gessellsch, 1885, p, 290.

Hensen, Ein Beitrag zur Kenntniss des Transpirationsttromes, Arb. d. Bot. Inst. Würzburg, 1885, p. 305.

Scheit, Die Wasserbewegung im Holze. Jenaische Zeitschrift für Naturk, 1885. Cited by Ward, l. c.

Schwendener, Untersuchungen über das Saftsteigen, Sitzungsb. d.k. preuss. Akad. Wies, 1886. See Ward.

collenchyma and the cortical parenchyma shows a very turgid condition as compared with the same tissue on the opposite side of the stem as shown in the right hand figure. The structural features of these artificially induced cushions do not differ from those induced under the operation of the natural forces, and we are justified in concluding that this experiment forms additional cumulative evidence that the phenomenon is a result of the unequal operation of the physiological processes concerned in plant growth.

Cultural Experiment. In view of the large quantities of water absorbed by the roots in excess of the actual transpiration, a cultural experiment was suggested to be governed by such conditions as might be quite easily obtained in the soil of the bed where the plants grew which were most seriously affected. For this experiment twelve potted plants of the Lorillard variety were selected, because that variety seemed to be more resistant than the No. 18.

December 7th, they were placed on boards which rested on the soil of the bed at the south side of the tomato house where the plants of variety of No. 18 were growing. They were allowed to remain in this condition for two days without any water, when the soil was quite dry and the leaves were limp. They were then divided into four lots of three each.

Those of lot No. 1 were removed from the pots and transplanted in the soil bed near affected plants at the east end of the bed, the soil having been stirred previously and allowed to become partially dry.

Those of lot No. 2 were allowed to remain in the pots on the boards.

Those of lot No. 3 were removed from the pots and transplanted in the soil of the bed by the side of affected plants at some distance from those of lot No. 1.

Those of lot No. 4 were transplanted to soil by the side of the walk where were other affected plants.

Lots 1 and 2 were now given from day to day only sufficient water to keep them growing slowly, but not enough so that at any time the plants could become very turgid.

Lots 3 and 4 were supplied with sufficient water to keep the soil nearly saturated, enough so that the roots could absorb all the water possible at their highest activity, but not so much as to interfere with that activity. The plants of lots 3 and 4 were therefore kept very turgid by the large amount of water absorbed in comparison with that given off at the leaves, and in a few days the cushions of radially

NOTE.—I wish to acknowledge here the generous assistance in carrying on these experiments rendered by Professor Bailey and Messrs. Corbett and Lodeman of the Horticultural Department.

elongated cells began appearing on the under side of the leaf veins and mid-rib as well as on the under side of the petioles. In a few days more the curling of the leaves was perceptible, and in about ten days the leaves of nearly all the plants of these two lots were badly affected.

Those of lots 1 and 2 represented only a very few of the cushions on the leaf veins, and if the experiment had not been disturbed probably none would have appeared. During the period of about two weeks these plants were watered quite heavily twice by an attendant who had not been apprised of the nature of the experiment. Notwithstanding this, the difference in the plants resulting in the different degrees of irrigation was remarkable. The result of this experiment seems to be conclusive concerning the physiological nature of the disease.

Relation of tissue strength to the disease. An analysis of the laws of plant growth in connection with a study of the tissue strength and firmness of the tomato plants grown in the forcing house, as well as their environment, shows that the operation of the same forces which have produced this trouble has also produced a structural condition of the plant which renders it in the highest degree susceptible. One of the most striking things about the plants of the No. 18 variety is their rank growth and the succulent condition of the stems, petioles, veinlets and mesophyll of the leaves. They are remarkable for their frail and bulky nature. The young stems and petioles of a size up to 1 *cm* in diameter crush between the thumb and finger with very little pressure. In this variety the stems, petioles and veinlets are very subject to the disease. In the Lorillard variety the stems have been very little affected, the trouble occurring chiefly on the veinlets of the leaf. A comparison of the tissue strength of these two varieties gives the key to their different tendencies in this respect. A stem or petiole of the Lorillard variety of the same stage of growth is in very strong contrast with those of the No. 18. Grasped between the thumb and finger there is a sense of great resistance to pressure, and when crushed the tissue appears fibrous and little watery compared with the soft, pulpy tissue of the No. 18.

A microscopic examination of young stems of the same stage of growth of these two varieties, presents the conditions upon which this difference in firmness of tissue depends. Plate VIII, figures 17 and 18, are from camera-lucida drawings of sections of stems from a No. 18 and Lorillard plant of the same stage of growth. In the Lorillard plant considerable woody tissue has already made its appearance as is shown in figure 18. The bast cells near the cortical parenchyma have also acquired their characteristic features. In the No. 18 plant, figure 17, at the same stage of growth there are as yet no cells presenting the characteristics of woody or bast cells. The presence of the woody cells themselves probably does not exert any influence in checking the tendency on the part of the cells of the fundamental tissue to stretch under the influence of turgescence. But it indicates a slower rate of tissue growth and firmer and, therefore, more resistant cell walls in the fundamental tissue.

There is, perhaps, some inherited disposition on the part of different varieties to this trouble. The history of the No. 18 strengthens this view. The original plant was remarkable for its rank growth, abundant foliage and wide reach of limb, so that it was trained to lateral supports similar to some methods of grape training.

But there are also individual variations in the firmness or succulent pulpy nature of the stems, dependent upon varying conditions of growth and environment. This is a matter of common observation in all plants. The individual variations in the succulency or firmness of the tissues of the tomato plant render them more or less susceptible to the trouble.

Relation of growth to the development of the cushions. The relation of the actively growing parts of the plant to these œdematous portions also lends support to the view that they are the result of excessive turgescence. Turgescence is one of the first conditions of growth, and other things being equal, rapidity of growth and the proportions of the growing shoot bear a close relationship to the degree of turgescence. The greater the degree of turgescence the larger will be the cells and the thinner their walls. Where the growing shoot or leaf meets with no obstruction to growth, the multiplication of cells and their enlargement and disposition into the various tissue elements accommodates all the water which by root pressure is distributed to them. The rate of growth is sufficient to relieve the great pressure though transpiration may be below the normal rate. Transpiration takes place more rapidly in young leaves* and shoots, but I do not think the difference in the susceptibility of very young and somewhat older tissues bears any very great relation to their different capacities for transpiration as will be shown below.

In the plants which have been most susceptible to the trouble, it has been very noticeable that the growing shoot for four to six inches was entirely free from the cushions, while below this rapidly growing region the turgescence effected the abnormal stretching of groups of cells. The rate of growth at this point having declined, the excessive

* Sachs' Physiology of plants.

turgescence could no longer be relieved. In making a section of a stem at this point before the radial elongation of the superficial layers of cells began, it would be possible to tell on which side of the stem, or at what points on the circumference, the cushion would be developed. All of the cells in such succulent, rapidly developed stems are proportionately large and thin walled. But the force of the excessive turgescence has produced unequal results in the size of the cells at various points in the cortical parenchyma and the adjacent collenchyma and epidermis, so that the section shows much larger cells with consequently thinner walls at one or more points outside the cambium ring.

Not only do these cells contain more water but their cell walls are less resistant. It is at these points the radial elongation of the cells takes place, as can be seen by a comparison of numerous sections of affected stems.

In farther confirmation of this fact, that active growth relieves the tension and prevents the trouble temporarily, is the following observation made on the plants of the No. 18 variety which grew on the south bench at a point where the glass was about four feet above the soil. Before the growing ends of the plants reached the glass, the terminal portion, of five or six inches, was entirely free and the plants were in all respects similar to those of the same variety grown elsewhere, though perhaps not quite so rank and succulent. When the tops reached the glass their cramped condition, the greater humidity and other contingent circumstances prevented growth or reduced it to a minimum. Turgescence, however, continued, and in a few days nearly the entire surface of the terminal portion of the plants showed the development of these cushions. The trouble extended to the very end at the base of the leaf bud, and the very young and intermediate leaves were also affected, while plants of the same variety in other parts of the house, where there was still freedom for growth of the shoots and leaves, were no different from their former condition.

Similar developments in other plants. Reference has been made to probably a similar outgrowth produced on potato stems by placing rapidly growing potted potato plants under a bell jar.*

Sorauer† also describes a similar disease on *Ribes aureum*. In this

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*Ward, on some relations between host and parasite, etc. Proceed. Roy. Soc., Vol. 47 1890-1891, p. 393-443.

†Wassersucht bei Ribes aureum, Freihoffs' Deutsche Gärtnerzeitung, Aug., 1880. See Just's Bot. Jahresb, 1880. 11 Abth. p. 656-657.

Sorauer, Pflanzenkrankheiten, Zweite Auflage, Bd. I, p. 235-238.

Göschke, Die Wassersucht der Ribes, Monatsschrift d. Verein z. Beförd d. Gartenbaues in den kgl. Preuss. Staaten, Octoberheft, 1880, s 451. See Just's Bot. Jahresb, 1880, II Abth., p. 657.

case, the outer tissues being quite firm, the radial elongation frequently takes place in the deeper lying thin walled cells. In the preparation of the plants for forcing the lateral shoots are cut off. In the spring, when placed under conditions of forced culture in the plant houses there being few buds where growth can take place and thus relieve the stem of the great amount of water absorbed by the roots, localised centers display abnormal turgescence through the radial stretching of the cell walls.

In 1879 experiments were conducted under the direction of Sorauer, in the forcing houses at Pankow, near Berlin, with well rooted stems placed under conditions favoring forced growth. The results were quite positive, excellent examples of the trouble being thus produced.

He cites similar developments in the stems of young plum plants in water culture where the base of the stem was set too deep in the water. Also plants of *Phaseolus vulgaris* were subject to the trouble, when cultivated in wet sand if the seedling was too deep in the soil.

Masters,* at a meeting of the Royal Horticultural Society in 1878, showed leaves of potatoes, the under surface of which was marked with warts similar to those which occur on vine leaves when grown in too close and moist an atmosphere. The conditions under which the potatoes were grown were such as to produce the growths in question.

In 1889, vine leaves were exhibited at a meeting of the same society, which possessed similar warts on the under surface. The vines were grown under glass. Ward, to whom the matter was submitted, said it was due to poor ventilation of the house whereby the humid atmosphere favored abnormal turgescence which resulted in these outgrowths.†

Quabius ‡ reports the trouble on pears grown out doors, which is the same as that in *Ribes aureum*.

Conclusion. Root pressure varies greatly in different plants. It would be interesting to know if there was any variation existing in the root pressure of different varieties of tomato plants grown under the same conditions, and if there was any correlation between the unit of pressure and the susceptibility of the variety to the œdema; or, if root pressure is constant in the different varieties, does any variation exist in the power of the stem to lift the water which the roots absorb?

The study thus far made and presented in this report is in the nature of a contribution toward a solution of the at present obscure and

* Gardener's Chronicle, 1878, I, p. 802.

† Gardener's Chronicle, 1889, I, p. 503.

‡ Wassersucht bei Birnen. Jahresb. d. Schles. Centralverein's für Gärtner und Gartenfreunde zu Breslau, 1881. See Just's Bot. Jahresb, 1872, ii, p. 704.

unequal operation of the natural forces which are associated in the etiology of this most interesting phenomenon in abnormal plant development. To fully carry out this would lead the present writer too far afield at this time upon an inquiry into the operation of the laws of plant growth under artificial conditions of environment. The subject is none the less one of great importance both from a scientific and economic standpoint, and deserves serious consideration. A student of cryptogamic botany, and especially one who devotes any serious attention to the relation existing between mycology and plant pathology cannot escape an inquiry into the pathological changes induced by the action of a symbiotic organism,* or whether the symbiont merely takes advantage of a low vitality or degenerate tissues introduced through unfavorable surrounding conditions, or the unequal operation of physiological laws. So much has been demanded of the writer by the present case and until the investigation had been carried to the extent presented here, it could not be said whether or not any symbiont stood in causal relation to the trouble.

To properly conduct the inquiry farther would necessitate a broad treatment of the manifold related forces. Compartments should be arranged so that the temperature of the soil and air could be controlled independently. Several such compartments should be arranged to maintain the soil at a given temperature and vary the air temperature. Several others with a given air temperature and varying soil temperature; variations also in the humidity of the air and moisture of the soil, the latter as has been shown can be treated to control the trouble. Studies with different kinds of soils would undoubtedly yield interesting and important results, for clay soil as is well known is more retentive of moisture and would less readily yield its moisture to the roots. Means for the artificial agitation and interchange of the air should be provided. The inquiry should embrace studies of nutrition and assimilation. The effect of artificial light should be studied in connection with the trouble. Although some of the earlier experiments, with the use of artificial light cast doubt † upon the question of carbon assimilation under such conditions it has

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* Symbiont here is used in the broadest sense of that term, which means a common life for a greater or less period between two organisms.

† DeCandolle, Memoires des savans étrangers de l'Institut des Sciences, T. 1, 1806, p. 333.

Physiologie végétale, 1832, T. 1, p. 131.

Biot. Froriep's Notizen, xiii, 10, 1840.

Hervé Mangon, Production de la matière verte des feuilles sous l' influence de la lumière electrique. Compt. Rend, herb. d. Sci. Paris, 1861, T. liii, p. 243.

recently been abundantly shown that carbon assimilation takes place * and in such amounts as in some cases to be a profitable use of such means of lighting.

Finally, the question of the origination of varieties, especially suited to forcing-house culture should be taken up, keeping in view the desirability of the proportionate and harmonious evolution of correlated structures and functions.

GEO. F. ATKINSON.

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* Famintzin, Die Wirkung des Kerasin — Lamp lichtes auf *Spirogyra orthospora* Næg, Bulletin d. l' Acad. Imp. d, Sc d. St. Petersbourg, T. 10, column 4-14, 1865, also, T. 12, col. 97-108.

Prillieux, de l' influence de lumière artificielle sur la reduction de l' acide carbonique par les plantes. Compt. Rend, d, Sci. Paris, 1869, 2d Sem., pp. 408-412.

Heinrich, Versuchs-Stationen, 1871, xiii, p. 153.

Famintzin, Die Zerlegung der Kohlensäure durch Pflanzen bei künsthichen Beleuchtung. Bull. d. l' Acad. d. sci. d. St. Petersbourg, T. 20, pp. 136-142, 1880.

Die Wirkung der Intensität des Lichtes auf die Kohlensäurererzetzung durch Pflanzen Ibid pp. 296-314.

Déherain et Maquenne, Sur la décomposition d l' acide carbonique par les feuilles éclairies par lumière artificielles. Ann. Agronomiques, T, v, 1880, pp. 401-416.

Famintzin, La décomposition de l' acide carbonique par les plantes exposées á la lumière artificielles. Ann. d. Sci. Nat. Bot., 1880, T. 10, pp. 62-66.

Siemens, On the influence of electric light on vegetation and on certain principles involved. Proceed. Roy. Soc. 1880, vol. 30, pp. 210-219. Some farther observations on the influence of electric light on vegetation. Same vol., pp. 293-295. Recent applications of the dynamo — electric current to .... Horticulture, etc. Editorial in Nature. Vol. xxii, 1880, p. 135.

Ricasoli-Firidolfi, L'. Orticulturs elletrica, Bull. della R. Soc. Tosc. d' Orticult. V. 8, Firenge, 1880. Cited in Just's Bot. Jahresb, 1880, 1, p. 315.

Siemens, Ueber den Einfluss des Elektrischen Lichtes auf die Pflanzen, Forschungen auf dem Gebiete der Agriculturphysik Bd, 5, S. 486. See Just's Bot. Jahresb., 1882, i, p. 43.

Wittrock, Om elektriska ljusets inflytande pä vaxterna, Svenska Trädgards füreningens Tidskrift, 1882. Refers to Siemen's researches upon continuous electric lighting and compares the results with the long known facts concerning the effect of continuous sunshine in the arctic region which hastens development, and produces beautiful and pure colors in flowers, and promotes the formation of fruits rich in aroma, and hardy seeds. See Just's Bot. Jahresb. 1873, p. 564.

Bronold, Ueber Elektrische Pflanzenculturversuche Zeitschrift d. landw. Vereins in Bayern, 1884, Jahrg. 74, Heft. i, p. 16-18. See Just's Bot. Jahreb. 1884, i. p. 6.

Bailey, Some preliminary studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants, Bulletin 30. Cornell University Agr. Exp. Station, Aug. 1891.

DESCRIPTION OF PLATES.

Plate I. Photographs showing œdematous cushions on stem and leaves of tomato.

Plate II. Photograph showing detail of connection of tomato cuttings with the hydrant, and drops of water hanging from edges of leaves which were forced through the veins by the water pressure.

Plate III. Anatomical structure of œdematous cushion on leaf vein. Figure 4, healthy part of vein; figure 5, from center of cushion.

Plate IV. Anatomical structure of œdematous cushion in mesophyll of leaf, near termination of leaf vein. Figure 6, appearance of small cushion magnified with pocket lens. Figure 7, section through edge of small mesophyll cushion. Figure 8, section through center of partially collapsed mesophyll cushion. Plate IV was made from specimens sent by L. R. Jones, of Burlington, Vermont.

Plate V. Structure of young œdematous cushion in young stem of No. 18 variety, showing also detail of tissue. In this and all the plates which follow, *med.* = portion of parenchyma from the pith of medulla; *w* = woody cells; *ca* = cambium zone; *b* = bast; *c p.* = cortical parenchyma; *col* = collenchyma; *ch* = chlorophyll layer of cells; *ep* = epidermis

Plate VI. Figure 11, from center of young œdematous cushion in young stem of No. 18 variety, taken from same series as figures 9 and 10 of Plate V. Figure 12, from center of older cushion on older part of stem of No. 18 variety.

Plate VII. Comparative study of œdamatous cushions produced artificially, with the normal tissue on opposite side of stem. Figures 13 and 14, from No. 18 variety; figures 15 and 16, from Lorillard variety.

Plate VIII. Comparative study of tissue firmness of No. 18 variety (figure 17) with Lorillard variety (figure 18) at same stage of growth.

SUMMARY FOR PRACTICAL PURPOSES.

The œdema of the tomato is a swelling of certain parts of the plant brought about by an excess of water which stretches the cell walls, making them very thin and the cells very large. The excess of water may be so great that the cell walls break down, and that part of the plant dying, exerts an injurious influence in adjacent parts.

The excess of water in the tissues is favored by the following conditions :

1. *Insufficient light.* The long nights of the early winter months, numerous cloudy days, and in part, the walls and framing of the forcing house, deprive the plants of needed light. By a process known as *transpiration*, plants are relieved of much water when well lighted, but in poor light, since the roots are absorbing water, it is apt to accumulate to excess. Well lighted parts of the house then should be selected for the tomatoes.

2. *Too much water in the soil.* Water in excess can be withheld from the soil and prevent the trouble, and yet provide enough for the plants to grow.

3. *The temperature of the soil may be too near that of the air.* A high temperature of the soil makes the roots active, and if the temperature of the air is not considerably higher an excess of water is apt to accumulate in the plant. The aim would be then to have the temperature of the air considerably higher than that of the roots.

Lack of proper light also brings about the following harmful conditions:

1. *Acids in the plant accumulate in the dark and in strong light they decrease.* When there is an abundance of water in the plant these acids draw large quantities into the cells, causing the cells to swell, resulting many times in œdema, or in the killing of the protoplasm so that these parts of the plant die and become brown or black.

2. *Lack of light causes weak cell walls.* It is only when well lighted that plants are capable of making substances to build up cell walls with. Therefore, lack of light not only favors the accumulation of water, if other things are favorable, but it prevents the plants from building up strong tissues. In such cases plants can *grow themselves to death.* Possibly artificial light might be used to advantage.

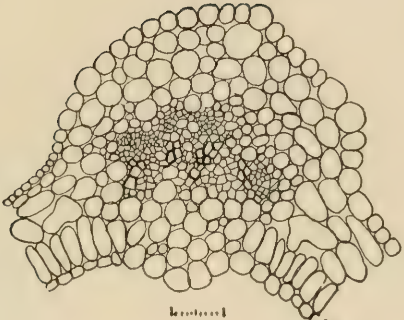
A quiet and close atmosphere also favors the accumulation of water in the plant. Good ventilation should then be secured. Some means for the artificial agitation or exchange of the air at night might probably be profitably devised.

Varieties of tomatoes more subject to the œdema. Those with a tendency to a very rapid and succulent growth are more liable to the trouble. Tomatoes which develop a firm woody young stem are less liable to it.

GEO. F. ATKINSON.

PLATE I.— Œdema of the Tomato.

PLATE II.— Photograph of Experiment for Injection of Cuttings with Water.



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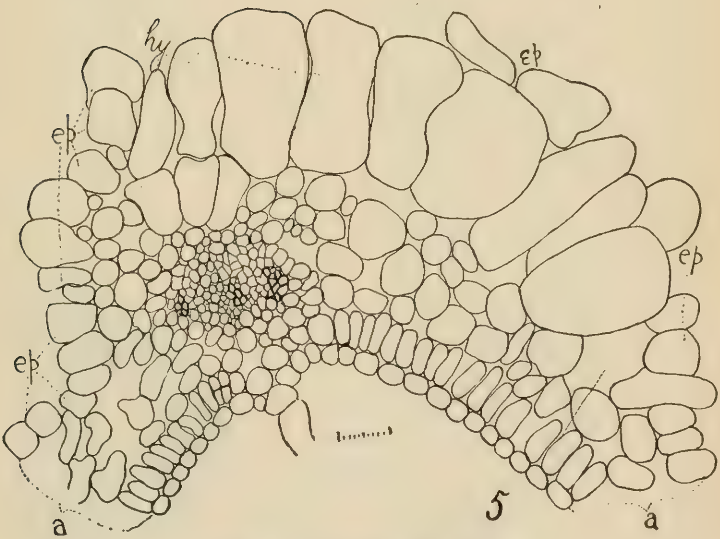

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PLATE III.— Œdema of the Tomato.

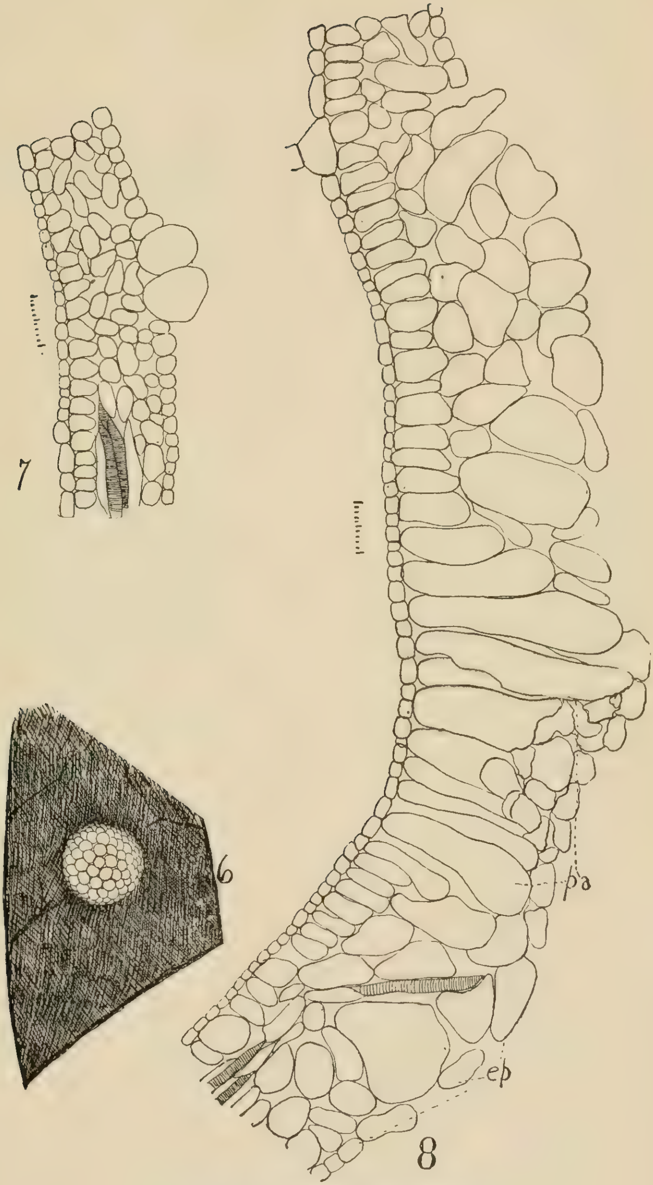


PLATE IV.—Œdema of the Tomato.

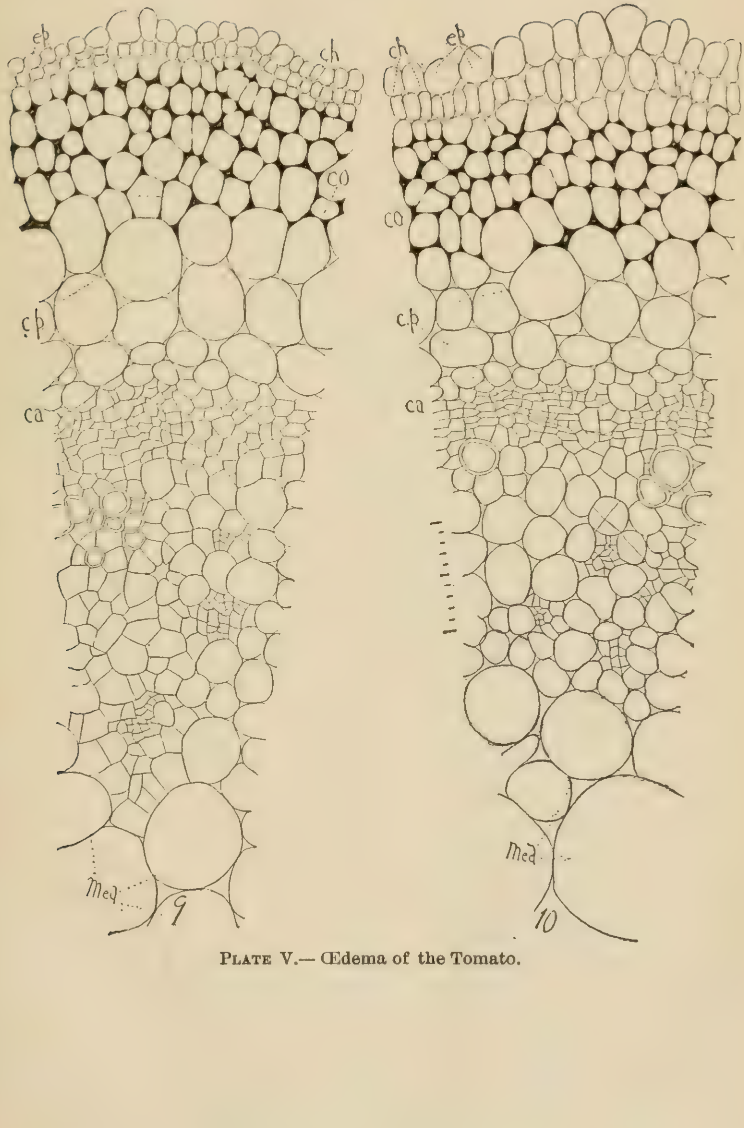


PLATE V.— Œdema of the Tomato.

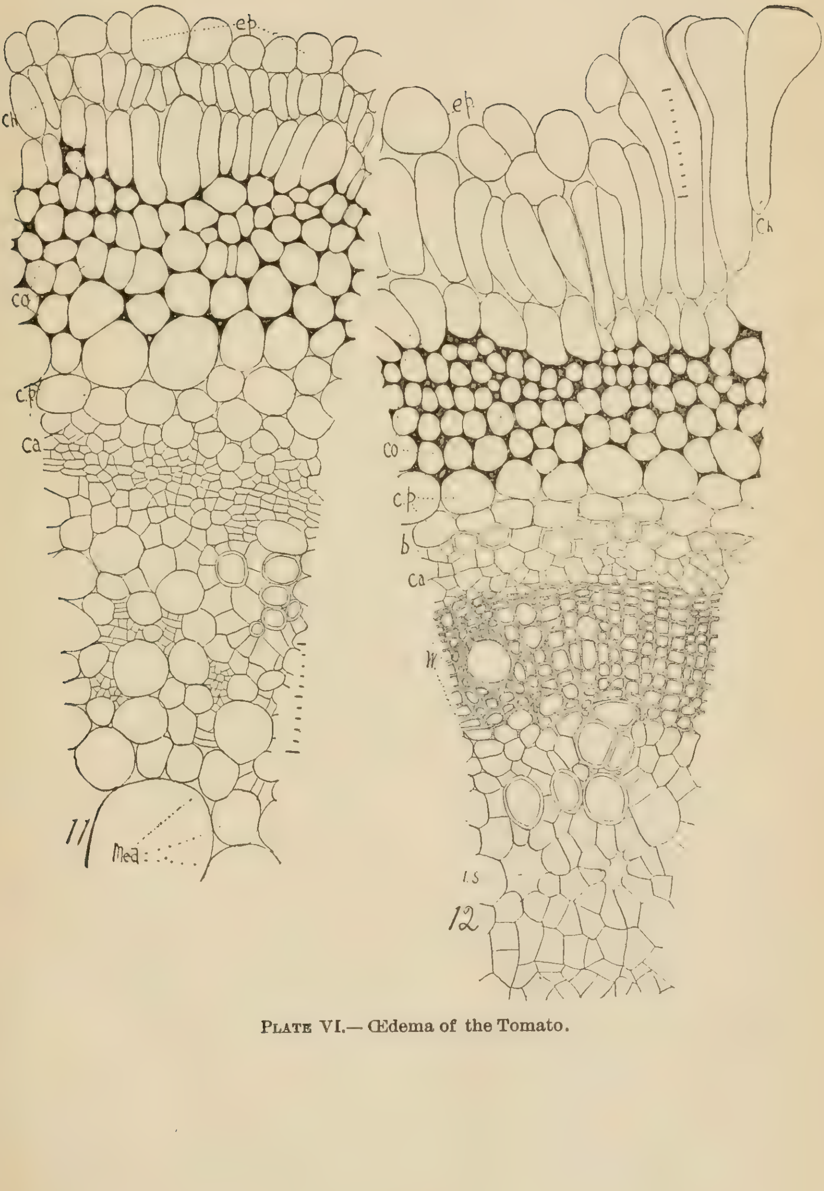


PLATE VI.— Œdema of the Tomato.

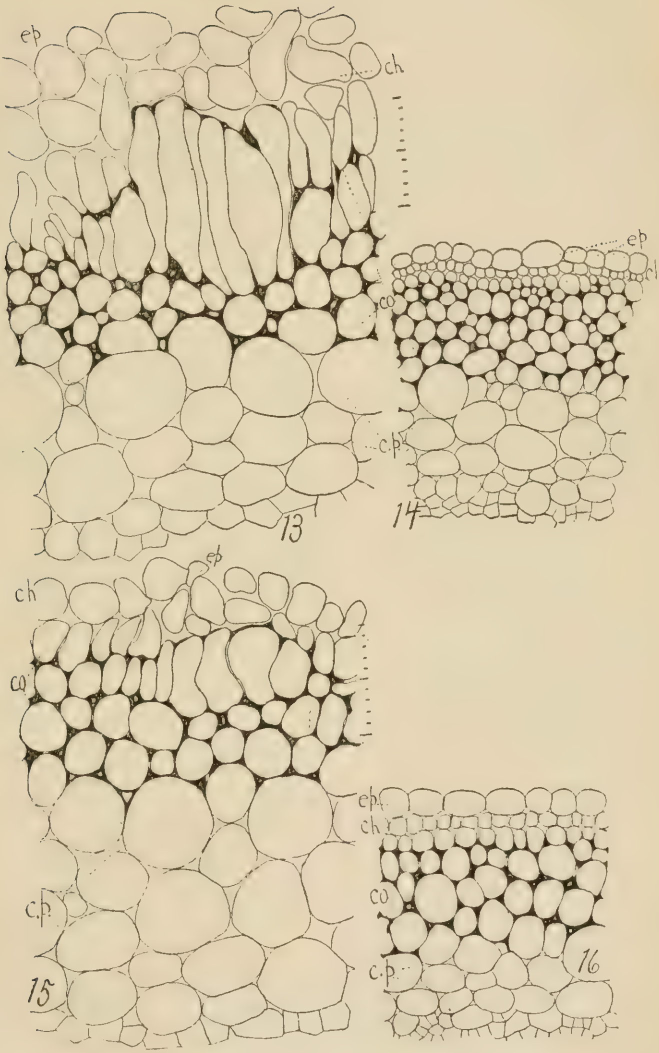
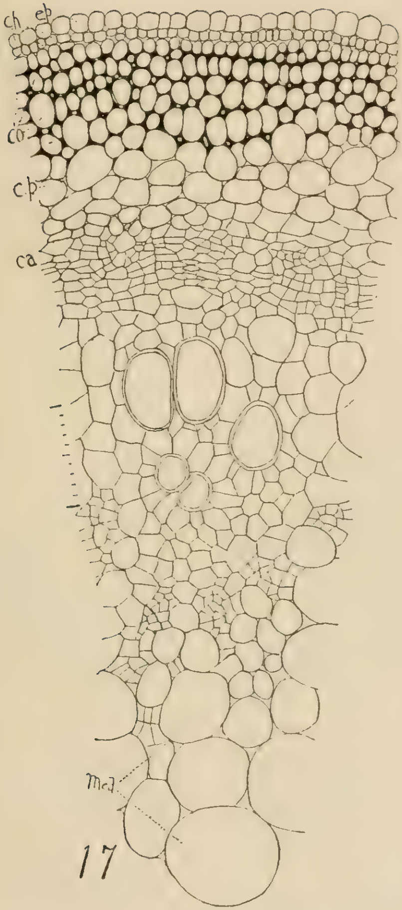


PLATE VII.— Œdema of the Tomato.



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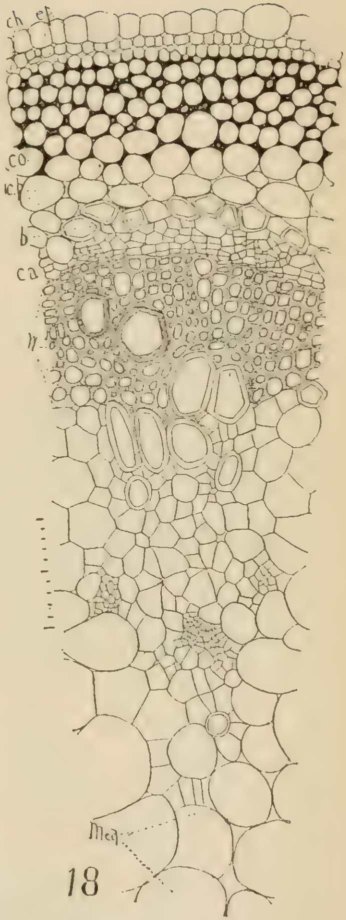

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PLATE VIII.— Œdema of the Tomato.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

BULLETIN 54—JUNE, 1893.

DEHORNING.

By I. P. Roberts.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.— Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.

THE LEGALITY OF DEHORNING.

The practice of removing the horns from cattle was first publicly advocated by H. H. Haff of Illinois about 1885 or 1886, and since that time has come to be extensively practiced in all parts of the country. It has been found to be of great practical utility in rendering animals more docile and quiet, in rendering them much less capable of injuring each other or mankind, and in reducing the space necessary for safe housing and shipping. The operation though somewhat severe, has been found to be a very safe one, usually leading to little or no functional derangement and not followed by severe pain or profuse hemorrhage. Nevertheless it has seemed to many that to deprive an animal of its horns was to practice upon it an unwarrantable cruelty, and numerous prosecutions, therefore, have taken place under the law for the prevention of cruelty to animals. Several such prosecutions have recently taken place in this State and as numerous inquiries in relation to the general subject have been received at this station, it has seemed well to give a brief summary of the present status of the matter.

The New York law, covering case of cruelty to animals, is found in Sections 655 and 699 of the Penal Code, and is as follows:

The New York Law Concerning Cruelty to Animals.

Sec. 665. *Overdriving Animal; Failing to Provide Proper Sustenance.*— A person who overdrives, overloads, tortures or cruelly beats or unjustifiably injures, maims, mutilates or kills any animal, whether wild or tame, and whether belonging to himself or another, or deprives any animal of necessary sustenance, food or drink, or neglects or refuses to furnish it such sustenance or drink, or causes, procures or permits any animal to be overdriven, overloaded, tortured, cruelly beaten or unjustifiably injured, maimed, mutilated or killed, or to be deprived of necessary food or drink, or who willfully sets on foot, instigates, engages in, or in any way furthers any act of cruelty to any animal, or any act tending to produce such cruelty, is guilty of a misdemeanor.

SEC. 669. DEFINITIONS. 1. The word "animal," as used in this title, does not include the human race, but includes every other living creature.

2. The words "torture" or "cruelty" includes every act, omission, or neglect, whereby unjustifiable physical pain, suffering or death is caused or permitted.

RECENT CASES UNDER THE LAW.

On April 13, 1893, upon complaint of an agent of the American Society for the Prevention of Cruelty to Animals, Mr. O. H. Smith, of Ellicottville, N. Y., president of the Farmers' Association of Cattaraugus county, was arrested charged with cruelty to animals in having dehorned his herd of cows in the autumn of 1891. Mr. Smith was taken before a Justice of the Peace, Mr. John Ward, of Ellicottville, and gave bonds to appear for trial on April 26th, but before the trial was joined, upon the affidavit of Mr. Smith's counsel, Hon Wm. G. Laidlaw, County Judge Vreeland granted an order removing the case from the Justice's Court and carrying it to the Grand Jury of the county. On May 16th, the matter came up before the Grand Jury. A number of witnesses, on behalf of both Mr. Smith and the Society for the Prevention of Cruelty to Animals were examined, but the Grand Jury failed to find sufficient evidence of cruelty and refused to indict Mr. Smith.

A second case is that of Mr. J. N. Middaugh of Friendship, Allegany Co.; his case was entirely similar to that of Mr. Smith's, except that he had dehorned a much larger number of cattle. The history of the case is about as follows:

J. N. Middaugh is a veterinary surgeon, residing at Friendship, Allegany Co., N. Y. During the past winter he dehorned over two thousand head of cattle with entire success in different parts of the county. About April 29th he was arrested on a warrant sworn out by an agent for the American Society for the Prevention of Cruelty to Animals, and taken before Justice Torrey of Wellsville. On motion of Middaugh's attorneys, Church & Church, the case was removed from trial before the Justice, and Judge Norton made an order to refer the matter to the Grand Jury and the bail of the accused was fixed at $200. On May 23, the complainant appeared before the Grand Jury with two veterinary surgeons from Philadelphia. Each testified as to the anatomy of the horn and of the probable degree of pain caused the animal by the operation of dehorning. Each also testified that he had never seen the operation performed or had observed its effect upon animals, or observed the action of animals particularly before and after the operation. The Grand Jury, prompted by a desire to go to the bottom of the matter, subpœnaed about thirty of the representative farmers of the county who were large cattle breeders and who had observed extensively the effect of dehorning upon their own and other cattle. Without exception these witnesses testified that they believed dehorning to be highly beneficial and in the interest of humanity. Several of the Grand Jurors had themselves had experience with dehorning, and these, including the foreman, were excused from all consideration of the matter and excluded from the jury room during the entire examination, that no claim could be made but that the case was fairly considered. After all the testimony had been put in, the ballot was taken and not a single vote was given for the indictment.

It will thus be seen that the Grand Juries of two counties of the State, after full and careful testimony, have decided, by refusing indictments, that the removing of the horns from an animal does not constitute "cruelty" under the statute.

PROSECUTIONS IN OTHER STATES.

As has already been said, H. H. Haaf of Illinois, was one of the first to publicly advocate and largely practice dehorning. He was likewise one of the first to be prosecuted therefor. On complaint of the Illinois Humane Society, Haaf was arrested for practicing cruelty to animals in having removed the horns from a certain heifer. He was tried before Justice Steele at Geneseo, Ill., on January 22, 1886. A large number of witnesses were examined on both sides and a verdict of acquittal was rendered Mr. Haaf.

At least two prosecutions have taken place in Pennsylvania, one in 1886, in which the Pennsylvania Society for the Prevention of Cruelty to Animals prosecuted a farmer named Hirst. The case was submitted to a jury, who dismissed the action but imposed one-half the costs on the defendant and one-half on the Society. The other in 1892, in which the Western Pennsylvania Humane Society brought an action against a farmer near Pittsburg. A large number of witnesses were examined and a verdict of acquittal was brought in by the jury.

THE CASE IN CANADA.

By far the most thorough examination of the legal aspects of dehorning in its relation to cruelty to animals has been made in Canada and published in 1892, in the Report of the Ontario Commission on the Dehorning of Cattle. From this report we quote as follows:

Origin of the Practice in Ontario.

The practice of dehorning cattle appears from the evidence to have been first introduced into this Province in the year 1888, by Messrs. Kinney and Johnson, farmers, of South Norwich, Oxford county. It was not, however, adopted to any great extent until February, 1890, when Mr. Chauncey Smith, a farmer's son residing in the township of Dereham, Oxford county, on returning from a visit to the State of Illinois, where the practice prevailed, set an example by dehorning his father's herd. In a short time this example was followed by Mr. Smith's neighbors, many of whom became warm advocates of the practice.

Considerable controversy arose as to the amount of pain involved in the operation, and in February, 1891, Mr. W. V. Nigh, a farmer of of Avon, Middlesex county, was prosecuted before two Justices of the Peace at London on the charge of cruelty. The case was dismissed on the evidence of ten witnesses that the operation was a beneficial one and the suffering of short duration.

The practice continued to extend, and the services of Messrs. Chauncey Smith and W. A. Elliott, who had made a study of the operation, were frequently in demand. Mr. Smith stated in evidence that he had dehorned 250 head while Mr. Elliott gave the number of cattle he had operated upon to be about 400. The great majority of these operations took place in Oxford, Norfolk and Elgin counties, and although dehorning has been tried experimentally in various parts of the Province, the practice is largely confined at present to the counties mentioned.

Acting on behalf of the opponents of the practice, Mr. Charles Hutchinson, Crown Attorney of Middlesex,* instituted proceedings in January, 1892, against Messrs. William York, Sr., W. A. Elliott and Edward York, charging them with cruelty to animals in having cut off the horns of the cattle of the first named defendant. The case was called at the Interim Sessions, London, on January 6th, before Messrs. Smythe and Lacey, Justices of the Peace for the County of Middlesex, and after a thorough trial each of the defendants was fined $50 and in default of payment one month in the County Jail.

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* The Dominion statute against cruelty to animals under which the prosecutions were brought, reads as follows: "Everyone who wantonly, cruelly, or unnecessarily beats, binds, ill treats, abuses, overdrives or tortures any cattle, poultry, dog, domestic animal or bird shall, upon summary conviction before two justices of the peace, be liable to a penalty not exceeding $50 or imprisonment for any term not exceeding three months."

The proceedings at the trial were given a widespread publicity and an animated newspaper controversy was carried on for several weeks. The greatest difference of opinion was noticeable, the advocates of the practice claiming that it was a positive kindness to the animals, in addition to being a commercial advantage, while many who were opposed to it regarded the operation as one of excruciating torture.

In view of these circumstances, a Commission was issued on March 9, 1892, by the Ontario Government to Hon. Charles Drury, of Crown Hill, Farmer; Richard Gibson, of Delaware, Breeder; D. M. Macpherson, of Lancaster, Dairyman; Andrew Smith, of Toronto, Veterinarian; Henry Glendinning, of Manilla, Farmer; and J. J. Kelso, of Toronto, Journalist, authorizing and requiring them "To obtain the fullest information in reference to the practice recently introduced into this Province of dehorning cattle, and to make full inquiry into and report with all reasonable speed the reasons for and against the practice, as well by the examination of witnesses as by collecting whatever is accessible of the evidence which has been given by experts or others in the trials which have taken place on the subject in England, Ireland and Scotland, and in this Province, the judgments in the cases tried and any other useful information from any quarter which may be in print or otherwise obtainable." Hon. Mr. Drury was named as chairman and Mr. Kelso as secretary.

Evidence before the Commission.

Evidence was received from the representatives of all the interests affected by the practice, including general farmers, dairymen, drovers, exporters, wholesale and retail butchers, cattle market attendants, tanners, hide merchants, veterinary surgeons, medical practitioners and members of Humane Societies,—ninety-eight in all.

Of the farmers examined, nearly seventy in number, all who had either performed or seen the operation performed, with three or four exceptions, were strongly in favor of it, the majority stating that they were prejudiced against it on the grounds of cruelty until they gained a practical knowledge of it. Of the farmers opposed to the practice not more than three or four had ever seen the operation but they thought it cruel and unnecessary.

Evidence as to the loss caused by animals using their horns upon each other was given by cattle buyers and others in frequent attendance at the cattle market, and also by butchers and tanners.

Among veterinary surgeons a considerable conflict of opinion was found to exist. As in the case of the farmers those who had seen the operation and observed its effects were in favor of it, while those who had not seen it were opposed to it.

Indeed, as regards all the evidence received by the Commission it might almost be given as the rule that where the operation was properly and skillfully performed those witnessing it, however prejudiced before, became converts to it, while the great bulk of the opposition came from parties not acquainted with the operation, and who entertained exaggerated ideas as to its severity.

In no case were witnesses able to refer to an instance where a farmer was dissatisfied with the results or willing to give up his right to continue the practice, after having performed the operation.

In addition to the evidence as to the amount of pain involved in the operation, much evidence was received as to the commercial advantages accruing from the operation, and emphasizing the point that a great deal of suffering is prevented by the removal of the horns.

No fault could be found with the character and bearing of those who testified in favor of the practice. They were men who would readily be selected as representative of the best class of farmers, and even those opposed to them on this question willingly testified to their respectability and good standing in the community.

A great deal of opposition to the practice was met with from members of humane societies and others who believed that the operation was purely for commercial considerations and therefore unjustifiable, and that the pain inflicted was excessive. These witnesses were strengthened in their belief by the judgment of Lord Chief Justice Coleridge and Mr. Justice Hawkins,* a verbatim report of that adverse decision having been printed and distributed by the Royal Society for the Prevention of Cruelty to Animals.

Recommendations of the Commission.

The Commission would therefore recommend as follows :

1st. That the practice of dehorning be permitted where performed with reasonable skill, with proper appliances, and with due regard to the avoidance of unnecessary suffering, and that the Ontario Government should bring to the attention of the Dominion Government the desirability of amending the law relating to cruelty to animals, so as to give effect to this recommendation.

2d. That the Ontario Government should direct the management of the Ontario Experimental Farm to experiment with chemicals

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*P. 137.

on the horns of young calves and also by cutting out the embryo horn, with a view to ascertaining whether these methods are more desirable than sawing off the horns when they have attained their full growth.

CHARLES DRURY, Chairman,
RICHARD GIBSON,
HENRY GLENDINNING,
D. M. MCPHERSON,
ANDREW SMITH,
J. J. KELSO, Secretary.

IN GREAT BRITAIN.

The practice of dehorning seems to have been in vogue considerably earlier than in this country and there are decisions in regard to its legality going back as early as 1884. The English law is similar to the ones in force in this State and in Canada, and is as follows: "If any person shall cruelly beat, ill treat, over drive, abuse or torture, or cause or procure to be cruelly beaten, ill treated, over driven, abused or tortured any animal, such offender shall be subjected to such punishment as is prescribed by that statute."

A summary of the British decisions is given below:

Summary of British Trials.

Ireland, 1884 — Brady v. McArgyle. Magistrate refused to convict. Exchequer division held that conviction should have been entered. (Baron Dowse and Mr. Justice Andrews.)

Ireland, 1885 — Callaghan and McAvoy v. the S. P. C. A. Three magistrates at the petty sessions held that they were bound to convict in accordance with the above decision. Common pleas division of the High Court of Justice overruled this, and held that the operation, skillfully performed, did not come within the meaning of the act. (Chief Justice Morris, Mr. Justice Harrison and Mr. Justice Murphy.)

Scotland, 1888 — Penton v. Wilson. Acquitted by the sheriff-substitute. Case appealed to a higher court, and the sheriff-substitute sustained. (Lords Young, McLaren and Rutherford Clark.)

England, 1888 — Ford v. Wiley. Acquitted by a board of five magistrates. Higher court held that conviction should have been entered. (Lord Chief Justice Coleridge and Mr. Justice Hawkins.)

Scotland, 1891 — Penton v. Wilson. Appealed to a higher court, and the two previous decisions unanimously confirmed. (The Lord Justice Clark, Lords McLaren, Trayner, Wellwood and Kyllachy.)

Ireland, 1891 — Newland v. McDonagh. Two magistrates refused to convict. Higher court sustained this decision. (The Lord Chief Justice, Mr. Justice O'Brien, Mr. Justice Johnson, Mr. Justice Holmes and Mr. Justice Gibson.)

Summary.

In the United States, so far as we have been able to learn, all trials upon charges of cruelty to animals by dehorning have resulted in the acquittal of the accused parties.

In Canada at least two trials resulted in the acquittal of the accused, but in a third trial the conviction of the parties resulted in the appointment of a Government Commission which made a report strongly recommending the practice and urging the passage of the necessary legislation to give it effect.

In Great Britain there have been decisions on both sides. Those in Ireland and Scotland being in favor of the legality of the practice and those in England, notably that of Lord Chief Justice Coleridge and Mr. Justice Hawkins, against. Of twenty judges of higher courts who have passed upon the subject, sixteen declared the practice to be legal, while four pronounced it illegal.

ON PREVENTING THE GROWTH OF HORNS.

Ever since the practice of dehorning has come into favor it has seemed to many that if by some means the horns could be prevented from growing it would be for many reasons much preferable to removing the horns from full-grown animals. As several so-called " Chemical Dehorners " have been on the market for some time, it has seemed well to undertake some experiments with certain caustic reagents to ascertain, if possible, if any could be relied upon to prevent the growth of horns. Accordingly on November 5, 1891, five calves were selected from the University herd for experimentation in preventing the growth of horns by the application of various chemical compounds. These chemicals were compounded and either applied by or under the direction of Prof. James Law, Professor of Veterinary Science.

One of these calves was a thoroughbred Jersey; one a thoroughbred Holstein, and the remaining three, high grade Holsteins.

The following table shows the age and breed of the calf and the chemicals used on each horn:

		Age in days.	
Calf No. 1...	Holstein..	30	Right horn, caustic potash. Left horn, caustic potash.
Calf No. 2...	Holstein..	34	Right horn, hydrochloric acid. Left horn, sulphuric acid mixed with sulphur.
Calf No. 3...	Jersey ...	64	Right horn, chloride of zinc. Left horn, chloride of zinc.
Calf No. 4...	Holstein..	65	Right horn, sulphuric acid with glue and carbolic acid. Left horn, chloride of antimony.
Calf No. 5. .	Holstein..	45	Right horn, chromic acid ointment. Left horn, chromic acid solution.

The caustic potash applied to the horns of calf No. 1 was in the form of a paste and a liberal amount was applied to each horn. Only calves Nos. 1 and 3 suffered from the application; these apparently suffered considerable pain soon after the application and this pain continued until the second day; after that time all calves appeared bright, active and without pain.

November 12th a careful examination of all the horns was made and the following conditions were noted:

Calf No. 1.—Right horn, growth apparently destroyed.
Left horn, " " "
Calf No. 2.—Right horn, not affected.
Left horn, growth apparently destroyed.
Calf No. 3.—Right horn, not affected.
Left horn, " "
Calf No. 4.—Right horn, not affected.
Left horn, " "
Calf No. 5.—Right horn, not affected.
Left horn, " "

The left horn of calf No. 4 was somewhat sensitive to the touch, but appeared to be perfectly healthy. As most of the horns treated were not affected by the reagents it was thought best to give them another treatment and by so doing to try still other chemical reagents; accordingly the following chemicals were applied:

Calf No. 2.— Right horn, chloride of mercury and hydrochloric acid.

Calf No. 3.— Right horn, caustic potash.
Left horn, caustic potash.

Calf No. 4.— Right horn, chloride of mercury and hydrochl'c acid.
Left horn, chloride of mercury and sulphuric acid.

Calf No. 5.— Right horn, chloride of mercury and hydrochl'c acid.
Left horn, chloride of mercury and sulphuric acid.

The caustic potash applied to calf No. 3 was not so concentrated nor so much applied as to calf No. 1 in the first trial.

An examination of all the calves Feb. 14, 1892, showed the conditions to be as follows:

Calf No. 1.— Both horns destroyed.

Calf No. 2.— Right horn not affected.
Left horn destroyed.

Calf No. 3.— Right horn not affected.
Left horn not affected.

Calf No. 4.— Right horn not affected.
Left horn destroyed.

Calf No. 5.— Right horn not affected.
Left horn not affected.

It will be seen that the second application destroyed the growth of only one horn, the left horn of calf No. 4, and from the action of the different reagents on the calves of different ages it seemed evident that chemicals, to be effective in preventing the growth of horns and not make serious sores, must be applied early in the life of the animal.

As caustic potash had proved the most effectual in these trials, it was used exclusively in succeeding experiments. Since the above experiments were made the growth of the horns on seven other calves have been successfully prevented by a single application of caustic potash to each horn, *but in no case was the application made when the calves were more than one month old*. Illustrations 1, 2 and 3 show the appearances of the heads after treatment with the various chemical agents. These illustrations were reproduced from photographs taken in December, 1892.


FIG. 1.

Fig. 1 is the head of calf No. 1, growth of horns destroyed by caustic potash paste.

Fig. 2 is the head of calf No. 2; left horn destroyed by sulphuric acid mixed with sulphur.


FIG. 2.

Fig. 3 is the head of a calf with horns destroyed by stick caustic potash applied in small quantity to the embryo horns early in life.


FIG. 3.

The results of all the experiments made at this station lead us to believe that the use of caustic potash is by far the easiest, most humane and most certain method of securing hornless cattle. The best time to apply preventive reagents is early in the life of the animal, just as soon as the little horns can be distinguished by the touch. The manner of applying caustic potash* is as follows:

The hair should be closely clipped from the skin and the little horn moistened with water to which soap or a few drops of ammonia have been added to dissolve the oily secretion of the skin, so that the potash will more readily adhere to the surface of the horn. Care must be taken not to moisten the skin except on the horn where the potash is to be applied. One end of a stick of caustic potash is dipped in water, until it is slightly softened. It is then rubbed on the moistened surface of the little horn. This operation is repeated from five to eight times, until the surface of the horn becomes slightly sensitive. The whole operation need take only a few minutes and the calf is apparently insensible to it. A slight scab forms over the surface of the budding horn and drops off in the course of a month or six weeks, leaving a perfectly smooth poll. No inflammation or suppuration has taken place in any of the trials we have made. The results of these experiments warrant the following recommendations:

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* Caustic potash comes in the form of round sticks about the size of a lead pencil. It may be had at any drug store and should be kept from exposure to the air as it rapidly absorbs moisture.

1. That for efficiency, cheapness and ease of application, stick caustic potash can be safely recommended for preventing the growth of horns.

2. The earlier the application is made in the life of the calf, the better.

PATENTED CHEMICAL DEHORNER.

On March 16, 1893, we received from the John March Co., 17 & 19 River St., Chicago, Ill., a circular concerning their "Method of Dehorning easily, safely, perfectly and cheaply with the John March Company's Chemical Dehorner." Accompanying the circular was a bottle of the "Dehorner" containing about a gill of clear liquid. The circular, besides setting forth the merits of the liquid and quoting numerous testimonials, laid claim to a patent granted July 12, 1892, "On method of preventing the growth of horns by applying any substance to the embryo horn to prevent its growth," and warning all against infringement.

The existence of such a patent with such sweeping claims was a great surprise to us, as various compounds intended to prevent the growth of horns had been largely advertised in the agricultural press for several years, and caustic potash had been publicly recommended for the purpose at least as early as February, 1892.*

On looking the matter up it was found that patent No. 478,877 was issued July 12, 1892, to John March, assignor to the John March Company, on a Method of Suppressing Horns in Cattle, the important specifications of which are as follows:

"Be it known that I, JOHN MARCH, of White Oak Springs, in the county of Lafayette and State of Wisconsin, have invented certain Improvements in the Method of Suppressing Horns in Cattle, of which the following is a specification. * * * The object of my invention is to avoid the troubles and dangers attending the removal of a fully developed horn; and to this end it consists in effecting by chemical means the suppression of the horns while still in an embryotic or incipient stage. I have found, after many experiments, that it is possible by properly treating the young horn to arrest its growth, and this without in any way affecting or impairing the health or appearance of the animal in other respects. I have found that various chemicals and chemical compounds may be employed to accomplish my end. I recommend, however, the following composition of matter: Concentrated potash, one hundred parts; water, one hundred and ninety

* "Dehorning Calves," *Indiana Farmer*, Feb. 6, 1892.

parts; logwood, ten parts. The essential element of the composition is the potash, which may be used without logwood and of any suitable degree of attention.

"In practice I commonly make use of the solution when the animal is from one to ten days of age. It is simply applied externally to the young or incipient horn by means of a brush or other instrument, and in most cases I find that a single application is sufficient to answer the purpose in view. * * * Having thus described my invention, what I claim is: 1. The improvement in the art of suppressing horns in cattle, consisting in applying to the incipient horn a substance, substantially as described, to check its growth. 2. The improvement in the art of suppressing or eliminating horns in cattle, consisting in treating the incipient horn with potash, substantially as herein described."

The "Dehorner" was submitted to the Station Chemist, Mr. G. W. Cavanaugh, for analysis and his report is as follows:

"The sample of chemical Dehorner has been found on analysis in this laboratory to consist of a solution of 32.25 per cent of caustic soda in water. Caustic soda is worth 15 cents per pound and one pound would make about 1 litre of solution of the above strength. The bottle contains 1–10 litre and therefore the amount in the bottle would cost about 1½ cents."

The price given in the circular is $1.00 per bottle.

Concerning the efficacy of the "Dehorner" there can be little doubt; caustic soda is almost identical with caustic potash in its caustic properties and our experiments and those of others have shown caustic potash to be effective in preventing the growth of horns.* Moreover, experiments at the Wisconsin Agricultural Experiment Station have shown that the March Dehorner will do what is claimed for it.

We are therefore inclined to the following conclusions:

1st. The John March Company's Chemical Dehorner is undoubtedly effective for the purpose intended.

2d. It is not made of the materials called for in the specifications of the letters patent.

3d. It is sold at an exorbitant price.

4th. There need be little fear of infringement of a patented article consisting of a single well-known chemical reagent, or of a method already so well known and advertised.

I. P. ROBERTS.

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*8th Annual Rept. of Agric. Expt. Station of the Univer. of Wisconsin, p. 289.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BULLETIN 55—JULY, 1893.

GREENHOUSE NOTES

FOR 1892–93.

I. Third Report upon Electro-Horticulture.

II. Winter Cauliflowers.

III. Second Report upon Steam and Hot-Water Heating.

By L. H. Bailey.

ORGANIZATION.

Board of Control.—The Trustees of the University.

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.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.— Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55. Greenhouse Notes.

I. Third Report upon Electro-Horticulture.

For four winters we have made a study of the influence of the electric arc lamp upon plants grown in greenhouses. The results of these investigations, so far as published, appear in Bulletins 30 and 42. During two winters the lamp was hung inside the house, and part of the time the light was naked and at other times screened by a glass globe. It was found that lettuce was greatly hastened in growth by the light, and various flowers were earlier and brighter under its influence. Many plants were injured by the naked light, but sustained no injury or were even benefited by a light which was modified by passing through an opal globe or even through common glass. It therefore seemed reasonable to expect that if the light were placed above the house the glass roof would afford a sufficient screen, and this feature of the investigation was the particular subject of the bulletin last year (Bulletin 42, September, 1892). It was found that radishes and other plants which were injured by a naked light inside the house and even by a light modified by an opal globe, were benefited by a light above the roof; and lettuce and flowers still showed a marked benefit from it. This experiment was repeated last winter and the results are given in the sequel. We also continued our observations upon the effect of colored glass screens interposed between the lamp and the plants for the purpose of ascertaining what part of the spectrum influences plants — an inquiry which we mentioned last year but upon which no report has heretofore been made. Finally, we have to report a preliminary investigation to determine to what distance the influence of the light extends.

Cauliflowers. 1. *The Light above the House.*

We had already demonstrated to our satisfaction when our last report was made (Bulletin 42) that lettuce is much benefited by electric light passing through a greenhouse roof; and our experiments also showed that flowers may receive a like benefit. In short, no plants which we grew were injured by such light with the single exception of cauliflowers, which were decidedly poorer in the light house than in the dark one. The cauliflower experiment was confined to two dozen plants, however, and we were naturally solicitous to repeat it upon a larger scale. This repetition we shall now consider.

The lamp was hung over a house sixty feet long, and it was nine feet above the nearest point in the roof. It was hung midway the length of the house, and beneath it the house was divided by a curtain partition. The lamp was surrounded by a clear glass globe, one side of which was painted a dense black in order to throw the light into the opposite compartment of the house beneath. By an arrangement of roof curtains, in connection with the moveable partition and the blackened globe, one compartment was kept dark at night, while the other was well lighted. In the day time, the partition was withdrawn so that both compartments received equal conditions of heat and ventilation.* The central bed of the house, eight feet wide, was used for the cauliflowers in this experiment. The bed is solid; that is, a ground bed, having no bottom heat. Cauliflower seeds of three varieties — Extra Early Dwarf Erfurt, Gilt Edge Snowball, Early Snowball — were sown in "flats" or shallow boxes, August 24th. The plants were set in the bed October 4th, at which time they were about six inches high. The electric light was started a week later, October 11th. The light ran on an average from five to six hours each night. The following record shows the exact hours of light throughout the experiment:

Oct. 11 to	15,	light ran	from	5:30	to 11 P.M.,	or $5\frac{1}{2}$	hrs.	each night.
	16,	"	"	6	to 11	or 5	"	"
17 to	20,	"	"	5:30	to 11	or $5\frac{1}{2}$	"	"
	21,	"	"	6	to 11	or 5	"	"
22 to	24,	"	"	5:30	to 11	or $5\frac{1}{2}$	"	"
25 to	28,	"	"	5	to 11	or 6	"	"
29 to Nov.	5,	"	"	5	to 6:30	or $1\frac{1}{2}$	"	"
	6,			——	——	0		
	7,	"	"	5	to 9	or 4	"	"
	8,	"	"	5	to 10	or 5	"	"
9 to	20,	"	"	5	to 11	or 6	"	"
	21,	"	"	4:45	to 11	or $6\frac{1}{4}$	"	"
22 to	25,	"	"	5	to 11	or 6	"	"
	26,			——	——	0		
27 to	29,	"	"	5	to 11	or 6	"	"
	30,	"	"	5	to 9	or 4	"	"
Dec.	1,	"	"	4:30	to 11	or $6\frac{1}{2}$	"	"
	2,	"	"	5	to 11	or 6	"	"
	3,			——	——	0		

*The lamp was hung in the same position as shown in the illustration on page 135 of Bulletin 42, except that it was a few feet higher. House A B considerably remodelled inside, was used for the experiment.

Dec.	4, light ran from	5 to 11 P.M.,	or 6	hrs. each night.
5 to	6, " "	5 to 9	or 4	" "
7 to	12, " "	5 to 11	or 6	" "
	13, " "	5:30 to 11	or $5\frac{1}{2}$	" "
14 to	24, " "	5 to 11	or 6	" "
25 to	26,	—— ——	0	
27 to	31, " "	5:30 to 11	or $5\frac{1}{2}$	" "
Jan. 1 to	2,	—— ——	0	
	3, " "	5 to 11	or 6	" "
	4, " "	5 to 9	or 4	" "
	5, " "	5 to 8:30	or $3\frac{1}{2}$	" "
	6, " "	5 to 9:30	or $4\frac{1}{2}$	" "
7 to	12, " "	5 to 11	or 6	" "
	13, " "	5 to 1	or 8	" "
14 to	15,	—— ——	0	
16 to	18, " "	5 to 7 9:30 to 11	or $3\frac{1}{2}$	" "
	19,	—— ——	0	

100 days; $484\frac{1}{2}$ hours of light; average for each night, 4.8 hours.

The lamp was the same pattern as that used for two preceding winters, a 10 ampere 45 volt Westinghouse alternating current lamp of 2,000 nominal candle power.

The first heat was turned on the house October 25th. About this time some difference began to be noticed in the size of the plants in the two compartments, those in the light being ahead. On November 1st the plants in the light compartment were fully ten per cent larger than in the dark or normal room. The plants in the light gained slowly but steadily over the others in height and general appearance, but it was noticeable that they began to head later than the others. This fully corroborates the results secured from the small experiment of the year before. On December 9th there were 19 heads forming in the dark compartment, and only 12 in the other. The first cauliflowers were picked January 13th, and the harvesting continued at intervals for a week. The measurements of the plants at harvest were as follows:

VARIETY.	AVERAGE WEIGHT OF PLANT.		AVERAGE DIAMETER OF HEAD.		AVERAGE LENGTH OF LONGEST LEAF.	
	Light.	Dark.	Light.	Dark.	Light.	Dark.
	Ounces	Ounces.	Inches.	Inches.	Inches.	Inches.
Early Snowball..........	5.5	4.77	2.1	2.3	9.8	11.48
Gilt Edge Snowball......	6.1	6.26	1.8	2.4	10.9	11.22
Erfurt..................	9.67	5.6	3.2	2.27	14.4	12.33
Average............	7.09	5.54	2.4	2.3	11.7	11.67

Review.— These averages are conflicting. The two strains of Snowball gave much larger heads in the dark house as shown by the average diameter of the heads. This corresponds with the results obtained a year ago. But the plants — or leaves — were also longer in the dark house, which is opposed to former results. In one instance the plants averaged heavier in the light house, and in the other instance the figures are reversed. With Erfurt decidedly better results were obtained in the light house. The total average of the results shows that in size of head and length of leaves the light and dark houses gave about equal results. It was noticeable, however, that the plants under the light held their leaves more erect than the others. It is probable that under the conditions of this experiment the electric light exercises very little pronounced influence upon cauliflowers.

2. *To what Distance does the Influence of the Light Extend? The Lamp inside the House.*

On the 25th of January, 1893, the curtain partition was removed from the greenhouse, and the electric lamp, without a globe, was hung inside at the extreme end of the house and about three feet above the soil in the cauliflower bed. A large mirror was hung behind it to throw the light down the entire length of the 60-foot rows. The lamp can be seen in the further end of the house in Plate II. On the same day, young cauliflower plants were set in this bed, the old crop having been removed and the soil fertilized and thoroughly cultivated. These young plants were some two months old, and were about six inches high when set into the beds. The light ran as follows:

January	25 to	31,	light	ran	from	5	to 11	or	6	hours.
February		1,	"	"	"	5	to 5 A. M.	or	12	"
		2,	"	"	"	5	to 11	or	6	"
		3,					——		0	"
	4 to	5,	"	"	"	5	to 11	or	6	"
	6 to	16,	"	"	"	5:30	to 11	or	5½	"
	17 to	18,	"	"	"	6	to 11	or	5	"
		19,	"	"	"	6:30	to 11	or	4½	"
		20,				——	——		0	"
		21,	"	"	"	5:30	to 11	or	5½	"
		22,				——	——		0	"
	23 to Mar.	8,	"	"	"	6	to 11	or	5	"
March	9 to	10,	"	"	"	6:30	to 11	or	4½	"
	11 to	14,	"	"	"	6:30	to 9	or	2½	"
		15,	"	"	"	6	to 11	or	5	"
	16 to	21,	"	"	"	7	to 11	or	4	"
		22,				——	——		0	"
		23,	"	"	"	5:30	to 11	or	5½	"
		24,	"	"	"	6:30	to 11	or	4½	"
	25 to Apr.	20,	"	"	"	7	to 11	or	4	"

The plants standing near the light were injured by it. By the middle of February, the leaves on the plants within four or five feet of the lamp were much curled and crinkled. On the first of March this curling was apparent ten feet from the lamp, and the plants were stunted and had a more strict or upright growth than those farther away. The same injury was noticed in lettuce plants which had been set between the cauliflowers, although it

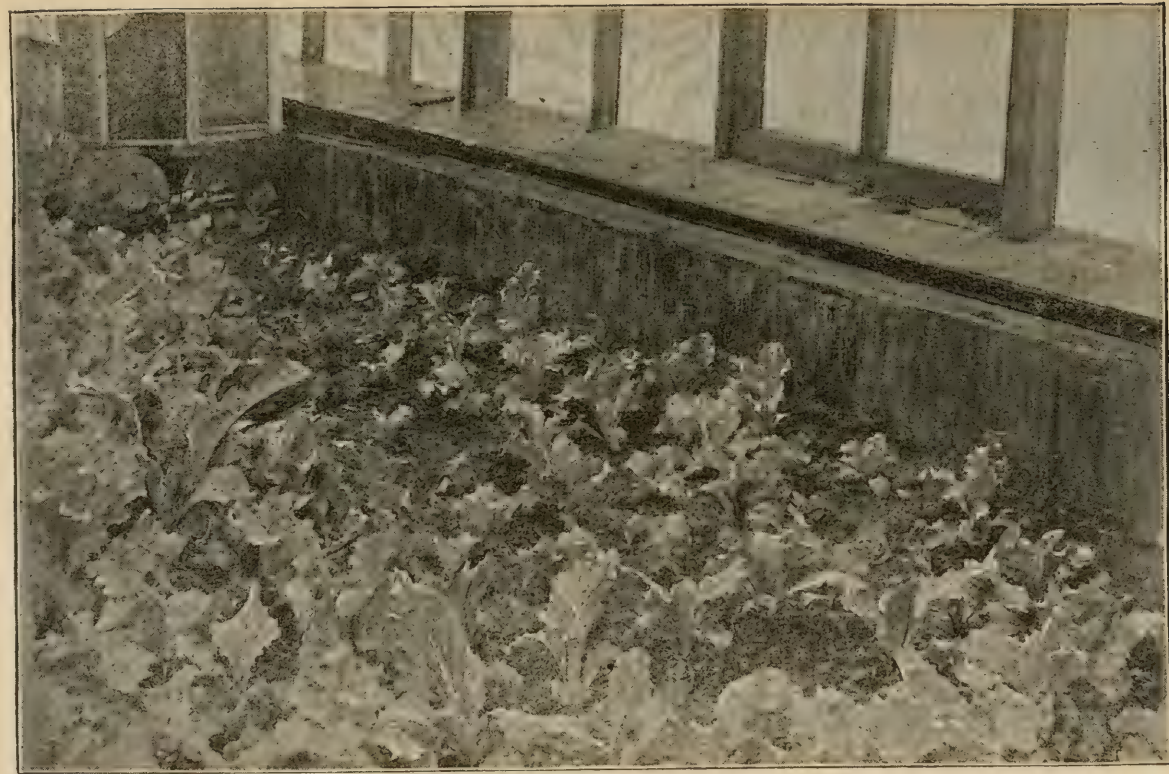
DWARF ERFURT.						EARLY SNOWBALL.					
Row from light.	Weight of plant.		Diameter of head.	Average length of two longest leaves.	Date of harvest.	Row from light.	Weight of plant.		Diameter of head.	Average length of two longest leaves.	Date of harvest.
	Lbs.	Ozs.	Inches	Inches.			Lbs.	Ozs.	Inches	Inches.	
6	2	7	6½	21	April 26	2	0	15½	3¾	17	April 7
7	2	0	6	23	14	4	0	10½	4½	12½	7
	1	10½	6	19½	21		0	8½	3½	12½	7
8	2	10	6	23	22	5	1	1	3	15	7
9	1	11	5½	19¼	10		2	12	6	24	20
10	1	12	5½	18¼	29	6	2	0	5½	21½	22
11	1	15	6	23	25	7	2	9	6	21½	20
	1	6	5	17	14	8	2	0	6	20½	22
	2	6	7	18½	21	10	1	12	5	19½	7
13	1	10	5	20½	14	11	2	2	5½	22½	22
	2	8	6	24	26	12	1	7	5	19½	27
14	1	1	5	15½	30		2	9	6½	22½	20
15	1	8	5¾	20¾	22	13	2	6	5½	22	16
	2	6	7	21½	29		1	2¾	3½	19½	7
16	2	5	6½	26	21	14	1	3	6	23½	14
17	1	12	7	20	21		2	12	6¼	21½	22
	1	14	6	22½	22	15	2	10	6	23½	9
18	2	8	6½	22½	22	16	1	14	5¾	20½	22
19	1	7	4½	20	4	17	2	9½	7	25¼	20
	1	14	6	21	17		1	12	4	20	6
20	2	0	7	18½	17	19	1	14¾	4½	20½	7
21	1	6	6	22	29	20	2	0	6	21	29
	1	9	5	21½	29	21	4	0	6½	21¾	14
	1	5	6	18¼	30		2	12	6½	24	22
23	1	15	5¾	19½	22	22	3	3	7	24	22
	2	7	7	20	26	23	2	14	7	23½	22
	1	13	6¼	18	29	24	1	13½	5	18½	7
25	1	14	5½	16½	14	25	3	0	6½	21½	14
	2	11	6	22	17	26	2	4	6	25	29
26	2	10	6	21½	27	27	2	7	6½	20	17
	2	5	6½	19	21	28	2	3	6	22½	22
29	2	10	7	21½	26	29	2	13	7	21	29
30	2	11½	6½	24	22	30	1	10	6	20½	22
	2	13	6	24½	22	31	2	9	6	22	22
	2	1	7	21½	26	32	2	3	5	23½	16
31	1	10	5	2 ½	26		1	6	4½	17½	March 31
	1	4	6	20½	28	33	1	6½	4¾	18½	31
	1	4	4	19¼	7		1	11	6	19¼	April 28
32	2	4	6	21½	17	34	1	11½	6½	18½	26
	1	10	6¼	20¼	22	37	2	7	6½	23	15
33	2	11	5¾	23½	22		1	1½	4	16¼	March 29
34	3	1	5	20	14	38	1	4	4½	16¾	29
	2	5	7½	21	26		1	14	6	19½	April 14
	2	8¾	5½	22½	26	39	1	3	4	17¼	6
35	2	2	5½	21½	17		1	1½	3¾	17¾	7
	2	13	6	22	22	......	......	......	......	......	......
	1	14	6	20	22	......	......	......	......	......	......
36	2	8	5½	22	26	......	......	......	......	......	......
39	1	1	3¼	16	4	......	......	......	......	......	......
	2	5	7	23	26	......	......	......	......	......	......
40	2	5	5½	23	27	......	......	......	......	......	......
	2	7	6	25¼	27	......	......	......	......	......	......
41	1	0	4½	14½	27	......	......	......	......	......	......

was less marked. The first heads to develop were noticed on Snowball plants, March 21st, near the end of the bed farthest from the light. The first heads were sold March 29th, from near the dark end of the house. The harvest was continued until May 1st, as demand arose, the largest heads being taken at each gathering. On the first day of May, all the remaining heads were picked. The table (page 132) gives the yield and measurements of the plants, proceeding from the light end to the dark end of the bed. There were five rows running lengthwise the bed, Nos. 1, 3 and 5 being Dwarf Erfurt and Nos. 2 and 4 Early Snowball. The plants were set about 16 inches apart, so that there were forty-one rows crosswise the bed, each row containing five plants, three of Erfurt and two of Snowball. The table shows the behavior of each variety in reference to proximity to the light, earliness, weight of entire plant without root, diameter of head when picked, and length of the longest leaf. The plants which were harvested on May 1st, when the experiment had closed, are not included in these figures.

Review.—While it is true that the very earliest heads were obtained from points far removed from the light, there does not appear to be any uniform behavior, so far as these measurements go, in reference to the light. Plants near the light were much injured, and it is only until the fifth or sixth rows are reached — or a distance of seven to ten feet — that plants and heads of normal size are procured. It must be said, however, that the lamp hung so low that beyond fifteen or twenty feet the plants were much shaded by their own leaves and by plants in front of them, and that the influence of the rays was therefore much broken. The general results, therefore, seem to indicate that the baneful influence of the naked electric arc lamp, of this pattern, is dissipated, in cauliflowers, at a distance of about ten feet, and that beyond that point the light appears to exert little influence.

3. *Experiments with Color Screens.*

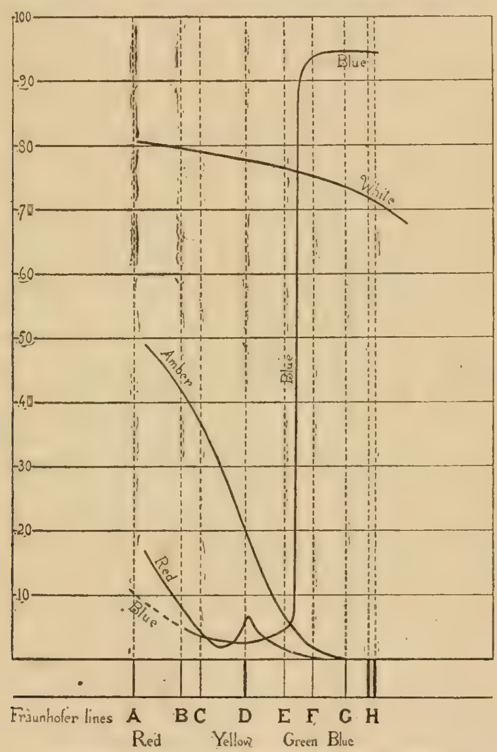
It would be useful to know what parts of the spectrum produce the singular effects which we have observed in our experiments. The good results which follow the use of a clear glass screen indicate that some of the injury is wrought by the ultra-violet rays. It is supposed, however, that the orange rays promote assimilation and consequently may accelerate growth. Two yearsa go an experiment was projected to determine the behavior of plants under electric lights of different colors. A lamp like the one used for the other experiments was surrounded by a six-sided frame, the back of which was a bright tin reflector to throw the light



I.— Lettuce Plants in Red and Naked Lights.

II.— Winter Cauliflowers Ten Weeks after Planting.

strongly upon the plants, four of the front sides being supplied with plain, orange, blue and red panes respectively, and the remaining side being left open, with no screen whatever. The panes of glass used in these screens were the best samples of their respective colors which could be purchased. The blue, however, was really a purple, and the orange was a dark amber. Spectrophotometric measurements were made of these panes under the direction of Professor E. L. Nichols, by Miss Mary C. Spencer, whose diagrammatic results are shown in the accom-



Spectro-Photometric Measurements of Panes.

panying chart. The spectrum is represented below, by the familiar Fraunhofer lines and by the relative positions of the different colors. The Fraunhofer lines are projected upwards by dots to show readily what portions of the spectrum are cut off by the various samples. The horizontal lines measure the amount of light of any color transmitted, in decimal figures. Thus it will be seen that the blue glass transmitted about ten per cent of the red rays, less than five per cent of the yellow, while it was almost perfectly transparent to the blue rays. The red pane transmitted nearly twenty per cent of the red rays, very few of the rays lying between red and yellow, about seven per cent of the yellow rays, while all the blue rays were cut off. Amber transmitted about forty per cent of the orange rays, with a very small per cent of the green and none of the blue. The plain or white glass transmitted eighty per cent of the red rays, and sank to about seventy per cent of the blue rays. A portion of this color screen may be seen in the upper left corner of Plate I.

The first year's experiment was started late in winter, and little was learned from it except the proper methods of conducting the investigation. Trays of germinating radish seeds, in soil, were placed in the various fields at equal distances from the arc, and the behavior of the young plants was watched with interest. March 12, 1892, the plants being from one to three inches high and in seed-leaf, marked heliotropism was noticed in the morning, even when the light had stopped burning at 11 o'clock the previous evening. In the naked light the young plants pointed strongly towards the lamp. The red and white lights produced a little effect in drawing the plants towards the lamp, while in the blue field the effect was scarcely perceptible and in the orange field it was none. On the morning of March thirteenth, the results were about the same, except that the red and white lights seemed to have had more effect than on the previous night. It was apparent that the smallest plants were those in the orange light. The next night the light burned but a short time, and on the following morning the plants all looked towards the sunlight. On the fifteenth, the heliotropism towards the lamp was again marked. The best plants were those in the naked light and the poorest those in the orange light.

On the 7th of November, 1892, lettuce plants, for which the seed had been sown October third, were set in a ground bed eight feet wide and twenty-three feet long. A week later, the electric lamp, surrounded by the color screen, was hung in front of this bed, four feet above it and three feet from it. The light burned about five hours each night, usually from 5 o'clock until 11. December first there was no difference in the plants under the various lights, and the lamp was then transferred to the opposite side of the bed and hung only a foot and a half above it, as shown in Plate I. This change was made in order to bring the light nearer to the plants and also to bring all the five screens to bear upon the crop. In the former position only the red, blue and orange screens threw light upon the plants, the plain glass and naked sections being out of range of the bed. The position of the screens was also reversed in changing the lamp, save the blue, which occupied the middle portion of the frame. The light now began to influence the plants, especially by drawing or bending them towards it. This heliotropism was most marked in the blue field, somewhat less in the orange or amber field, and a trifle less in the red. A week after the lamp was moved, this influence was manifest; but at this time neither the plain screen nor the naked light seemed to have made an impression upon the lettuce plants. Three weeks after the moving of the light, however, decided differences had developed in the various fields. The plants in orange or amber light were the largest and best; these were followed, in order, by those in the red, blue, plain and naked sections. The naked light had now begun to injure the plants seriously, a phenomenon which has been repeated throughout our experiments from the first. Early in January auxanometers, for measuring the hourly growth of plants, were started under the naked light, and in the red, blue and orange fields, at equal distances from the arc. The machines were set in motion upon the fifth of January, each being attached to the tip of a growing leaf about an inch and a half in length. On January eighteenth all the machines were changed onto new leaves. During January the lettuce was making a heavy growth. The house had been kept very cool previous to this time and the plants had grown rather slowly, although they were in the best of condition throughout the experiment. The variety was Simpson Curled. The accompanying table (page 156) is a graphic representation of the auxanometer readings. The bars show the growth in the different fields for the hours specified, magnified — to render it more readable — about three times. The number of hours of electric within the specified time is shown at the extreme right. The

Records of Growth Under the Different Lights. (Lettuce.)

DATE, 1893.	Growth under naked light.	Growth under red light.	Growth under blue light.	Growth under orange light.	Hours of electric light.
January 5– 6, 27 hours					3½
" 6– 7, 26 "					4½
" 7– 8, 24 "					0
" 8– 9, 25 "					6
" 9-10, 22 "					6
" 10-12, 47 "					12
" 12-13, 24 "					6
" 13-14, 24 "					6
" 14-16, 49 "					7
" 16-18, 48 "					9½
" 18-19, 23 "					3½
" 19-20, 24 "					0
" 20-21, 24 "					6
" 21-22, 25 "					6
" 22-23, 22½ "					6
" 24-25, 24 "					6
" 25-26, 24 "					6
" 26-27, 24 "					6
" 27-28, 25 "					6
" 28-29, 24 "					6
" 29-31, 49 "					12
Average					5-9

short growth under the naked light is apparent at a glance. The red field gave second poorest results in the early part of the test, but it made remarkably large growths later on. At the time when these readings were begun, the orange lights had the largest plants, and the crop graded off through the red, blue and plain lights; but about the 20th of January the differences were seen to be disappearing. The small plants were catching up when the experiment was closed, January 31st, all the fields were of nearly equal size, except the naked light plants which were still weak and small. Plate I showed at the right the very small plants under the naked light, as compared with those in the red, next to them. In other words, the plants in the orange field were earlier than others during the greater part of their life, but they ceased to hold their own when the crop approached maturity. It is impossible to say why the different lights should have exerted more equal effects when the plants began to spread and to attain a mature condition, but such appears to be the fact. Some of this equalization of growth may have been due to the greater number of hours of sunlight in February, and to a slight falling off in the hours of electric light. While the auxanometer records show wide differences at first, therefore, the general average growth of the entire period is very much alike in all the examples.

The second crop of lettuce was placed in the bed March 2d. This was Grand Rapids Forcing. The light was started on the 8th and ran until April 25th. Essentially the same differences were noticed as in the last experiment, except that they were much less marked, owing to the greater number of hours of sunlight and the fewer hours of electric light. When the light stopped, all the fields, except the naked light, were in about equal condition.

Review.— This experiment seems to show, therefore, that lights of different colors exert decided influences upon radish and lettuce plants early in their growth; but these differences tend to disappear as the plants approach maturity. The naked light, as usual, was very injurious to the plants; but in no other case was the influence of the light sufficiently marked to make any important difference in the value of the crop.

Arrangements are now being made to grow plants in a spectrum during the coming winter.

II. Winter Cauliflowers.

There is probably no vegetable which is capable of profitable forcing in America concerning which so little has been written in reference to its treatment under glass as cauliflowers. It is true that the literature of vegetable forcing is very meagre in this country, and it is therefore little wonder that the cauliflower, which is scarcely known as a winter crop outside the establishments of wealthy persons who employ gardeners, should have received so little attention from writers. Our own experience in the forcing of cauliflowers for winter use extends over only three winters with four crops; but inasmuch as the first crop was a failure and the last were very successful, the narrative may possess some value. It should be said here that in speaking of the forcing of cauliflowers I refer to the practice of growing them under glass to maturity in the cold months, and not to the much commoner practice of growing them to a large size under frames or sash-covered houses and stripping the sash off upon the approach of warm weather and allowing them to mature without cover. Our first crop was attempted in the winter of 1890–91. The seeds were sown in "flats" or shallow boxes, and the young plants were transplanted into pots. When the plants were eight or ten inches high they had been shifted to 8-inch pots, and knowing that the cauliflower delights in a low temperature, the pots were set upon the ground in a cool lean-to house, where the temperature often went below 40°. The floor of this house was cold and wet, and it was soon evident that the plants were suffering. They were removed, therefore, into an intermediate temperature. Growth soon began again and small heads began to form before the plants had reached the proper size. These heads, however, soon split or "buttoned" and none of them were merchantable. The lesson was evident. The plants had been checked, and under the sudden stimulus of a new growth the premature heads were ruptured. The experiment was repeated the following winter in a small way, the attempt being made to keep the plants in a uniform condition of vigor and growth throughout their life time. This attempt was successful, and it lead to two larger experiments of the past winter. In this second trial, the plants were grown in 6-inch pots, but this was thereafter abandoned as too expensive.

The house in which the two crops of last winter were grown is a low two-thirds span, facing the south, 60 feet long by 20 feet wide. It is built upon a side hill, and it has three benches, the two lower ones being used for the cauliflowers. The lowest bench, against the south wall, has a board bottom underneath seven or eight inches of soil and is supplied with mild bottom heat from two and 1¼-inch steam pipes. The main or central bench, seven feet wide, is solid; that is, it is a ground bed and has no bottom heat. The soil in this bed is about eight inches deep and it rests upon a natural subsoil of very hard clay. The soil in both beds was placed upon them last fall, and it was made of good garden loam with which a very liberal supply of old manure was mixed. One load of manure mixed with three or four of the earth makes a good soil; and if it is somewhat heavy or pasty, sand must be supplied to it to afford perfect drainage and prevent it from getting "sour" or hard. We prepare soil for all winter vegetables in essentially this manner. The lower bed, which had bottom heat, did so poorly under both crops that I shall dismiss it at once from this account. The plants were later than those in the solid bed and never equalled them in size and percentage of good heads; and they were conspicuously lacking in uniformity. So few good heads formed that the bed did not return the labor expended upon it.

Seeds for the first crop were sown in boxes on August 24th. The plants, having been once transplanted, were set in the beds October 4th and 5th, about 16 inches apart each way. Three varieties were used,—Extra Early Dwarf Erfurt, Gild Edge Snowball and Early Snowball, all supplied by J. M. Thorburn & Co.

The plants were watered two or three times a week, as occasion demanded, and the ground was frequently stirred with a hand weeder. An abundance of air was given during the day, a row of small ventilators along the peak of the house being thrown open even in sharp weather if the sun was bright. From 60° to 70° during the day and about 50° at night were considered to be the ideal temperatures, although in very bright days the mercury might register 80° for a time and the night temperature several times sank below 40°. There was a tendency for the plants to damp off soon after they were set, but care in not watering too much and in giving an abundance of fresh air seemed to keep the trouble in check; and new plants were set into the vacancies. We were obliged to contend with two other enemies, the green-fly or aphis, and the common green cabbage worm.

The aphis are readily kept in check by tobacco smudge. The first cabbage worms were noticed November 21st, and for a couple of weeks they had to be carefully picked. The boxes of young plants had stood out of doors during September and it is probable that eggs were laid upon the plants at that time.

The first week in December heads were beginning to form. The first heads were sold January 13th, four and a half months from the sowing of the seed. The Erfurt gave the earliest and evidently the best results. The plants had been checked somewhat late in their history by very dark weather and possibly by some inattention in management, and many of the heads began to "button" or to break into irregular portions with a tendency to go to seed. The house was needed for other experiments, and on January 20th the plants were all removed. At this time nearly three-fourths of the crop had matured sufficiently to give marketable heads, although many of the heads were small. Winter cauliflowers, in common with all forced crops, should be harvested when small, for products of medium or even small size sell for nearly or quite as much as large ones in winter, and the cost of raising them is much less. A head four inches across is large enough for January sales, and many of the heads which we sold were considerably smaller than this. These heads sold readily at our door for twenty cents apiece.

January 25th, 1893, a second crop of cauliflowers was set in the beds, comprising Early Snowball and Dwarf Erfurt. Seeds for this crop were sown in flats October 21st. On November 5th the plants were transplanted to other flats, and on December 16th shifted to 3-inch pots, where they remained until set in the bed. On April 8th the plants had reached the size shown in the photograph in Plate II. At this time they completely covered the ground and choked out lettuce which we had placed between them. About the 20th of March heads were found to be forming in the Early Snowball. In the former experiment Erfurt gave the first heads. A week later than this, Snowball had heads three to four inches in diameter while Erfurt showed none. The first heads were sold on the 29th of March, about five and a third months from the time of sowing. It will be observed that the time between sowing and harvest is greater in the second crop than in the first. This is because the plants were wholly grown in the dark and short days of mid-winter. It should be added, also, that the climate of Ithaca is excessively cloudy and that the forcing of plants presents special difficulties here. An attempt was now made to keep the plants in a uniform but not exuberant state of vigor to prevent the heads from buttoning. The crop held up well and on the 1st of May, when the experiment closed, there were many merchantable heads unsold. Ninety per cent of the plants made good heads, which is a very large proportion, even for the best field culture. In this crop, the heads were allowed to attain a larger size than in the mid-winter crop, the average diameter being about six inches. A good head of Snowball is shown on page 145. It is rarely necessary to bleach the heads, as is done in field culture. Late in the season, in April, it may be necessary to break a leaf down over a head now and then to protect it from too hot sun, but ordinarily the heads will be perfectly white under glass, when full grown. The house in which these plants were grown is glazed with single thick, third quality glass. The heads are as sweet and tender as the best field product, and we have never grown a crop under glass, either of vegetables or flowers, which was so satisfactory and which attracted so much attention as these crops of cauliflowers. As to varieties, there is evidently little choice between the Erfurt and Snowball strains. In the last and most successful crop, the Early Snowball was the earlier, but otherwise it had little if any superiority over the other.

We endeavored to grow lettuce between the cauliflowers but it was soon choked out by the dense growth of the large plants and was not successful. The two borders of the beds grew good crops of mustard, however, which makes delicious "greens" in winter. For this purpose we like the Chinese mustard.

Summary.—Cauliflowers are easily grown as a winter crop if they are kept in vigorous and uniform growth. They need a rich soil, careful attention to watering, cultivation and ventilation, and a cool temperature like that employed for lettuce. They appear to thrive better without bottom heat than with it. The Early Snowball and Erfurt strains force well. Plants should be set in the beds when from six weeks to three months old, according to the season of the year, and from four to five months elapse before the first heads are fit for market. The heads ordinarily require no bleaching, and they are ready for sale when from four to six inches in diameter.

III. Second Report Upon Some of the Comparative Merits of Steam and Hot Water for Greenhouse Heating.

In the winter of 1891--2, a series of tests was made to determine some of the relative merits of steam and hot water for the economical and efficient heating of forcing-houses. The conclusions of the experiment — which are published in Bulletin 41 — were to the effect that steam is perhaps better for large forcing-houses, for several reasons.* Our experiments have been severely criticised, especially upon the score that the hot-water boiler which we used is a poor machine for the purpose. The experiment was repeated during the last winter with great care, but in this instance one boiler was used for both steam and hot water. That is, for a certain season it was run with water, and then for a season with steam. No change whatever was made in the heater or the piping when these transfers were made except to shut off the expansion tank when steam was used. This expansion tank was a large pail standing about four feet above the heater and connected with it by an inch pipe, which was closed by a valve. The heater is a small portable machine designed exclusively for hot water; and in order to make a shift for a steam dome, a piece of 4-inch gas pipe 14 inches long was secured vertically to the top of the heater.

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*The conclusions were as follows:

1. The temperature of steam pipes averaged higher than those of hot water pipes, throughout the entire circuit for the entire period of test.

2. The higher the inside temperature in steam pipes the less is the proportionate warming power of the pipes at a given point. The heat is distributed over a greater length of pipe, and as steam is ordinarily carried at a higher temperature than hot water, it has a distinct advantage for heating long runs.

3. When no pressure is indicated by the steam gauge, the difference between the temperatures of the riser and the return, is greater with steam than with hot water.

4. Under pressure, the difference is less with steam than with hot water.

5. There is less loss of heat in the steam risers than in the hot water risers, and this means that more heat, in the steam system, is carried to the farther end of the house and more is spent in the returns as bottom heat.

6. This relation is more uniform in the steam risers than in the hot water risers, giving much more even results with steam than with hot water.

The piping was all designed for hot water; that is, the highest points in the risers or flows were at the further extremities of the runs. All the conditions, therefore, were decidedly in favor of hot water; and whatever advantage steam may have had in our first experiment, it was much overbalanced in the present investigation. This little heater was used to warm a small cool house, used for lettuce and other plants requiring similar temperature, and comprising a ground area of 432 square feet. It is a lean-to house, facing the south, with the back wall 9 feet high. Thermometers were let into the pipes for the purpose of obtaining inside temperatures, after the manner explained in Bulletin 41. These experiments were conducted by Fred W. Card, Fellow in Horticulture, who made the former investigation, and the remainder of this paper comprises his accounts of the subject.

Methods.— The experiments of the present season were made in a lettuce house about 16x27 feet in size, with ground beds and a lean-to roof. It is protected on the west, north and east sides by the general work-room; a solid wall of earth, and a cool pit respectively, leaving only the south side and roof exposed, both of which are covered with third quality single-thick glass. The same boiler and the same piping served for all tests except the last one of both steam and hot water, when a long run was added, to test the results of a more extended circulation. The only change ever made in the apparatus was the removal of the expansion tank when steam was used. This tank was placed near the roof of the work-room and was about 9 feet above the top of the boiler. The level of

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7. When the fires are operative, the fluctuation in the temperature of the risers at any given point is much greater with hot water than with steam.

8. An increase in steam pressure raises the temperature of the entire circuit, but the temperature does not rise uniformly with the pressure.

9. The first application of the pressure increases the temperature of the returns much more than that of the risers.

10. Steam is better than hot water for long and crooked circuits.

11. Pressure is of great utility in increasing the rapidity of circulation of steam, and in forcing it through long circuits and over obstacles.

12. Unfavorable conditions can be more readily overcome with steam than with hot water.

13. Hot water consumed more coal than steam; and was at the same time less efficient. This result would probably be modified in a shorter and straighter circuit, with greater fall.

14. Under the conditions here present, steam is more economical than hot water and more satisfactory in every way ; and this result is not modified to any extent by the style of heaters used.

the walk in the house is but two or three inches above that of the work-room floor, on which the boiler stands, but the tops of the beds rise several inches higher. This necessitated overhead heating entirely, and gave insufficient fall for any system to work well. The pipe contained numerous angles and was a decidedly difficult series to heat. The heater used was a small hot water boiler, known as the Novelty Circulator, made by the Abram Cox Stove Co., put up in sections and not suitable for steam heating, for which purpose it should have been provided with a steam dome and greater evaporating surface, while as put up there is nothing but a short piece of four-inch pipe to take the place of this. The general slope of the pipes was also better suited to the flow of hot water, as generally recommended.

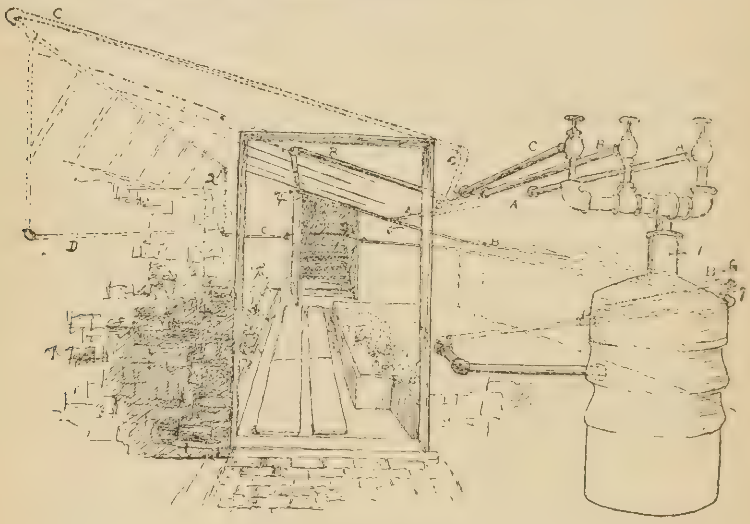


Diagram of the Apparatus.

The boiler was placed in the work-room just outside the house to be heated, but separated from it by a stone partition. The above engraving shows the relative positions of the series. Three risers are taken from a horizontal pipe lying on top the steam dome at the top of the boiler, and pass directly through the partition into the house.

Riser C runs from this horizontal pipe, 4½ ft. east horizontally into the house, then rises 6 in., then rises obliquely 6 ft. 10 in., passing to northwest corner, eastward 26 ft., near the roof with slight rise to opposite end, then falls 3½ feet vertically downward. Connected with this is a lower loop, D, starting 6 in. from the northwest corner, which drops vertically 3 ft. 6 in., then extends 25 ft. 9 in. eastward to the perpendicular drop just mentioned, entering it 4 in. above the bottom.

Continuing from here, run C extends 4 ft. south, 4 ft. east into cool pit, 3 ft. south, $4\frac{1}{2}$ ft. west into house again, $6\frac{1}{2}$ ft. south to southeast corner of house, 26 ft. 3 in. west to southwest corner, 6 in. north obliquely downward, where it is enlarged to a 2-in. pipe and continues 7 ft. 3 in. further in the same direction, 2 ft. 4 in. west, 1 ft. south, 10 in. west to boiler.

Riser B extends 6 ft. 8 in. east, 2 ft. 8 in. north obliquely upward, 21 ft. east to within 3 ft. of opposite end. An extra crook was put in this riser January 31, giving measurements 4 ft. 5 in. east, 2 ft. 3 in. north, 3 ft. 3 in. east, 2 ft. 3 in. south, 13 ft. 2 in. east in place of the 21 ft. straight east. This crook or offset was made for the purpose of testing the effect of angles or "corners" in the flow of hot water and steam (page 170). Return falls 9 ft. 8 in. south obliquely downward, 23 ft. 2 in. west to southwest corner, 4 ft. north obliquely downward, 2 in. down to the 2-in. pipe of C, entering it 3 ft. 4 in. from where the 2-in. pipe begins. The drawing does not show this last connection just where it should be.

Riser A extends straight east 28 ft., entering riser B 5 ft. 10 in. from the bend at the southeast corner of house.

The long run added March 14th, extended 2 ft. 8 in. vertically upward, 9 ft. 9 in. northwest, 72 ft. west to west end of a radish house, rising gradually the whole distance, $6\frac{1}{2}$ in. vertically downward, 79 ft. east with gradual fall to east side of work room, 6 ft. south, 4 ft. 6 in. down vertically, 4 in. south to main return 6 in. from boiler.

All the runs are $1\frac{1}{4}$ in. pipe except the last of the general return as indicated in the description of series C.

The three risers passing into the test house were about 3 ft. 3 in. above the general water level of the boiler as kept for steam. This fall was so slight that this water level cut the oblique 2-in. return about at the top of the T., where the return from risers A and B entered it, thus leaving a 2-in. column of water extending out about 8 ft. from the boiler, part of this distance being horizontal and part oblique.

All thermometers in this test were inserted in the pipes, being packed with rubber in nipples of $\frac{1}{4}$-inch pipe which were in turn screwed into the heating pipes. They were located as follows:—No. 1 in the 4-inch pipe, which served as a steam dome for the boiler; No. 2 in the left riser (C) at the upper northeast corner of the house; No. 3, in this same run inside the cool-pit just before the pipe re-enters the house; No. 4 in the middle riser, B, close to the end farthest from the boiler; No. 5, in the same way at the end of the right riser (A); No. 6 in the upper return in the south side of the house near southwest corner; No. 7 just below it in the lower return.

Three series of general comparisons were made between hot water and steam. From December 29th to January 16th, the apparatus was used for hot water; from January 16th to February 10th, it was used for steam. February 10th to 23d, hot water; February 24th to March 13th for steam. March 16th to 24th for steam; March 25th to April 1st for hot water. The last couplet concerns the comparative tests on the length of the run as influencing the behavior of steam and hot water.

Comparison of out-door and in-door temperatures.

HOT WATER.

	Dec. 29 to Jan. 16.	Feb. 10–23.	Mar. 25 to April 1.
Average minimum night temperature indoors....	48 15–16	50 3–11	52 1–3
" " " " outdoors...	8 1–12	19 3–11	28 2–3
Difference......................	40 41–48	31	23 2–3

STEAM.

	Jan. 16 to Feb. 10.	Feb. 24 to Mar. 13.	Mar. 16 to Mar. 24.
Average minimum night temperature indoors	46 11-17	51 5–7	47
Average minimum night temperature outdoors	16 10-17	22 3–7	25 4–7
Difference..........................	30 1-17	29 3–7	22 3–7

This table shows a slightly greater efficiency of hot water in maintaining a difference between the minimum night temperature outside and in the house. It will be noticed that the greatest difference occurs in the first hot water test. This was during very cold weather, the outside temperature being frequently below zero, and these were the mornings which naturally showed the greatest difference between the outside and house temperature; so that all of this greater difference can not justly be attributed to the geater efficiency of the hot water heating.

Coal consumption.— The coal used during the test was anthracite, egg size, all of which was weighed as used; the following table shows the amount used each day throughout the season.

HOT WATER — FIRST TEST.

Dec.	22,	140 pounds.	Jan.	5,	100 pounds.
	23,	75		6,	75
	24,	75		7,	75
	25,	75		8,	100

Dec. 26, 75 pounds.
27, 75
28, 100
29, 85
30, 75
31, 100
Jan. 1, 75
2, 100
3, 75
4, 75

Jan. 9, 100 pounds.
10, 100
11, 100
12, 100
13, 100
14, 100
15, 100

Total first hot water test, 2250
Average per day, 90

SECOND TEST.

Feb. 10, 100 pounds.
11, 75
12, 75
13, 125
14, 100
15, 100
16, 125
17, 125

Feb. 18, 125 pounds.
19, 125
20, 125
21, 100
22, 100
23, 125

Total second hot water test, 1525
Average per day, $108\frac{13}{14}$

THIRD TEST.

Mar. 25, 150 pounds.
26, 100
27, 125
28, 100
29, 125

Mar. 30, 100 pounds.
31, 125
Apr. 1, 125

Total third hot water test, 950
Average per day, $188\frac{3}{4}$

STEAM — FIRST TEST.

Jan. 16, 50 pounds.
17, 100
18, 100
19, 100
20, 100
21, 100
22, 100
23, 100
24, 100
25, 75
26, 75
27, 75
28, 75
29, 75

Jan. 30, 100 pounds.
31, 125
Feb. 1, 100
2, 125
3, 125
4, 125
5, 125
6, 100
7, 100
8, 100
9, 100

Total first steam test, 2450
Average per day, 96

SECOND TEST.

Feb. 24,	125 pounds.	Mar. 7,	100 pounds.
25,	100	8,	100
26,	75	9,	100
27,	75	10,	100
28,	100	11,	100
Mar. 1,	100	12,	100
2,	100	13,	Disconnected
3,	100	14,	150
4,	125		
5,	100	Total second steam test,	1825
6,	75	Average per day,	$101\frac{7}{18}$

THIRD TEST.

Mar. 15,	100 pounds.	Mar. 22,	100 pounds.
16,	125	23,	100
17,	100	24,	100
18,	125		
19,	125	Total third steam test,	1100
20,	100	Average per day,	110
21,	125		

Total coal consumption with steam, forty-seven days........	4725
Average per day	$100\frac{25}{47}$
Total coal consumption, hot water, fifty-three days..........	5375
Average per day..	$101\frac{22}{53}$

Fluctuation.— The detail record of temperatures showed that the fluctuations both with steam and hot water were unusually large. This is largely owing to the small size of the plant and its inadaptability to steam heating. The expansion tank was small and would sometimes boil over, and reduce the amount of water so much that after cooling somewhat, there would not be sufficient water to fill the pipes, while with steam the conditions were such that a uniform and satisfactory circulation could not be insured without a small amount of pressure, which could not be maintained.

Influence of pressure.— The effect of pressure can not be more forcibly shown than by giving the average temperature of all the thermometers for the fifteen steam readings when the steam gauge showed a pressure of 1 lb. or more, and comparing these with the general averages throughout the test as shown (on page 170) in a majority of cases when no pressure was present.

Av. temp. at boiler with 1 lb or more pressure.............							213	2–15
"	"	of thermometer No. 2, Riser C, 1 lb or more pressure					214	7–15
"	"	"	"	No. 3, Riser C,	"	"	202	11–15
"	"	"	"	No. 4, Riser B,	"	"	212	8–15
"	"	"	"	No. 5, Riser A,	"	"	214	2–5
"	"	"	"	No. 6, Upper return B,	"	"	205	3–5
"	"	"	"	No. 7, Lower return C,	"	"	162	3–5

These figures fully agree with the results obtained in the tests of the previous winter, and demonstrate the utility of pressure in forcing steam through long and unfavorable circuits. The observations then made as to the effect of different rates of pressure on the temperature within the pipes were as follows:

1 lb of pressure increases the temperature..........				1—3°
2 lbs	"	"	"	3—4°
3 lbs	"	"	"	5—8°
5 lbs	"	"	"	12—14°

These figures only roughly approximate the temperature under different rates of pressure, and the ratio is not wholly a constant one in practice, but in a general way about the same ratio holds good in the present tests.

The average temperature of the thermometer in the lower return is far below that of the others as well under pressure as without, and this difference was more noticeable towards the last of the test. This serves as a good illustration of the bad effect of uniting returns before they are carried below the water level of the boiler. The water level of the boiler reached about to the point where the upper return dropped into the oblique 2-inch pipe of the lower one, and doubtless whenever the water was low enough to admit of an air connection here, the steam returning from the upper one would serve as a trap to shut off the circulation from the lower, a fact which was frequently demonstrated by closing the valve of the upper return, when a circulation would at once develop in the lower one, with a very sudden rise in the temperature of that thermometer. In the latter part of the season the water was kept at a lower level to provide more space for the formation of steam in the boiler, and this difficulty was more noticeable.

Influence of crooks and angles.—As previously explained (page 165), a section was cut from the middle riser, B, Jan. 31, and re-connected 2

22

ft. and 3 in. beyond by pipes at right angles, thus introducing four extra angles in this riser. The following table shows the average temperatures at the boiler and at the east end of this riser in the steam and hot water tests just preceding and following this change:

HOT WATER.

Dec. 22–Jan. 16, without extra crook.

Average temperature boiler	159	14–43
" " riser east end	145	10–43

Feb. 10–23, with extra crook.

Average temperature boiler	178	6–11
" " riser east end	131	18–23

STEAM — GENERAL AVERAGE.

Jan. 16–31, without extra crook.

Average temperature boiler	206	8–21
" " riser east end	187	1–21

Jan. 31–Feb. 10, with extra crook.

Average temperature boiler	200	1–3
" " riser east end	135	5–21

STEAM — 1 LB. OR MORE PRESSURE.

Jan. 16–31, without crook.

Average temperature boiler	211	1–4
" " riser east end	212	1–4

Jan. 31–Feb. 10, with crook.

Average temperature boiler	211	3–7
" " riser east end	212	

STEAM — NO PRESSURE.

Jan. 16–31, without crook.

Average temperature boiler	204	4–5
" " riser east end	184	

Jan. 31–Feb. 18, with crook.

Average temperature boiler	193	3–11
" " riser east end	123	3–11

This shows that, taken as a whole, these extra angles impeded the circulation of steam more than of hot water. But if we compare the temperatures taken under one or more pounds prsesure, as in the third part of the table, it is seen that there the extra angles have no perceptible effect, while if only the readings taken with no pressure are averaged, as in the last part, the difference is very great.

This shows that crooks and angles impede the circulation of steam under pressure much less than of hot water, and emphasizes the utility of pressure in forcing steam through long and crooked circuits; and it also enforces the great value of steam over hot water in all places where difficult runs are necessary, and where additions and alterations are likely to be made to the house.

When the long run was added, March 16th, it was necessary to raise the expansion tank above the roof, which increased the water pressure to an average of $3\frac{1}{2}$ pounds. The average difference between the temperature at the boiler and the east end of the middle riser, was less in this test than in the previous one with hot water, after the addition of the extra crook, but this may have been purely accidental, rather than due to any beneficial effect of the greater pressure afforded to the tank.

Time required to heat up each system.—

HOT WATER.

	No fire A. M.	Fire 15 minutes.	Fire 30 minutes.	Fire 45 minutes.	Fire 1 hour.	Fire 1¼ hours.	Fire 1½ hours.	Fire 1¾ hours.	Fire 2 hours.
Time	11.10	11.25	11.40	11.55	12.10	12.25	12.40	12.55	1.10
Boiler thermometer No. 1	53°	83°	89°	110°	145°	160°	175°	192°	204°
Boiler thermometer No 2	45°	52°	78°	87°	119°	139°	147°	153°	180°
Boilor thermometer No. 3	45°	45°	61°	71°	95°	118°	123°	140°	155°
Boiler thermometer No. 4	45°	71°	82°	98°	132°	141°	141°	131°	187°
Boiler thermometer No. 5	45°	50°	68°	80°	107°	125°	128°	120°	154°
Boiler thermometer No. 6	45°	51°	72°	82°	108°	118°	116°	107°	135°
Boiler thermometer No. 7	45°	51°	59°	72°	91°	112°	120°	133°	147°

STEAM.

	Fire 20 minutes.	Fire 30 minutes.	Fire 40 minutes.
Time	5.35 P. M.	5.45 P. M.	5.55 P. M.
Boiler thermometer No. 1	152°	206°	210°
Boiler thermometer No. 2	cold*	cold*	212°
Boiler thermometer No. 3	cold*	cold*	195°
Boiler thermometer No. 4	53°	53°	209°
Boiler thermometer No. 5	cold*	cold*	210°
Boiler thermometer No. 6	51°	51°	209°
Boiler thermometer No. 7	49°	49°	207°

* Low temperatures can not be accurately given in all cases, because the thermometers were inserted into the tubes so far that they could not be read below about 50 degrees.

These tables show that with this small plant, the hot water circulation began almost at once after the fire was started, but required nearly two hours to reach a point where it would give off much perceptible heat to the house. With steam, on the other hand, no effect was shown in the pipes thirty minutes after the fire was started, but in forty minutes they were all giving off heat at their ordinary capacity. While hot water moved off first, steam reached the goal the quicker.

Influence of length of pipe.— By taking the averages for the final test under each method, with the long run added, (see pages 164, 165), it was found that in passing through some 84 feet of pipe to the further end of this run, the hot water lost 54 8-13 degrees of heat while the steam lost 7 1-15 degrees, showing that the distance to be traversed is a much more important consideration with hot water than with steam. This run was put up in the way supposed to be best adapted to hot water circulation, namely, highest at the point farthest from the boiler, and it had an abundant fall.

Conclusions.

Under the present conditions, which, as previously stated, were strongly in favor of hot water, the following results can be deduced. It will be observed that they confirm several of the conclusions of last year.

1. Hot water maintained a slightly greater average difference between the minimum inside and outside night temperature than steam.

2. There was practically no difference in the coal consumption under the two systems.

3. With a small plant like this, the fluctuations under both systems are much greater than in larger ones, and neither proved very satisfactory.

4. The utility of slight pressure in enabling steam to overcome unfavorable conditions is fully demonstrated.

5. The addition of crooks and angles is decidedly disadvantageous to the circulation of hot water and of steam without pressure, but the effect is scarcely perceptible with steam under low pressure.

6. In starting a new fire with cold water, circulation commences with hot water sooner than with steam, but it requires a much longer time for the water to reach a point where the temperature of the house will be materially affected, than for the steam to do so.

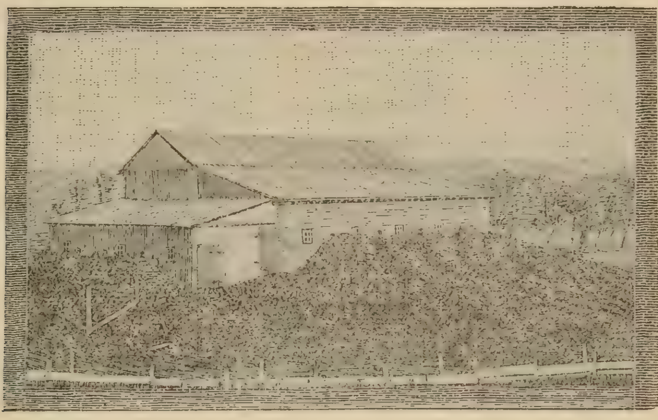
7. The length of pipe to be traversed is a much more important consideration with water than with steam.

8. A satisfactory fall towards the boiler is of much greater importance with steam than the manner of placing the pipes.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

BULLETIN 56—AUGUST, 1893.



THE PRODUCTION OF MANURE.

By GEORGE C. WATSON.

ORGANIZATION.

Board of Control.—The Trustees of the University.

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.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55 Greenhouse Notes.
56. The Production of Manure.

The Production of Manure.

During the winters of 1891–2 and 1892–3 experiments were made to determine the proportion of nitrogen, phosphorus acid and potash recovered in the voidings of the various domestic animals from the amount of these ingredients consumed in the food under the varied conditions which our domestic animals are usually kept. Particular reference was given to the age of the animals, quality and quantity of food consumed, together with the value of the total voidings as plant food and some reference to the value of different absorbents for stable use.

In bulletin No. 27 are given the results of experiments to determine the amount and value of voidings from horses, cows, sheep and pigs. These experiments have been repeated under the same conditions as then existed and also under quite different conditions as regards quality and quantity of food consumed. In some instances the ration was made highly nitrogenous for the express purpose of comparing the percentage of plant food recovered with that recovered from rations containing a much less proportion of nitrogen. In general, however, the food fed during the experiments was similar in quantity and quality to that usually fed on the University farm.

In all the experiments the word excrement is used to denote the voidings of animals and the word manure to denote the voidings mixed with straw or plaster or both. The values given are calculated as nitrogen at fifteen cents, phosphoric acid at six cents and potash at four and one-half cents per pound.

Experiments with sheep.— For each of these experiments two sheep were used and in each trial they were confined in a pen, the bottom of which was covered with water-tight galvanized iron pans. Clean fine-cut wheat straw of known composition was used for bedding in sufficient quantities to keep the sheep clean. The sheep in experiments Nos. 1 to 5 inclusive were mature thoroughbred Shropshire and Horn Dorset rams, in experiment No. 6, grade Merino were used. In each trial the sheep were weighed at the beginning and end; the average weight only is given in the tables. The ration fed consisted, in all trials, of hay and grain of known composition. The following tables give in detail the results of each experiment:

POUNDS OF FOOD CONSUMED AND WATER DRANK.

NUMBER OF EXPERIMENT.	Water.	Hay.	Corn.	Oats.	Wheat bran.	Cotton-seed meal.	Linseed meal.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
1	185.75	81.25	11.50	11.50	....	....	....
2	144.25	58.50	11.25	11.25	....	....	....
3	188.00	50.00	40.55	41.25	....	....	....
4	298.00	92.50	....	....	35.29	17.64	8.82
5	374.25	76.50	....	....	38.14	19.07	9.54
6	194.25	67.00	4.56	....	17.78	8.88	0.77

FOOD CONSUMED AND EXCREMENT RECOVERED.

	NUMBER OF EXPERIMENT.					
	1.	2.	3.	4.	5.	6.
Length of experiment, in days	15	12	13	16	14	21
Weight of sheep	296	318	328	343	381	234.5
Pounds of nitrogen consumed	1.92	1.48	2.298	4.345	4.25	2.445
Pounds of phosphoric acid consumed	.531	.425	.814	2.12	2.19	1.12
Pounds of potash consumed	1.28	.949	1.078	2.299	2.14	1.43
Pounds of excrement recovered	140.75	137.50	199.25	296.	203.25	160.75
Pounds of nitrogen recovered	1.08	.994	1.80	2.83	1.59	1.758
Pounds of phosphoric acid recovered	.35	.298	.665	1.466	1.08	1.106
Pounds of potash recovered	1.089	.830	9.63	1.06	.77	.541
Pounds of excrement recovered per 1,000 lbs. live wt. of animal per day	31.7	36.4	36.4	31.2	37.9	29.8
Value of manure per ton	$3 16	$2 65	$3 30	$3 49	$3 15	$4 17
Value of excrement per ton	3 35	3 01	4 55	6 62	3 44	4 85

VALUE RECOVERED PER 1,000 POUNDS LIVE WEIGHT OF ANIMAL PER DAY.

NUMBER OF EXPERIMENT.	Nitrogen.	Phosphoric acid.	Potash.	Total.
1	$0.037	$0.005	$0.011	$0.053
2	.04	.005	.01	.055
3	.063	.009	.01	.082
4	.077	.016	.009	.102
5	.045	.012	.007	.064
6	.054	.014	.005	.073
Average	$0.053	$0.011	$0.0086	$0.0715

It will be noticed that the voidings recovered in these experiments are comparatively rich in nitrogen and poor in phosphoric acid and potash. This is true not only of the average but also of each individual experiment. In trials Nos. 1 and 2 where the aim was to feed as nearly as possible a maintenance ration the proportion of nitrogen to phosphoric acid and potash does not differ materially from the proportion of these ingredients recovered in experiments where the sheep were fed all the grain they would eat as was the case in experiments Nos. 3, 4 and 5.

The average value of the excrement recovered, per 1,000 pounds of live weight of animal per day, which is a little over seven cents, fairly represents the value of the excrement from a large flock of sheep where a portion of them are fattening animals. It is true that during some of the experiments the sheep were fed a heavy grain ration, but in others they were fed a light ration of carbonaceous grain. The average ought to represent fairly well the excrement from flocks fed clover hay and a fair grain ration.

As the amount of water drank and the food consumed varied greatly in this series of experiments, it will be of interest to notice by comparison the relation of the amount of water drank to the dry matter consumed in the food, and also the relation of the water drank to the nitrogen consumed. The following table gives the dry matter, nitrogen and water consumed in each experiment:

CONSUMED PER 1,000 POUNDS OF LIVE WEIGHT OF ANIMAL PER DAY.

NUMBER OF EXPERIMENT.	Pounds of dry matter consumed.	Pounds of nitrogen consumed.	Pounds of water drank.
1	21	.433	42
2	20	.402	39
3	27	.537	44
4	27	.786	57
5	25	.793	65
6	18	.496	39

Quite contrary to a somewhat popular idea of stock feeders, that the amount of water consumed is controlled to a great extent by the amount of dry matter in the food, the facts brought out by these experiments show quite conclusively that the water consumption is governed far more by the amount of nitrogen in the food than by the total amount of dry matter which it contains. It will be noticed that with one exception (ewes in experiment No. 6) the lowest in nitrogen consumption drank the least water, the next higher in nitrogen consumption was the next higher in water drank, the third in nitrogen consumption also was third in the amount of water drank and this order was maintained throughout the remaining experiments.

The variation in the amount of water drank is controlled more by the secretion of urine than by the amount of total dry matter consumed in the food. This fact has been noted by experimenters in stock feeding and was published by Lawes and Gilbert in "Supplementary Report on the Experiments on the Feeding of Sheep," volume II, page 19, which says: "It may be interesting to remark that the proportion of water drank to the food consumed was the greatest * * * where the amount of nitrogenous substances was the greatest. This is quite consistent with the observation of ourselves and others, that under otherwise equal circumstances the larger the amount of nitrogenous constituents the greater will be the amount of urea passed off in the urine and that, as has recently been shown, the greater the elimination of urea the greater will be the demand on the system for water."

Hålliburton gives practically the same law governing the secretion of urea when he says: * "The quantity of urea in urine varies a good deal, the chief cause of variation being the amount of proteid (nitrogenous) food digested. In a man who is in a state of equilibrium and on an ordinary mixed diet the quantity of urea secreted daily is between twenty-five and forty grams. On a diet poor in proteids it may sink to fifteen or twenty grams, and on a diet rich in proteids it may rise to 100 grams per diem."

It does not follow that where nitrogenous food forms a large portion of the ration that the *manure* will contain a much larger per cent of nitrogen than if the food were only moderately rich in nitrogenous constituents, for in ordinary practice the increased secretion of urine will demand a greater supply of bedding which would decrease the percentage of nitrogen in the manure, so that the proportion of nitrogen to the weight of manure would not be increased while the total nitrogen voided would be in great excess of that voided from less nitrogenous food.

Experiments with calves.— Two high grade Holstein calves were placed on the manure cans as described in the experiments with sheep. The calves were bedded liberally with fine cut, clean, white straw.

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* Chemical Physiology on Pathology, p. 723.

The following tables give the amount and kind of food fed and the details of the experiment :

FOOD CONSUMED AND WATER DRANK.

NUMBER OF EXPERIMENT.	Water, pounds.	Skim-milk, pounds	Corn meal, pounds.	Linseed meal, pounds.	Wheat bran, pounds	Hay, pounds.
1	......	707	6.25	......	6.26	36.25
2	284	......	20.86	7.28	20.86	96.50

FOOD CONSUMED AND EXCREMENT RECOVERED.

	Experiment No. 1.	Experiment No. 2.
Length of experiment in days...............	12	15
Weight of calves in pounds.................	379	580
Pounds of food consumed	755.75	145.50
Pounds of nitrogen consumed...............	5.042	3.064
Pounds of phosphoric acid consumed.........	1.939	1.308
Pounds of potash consumed	1.519	1.871
Pounds of excrement recovered	480.75	327.50
Pounds of nitrogen recovered...............	1.983	2.22
Pounds of phosphoric acid recovered.........	0.314	0.820
Pounds of potash recovered.................	1.556	1.642
Pounds of excrement recovered per day per 1,000 pounds live weight of animal	97.5	38.2
Value of excrement per day per 1,000 pounds live weight of animal	$0.078	$0.056
Value of manure per ton	1.69	2.67
Value of excrement per ton.........	1.60	2.79

ANALYSES OF MANURE.

	Water, per cent.	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.
Experiment No. 1	83.82	0.39	0.094	0.45
Experiment No. 2	71.64	0.605	0.25	0.615
Average	77.73	0.497	0.172	0.532

As would be expected, the manure made in experiment No. 1, where skim milk formed a considerable portion of the diet, was particularly poor in nitrogen and phosphoric acid. Not only was the skim milk more digestible, which resulted undoubtedly from a greater proportion of these fertilizing constituents being used to build up the animal body than was the case in experiment No. 2 where less digestible food was fed, but the increased secretion of urine from the skim milk diet required so great an amount of bedding to keep the calves clean that the manure was necessarily poor.

The difference in the percentage of water of the manure of these two experiments must not be taken in any way to represent the difference of water in the excrement, for in experiment No. 1 it was found necessary to give nearly double the amount of straw bedding that was given to the calves when hay and grain formed the ration. The excrement recovered from these two trials with calves will not differ materially in quantity or quality from that recovered in ordinary practice, for the food fed did not differ materially from that usually fed throughout the country. So that the average value recovered per 1,000 pounds of live weight per animal per day, which is nearly seven cents, will represent the value of the excrement produced from this class of animals throughout the State as well as on the University farm.

Experiments with pigs.— Three trials were made with pigs by keeping them confined on galvanized iron pans, as described with sheep. The pans were large enough to afford comfortable quarters for the pigs, and enough cut straw was used for bedding to keep them clean.

In each trial three thrifty grade Poland China pigs were selected and the food fed was the same kind that had been fed to these pigs for several weeks previous to the experiments. The following tables give the food consumed and the details of each experiment.

Food Consumed.

Number of experiment.	Skim milk, pounds.	Corn meal, pounds.	Wheat bran, pounds.	Linseed meal, pounds.	Meat scrap, pounds.
1	110	64.4	......	......	32.1
2	168	59.32	......	......	29.66
3	135	4.57	4.57	6.86	....

FOOD CONSUMED AND EXCREMENT RECOVERED.

	Number of Experiment. 1.	2.	3.
Length of experiment in days	7	7	7
Weight of pigs	412	459	333
Pounds of food consumed	206.5	256.98	151.
Pounds of nitrogen consumed	4.698	4.723	1.34
Pounds of phosphoric acid consumed	2.29	2.27	.59
Pounds of potash consumed	.589	.624	.322
Pounds of excrement recovered	330.5	342.25	130.75
Pounds of nitrogen recovered	3.217	3.481	1.33
Pounds of phosphoric acid recovered	1.70	1.45	.48
Pounds of potash recovered	.534	.472	.323
Pounds of excrement recovered per day per 1,000 lbs. live weight of animal	108.9	75.8	56.2
Value of excrement per day per 1,000 lbs. live weight of animal	$ .2106	$ .186	$ .104
Value of manure per ton	3.47	3.46	2.94
Value of excrement per ton	4.21	4.46	4.45

ANALYSES OF MANURE.

NUMBER OF EXPERIMENT.	Water, per cent.	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.	Value per ton.
1	78.47	.88	.48	.29	$3.477
2	74.58	.91	.40	.28	3.462
3	69.34	.74	.30	.40	2.94
Average	74.13	.84	.39	.32	$3.29

The seemingly high value of the excrement recovered per day in experiments 1 and 2 was due to the rich nitrogenous food which went to make up the ration during these experiments. As nitrogen is by far the most costly of the fertilizing constituents a comparatively slight increase in this element will materially increase the value of the excrement. About one-third of the ration exclusive of skim milk fed these pigs consisted of meat scrap, a commercial article obtained from the fertilizer manufacturers at a cost of thirty-five dollars per ton and apparently composed of dried meat, blood and small pieces of bone. This meat scrap contained nearly ten per cent of nitrogen.

It will be noticed that the value of the excrement per ton is nearly the same in each of these three experiments, while the value recovered per day is nearly twice as much when the ration consisted of corn meal and meat scrap, as when corn meal, wheat bran and linseed meal were fed. The highly nitrogenous ration greatly increased the liquid voidings and this, more than any other one thing, caused the great weight of total voiding per day without proportionately increasing the percentage of nitrogen.

The value of the excrement per ton was very nearly the same in the three experiments, although the value per day was more than twice as great in one experiment as in another.

These pigs were fed a highly nitrogenous ration for the production of lean meat and without doubt the excrement valued at seventeen cents per day, from 1,000 pounds live weight of animal, is considerably more than would have been obtained had the grain ration consisted mostly of corn.

Experiments with cows.—In the experiments described thus far a small number of animals have been kept on water-tight galvanized iron pans for several days; with cows, however, it was thought best to test a larger number of animals for a shorter period of time, consequently eighteen cows of the university herd were kept tied in the stalls for twenty-four hours and bedded liberally with cut wheat straw and the drops in the rear of the cows sprinkled with plaster. The ration fed consisted of hay, corn, ensilage, grain and roots as shown in detail for each experiment in the following table:

FOOD CONSUMED AND BEDDING USED.

NUMBER OF EXPERIMENT.	Number of cows.	Hay, pounds.	Ensilage, pounds.	Beets, pounds.	Wheat bran, pounds.	Corn meal, pounds.	Cotton-seed meal, p'nds.	Straw used, pounds.	Total weight of cows.
1	18	220	825	95	73.60	17.40	29.00	168.7	20,279
2	18	220	755	180	60.48	15.12	50.40	173.0	20,278
3	17	210	805	170	75.00	15.00	50.00	156.0	19,463
4	18	130	720	30	66 60	4.00	41.40	114.5	19,790

The ration fed during these experiments was the same as that usually fed; no change of food was made in any way on account of the manure experiments. The only change the cows were subjected to was in confining them for twenty-four hours in the stalls, when the practice had been to turn them out in the covered barnyard a portion of each day. So the fertilizer value of the excrement recovered during these trials will fairly represent the average value recovered from the university herd during the winter months, when the cows are fed a hay and grain ration similar to those given in the preceding table.

In comparing this ration with rations fed on farms throughout the State, it must be borne in mind that these cows were large, averaging nearly 1,125 pounds per head, and that it would be better to make the comparison per 1,000 pounds live weight rather than per head.

It is for each farmer to determine for himself whether he supplies his cows with an amount of plant food equal to that fed the university herd before the results of these trials are to be applied direct to his own herd. It must be borne in mind that in all of these trials nearly all of the cows were giving milk and would average about the middle of the milking period.

The following tables give the amount of dry matter consumed and the amount and value of excrement recovered.

PER 1,000 POUNDS LIVE WEIGHT OF ANIMAL PER DAY.

NUMBER OF EXPERIMENT.	Dry matter consumed.	Excrement recovered.	VALUE PER TON.	
			Manure.	Excrement.
	Pounds.	Pounds.		
1	23.7	69.7	$1.76	$1.83
2	23.2	78.3	1.97	2.13
3	25.3	76.5	1.88	2.02
4	21.3	72.1	2.47	2.69
Average	23.4	74.2	$2.02	2.167

RECOVERED FROM 1,000 POUNDS OF ANIMAL PER DAY.

NUMBER OF EXPERIMENT.	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	Pounds.	Pounds.
1	.303	.226	.120
2	.370	.216	.334
3	.343	.217	.283
4	.390	.324	.406
Average	.351	.245	.286
Average value	$.052	$.0147	$.012
Total value	.0802	....	....

It will be seen here also that the nitrogen makes up by far the greater value of the manure, that cow manure is comparatively rich in nitrogen and poor in phosphoric acid and potash is shown not only in the average but also in each individual experiment.

The following table gives the chemical analyses of the manure of each experiment:

ANALYSES OF MANURE.

NUMBER OF EXPERIMENT.	Water.	Nitrogen.	Phosphoric acid.	Potash.
	Per cent.	Per cent.	Per cent.	Per cent.
1	80.46	.396	.24	.32
2	71.11	.42	.25	.46
3	75.62	.40	.26	.41
4	70.80	.49	.41	.57
Average	75.25	.426	.29	.44

The value per day of excrement from 1000 pounds live weight of animal which is a trifle over eight cents represents the value of the excrement produced by the University herd at the prices given. This agrees closely with the results of a former trial published in Bulletin 27, p. 38, which gives eight and two-tenths cents as the average value for the excrement from 1000 pounds live weight of animal per day. As the value given in the former trial was estimated at nitrogen worth 17 cents, phosphoric acid 7 cents. and potash 4 cents per pound, the value per day would be eight-tenths of a cent more than the value given in this bulletin for the same amount of plant food.

As the amount of bedding used in these experiments did not differ materially from the amount used in ordinary practice where the cows are kept tied in the stalls most of the time, the average of these analysis may be said to fairly represent the manure made by milch cows when fed a liberal grain ration.

Experiment with horses.— Five horses, four work horses and one two year colt were put on an experiment of manure production for twenty-four hours. These horses were kept in stalls, the floors of which were water tight. Both the stalls and the drop at the rear of the stalls were bedded with a fine cut wheat straw and sprinkled with plaster.

The work horses were fed hay, and a grain ration of twelve quarts per day, consisting of oats, corn meal and wheat bran; the colt had hay only. The following is the data obtained of the manure recovered.

	Pounds.
Total weight of horses	6410
Plaster used	129
Straw bedding used	112.75
Total weight of manure	555

Value of excrement per year per 1000 lbs. live weight	$27.74
Value of manure per ton	2 21
Value of excrement per ton	3 18

ANALYSIS OF MANURE.

	Per cent.
Water	48.69
Nitrogen	.49
Phosphoric acid	.26
Potash	.48

PER 1,000 LBS. LIVE WEIGHT OF ANIMAL PER DAY.

	Nitrogen, pounds.	Phos. acid, pounds.	Potash, pounds.	Total value.
Recovered	.376	.181	.216	
Value recovered	$ .0559	$ .0108	$ .0097	$ .076

Value per year, $72.74.

Excrement recovered per 1000 lbs. live weight of animal per day, 48.8 lbs.

In this experiment the quantity of straw used as bedding was sufficient to keep the horses clean and probably would be similar in quantity to the amount of straw used in ordinary practice. The amount of plaster used, however, was greater than would ordinarily be be use; this would tend to make the manure of less value per ton than average horse manure where plaster was not used. The value of the excrement, however, would not be changed by the use of plaster unless it prevented waste by its use as an absorbent. The following table gives the average analysis of each kind of manure:

ANALYSES AND VALUE PER TON.

KIND OF MANURE.	Number of experiments.	Nitrogen, per cent.	Phosphoric acid, per cent.	Potash, per cent.	Water, per cent.	Value per ton.
Sheep	6	.7675	.391	.591	59.52	$3.30
Calves	2	.497	.172	.532	77.73	2.176
Pigs	3	.84	.39	.32	74.13	3.29
Cows	4	.426	.29	.44	75.25	2.02
Horses	1	.49	.26	.48	48.69	2.21

It will be noticed that the average amount of nitrogen recovered in all the manures is considerable more than that of the potash and about twice the amount of phosphoric acid. It is true that in some cases the food fed was highly nitrogenous, but in the majority of cases the ration was the same as that usually fed on the University farm.

It remains for the farmer to determine whether the ration he feeds is greater or less in quantity, or poorer or richer in quality than the rations fed in these experiments before he applies these values to the excrement from his own stock. To enable him to do this with some degree of accuracy the following tables give the fertilizer analyses of foods fed in these experiments and percentages of plant food recovered in the excrements of all experiments :

FERTILIZER ANALYSES OF FOODS.

	Nitrogen.	Phosphoric acid.	Potash.
	Per cent.	Per cent.	Per cent.
	1.51	.69	.34
Corn meal	6.95	3.05	1.84
Cotton-seed meal	1.90	.45	1.46
Clover hay (mixed)	1.65	.54	2.55
Linseed meal	5.36	1.90	1.10
Meat scrap	9.62	5.01	.74
Oats	1.785	.75	.51
Wheat bran	2.52	2.84	1.49
Wheat straw	.27	.25	1.13
Skim milk	.58	.22	.12

AVERAGE PER CENT RECOVERED OF ALL EXPERIMENTS.

	Number of experiments.	Nitrogen.	Phosphoric acid.	Potash.
		Per cent.	Per cent.	Per cent.
Sheep	6	62	73	64
Calves	2	56	39	96
Pigs	3	80	73	89
	....	70	62	83

Average of the three constituents, seventy-one per cent.

Without doubt the general average of the plant food recovered is considerably lower than would be the case in ordinary practice where a larger proportion of mature animals are kept. It is frequently stated in general terms that eighty per cent of the fertilizer value of animal food is recovered in the excrement, and when we consider that of the eleven experiments five were made with young animals it is fair to presume from the results of these experiments that considerably more than seventy per cent would be recovered in ordinary practice, particularly if a considerable portion of the stock fed were fattening animals. Below is given in tabular form the average amount of excrement and ts value recovered from 1,000 pounds of live weight of animal.

EXCREMENT RECOVERED PER 1,000 POUNDS LIVE WEIGHT OF ANIMAL.

KIND OF ANIMAL.	Number of experiments.	Pounds per day.	Value per day.	Value per year.
Sheep	6	34.1	$.0715	$26.09
Calves	2	67.8	.067	24.45
Pigs	3	83.6	.1668	60.88
Cows	4	74.1	.0802	29.27
Horses	1	48.8	.076	27.74

It will be seen from this table that the largest amounts recovered per day were in experiments where the food consumed gave a comparatively narrow nutritive ratio or else the food was largely liquid as was the case with the calves. In either case, it was the amount of urine secreted that greatly increased the total weight of excrement.

As the values given in this bulletin have been based on those given for the value of commerical fertilizers it does not follow that any farmer under all conditions will be able to get that value from the manure any more than he is guaranteed to receive that value from the same amount of plant food in commercial fertilizers. It may be the prices given are too high and that they should be greatly reduced or even cut in two. The value per pound of each fertilizing ingredient should be determined by each farmer for himself as he determines whether he can or can not afford to buy commercial fertilizers at the market price. These values, however, afford a means of comparing the value of manures made by the different kinds of domestic animals and vary from $24.43 per year from calves to $68.88 per year from pigs. These values are calculated for the year at the same rate and value for the whole year as the average of the experiments, which would probably be somewhat too high for the classes of animals that are turned to pasture a considerable portion of the year; for animals that are kept in stalls or pens throughout the year there is no reason why the average of these experiments will not represent the production and value for the whole year. It is, therefore, evident that barn manures when produced from fairly nitrogenous food liberally fed, contain a much larger proportion of nitrogen than either phosphoric acid or potash, and that where commercial fertilizers are used with such manures, the most economical application will be secured by applying a much larger proportion of phosphoric acid and potash in the commercial manures than is usually sold in complete fertilizers throughout the State.

As the value of the manure depends so much on the character of the food consumed it will be of interest to notice the difference in the fertilizer value of the foods fed in these experiments and also two other common foods. The following tables give such values:

FERTILIZER VALUE OF FOODS.

	Value of nitrogen in one ton.	Value of phosphoric acid in one ton.	Value of potash in one ton.	Total value per ton.
Corn meal	$4.530	$0.828	$0.306	$5.664
Corn ensilage*	0.780	0.144	0.315	1.240
Clover hay	5.700	0.540	1.314	7.554
Cotton-seed meal	20.850	3.660	1.650	26.160
Linseed meal	16.080	2.280	0.990	19.360
Meat scrap	29.010	6.012	0.666	35.688
Oats	5.355	0.900	0.450	6.700
Skim-milk	1.740	0.260	1.080	2.108
Timothy hay*	3.000	0.432	1.170	4.600
Wheat bran	7.560	3.400	1.341	12.301
Wheat straw	0.810	0.300	1.017	2.127

It will be readily seen from the foregoing table that there is even more difference in the fertilizer value of foods per ton than there is in the value of the excrement from the different kinds of domestic animals usually kept on the farm.

Of all foods fed in this series of experiments the meat scrap contained by far the largest amount of plant food, and its value was also the greatest. The great fertilizer value assigned to this food was due to the large per cent of nitrogen which it contained; although rich in phosphoric acid for an animal food the value of this constituent is small

* Values calculated from analyses given in fifth and seventh annual reports of New Jersey Experiment Station.

when compared to the value of the nitrogen. The value of the potash in this food was only about one-half the value of the potash in the clover hay, while the value of the nitrogen and phosphoric acid was more than five times as great as the value of these constituents contained in the hay. While meat scrap heads the list of foods in value of its fertilizing constituents, it does not follow that its feeding value is above that of other foods given in the table. The feeding value and the fertilizer value of foods are separate and entirely distinct values, and care should be taken not to use them interchangeably. While a food may have a high feeding value for certain purposes, its fertilizer value may be correspondingly low. To illustrate this point, corn meal has a high feeding value for the production of fat meat, while on the other hand its fertilizer value is very low, being only about two and one-half times more than of wheat straw.

Of the vegetable foods cotton-seed meal has the greatest value in fertilizing constituents, and as was the case with meat scrap the greater part of the value is in the proportionately large amount of nitrogen which it contains, and also like meat scrap the fertilizer value is equal to the selling price as a cattle food in our markets.

It will be noticed that corn meal has a low fertilizer value; not only is it poor in phosphoric acid and potash but it is also low in nitrogen, the total value, five dollars and sixty six cents per ton, being only a little more than two-thirds of the fertilizer value of clover hay. While corn meal ranks high as a food its fertilizer value is low and is often over-estimated by many stock feeders. This over-estimation in fertilizer value probably comes from estimating the fertilizer value from the feeding value.

The clover hay fed in this series of experiments had a fertilizer value of seven dollars and fifty-five cents per ton, which is often as much as the selling price of clover hay. It is true with the hay also, that the greater part of the fertilizer value is in the nitrogen which it contains, although the mineral matter contained in the hay is considerably more than that in corn meal.

When we compare the fertilizer value of corn meal and clover hay we may expect greater value in the manure produced from a ton of clover hay than from a ton of corn meal.

Oats have a fertilizer value of \$6.70 per ton, which is greater than that of corn meal but less than that of clover hay.

Wheat bran is the richest in mineral matter of our common concentrated foods, having a fertilizer value of \$12.30 of which the phosphoric acid and potash has a value of $4.74, being a much larger proportion of mineral matter than that contained in the other concentrated foods fed in these experiments.

All the foods so far considered that have a high fertilizer value have been rich in nitrogen when compared to the amounts of phosphoric acid and potash which they contain. As would be expected from foods that are nitrogenous in composition, we have found that the excrement produced from these foods have also been too nitrogenous for a well balanced plant food, and when applied as a fertilizer should be accompanied with a further application of phosphoric acid and potash.

Comparatively little work has been done in the past decade to determine the amount of plant food recovered in the excrement from that consumed in the food under the various conditions which our domestic animals are usually kept. Particularly do all recent investigations appear insignificant when compared to the importance of the need of a more thorough knowledge concerning the production, value and care of barn manures. It is only through repeated, thorough investigations, showing positively beyond a doubt the value of animal excrement and the proportionate amount of plant food wasted to that actually restored to the land, that better care will be given barn manures, by farmers in general, and more economical methods of applying manure be practiced. Should the results of these experiments prove of some aid in practicing greater economy in the manufacture, care and application of barn manures the time and labor bestowed on these investigations will be well repaid, knowing that the aid given is for the advancement of one of the most important questions to be met by the farmers of this State.

GEORGE C. WATSON.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BULLETIN 57—SEPTEMBER, 1893.

RASPBERRIES AND BLACKBERRIES.

I. Black Raspberries as a Farm Market Crop.

II. Various Observations upon Raspberries and Blackberries

By Fred W. Card.

ORGANIZATION.

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BULLETINS OF 1893.

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51. Four New Types of Fruits.
52. Cost of Milk Production.— Variation in Individual Cows.
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57. Rasberries and Blackberries.

I. Black Raspberries as a Farm Market Crop.

The growing of raspberries to be sold fresh in market is comparatively well understood, although it has its difficulties. The chief design of this bulletin is to call attention to the adaptability of the black raspberry for evaporating, as a farm market crop, to be grown by anyone who may have a taste for that work, regardless of proximity to markets; and the object is rather to disseminate information collected from various sources than to make a record of experiments. Many of the farmers of the country are practically debarred from competing in certain lines of production on account of the heavy expense of getting their products from the farm to the market, or to the nearest railroad station. To grow potatoes when the distance is so great that half a day is required to deliver a load to the station, is to work under a very serious disadvantage, for the product possesses small value in proportion to its weight, a load of a ton and a half being worth only from $20 to $30; hence to deduct $1.50 from this amount for the mere cost of hauling means the loss of a large percentage of the profits. An equal weight of evaporated raspberries, on the other hand, would be worth on an average about $600, and an item of $1.50 for hauling is a very different matter.

The advent of the berry harvester makes it possible to conduct berry farming in just such remote locations. Without this implement, the evaporator is just as dependent on location as the grower who sells fresh fruit, for it is only in the vicinity of towns of considerable size that pickers can be secured in sufficient numbers to make a safe business in small-fruit growing.

Varieties.— The variety chiefly grown for evaporating purposes throughout the great evaporting sections of central and western New York is the Ohio, yet it is by no means certain that this is the best. It is a comparatively dry berry of secondary quality, containing a large proportion of seeds, and giving a high yield in pounds of dried fruit. Hence it has naturally come into favor with growers, for the latter reason, if for no other. It has been shown, however, that the mere fact of dryness in a variety does not make it yield heavily when evaporated. In some tests made by Professor Goff several years ago, the smallest and juciest berries were found to yield the most dried fruit. With a few of our best growers the Gregg is coming to supplant the Ohio, and where it proves to be hardy it is a more desirable variety to grow, especially if picking by hand is practiced, for the large firm berries are much preferred by pickers. They adhere to the bushes more firmly than most other varieties, and some growers do not find it satisfactory to gather them with the harvester; others, however, do gather them successfully in that way. The variety does not prove so universally hardy and satisfactory as the Ohio.

In tests made at the Ohio Experiment Station several years ago, the Gregg was found to yield the greatest amount of food value per bushel of green fruit of any variety tried, although it did not equal the Ohio in pounds of dried fruit per bushel.

Soil.— Raspberries succeed on almost all good soils, yet to secure the most profitable results they should have one which is well drained but moist and easily worked. A sandy or clay loam is excellent. The one thing which they will not abide is a wet, heavy soil or standing water about the roots.

Fertilizers.— No other fertilizer is nearly so popular among growers as stable manure. In replies to questions sent to growers asking what fertilizer is found to be most satisfactory, stable manure is mentioned 44 times, while wood ashes rank next, being mentioned 24 times. The next choice is commercial fertilizer and ground bone or bone meal, each of which is mentioned 4 times. Four growers also say that they use no fertilizers at all; these live in the West. A number of other things are mentioned from one to three times in these replies, among which are superphosphate, compost leaves, mulch of any kind, etc. Ashes and manure-mulch are mentioned three times as giving good satisfaction. One wide awake grower says the best fertilizer is a Planet, Jr., cultivator, and although its efficacy may be open to doubt when used alone, it certainly ranks high in combination with some of the other things mentioned.

It is coming to be more and more fully demonstrated that thorough cultivation is one of the best means of supplying fertility to crops. One other means of supplying fertility, which is worthy of mention, is very successfully employed by M. A. Thayer, of Sparta, Wis. This consists of red clover grown on land by itself, cut when in blossom and applied close along the rows as a mulch while the center of the spaces is kept thoroughly cultivated. This method, accompanied with severe pruning and careful attention to details, has led to some phenomenal yields on his farm.

Perhaps it ought to be said that the strong preponderance of opinion in favor of stable manure doubtless gives it a higher rank than its comparative value merits, for the reason that it is the one material which nearly every grower is most likely to have and to use, and when properly applied it is sure to give satisfaction. It does not follow, however, that thoroughly reliable commercial fertilizer applied in the right proportions might not have given just as good results.

Stable manure contains an excess of nitrogen in proportion to the other ingredients and may be very profitably supplemented with potash and phosphoric acid in the form of commercial fertilizers.

Preparation and Planting.— Little space can be devoted to these subjects. It may be said in general, however, that raw sod ground should be avoided if possible, and it always pays to give the ground a very thorough preparation. Spring planting is always to be preferred for black-caps; yet, if for any reason it is desirable to secure the plants in the fall, a very good method is to plant them in shallow furrows and mulch well through the winter, leaving them in this position until the young shoots have made a growth of several inches in spring; then set in their permanent place. This insures the weeding out of any poor plants and secures a perfect stand in the field. Plant deep. Careful growers who have given attention to this point have satisfied themselves that three to four inches is none too deep to give best results. The plants should be set in the bottom of the furrow and covered lightly at first, gradually filling up the furrow as growth progresses. Plants thus set appear to stand drought better and there is less trouble with the canes blowing down than when planted shallow. One point in connection with planting which should not be neglected is pruning back the plants closely when set. Experienced growers rarely neglect this, but in home gardens, at least, plants are often seen where long canes are left, apparently with the idea of getting fruit at once. Any fruit obtained the first year, however, is at the expense of the growth and vitality of the plant and will be charged up against ensuing crops at much more than compound interest; and plants which are not cut back nearly to the crown when set, do not readily throw up canes from the root, but branch out from the old stalk.

Pruning.— Growers are in general pretty well agreed as to the methods of pruning black-caps. One point, however, needs to be emphasized, that the young shoots should be nipped back low and when they reach the desired height, not allowing them to get considerably higher and then cutting back to the height required. If pinched low, the plant will at once throw out strong and vigorous branches near the ground, making a well balanced self-supporting bush. On the other hand, if it is allowed to grow higher and is then cut back, only weak buds are left, and the result is that they do not develop so rapidly and only three or four of the upper ones start at all, producing a top-heavy and unsatisfactory plant. Sheep shears are very convenient for this summer pruning, or it may be quickly done by merely pinching out the tip with the thumb and finger. To determine whether the manner of doing this would make any difference, two sections of row were marked and in one case the canes were all cut with shears, taking care that the cut should be in a slanting direction so that water would run off readily. In the other case the canes were snapped off by bending them quickly with the thumb and finger, leaving an irregular, ragged end. The canes had grown too high, so that rather more was removed in both cases than ought to have been in the best practice. An examination the following spring showed no perceptible difference in the condition in which the two lots came through the winter. The cane nearly always died back to the first bud in either case, so that while theoretically a smooth, slanting cut would seem to be best, practically it does not matter.

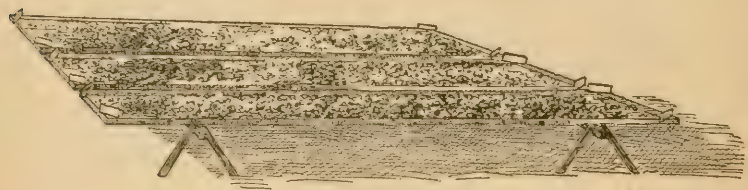
Harvesting.—The means of gathering the crop is one of the most important considerations in growing small fruits, and as before intimated, upon the success of the berry harvester depends the adaptability of raspberries as a farm crop. This harvester is a very simple affair (see picture on page 191), consisting of a canvas tray some three feet square, there being only enough wood about it to form a framework and enable it to be moved about. Under the corner which rests on the ground, there is a sort of shoe of wood enabling it to be slid along from bush to bush easily. In one hand the operator carries a large wire hook with which the bushes are drawn over the canvas or lifted up if too low down and in the way. In the other hand is a bat resembling a lawn tennis racquet with which he knocks off the ripe berries. This is merely a canvas-covered loop of heavy wire fastened in a convenient handle. In place of this, some use a wooden paddle but this probably bruises the berries unnecessarily. In gathering by this method, the berries are allowed to become pretty ripe and the plantation is gone over but two or three times in a season. Many dry leaves, some stems and a few green berries are knocked off with the fruit, but the leaves are no disadvantage for they help to absorb moisture before and after drying, and may aid in preventing mold if the fruit has to stand for some time before going to the evaporator.

The leaves are quickly taken out by running the fruit through a fanning mill after it is dried. Some growers fan them out before drying, but this has the disadvantage of bruising and crushing more berries The berries are usually allowed to stand in the field in boxes for a time after gathering and any insects which may have fallen in will usually crawl out and disappear.

Growers who have had much experience say that a man will average eight to ten bushels a day with the harvester, although much more can be gathered in the best picking. One one farm visited last year, two men and two girls had gathered thirty-one bushels the day previous in ordinary picking, and one of the men had been in the field only part of the time. This shows the first cost of gathering to be less than half a cent per quart. Running them through the fanning mill costs but a trifle ; then before marketing they are picked over by hand to remove stems, green berries and other litter. This does not cost over one cent a pound and is sometimes paid for by the pound at that rate, so that the whole cost may be placed at one cent a quart as against two cents usually paid for hand picking. Growers who have had experience with both methods seem to be united in the opinion that harvesting yields a better quality of dried fruit than hand picking, for the reason that, if picked by hand, they cannot afford to look them over again after drying, and so they do not go to market in as clean and nice condition as those which come from the harvester.

Some extensive and general fruit growers find it inconvenient to attend to the matter of looking over the dried product at the same time that other fruits, which follow on after the raspberries, are claiming their attention, and for that reason prefer to pick a large part of the crop by hand and market it fresh if they can get pickers conveniently. In that case, they find the harvester a great convenience to finish up the last of the crop. Every grower knows how much dissatisfaction and unpleasantness arise in keeping the pickers at their work after the berries begin to get thin. With the harvester, the late berries can all be finished up at one time with a great deal of satisfaction to all concerned. This plan is equally available for those who sell their fruit fresh. The last of the crop can be gathered and dried, thus proving a relief to the market and the patience of the grower and the pickers. This plan of harvesting was invented and introduced by Mr. Benedict, of Dundee, N. Y., and is extensively used by the berry growers of that region.

Drying out of doors.—Various methods of drying are employed, the simplest of which is to dry on boards in the sun. This usually takes from three to five days and the picture shows the way in which it is ordinarily done. Platforms or trays about twelve feet long and three to four feet wide are made of matched boards. A narrow strip is nailed around the edge of each tray to prevent the berries from rolling off. The trays rest upon long horses made of scantling, to hold them at a convenient height from the ground. A little block is tacked across each corner of the trays so that at night or in case of a shower they can be stacked up on top of each other and covered with boards or canvass. This is of necessity a slow way of drying and the cost of lumber for trays to handle a large crop would be an item of considerable expense. One of the chief objections to the method, however, is the large number of flies which it calls to the scene. This does not tend to render the fruit an appetizing product, and must act against all dried raspberries in market among those who are familiar with the method. Sun-dried raspberries are usually quoted about one

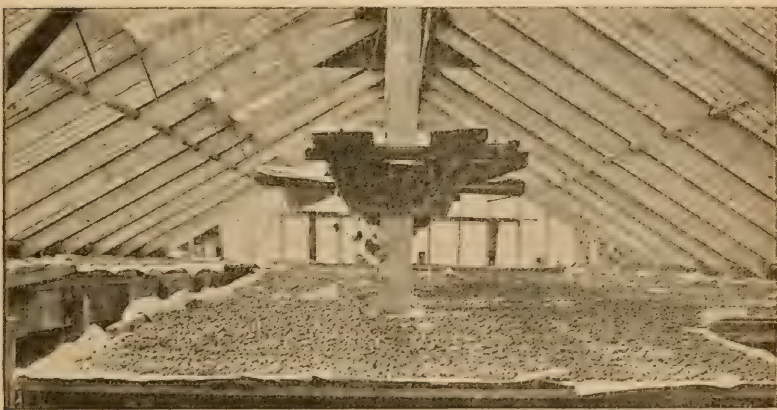


Drying berries out of doors.

cent a pound below evaporated berries, but consumers can never be sure which they are getting. It is possible that these trays might be covered with fly netting, but this would increase the time needed for drying, and even that does not wholly obviate the difficulty, unless the netting is held above the fruit in some way. A recent attempt to dry blackberries under glass when covered with netting proved such a failure, inducing so much more molding, that it can hardly be recommended.

Drying under Glass.— Another method employed by those who have greenhouses for the winter forcing of vegetables, is to utilize the space under the glass during the berry season for this purpose. The cut is reproduced from a photograph taken in a forcing-house on the farm of J. W. Corbett, near Watkins, N. Y., in the summer of 1892, and is an excellent illustration of this plan of drying. In this situation the berries usually dry in about three days in bright warm weather and are of course less liable to injury from storms, than outside. The plan is open to the same objection regarding flies that was mentioned in the out door drying, however. It is advisable to have as much air passing through the house as possible, hence the door and ventilators are left open. It would seem, however, that by using screen doors and protecting the ventilators with netting, most of the flies might be excluded.

Drying with Evaporators.—For a business of any considerable extent, by far the best way of drying is by means of some good evaporator. There are many different makes of these in market, most of which do good work. The hot air machines were first introduced and are still very largely in use. Later steam came to be used and many of the large machines are now fitted for steam heating. These being newer are



Drying berries in a forcing-house.

naturally said to be superior, and if they can be operated in connection with a plant where exhaust steam can be utilized, they undoubtedly possess an advantage. One of the points of superiority is the less liability to scorching with steam. From several years' experience with a large hot air machine, however, I do not think this point has much weight, for with any reasonable care no fruit is scorched by either method. The temperature of the stack should run from 160 degrees to 180 degrees Fahrenheit. One very essential point in any machine, whatever the make, is a strong draft of air through the stack. The amount of vapor given off by a machine full of hot green fruit is very great, and every possible facility is needed for carrying it away. The difference in the amount of fruit which can be dried in a damp cloudy day and in a bright clear day when the wind is in the northwest, emphasizes this point very strongly. In some of the large horizontal machines, it is necessary to secure this draft by means of large fans revolved by steam power. With many of the machines in use the fruit is put in at the lower end ; the trays follow one after the other and can only be taken out at the opposite end, necessitating a two story building if it is an upright stack. This plan possessess the advantage of utilizing all the space in the stack, but, on the other hand, it possesses some decided disadvantages. All the trays must be carried down stairs or let down through the floor each time they are used, or carried back the length of the evaporator if it is a horizontal machine. Moreover, all the work must be timed and a tray put in just so often, otherwise it may reach the top too green and all operations must stop and wait till it is dry, or two or three trays must be put together and be sent through the whole length again with the chances that the first will then be dried altogether too much. If put in too slow, or if fruit is not coming in quite fast enough to keep the business going, it may be too dry when it reaches the top the first time. This is especially disadvantageous if it happens to be necessary to dry different kinds of fruit which do not require the same length of time in the evaporator. In a machine in which the trays are carried on hangers attached to an endless chain subject to the control of the operator, all this difficulty is done away. The trays are put in and taken out at the same place, and any tray can be brought around to the door and examined as often as desired and taken out when ready. In putting in fruit, one tray, only, is usually placed on a hanger at a time, so that in the natural course of the work every tray comes under the eye of the "stackman" as often as it needs to be examined.

I have no accurate figures as to the cost of evaporating, but it can be inferred approximately from the price which evaporators charge other parties for doing the work. In some sections this charge is one cent per quart, in others as low as two cents per pound. Two and a half cents per pound appears to be a fair price for drying and cleaning, and as the evaporator owner of course expects to make some profit, the actual cost must be somewhat below this. The yield varies somewhat in different years, so that one cent a quart may mean from three to four cents a pound.

The berries are taken from the machine when still so soft and juicy that to an inexperienced person it does not seem that they could possibly be kept from spoiling. They are placed on the floor or in bins in a curing room somewhere about the building, and are shoveled over every day for about three weeks. By this time any excessive moisture will have evaporated and the balance become evenly distributed throughout the whole mass, which is by that treatment rendered soft and spongy so that it can be readily pressed into the boxes for shipping, a thing which could not be done if they were dried down hard at first. The fruit is of much better quality also, when cured in this way, for it soaks out more readily, making a better product in every way.

Yield.— In reply to the question, "What do you consider a fair average yield per acre of black-caps?" which was one of the questions in a circular before mentioned, I have figures from fifty-eight growers. Computing the average from all these replies, as accurately as possible, we have for the answer 2,493 quarts, or nearly seventy-eight bushels per acre. The majority gave the number of quarts or bushels which they considered an average; others placed their answer in the form of from "seventy-five to 100 bushels," and two gave what they considered high or maximum yields, making it a little more difficult to get the exact average.

The lowest estimate given as an average yield was 576 quarts, the highest 9,600 quarts. I judge that neither of these are extensive commercial growers. The latter estimate is very interesting as showing what can be done with the best culture, for it comes from a very intelligent fruit grower, mainly interested in other lines and who evidently bases these figures on the yield in his own home garden, as his reply is given in the form of "60 quarts to the square rod." A majority of the estimates range from 2,000 to 3,200 quarts. One grower, whose answer to the question is "75 to 125 bushels," adds: "We give closer attention to many of the points in berry culture than most growers, and really average better than I give you." An Illinois grower whose estimate is 2,400 to 3,000 quarts says: "These yields are without any special fertilizing. By using 1,000 pounds of Mapes' fruit and vine commercial fertilizer or similar brands, the yield can be doubled, we are confident."

The yield in pounds of dried product per bushel of green fruit varies greatly with different seasons and parts of the same season. Early in a wet season, when the fruit has made a quick, vigorous and watery growth, it may take four quarts to make a pound of dried fruit. At the end of a very dry season, on the other hand, it may take only two quarts. So far as I have been able to learn, growers expect to average about ten pounds of dried fruit to the bushel.

In reply to the question, "In evaporating black-caps, does drought materially affect the yield in pounds of dried fruit per acre?" eight growers say "No," and one of them even asserts that he gets more dried fruit per acre in a dry season. Seventeen say that it does affect the yield, and three of them add that it injures the quality also. Two say "Yes, if early," two, "Slightly," and two, "Not unless very severe." The meaning to be gathered from these replies seems to be that a long drought extending through the early part of the season does injure the yield, but that dry weather, at ripening time only, does not cause any considerable loss, although it is well known that it causes much damage to growers who sell fruit fresh.

Profits.— Basing an estimate on the above figures, we may look for 750 pounds of dried fruit per acre with good thorough management. It is safe to say that this product, through a series of years, will average at least 20 cents per pound, making a gross return of $150 per acre from fields in full bearing. The cost of harvesting and marketing may be summed up about as follows: Harvesting at ½ ct. per quart, $12.50. Evaporating at 2½ cts. per pound, $18.75. Cleaning for market at 1 ct. per pound, $7.50. Marketing at 1 ct. per pound, $7.50. This leaves a little over $100 for rent of land, cost of growing and profits. Accurate figures concerning cost of production are hard to get and each grower can make his own estimates best. A crop of potatoes can be grown between the rows the year of setting which will usually pay that year's cultivation exclusive of the costs of plants, while the second year's crop of fruit will do the same and perhaps more. Plants can be bought at from $6 to $8 per thousand. If set 3x6 ft. it requires 2,420 plants to the acre. Some prefer to plant farther apart than this, in which case the number required would be proportionately less. On the whole raspberry growing for the purpose of making dried fruit can be recommended with confidence to the general farmer who is willing to give it careful attention.

II. Various Observations Upon Raspberries and Blackberries.

Various questions which are frequently asked of the Station are here given more or less full answers. Some of them demand a careful collating of the experiences of successful berry-growers and I consequently issued a circular to the growers in New York and other States, seeking information upon a variety of questions. I have also drawn upon my own experience in commercial berry-growing, and upon various experiments made at this Station.

Average Yields of Red Raspberries and Blackberries.— The average yield of red raspberries and blackberries as well as of black raspberries was asked of many growers. As to the yield of red raspberries, fifty-six growers replied and the average of their answers gives 2201 quarts or nearly 69 bushels per acre. The lowest estimate given in this case was 640 quarts, and the highest 8000 quarts. These were from the same men who gave the lowest and highest estimates of the yield of black raspberries respectively, mentioned in Part I. Most growers place the yield of black-caps higher than that of reds, but six good growers in New York, two in Pennsylvania and one in Delaware place the yields of reds higher than of blacks.

In answer to the same question concerning blackberries, fifty replies were received, and the average of them all is 3158 quarts, or over 98 bushels per acre, the lowest estimate being 1280, and the highest 10,000 quarts.

These figures possess great value, both to persons contemplating going into berry-growing and to those who are already in the business. Growers who find their yields below these averages can rest assured that something is wrong, and that unless some uncontrollable disease is devastating the fields, their system of cultivation undoubtedly needs improving. From the nature of the question, the answers are in most cases estimates rather than actual yields obtained, but they are estimates based on the practical experience of the growers themselves, hence can be taken as very reliable guides.

Pinching back Blackberry Canes.— In reply to the question, "At what height do you pinch your young blackberry canes," the answers ran about as follows: Five growers pinch at from 12 to 18 inches, three at from 18 inches to 2 feet, nine at 2 feet, one at from 2 to 2½ feet, eleven at 2½ feet, five at from 2½ to 3 feet, eight at 3 feet, one at from to 3 to 3½ feet, six at 3½ feet, two at from 3½ to 4 feet, eight at 4 feet, two at 5 feet. Six do not pinch at all and one expresses doubt as to which is the better method.

This shows considerable variance in practice, but a decided preference for low pruning. Forty-three of those who pinch off the young growth, prefer to do it at three feet or less, while 19 cut higher than this. It is quite likely that those who prune at 4 and 5 feet, make this serve as a single pruning and nearly agree with those who do not pinch at all. Several growers have found that much depends upon the variety and pinch some kinds low, and others not at all. Others vary the height according to the soil and vigor of growth. One large grower begins at two feet but rises a little higher each year to avoid the bearing of wood. Much depends, also, upon whether the plants stand alone, or are tied to a wire, after the manner of grapes.

The figures in the following list show the number of times each variety was mentioned in answer to the question, "What varieties are best adapted to close pruning?"

Snyder, 19,
Taylor, 8,
Erie, 6,
All varieties, 6,
Agawam, 6,
Wilson, 5,
Ancient Briton, 5,
Kittatinny, 4,
Lawton, 3,
Bushy varieties, 3,
Wachusett, 2,
Early Harvest, 2,
Bangor, 1,
Stone's Hardy, 1,
Ohmer, 1,
Minnewaski, 1,
All except Wilson, Jr., 1.

It has been found that some varieties show a lack of uniformity in their manner of bearing fruit. At times, most of it will be found close to the main stalk, at other times well out on the laterals. Early Harvest, Early Cluster and Lovett Best are among those which behave in this way. It is better to leave such varieties until the blossom buds show, before pruning, in order to guage the amount of fruit which shall be produced. In the Station gardens here, the Early Cluster has borne remarkably fine crops with comparatively close pruning. Wilson Early sets fruit buds thickly near the base of the laterals and should consequently receive close pruning on the side growths. Early Harvest requires longer pruning of laterals.

Pinching back Red Raspberries.—"Do you pinch back red raspberry canes; if so, at what height?" In reply to this question, thirty-four growers say "Yes," two of the number limiting it to strong growers, however. Thirty say they do not pinch at all; one pinches the first season only and six express doubt as to which is the better method. Among those who do practice it, more pinch at three feet than at any other given height. Eleven pinch at heights varying from fifteen inches to two feet inclusive; twenty-three pinch at heights above two feet but not exceeding three feet, and seven above three feet.

This is an interesting question because it shows such a wide difference of opinion. In a trip through the berry regions along Seneca Lake in the summer of 1892, several growers were found who had been pinching back reds but had come to doubt its advisability and were that summer letting them take their own course. My own experience had led me to pass through the same change of practice and I find that many growers elsewhere are making a similar report. From the present knowledge, I am inclined to think that it is better to do no summer pruning of red raspberries after the first year or two, unless it is in case of very strong growers. In any event, I believe it better to pinch low and early if it is to be done at all. If a plant is pinched as soon as it reaches twelve to eighteen inches in height, so that it will branch low, and develop in a way similar to the Cuthbert plant shown in the cut, it is in excellent shape to bear an abundant crop of fruit; but if neglected until three or four feet high and then cut back, it will usually send out a few weak branches near the top, most of which will be more or less badly injured by the winter and making at best a top-heavy and unsatisfactory bush. The only possible objection to this low branching, shown in the cut on page 206, is the liability to breaking from the settling of heavy snows; but this danger is usually slight.

Those who have observed the matter, report that summer pruning increases the tendency to throw up suckers; and if so it is a strong argument against the practice. It is a matter of wonder sometimes, that red raspberries often make such a feeble lateral growth when pinched, but if there is a greater tendency toward the production of suckers, that fact may explain it. It should not be inferred that the spring pruning is to be omitted also; the bearing canes are then cut back one-fourth to one-third, leaving them from $2\frac{1}{2}$ to 4 feet high. Only the true red raspberries are to be included here. Varieties like Shaffer are similar to black-caps in their habit of growth and should be pruned like them.

Evaporating Red Raspberries.— In answer to the question "Would it pay to grow red raspberries to evaporate if you had no market for the fresh fruit?" thirty-six growers say "No," four think it doubtful, and five say "Yes." Three say that it would pay to evaporate the Shaffer and perhaps some of the five who answered in the affirmative may have had this variety in mind rather than the true reds. Those who have tried it seem to be most positive in the belief that it will not pay. One

A desirable, low-branching cane.— Cuthbert.

grower says "No! No! I have tried it. Five quarts of fresh fruit make only a pound of evaporated." To test the yield in a small way, two quarts each of Shaffer and Cuthbert raspberries were dried on screens in the greenhouse. The baskets were well heaped, making good full measure. The Shaffers averaged twenty-two and one-quarter ounces to the quart and the Cuthberts twenty-three and one-quarter ounces, when put to dry. They were left a week and when taken up were dried more than they usually are when taken out of evaporators, although they were not hard. Each original quart of Shaffers then weighed four ounces and the Cuthberts averaged four and one half ounces. The Shaffers in this case were very ripe and soft. They make more pounds of dried fruit and are brighter and more attractive in color

Undesirable, high-branching canes.

when dried, if picked a little green, when they are red and have not taken on their characteristic dull purple color. Cuthberts dry to a dull unattractive color which would be much against them in market. The quality of both was excellent, and as the Shaffer is a very heavy yielder, t is probable that it might be grown and dried with profit, especially if a special market could be found for the product. They are rather soft to gather with the harvester, however, and if gathered in that way would be ripe and dark in color.

Drying Blackberries.— Dried blackberries are nearly always quoted in market, yet, so far as I have been able to learn, none are grown for that purpose, the supply coming almost wholly from the South, where the wild berries are gathered and are dried in the sun. They are usually poor in quality and quoted at a price which would render it very unprofitable to dry them if there were a market for fresh fruit. In order to learn something of their adaptability for this purpose, eight well-filled quart baskets just as we were selling them fresh, were taken for the purpose. They were made to correspond in weight, so that each quart, with the basket, weighed one and a half pounds. Deducting the weight of the baskets, left three pounds ten and one-half ounces of fruit in each of the two lots of four quarts. Granulated sugar was freely sprinkled over one lot. Four ounces of sugar was thus used, one ounce to each quart, making the weight of this lot plus the sugar five pounds fourteen and one-half ounces. Both lots were put in the greenhouse to dry August third, on wire screens, and covered with mosquito netting to keep away the flies. After one or two days of sunshine, there came one or two cloudy ones and the berries began to mold, so that the netting had to be removed. Those treated with sugar molded less than the others and stuck to the screens less in drying. August twelfth both lots were taken up and weighed. They appeared to be as dry as raspberries usually are when put into the curing-room, but quickly began to mold again when put in a pile together. The four quarts dried without sugar weighed at this date one pound ten and one-half ounces. The four quarts dried with sugar weighed one pound fifteen and one-half ounces. From these weights, it seems that not over twelve to fourteen pounds of dried fruit to the bushel can be expected. The weight of sugar applied seems to be retained, and possibly increases the weight slightly in addition, by retaining more of the juices of the fruit. Those treated with sugar seemed to remain in a softer and better condition for cooking. Judging from this attempt, the blackberry dries very slowly, and under present conditions, at least, there seems to be little promise that it can be profitably grown for evaporating purposes. The quality of dried blackberries is low. They seem to be lacking in sugar and pronounced qualities. Yet the addition of sugar in drying and the perfection of methods in evaporating, may enable the grower to utilize the surplus crop to advantage. But the chief hindrance to such an industry at present is the cheap Southern product.

Hardiness of Immature Canes.— Some growers believe that canes grown late in the season are hardier than those which have had the whole season in which to grow. One Ohio grower reports that in two season's trial, blackberry canes produced after the last of June by going through and pulling up all young shoots at that time, were loaded with fine berries the following season, while those of the whole summer's growth alongside bore but few. To test this, all the young canes were cut from a portion of a row of Snyder blackberries and Cuthbert and Shaffer raspberries, July 6, 1892. The canes thrown up after that date were allowed to go unpruned until the following spring. Upon examination in spring, the Cuthbert canes of late growth were found to have come through the winter in better condition than those which grew the whole season. They appeared to be farther advanced in growth and were uniformly green. The late grown Shaffers also came through in excellent condition. The row of blackberries on which the experiment were tried were badly killed, the late grown ones perhaps even more than the others. These later canes produce fine fruit, but they are smaller, and, judging from their appearance, the yield would be less than on those of longer growth. Whether such canes are hardier because they are immature, or whether they are really better matured is a question. It may be that starting late in the season and making a less rapid growth, they make firmer wood which is really in better condition to withstand the winter than the more vigorous and succulent earliest growth. Or possibly the early canes become somewhat weak and dry and lifeless before the approach of winter.

Removing Young Canes from Old Plantations.— When a plantation has reached the age at which it is decided to plow it up, the question naturally arises whether it will pay to remove all the young canes in the hope of giving more strength to those bearing the last crop. Experiments to test this were made by J. H. Hale, on his farm at South Glastonbury, Conn., and in a limited way at this Station during the present season. Mr. Hale writes as follows concerning the results of his own experiment with black-caps: "Regarding the new canes pulled out of the raspberries in the field we visited, we went over the whole field and took them out entirely with the exception of one row on each of the four varieties. The result was, that the bearing canes retained more life and vigor where the young sprouts were broken away, and while it made no marked difference in the size and quality of the fruit of the earlier pickings, the last two pickings were very much greater in quantity and larger in size of fruit where the canes were taken out, adding at least ten per cent to the crop. The season was somewhat dry, and the strong new growth in the rows where they were left, of course, absorbed a great deal of moisture from the soil, and may account entirely for the reduced yield here. In a general way, also, the fruit was a little earlier where the new canes were taken out."

In general, it may be said that our results fully agree with those of Mr. Hale. The young canes were removed in both cases about the time the plants were in blossom.

Forcing Raspberries and Blackberries.— When the ground began to freeze in the fall of 1892, several strong raspberry and blackberry plants of bearing age were dug about and when frozen, the ball of earth, with the plant, was lifted and transferred to boxes about 20 inches square in the forcing-houses. They were placed in a cool or lettuce-house and came on very slowly, the temperature evidently being too low for them, and no fruit ripened before April. One plant placed in a warmer house came on much more rapidly. As spring approached, bringing higher temperature and more sunshine, the plants began to blossom freely. At first, no hand pollinating was done, but it did not take long to prove that no perfect fruit would be formed without it, and afterwards the flowers were pollinated as they appeared, with good and perfectly normal fruit as the result. This can be quickly done by knocking off the pollen and catching it in a small watch glass set in a convenient handle of wood. The pistils are then dipped in this pollen in the same way in which tomatoes are pollinated. (See page 52, Bulletin 28.)

With young plants started in boxes or large pots in spring so as to be well established when transferred to the forcing-house in the fall or winter, there seems to be no reason why good crops of raspberries and blackberries can not be grown under glass. They appear to require a comparatively high temperature, however, and demand artificial pollination.

Thinning the Fruit.— To test the feasibility of thinning berries, rows of Cuthbert raspberries and Early Cluster blackberry were thinned by clipping off the tips of most of the clusters, and also by reducing the number of clusters, especially in the raspberry. The result was not encouraging, for the eye could detect no increase of size in the berries on thinned plants, and as the principal object was to increase the size and attractiveness of the fruit, it seems to have failed of its purpose. It should be said, however, that the season was favorable for berries and the crop was very fine. In a very dry season or with varieties much inclined to overbear, the result might be different. In general, however, the thinning can be managed well enough and much more cheaply by regulating the amount of bearing wood at the annual spring pruning.

Autumn Fruiting.— Certain varieties of raspberries possess a strong tendency to bear fruit in autumn on wood of the present season's growth, and it is sometimes recommended to take out the old canes in spring in order to induce this habit. To determine whether our common varieties would yield to this treatment, plants of Fontenay, Cuthbert and Shaffer were simply mowed off with a scythe in the spring of 1893 before the young canes started. The results are very definite, if not encouraging. The young canes have made a vigorous growth, but not a single cluster of flowers has appeared on either the Cuthbert and Shaffer plants. There are two or three fine clusters of fruit among the Fontenay plants thus treated, but this is one of the European varieties which are characterized by more or less continuous fruiting throughout the season. Just as good clusters are to be found and apparently as many of them where the plants have been treated in the ordinary manner.

The only advantage in autumn fruiting is the production of a small amount of fresh fruit for family use late in the season, but this trial seems to show little prospect of forcing tardy fruiting by means of encouraging a late seasonal growth.

Effect of Spraying on Pollination.— It is generally supposed that rainy and cloudy weather at blossoming time is injurious to the fruit crop, and the question occurs whether frequent spraying with water at this period would produce any noticeable effect. On June 15, 1892, spraying was begun on Caroline, Cuthbert and Turner raspberries. At that time the Caroline was well in bloom, while the others were scarcely beginning to bloom. The spraying was continued until July first two to four times each day when the weather was bright and pleasant, but omitted when there were rains to take its place. Showers were frequent during the period, but were well interspersed with bright weather and sunshine.

The results were entirely negative, showing no effect whatever from the spraying. The fruits on this portion of the row were just as perfect and abundant, and the plants appeared to suffer no more from fungous diseases than those not sprayed. It is to be noted, however, that the conditions were not the same as those present in continuous cloudy weather, for during much of this time the weather was bright, and insects were numerous and continued working among the blossoms regardless of their being wet so that opportunities for pollination were good.

The test is of interest as showing that there need be no fear of interfering with pollination by spraying for insects or diseases, even if necessary to do it at blossoming time. Of course, it should not be done at that time, ordinarily, on account of our friends, the bees.

Diseases.— Frequent inquiries are received at the Station in regard to treatment of the fungous diseases which prove such serious enemies to berries, and it is greatly to be regretted that so little information can be given concerning them. Of some of them we are ignorant even of the cause, much less of any method of prevention. There is enough work to be done in studying the diseases of this group of plants alone, to occupy the exclusive attention of any expert mycologist. The three serious diseases which I have met the most frequently are the familiar red-rust of the leaves and twigs, the anthracnose or pitting of the canes, and an apparently undescribed root-gall.

The red-rust (*Cæoma nitens*) is one of the diseases which proves very disastrous to black raspberries and blackberries in many sections. Fortunately, this is comparatively well understood and concerted energetic treatment on the part of growers will eradicate it. Studies made under the direction of the Department of Agriculture have shown that it possesses a perennial mycelium which lives over winter in the plant, and develops with the young canes the following spring. The truth of this statement was verified here in a very simple way. In the summer of 1892 a single blackberry bush was found in our plantation affected with this disease. On June 23, all the canes of this plant were cut off close to the ground. New ones immediately sprung up which to the eye appeared perfectly healthy. The following spring, however, at the usual season, the leaves and twigs were covered with the well known orange-red color, showing that the fungus had been continuing its growth all along within the tissues of the plant, ready to develop its spores at the proper time. With this one fact in the life history of the fungus in mind, it is easy to say that a plant once attacked is doomed, and that no amount of treatment can ever eradicate the disease from its tissues. Spraying may prevent the germination of some of the spores which it scatters abroad, but that is all, and it is far more effective and cheaper to begin at the source and prevent their production in the first place, by rooting out and burning every diseased plant the moment it is discovered. It may also be necessary to look after the wild raspberry, blackberry and dewberry plants in the vicinity, for if they are numerous and badly affected the disease may spread from them faster than from any other source.

The anthracnose, (*Glœosporium venetum*) is another serious disease with which we are not so well able to scope. It has been found by studies at the Connecticut station that a hyphæ of this fungus do not extend from the old to the new canes as in the red-rust, so that if all diseased portions could be cut away it would doubtless prove an effective remedy. The fungus is so general and indiscriminate in its attacks, however, that in most cases this is wholly impracticable. It is difficult to combat it with spraying also, for the reason that it is so hard to get all portions of the canes protected with a coating of the material used. Professor Green, of Ohio, who has made some experiments, finds reason for encouragement in spraying with Bordeaux mixture, but believes it will be found necessary to begin with young plantations and treat them thoroughly every year. This disease is usually first noticed upon the canes as discolored and sunken patches, although it may attack the leaves also. When the injury to the canes is well seated, the berries fail to mature and dry up and hang on the stems, and the growth is slight and sickly. The disease is wide-spread. (See Fig. 9 in Bulletin XIX).

Another disease is becoming quite prevalent on our grounds and has also been observed elsewhere, which manifests itself by large knotty swellings on the roots. So far, we have observed it only on Turner and Hansell raspberries. Its cause seems to be a mystery as no insect or fungus has been found in connection with it. Affected plants lose their vigor and productiveness and it is common in the rows affected. So far, the only thing that can be said is to avoid setting plants which show such swelling on the roots. I am afraid that this disease is more common and widespread than anyone knows. Weak and unproductive patches in berry plantations should be examined for this root-gall. In some parts of Western New York a root-gall of insect origin has been serious, but the present disease appears to have a different source.

The Dewberry of the Pacific Coast.—Within the last two or three years, varieties of dewberries which are wild upon the Pacific slope have been introduced to cultivation. These dewberries do not appear to have been studied and they have not been referred to their botanical species. The Skagit Chief and Belle of Washington were received from Washington (State) and planted in the fall of 1891. They have made a very long slender growth, lying flat upon the ground, and in appearance they are very different from the eastern dewberries. The Skagit Chief blossomed this season and it proved to be pistillate, with no stamens or pollen whatever. These varieties belong to the species *Rubus vitifolius*, of the Pacific coast. This is a very peculiar species because some of the plants bear only pistillate blossoms with abortive or rudimentary stamens, others bear staminate flowers, while still others are perfect flowered. This fact, together with the variability in other characters of the species, led to much confusion among the earlier botanical writers, the two sexual forms having been described as different species. In 1827 Chamisso and Schlechtendal described one form of the species as *Rubus vitifolius.** At the same time, on a later page, another form was described by the same authors as *Rubus ursinus.* In 1833 it was again described, this time by Douglas as *Rubus macropetalus.*

All the blossoms of the Skagit Chief observed this year appeared to be purely pistillate. The plants were in blossom June 2d, considerably in advance of the other dewberries and blackberries, and as a matter of course set no fruit. If all plants of the variety are pistillate, like ours, it is useless to plant it alone, and no doubt equally useless to plant it with our common varieties, for not only is the blossoming period different, but it is doubtful whether pollen from so different a species would prove effective in fertilizing it, if present. The Belle of Washington dewberry belongs to the same species as the Skagit Chief. This did not blossom here this year, so that we were unable to learn the character of its flowers. If this should prove to be a perfect or staminate form the two may be planted together with some hope of success.

RECAPITULATION.

1. Black raspberries can be made a profitable farm crop when grown for evaporating purposes, and gathered by the aid of the berry harvester, regardless of proximity to markets. An average yield with good culture is about 75 or 80 bushels per acre.

2. An average yield of red raspberries is about 70 bushels per acre. An average yield of blackberries is about 100 bushels per acre.

3. A majority of growers find low summer pinching of blackberries best for most varieties.

4. Growers are about equally divided in opinion as to whether red raspberries should be pinched back at all in summer. If pinched, it should be done low and early. The canes should be made to branch low.

5. Evaporating red raspberries has not yet proved profitable.

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* RUBUS VITIFOLIUS, Cham. & Schlecht. Linnæa, ii. 10 (1827).
R. *ursinus* Cham. & Schlecht, l.c. 11.
R. *macropetalus*, Douglas, Hook, Fl. Bor.-Am. i. 178 (1833).

6. There seems to be no immediate prospect that blackberries can be profitably grown for evaporating purposes.

7. Berry canes which made their entire growth after July 6th, stood the winter as well or better than those which grew during the whole season.

8. Removing all young canes from a plantation bearing its last crop of fruit materially increases the yield.

9. Raspberries and blackberries can be successfully grown under glass, but require artificial pollination and a comparatively high temperature.

10. Under ordinary conditions, thinning the fruit of raspberries and blackberries other than that done by the spring pruning, does not pay.

11. Cutting off the bearing canes early in spring does not induce autumn fruiting of raspberries.

12. Frequent spraying with water throughout the blossoming period did not interfere with pollination and subsequent fruit production.

13. The only remedy for red-rust is to dig up and burn at once every plant found to be affected. Cut away and burn all canes affected with anthracnose pits and spray the plantation with Bordeaux mixture. Root-galls weaken the plants, causing them to appear as if suffering from poor soil. Removing the plants and burning the roots is the only remedy.

14. The dewberry of the Pacific slope is *Rubus vitifolius.* This species often bears imperfect or pistillate flowers. The Skagit Chief bore pistillate flowers with us and was therefore infertile with itself.

FRED W. CARD.

Cornell University Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

BULLETIN 58—OCTOBER, 1893.

THE FOUR-LINED LEAF-BUG.

By Mark Vernon Slingerland.

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.

Bulletins of 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55. Greenhouse Notes.
56. The Production of Manure.
57. Rasberries and Blackberries.
58. Four-Lined Leaf-Bug.

The Four-lined Leaf-bug.

Pœcilocapsus lineatus.

ORDER HEMIPTERA; *family* CAPSIDÆ.

During the past three years this insect has been very destructive to the foliage of currant and gooseberry bushes in several localities in our State and in other States. In some instances it has rivaled the well-known Imported Currant Worm (*Nematus ventricosus*) in destructiveness, and it has proven a much harder pest to control.

In 1892 it was first noticed in alarming numbers on the currant and gooseberry bushes in the horticultural garden at this Station. By the

FIG. 1— Currant leaves killed by the insect.

middle of June nearly one-half of the leaves on the new growth turned brown, curled up and died (FIG. 1). The red, the white, the black and the Crandall flowering currants, and the gooseberries of all varieties were attacked. The bushes looked as though a fire had swept over them, leaving the prominent top-most leaves brown and dead. The death of these leaves so early in the season greatly checked, and in many cases entirely stopped, the new growth that the bushes would have otherwise made. As the insect usually confines its attacks to the leaves of the new growth, the fruiting portions of the bushes are injured but little for that season. But the check given to the new growth must materially affect the future bearing capacity of the whole bush and especially of these newer portions.

The present season, 1893, the pest again appeared in the horticultural garden but was less numerous and did less damage than in 1892. However, judging from the number of eggs laid this year, the pest will be as numerous as ever next summer. Mr. Chapman, at Peruville, N. Y., also had his bushes badly damaged by the insect this year.

Thus in its attacks upon currants and gooseberries during the last two years, the pest has shown itself a destructive and formidable foe. And the study of its past history which follows, shows that it has many other food-plants and more fully emphasizes the importance of the pest and the necessity for all the knowledge possible regarding its habits and life history that it may be combatted intelligently and effectually.

The Past History, Destructiveness and Distribution of this Pest.

Unlike many of our worst pests, this insect is not an importation from Europe. It is a native to North America. In 1798 the species was described by Fabricius, an European, who discovered it in a collection of insects from North America. It thus received its name in Europe nearly a century ago. Thirty-four years later, Say, an American entomologist, redescribed the insect under the name *Capsus 4-vittatus*, but suspected that it might be *Lygaeus lineatus* of Fabricius. The further history of the insect in this country may be conveniently grouped under two headings.

In New York State.—The first record of the occurrence of the pest in our State is in 1854. Emmons then figured (as a new species without any description or note) the insect as a New York species.

We next hear of the pest in our State as seriously injuring Dahlias. Dr. Fitch says that in 1858 he learned from Mr. Chatfield, an Albany florist, that upon all his dahlia plants that year, the first flower bud which appeared was attacked by these bugs and punctured so that it withered. The two or three flower stalks that then came forth from the base of this one were destroyed in the same manner. Other flower stalks put forth from the bases of these shared the same fate. The result was an enormously broad mass of leaves and stalks grew from one root, without a single flower resulting from the multitude of buds which had been developed. In 1864 Mr. Heffron, of Utica, told Dr. Fitch that these bugs had so infested his dahlias that only three or four little imperfect flowers were produced. And that in all the neighboring gardens that year the insect had been so destructive that no dahlias were to be had.*

In 1870 a wiegelia growing at Salem, N. Y., was noticed by Dr. Fitch to be so thronged with these bugs that scarcely a leaf was free from the rusty yellow spots and many leaves were dead. Some time before Dr. Fitch says he had met with the insect puncturing the flower buds of rose, causing them to perish. He also saw them on the leaves of currant, but never in sufficient numbers to do any appreciable injury. It was also known by Dr. Fitch to occur in sufficient numbers to destroy a portion of the leaves of the bittersweet (*Solanum dulcamera*) and tansy. He also records finding the insect on plantain, soapwort, snap-dragon, sumach and burning-bush. Some black spots occurring upon the green succulent ends of raspberry bushes were supposed by Dr. Fitch to have been made by this pest. This injury was, however, doubtless due to some other cause; for this insect has never been recorded as attacking raspberry, and although there was a row of raspberry bushes next to the currants upon which the insect worked in the horticultural garden here the former were not attacked.

It was not until 1881 that the pest again attracted notice in our State. Then Dr. Lintner found the insect very numerous on a black currant bush in his garden at Albany. Hardly a leaf on the whole bush escaped injury and the more tender ones were killed. Dr. Lintner also records a severe attack upon day-lilies in his garden about this time; their foliage was entirely destroyed. The pest has been observed in the same garden each year since, but not in destructive numbers.

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* These facts may explain why "the dahlia has ceased to be a flowering plant in Western New York," as Mr. Chamberlain, of Buffalo, says in a letter to the Garden and Forest for October 4, 1893. He says the plants are thrifty enough, but if buds form they all blast. Sometimes the young shoots have the appearance of having been stung by insects, but often buds turn black when half grown, with no appearance of insect interference. Such plants naturally throw their growth into the tubers. In the reply which follows the letter Messrs. Ellwanger & Barry, of Rochester, say that for several years their plants have not flowered to their entire satisfaction. They attribute the failure largely to continued dry weather and that growers usually allow too many stems to proceed from the same plant. They have not noticed that the plant has received any serious injury from insects or from fungi.

The evidence offered by Dr. Fitch seems conclusive that similar effects are produced on dahlias by the attacks of the pest. There is need, however, of more observations on this point. If growers will watch their dahlias closely they can soon determine whether or not this widespread loss of flowers is due to the punctures of this insect.

In 1884 the pest made a serious attack upon gooseberry bushes at the Experiment Station at Geneva, N. Y., and so injured the young tips that they have shriveled, withered down and died. During the preceding three years the insect had been present in the same garden. And in 1885 it did considerable damage to sage in this garden and also at Batavia, N. Y. In 1887 Dr. Lintner answered a query in regard to the pest which was destroying the correspondent's currant bushes at Fairmount, N. Y. And in the same year Mr. Van Duzee captured the insect in the neighborhood of Buffalo. This completes the record of the insect in our State up to the outbreak in the horticultural garden here in 1892.

Occurrence of the pest elsewhere.— In 1832 Say recorded the insect as common in the Northwest Territory, Pennsylvania, Indiana, Missouri and Georgia. In 1869 the editors of the *American Entomologist* received specimens of the insect from a correspondent in Painesville, O. It had appeared there the year before and was then quite injurious to the leaves of currant and various other shrubs, as wiegelia, deutzia, etc. Dr. Le Baron in 1861 found that the insect had done considerable damage to his currant bushes and still more to some parsnips in his garden in Illinois. In the same year Saunders says he had seen the insect upon currant bushes in Ontario, Canada, but never in alarming numbers. He had, however, seen it almost entirely destroy patches of mint and other plants. In 1875 Glover recorded the insect as very common in Maryland; and added another food-plant, the potato. Dr. Uhler in 1878 examined specimens of the insect taken near Pembina, North Dakota. He said it appeared to be common in many parts of the Northwest on the eastern side of the Rocky Mountains.

In May, 1886, Dr. Riley found the nymphs blighting the young shoots of both gooseberry and currant bushes at Columbus, O. In the same year Mr. Webster experimented with the insect at La Fayette, Ind., but failed to determine whether the insect injected a poisonous saliva into the wounds made by its beak, thereby causing the death of the punctured object. Prof. Weed found the pest affecting a considerable percentage of the terminal shoots of currant and gooseberry bushes on the grounds of the Ohio Experiment Station at Columbus in 1888. The same season Mr. Manning reports it as injuring more than twenty different species of plants in gardens at Brookline, Mass. The next we hear of the insect is from Kirkwood, Mo., where Miss Murtfeldt found it doing considerable damage to clover in 1890. The same year Prof. Smith lists as common throughout New Jersey. Prof. Cook records the insect as uncommonly numerous and destructive in Michigan to currant in 1891. In 1892, according to Coryell, the pest again appeared in Michigan but was less destructive than the preceding year.

From this study of the past history of the insect it will be seen that it is an old offender, having first attracted attention as a pest as early as 1858. New York and Michigan thus far seem to have suffered the most from the insect, although it is present in alarming numbers in several States. In our State, dahlias, currant and gooseberry bushes, and sage have so far suffered the most.

The record shows that the pest has a very wide distribution in North America, extending from Canada down through the Atlantic States to Georgia, and across the United States north of the Ohio River and reaching to the Rocky Mountains. It has not yet been recorded west of the Rockies nor from the central Southern States, but it is quite probable that it occurs in both these regions.

FOOD-PLANTS OF THE PEST.

The past history of the insect as above narrated shows a surprisingly wide range of food-plants. This fact is more strikingly illustrated in the following list of all of the plants upon which the insect has been found feeding as recorded by the different observers. The names are arranged in groups that indicate whether the plants were being grown for food or medicine, or for ornament, or were growing wild and thus might be termed weeds. The extent to which the different plants were injured by the insect is indicated opposite each.

Plants Cultivated for Food or Medicine.

Name.	Extent of injury.
Radish	Slight.
Clover	Considerable.
Pea	Slight.
Currant, Red, White and Black	Very bad.
Gooseberry	Very bad.
Squash	Slight.
Cucumber	Slight.
Parsnip	Very bad.
Valeriana officinalis	Bad.
Lettuce	Slight.
Potato	Slight.
Mint (*Mentha*)	Very bad.
Sage	Bad.

Plants Cultivated for Ornament.

Name.	Extent of injury.
Perennial Honesty (*Lunaria rediviva*)	Very bad.
Pink (*Dianthus*)	Slight.
Shrubby Althea (*Hibiscus syriacus*)	Considerable.
Geraniums (*Pelargonium*)	Considerable.
Burning-bush (*Euonymus atropurpureus*)	Slight.
Japanese Maple (*Acer japonicum*)	Considerable.
Sumach	Slight.
Sweet Pea	Slight.
Rose	Bad.
Flowering Currant	Very bad.
Deutzia crenata	Bad.
Hydrangea paniculata grandiflora	Considerable.
Syringa (*Philadelphus coronarius aureus*)	Considerable.
Hercules' Club (*Aralia spinosa*)	Considerable.
Weigela (*Diervilla*)	Very bad.
Chrysanthemums	Considerable.
Achillea sp	Considerable.
Dahlia	Very bad.
Bellflower (*Campanula persicaefolia*)	Considerable.
Lysimachia clethroides	Bad.
Phlox suffruticosa	Considerable.
Jacob's Ladder (*Polemonium reptans*)	Considerable.
Heliotrope	Bad.
Morning Glory	Slight.
Bittersweet (*Solanum dulcamera*)	Bad.
Snapdragon (*Antirrhinum*)	Slight.
Day-lily (*Hemerocallis*)	Very bad.

Our observations add to this list the Verbena and Flowering Tobacco (*Nicotiana affinis*), both injured considerably.

Weeds.

Name.	Extent of injury.
Buttercup (*Ranunculus acris*)	Bad.
Bouncing Bet (*Saponaria officinalis*)	Slight.
St. John's Wort (*Hypericum perforatum*)	Bad.
Wild Currant	Bad.
Bedstraw (*Gallium boreale*)	Considerable.
Tansy	Considerable.
Plantain	Slight.
Pig-weed	Slight.

We have also seen the Dandelion and Burdock injured slightly, and the Canada Thistle considerably by the insect.

Botanically considered these lists are of interest as they show an exceedingly wide range of food-plants for a single species of insect. Rarely do we find an insect attacking indiscriminately so many different plants with such widely different characteristics. The fifty-four species of plants represent forty-nine genera in thirty-one different families of the Flowering Plants. The Gymnosperms like the pine, etc., are not represented, and but one genus (*Hemerocallis*) of the Monocotyledons. Fourteen of the plants are useful for food or medicine; twenty-nine are ornamental; while but eleven are wild species. Thus the beneficial results from the attack, rarely severe, of the insect upon the weeds, so termed, is slight compared with its frequently very injurious attacks upon the cultivated plants.

The insect seems to have fully realized that "variety is the spice of life;" for it shows no impartiality, notwithstanding the juice of the leaves may be acrid, bitter, aromatic, mucilaginous, bland, or sweet, and their surfaces be rough or smooth. This list of the food plants is also of interest in connection with the egg-laying habits to be discussed on another page.

INDICATIONS OF THE PRESENCE OF THE PEST.

The insect usually makes its first appearance in this State about the middle of May on the newest, tenderest terminal leaves. The insects are then so small and active in hiding themselves that they are not apt

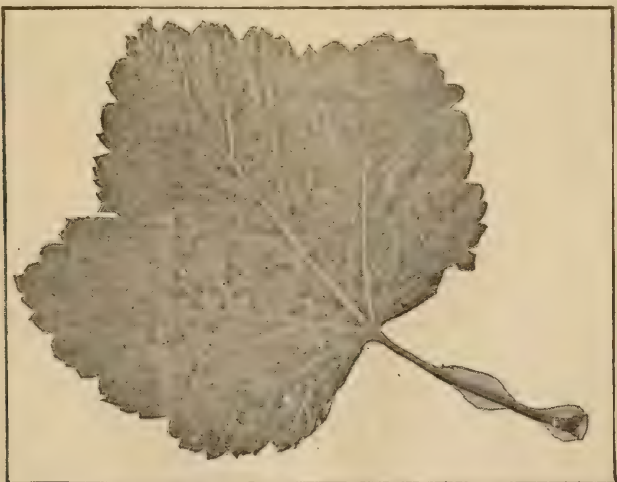

FIG. 2.—Currant leaf, showing the characteristic spots made by the insect, natural size.

to attract attention. Their work, however, soon becomes apparent. Minute semi-transparent darkish spots appear on the terminal leaves. These spots are scarcely larger than a common pin's head, and are round or slightly angular in shape depending upon the direction of the minute veinlets of the leaf which bound them. The insect has inserted its beak into the leaf and sucked out nearly all of the opaque green pulp or parenchyma of the interior within a small area bounded by the little veinlets. (Fig. 2.) The upper and lower epidermal layers of the leaf are not disturbed, except where the beak was inserted through one, and when the interior pulp is withdrawn these layers soon collapse, thus giving the spot a slightly depressed appearance. For two or three days these spots are not very conspicuous, as they differ but little in color from the remainder of the leaf. Soon, however, the collapsed epidermal layers turn brown and die, thus rendering the spots quite opaque and conspicuous. They are slightly more noticeable on the lighter lower side of the leaf than on the upper side.

As the insects increase in size they suck out the parenchyma from larger areas, the spots then often measuring one-tenth of an inch in diameter. If one insect confines its attack to a single leaf for some time, or when more than one works on the same leaf, these spots often coalesce and frequently the whole leaf turns brown, curls up and dies; being brittle it is often torn and broken by the wind. (Fig. 1.) In 1892 the injury to the currants and gooseberries in the horticultural garden here reached this stage and the whole field looked as though a fire had swept quickly through and killed the terminal leaves. When all the tenderest leaves have succumbed, the insect continues its attack on the older leaves lower down. During its lifetime a single insect will destroy at least two or three currant or gooseberry leaves. This accounts for the fact that the injury wrought often seems much out of proportion to the number of insects at work.

When the insects are very numerous, the growth of the shoots is often checked, they droop, wither and die. Some have thought that this blasting of the growth was caused by a poisonous saliva which the insect injected into the wound made by its beak. However, it is more probable that the shoot dies or its growth is checked on account of the death of its breathing organs — the leaves. On the currant, gooseberry and many other plants, the insect confines its attacks to the leaves, but on some ornamental plants, as the dahlia and rose, the most frequent point of attack seems to be the buds. This peculiar phase of the attacks of the pest has been described in the discussion of the past history of the insect.

In brief, the presence of the pest is indicated by the appearance of peculiar brown depressed spots (Fig. 2) on the tender terminal leaves. As the attack continues, whole leaves turn brown, curl up, become brittle and are torn or broken by the wind. (Fig. 1.) The young shoot is checked and frequently droops and dies. The buds of dahlias and roses are often blasted.

THE INSECT'S APPEARANCE.

The immature form. (Figures 4, 5, 6, 7 and 8.) — These immature forms of the insect are called nymphs. When first hatched (Fig. 4) they are so small that it would take nearly twenty of them placed end to end to measure an inch. (The hair lines at the right of the figures in each case indicate the natural size of the insect.) They are easily recognized, however, on account of the shining vermilion red color of the body marked with large blackish spots on the thorax. The antennæ and legs are of a greenish black color. The nymphs grow quite rapidly, casting off their skin five times and undergoing considerable changes in markings as shown in the figures. The body retains the same vermilion red color until the last nymphal stage is reached. The large black spots on the thorax of the newly hatched nymphs are seen to be the beginnings of the wing pads which gradually become more and more apparent at each moult, as shown in the figures.

The full grown nymph (Fig. 8) is of a bright orange yellow color and measures about 5.5 mm. (.21 inch) in length. Their black wing pads, which now have a broad yellowish green stripe near the outer margin, are very conspicuous and extend nearly half way to the end of the abdomen, which is also marked with black. The eyes are prominent and of a dark reddish brown color. The general shape of the nymphs, the relative proportion of the different parts, and the hairs and black markings on the antennæ, legs and other parts of their bodies are well represented in the figures 4 to 8. At the fifth or last moult the adult insect appears.

The adult insect.— Figure 3 shows the general shape and the characteristic black markings of the adult insect as seen from above. In the smaller figure at the right the adult is represented natural size. The general color of the body is bright orange yellow; the legs and the portions between the black stripes on the thorax and wing covers are of a dark apple green color, which usually changes to a lemon yellow after death. The wing covers are mostly of a leathery texture; the black caudal portion which slopes downward at an angle of about 45 degrees is membraneous with the exception of a triangular green portion that usually has a small black spot near its center. The prominent eyes are of a very dark reddish brown color. The sexes are easily distinguished. The females are slightly larger and broader; their abdomen is considerably larger, blunter, and somewhat keel-shaped (Fig. 9, *c*); the caudal border of the segments and the edge of

Fig. 3.— The adult insect; its natural size represented in small figure at the right.

the keel are sometimes blackish in color. The smaller abdomen of the male is more nearly cylindrical caudad and is provided with two black curved hook-like claspers near the tip, which is black on the venter. The four black stripes on the dorsum of the thorax are also usually noticeable wider in the males.

Its Classification.

Many persons in speaking of insects in a popular way call them "bugs." However, all insects are not bugs, but all bugs are insects In other words, when the term bug is properly applied to an insect it means that the insect belongs to a certain division, called the order *Hemiptera*, of the whole great group of insects. Thus only those insects which belong to the order of *Hemiptera* are true bugs. Familiar examples of bugs are the Scale-insects, the well-known Plant-lice, the Pear Psylla, the Bed-bug, the Chinch Bug, and the Squash Bug.

The pest under discussion is one of the true bugs It is a member of one of the largest families, the *Capsidae*, into which order *Hemiptera* is divided. The Chinch Bug belongs to a closely allied family. There are several hundred members of the family *Capsidae* and most of them live chiefly on the leaves of plants from which they derive their nourishment. Professor Comstock has, therefore, in his "First Lessons in the Study of Insects" (now in press) very aptly given to the *Capsidae* the popular name "Leaf-bugs."

Its scientific name.— The name by which this bug is now recognized by naturalists is *Poecilocapsus lineatus*. A glance at the synonomy of the insect as given on another page will show that it has had other names since it was christened by Fabricius nearly a century ago. But the law of priorty requires the recognition of the specific name *lineatus* (the Latin word for lined or striped) given by Fabricius. The genus *Poecilocapsus* was established for the reception of this and allied species in 1875 by a Swedish writer. The first part of the word *Poecilo*, is a Greek word meaning many-colored or spotted; *capsus* is a Latin word signifying wagon-body or an enclosure for animals. Thus the many-colored or striped appearance of the insect is twice suggested in its scientific name. The word *capsus* is without signification when applied to these Leaf-bugs.

Its popular name.—Most of our common insects, and especially those of economic importance, have received popular names. Various things suggest these names, as the food-plant and the habits of the insect, like the Squash Bug and Apple-tree Borer, or some peculiar characteristic of the insect as the 15-spotted Lady-bird Beetle. Unfortunately, however, the same insect may have several of these names, depending upon the locality or the author who writes it. For instance a certain insect is known in one locality as the Buffalo-bug or moth, in another the Carpet-bug, and in still others the Russian-moth.

The pest under discussion well illustrates this point. Dr. Fitch in writing of it in New York in 1870 called it the Black-lined Plant-bug. In 1891 Cook of Michigan named it the Yellow-lined Currant-bug.* The Four-striped Plant-bug is the name applied to the insect by LeBaron of Illinois in 1871. This name has also been used by Saunders in Canada in 1872 and 1883, by Glover, United States Entomologist, in 1876, by Weed of Ohio in 1888, and by Jack in Massachusetts in 1890. Still another name, the one that has priority over all the others, is the Four-lined Leaf-bug which was given to the pest in 1869 by Walsh and Riley. Dr. Lintner has used this name in all his writings on the pest in our State. Miss Murtfeldt of Missouri, also used it in 1891. And it occurs in Professor Comstock's text-books on entomology. The name comes from the number of stripes on the insect, and from its being one of the Leaf-bugs. It is thus the most appropriate popular name that has been proposed. It also has priority, has been used by out State Entomologist, and will come into use through

*This name is quite inappropriate as the general body color is yellowish and the stripes black, besides what are designated as yellow stripes are almost always in life of an apple green color, which usually changes to a lemon yellow several days after death. Again the pest is such a general feeder that it may as appropriately be called the gooseberry, the dahlia, the sage, or the mint-bug, etc.

the text-books mentioned. For these reasons it has seemed best to use the popular name, the Four-Lined Leaf-bug, in this bulletin.

THE LIFE HISTORY OF THE PEST.

Heretofore but little has been known of the life history of the Four-lined Leaf-bug. The earlier observers have given us graphic and quite accurate accounts of its habits and manner of working. And unfortunately they tried to reason out its life history from their knowledge of the life histories of allied insects. "Bad matters have been made worse" by later writers who have not tried to verify from observation the guesses of the early observers; and in consequence most of the preventive methods at present recommended to control this pest, being based upon the old theories, are found to be entirely useless when its true life history is observed.

It is curious how some of these unfortunate guesses of the earlier entomologists will cling to the literature and be handed down by later writers until it seems almost presumptuous to doubt them. Our observations upon the Four-lined Leaf-bug during the past two years have shown it to be a striking example of the necessity for more observations upon our common insects and less theorizing on the guesses of earlier writers who, however, "builded the best they knew" with their meagre facilities and left works which are mines of entertaining and useful information.

All of our observations have been made upon the pest as it works upon currant and gooseberry bushes, but the discussion will consider its other food-plants as well. Our attention was first called to the insect in the latter part of June, 1892, after it had reached its adult stage. Many observations were made to discover the eggs of the insect, and failing in this, every available hiding place was examined through the fall and early spring of 1893, to find the adults which we supposed were in hibernation. However, no trace of the insect could be found after it left the bushes in July.

FIG. 4.—Nymph recently hatched; first stage.

FIG. 5.—Nymph after first moult; second stage.

During the present year we have been more successful. The insect has been under observation both in the field and insectary during the whole season, with the result that, although the insect has been known for nearly a century, its true life history can now be recorded for the first time.

Its first appearance in the spring.—The first indications of the appearance of the insect on the currants in the Horticultural garden this year was about May 27.* At that time many minute vermilion red creatures (Fig 4) were seen at work on the tenderest leaves of the new growth. It was at once suspected that these little nymphs were an early stage of the pest which had done so much damage the year

FIG. 6—Nymph after second moult; third stage.

before. The eggs from which they hatched were soon discovered; and a detailed study of the habits and transformation of the nymphs, from the time they left the egg until they reached the adult stage was begun.

Detailed account of the different stages.—Several of the recently hatched nymphs were isolated in cages in the insectary and their develment watched. It was found that they moulted (or cast off their old skins for new elastic ones which formed underneath the old) five times, or passed through five nymphal stages before the adult stage was reached. Figures 4, 5, 6, 7 and 8 represent the insect on its first, second, third, fourth and fifth nymphal stages respectively as seen from above. All of the figures are, of course, much magnified as is shown by the hair line on the right of each which represents its natural length. But as all of the figures were drawn through a camera lucida to the same scale they

FIG. 7.—Nymph after third moult; fourth stage.

*The first appearance of the pest in the spring has not been before recorded. But from the fact that adults have been seen as early as June 2 in Ohio, the nymphs must appear a week or ten days earlier in some years. Mr. Webster says he used adults of this species in his experiments in Indiana on May 22. It seems as though there must be some mistake here, or else spring opened much earlier than usual so that the first nymphs appeared about May 4.

represent the relative differences in size between the different stages; and the gradual growth of the conspicuous black wing pads, in figure 8, from what seems but black spots in the first stage. The figures also show, clearer than descriptions would, the changes which take place in the black markings on the body and its appendages at the different moults.

FIG. 8.—Nymph after fourth moult; fifth and last nymphal stage.

During the first three stages the whole body is of a vermilion red color with the legs and antennæ blackish green; the last antennal joint has a distinct reddish shade and is slightly enlarged. In the fourth and fifth stages the distal half of the second and all of the third and fourth joints of the antennæ are black; the last joint becomes slenderer, and the basal portion of each antenna and the legs are of a light yellowish green color with two irregular bands of black across the dorsal aspect of each femur, and a yellowish green stripe appears on each wing pad. In the fourth stage the head and first thoracic segment are orange yellow in color, and a day or two after the fourth moult the whole body is of a similar color with irregular lighter yellowish stripes between the rows of black spots on the abdomen. In all the nymphal stages hairs occur on the head and arise in rows from black spots on each abdominal segment. In all stages of the insect, including the adult, the antennæ are thickly set with black hair, and as each joint is lighter at its extremities they have a ringed appearance; the legs are set with many short black spines; the eyes are always prominent and of a dark reddish brown color; the tip of the beak is black and a large black spot occurs on its base.

The newly hatched nymph (Fig. 4) measures 1.3 mm. (.05 inch) in length. The first moult occurs in three or four days.

The second nymphal stage (Fig. 5) lasts three days, and the insect attains a length of 2.1 mm. (0.8 inch).

After its third moult (Fig. 6) the nymph increases in length to three mm. (.12 inch), and the fourth moult occurs in from two to three days.

The fourth stage (Fig. 7) is passed in from five to seven days, and the nymph then measures 3.7 mm. (1.45 inch) in length.

The insect reaches its fifth and last nymphal stage (Fig. 8), the pupa of some authors, in from thirteen to fifteen days after leaving the egg. The duration of this stage is from four to five days, and the nymph measures 5.5 mm. (.21 inch) in length when the final or fifth moult occurs at which the adult insect appears.* Thus the nymphal stage of the insect is passed in from seventeen to twenty days.

The adults first appeared this year about June 13. This agrees with most of the recorded dates of their first appearance. Figure 3 represents the typical marking of the adult. Considerable variations occur besides the sexual one pointed out in discussing the appearance of the

* Dr. Lintner has watched this moult and described it in detail. He says: "The change from the pupa to the perfect insect was made in so short a time, that although more than a hundred examples underwent their transformation in a glass jar upon my table where they were frequently examined, yet in only one instance was the operation detected. It proved so interesting, particularly in the attendant gradual change of color, that it was watched and the following notes thereof taken.

When first discovered the pupal integument had split upon the back and separated so as to show the larger part of the thorax of the inclosed insect, the basal portion of the wings and the intermediate scutellum. The characteristic and conspicuous black marks pertaining to maturity were entirely absent—the only shades observable being orange, yellow and white; the thorax was pale yellow, the scutellum light yellow with its lateral angles orange; the wings were white. In this condition the insect rested for a few minutes, with the terminal half of its wings still encased in their sheaths, and with no movement other than a tremulous motion of the feet. It then turned itself around for a few times and moved several steps over the leaf, when it took position with its head directed downward, its front pair of legs holding to to the leaf and the others detached. Slowly the abdomen was withdrawn from its incasement and the colorless wings from their sheaths. Soon the yellow stripes of the wings began to appear and insensibly to deepen. As yet there was no indication of the black stripes traversing the thorax and wings, or of the black of the membraneous wing tips.

In 25 minutes from the observed commencement of the transformation (at 1 o'clock as noticed), the wing tips had fully expanded. The time occupied in the disengagement from the pupal case was not noted; it could not have varied much from five minutes. At 1 h. 15 m., there were indications of the black stripes in a duskiness of color. At 1 h. 40 m., the lines had deepened to a leaden hue and the antennæ were dark. At 2 o'clock, all the stripes, the small spot towards the wing tip, and the tip, had become blackish, and the bands on the legs were showing. When next observed, at 3 o'clock, the stripes were glossy jet black, and the mature coloring throughout had been assumed.

While change of color frequently attends insect moultings, and usually to a greater or less degree the larvel moults of the Lepidoptera, it is rare that so marked a change as that above noted, ranging from white to black, can be observed, and in so brief a time."

insect. Nearly ever writer in speaking of the lighter stripes between the prominent black ones describe them as bright lemon yellow in color; and no mention is made that they were ever any other color. But, as Dr. Fitch pointed out, they are of a bright apple green color in life. Only one specimen out of the many hundreds observed this season on the current bushes had these stripes yellow in life. Occasionally the stripes retain their green color for several months after being placed in cabinets, but usually the change takes place in a few weeks, especially if the specimens are kept in the light.

The black spots caudad of the outer black stripes on the wing covers are often wanting or nearly so. Among 75 specimens collected this season, 29 of them, mostly females, lack the spots. Thirteen of the specimens, mostly females, showed but little trace of the outer black stripes on the thorax; in some specimens both the stripes and spots were wanting. The black bands on the dorsel aspect of the femurs are sometimes obsolete, especially on the front legs.

Dr. Fitch says the females are much more numerous than the males. Among the 75 specimens mentioned above, 44 are females, and in the field this year there seemed to be nearly as many males as females.

Habits of the nymphs.—The nymphs confine their attacks to the tenderest opening leaves. Their mouth parts are formed into a little beak which, when not in use, extends along the venter close to the body, reaching nearly to the second pair of legs. In feeding, which occupies most of their time, this little beak is placed against the surface of the leaf and four thread-like organs working in a groove in the beak are forced into the tissues. The green pulp or parenchyma of the leaves is literally pumped or sucked through the beak into the body. When the beak is once inserted, the sucking is continued until nearly all the parenchyma has been taken from a round or angular area bounded by the minute veinlets of the leaf and about the size of a common pin's head. This makes a semi-transparent darkish spot on the leaf which turns brown in a day or two owing to the death of the outer or epidermal layers of the leaf. The spots are then quite conspicuous from either side of the leaf, although the nymphs work mostly from the under side. Figure 2 is a reproduction from a photograph of a currant leaf and shows fairly well the characteristic appearance of the work of the insect. The spots are not as distinct as they occur in nature for the difference in coloring between the spots and the rest of the leaf could not be brought out by photography. As the nymphs increase in size the spots are a little larger and more numerous until not only hundreds occur on a single leaf, but often nearly all the parenchyma is taken from the leaf.

The nymphs in any stage are surprisingly active. Their conspicuous coloring would seem to render them easily seen. But they usually manage to see you first and scamper off to the opposite side of the leaf or stem as though they were playing "hide and seek" until you are out of sight. The graphic description of the activity of the adults quoted under the next heading is equally applicable to the nymphs, except that they can only run and not fly.

We believe the nymphs will usually be found only on shrubby plants like the currant and sage ; a few may stray onto herbaceous plants. This seems rather a broad statement. But the discussion of the oviposition and hibernation of the pest on another page will show that it must follow as a natural consequence. And curiously enough, a careful sifting of the recorded facts regarding the insect indicate the same thing. For instance, in all accounts of attacks of the insect upon plants other than shrubs, there is nothing said about nymphs; only the adult is described. Furthermore, where the date of the attack is given, it is in every case after the time when the change to the adult stage occurs. In fact, the only published descriptions of the nymphal stages before the fifth or last were taken from specimens captured on sage.*

Habits of the adult.— The adult insects usually begin to appear about the second week in June. They are provided with a beak and feed in the same manner as do the nymphs. They are more voracious, however, and do more damage. As Dr. Fitch has very graphically said: "These bugs are extremely shy and constantly on the alert to escape notice. When approached they quickly and adroitly slip around the edge of the leaf to its opposite side, where they will be hid from view. Thus on coming to a mass of shrubbery on which there are hundreds of them, their presence will not be suspected, not one of them being anywhere visible. But upon bending a stalk aside so as to bring the other surface of its leaves into view, here and there one of them will be seen, standing quietly on its leaf with a look of perfect innocence and as if unconscious of any guile or deceit; yet watching its opportunity to do so unobserved, it again expertly dodges around to the back side of the leaf. If the hand approaches to seize it, it quickly drops itself down among the foliage beneath. Or if one hand is held under the leaf, whereby it in dropping falls into it

*Miss Murtfeldt speaks of the insect as occurring on clover in the middle of May, and says: "Its broad flat larva is of a dull, pale green color, variegated with a few ferruginous marks and shadings. The pupa is very similar, with the addition of the wing pads." These descriptions indicate that it is very doubtful if she saw the nymphs of the Four-lined Leaf-bug.

and the fingers are closed upon it, ere one is aware, it slips out at some opening between them and falls among the leaves or into the grass. It is not inclined to take wing except as a last resort. By its long, stout hind legs it is adapted for skipping; and its mode of progression is quite singular. It walks briskly a few steps and then gives a skip, throwing itself two or three inches, and then pauses and looks around, apparently to see if anything has noticed and is following it. It then walks a few steps further and gives another skip and again stops and looks back; being evidently aware that when it is moving it is much more liable to be seen by some enemy than when it is standing still." This account is not an exaggeration.

In this connection a statement crept into the literature in 1871, which has remained, and in several cases the only preventive method recommended is based upon it. Dr. LeBaron started it by saying: "The insects of the genus *Capsus* are very active, and instantly take to flight when alarmed, especially in the heat of the day. The only time when they can be captured and destroyed is very early in the morning, when they are chilled by the coolness of the night, and therefore disinclined to fly." After a little experience in trying to capture a few of the insects at different times during the day, we became presumptuous enough to doubt this statement. To test it, a cold rainy morning (June 30) was selected when the bugs would be torpid, if at any time. We were in the field just as day was breaking, before 5 A. M., and in spite of the fact that the books said the bugs should be torpid at this time, they were never livelier! It required just as much dexterity to catch one at that time in the morning as it had the preceding day at about noon. Some species of the *Capsidae* may be torpid early in the morning, but the Four-lined Leaf-bug is certainly an exception on some mornings.

The adults show a decided tendency to wander about onto different plants in the neighborhood of the one on which they feed as nymphs. Early in June nearly every Canada thistle and burdock

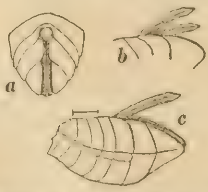

Fig. 9.—Abdomen of the female, showing the ovipositor; *a*, ovipositor hidden in groove; *c*, ovipositor exerted; *b*, blades of ovipositor.

growing in proximity to the currant bushes in the horticultural garden were fairly alive with the adults feeding. Some adults escaped from cages in the insectary and had soon sampled several of the plants in the room. To this wandering habit of the adult is due, we believe, most of the injury reported to the buds of flowering plants and the foliage of its other herbaceous food-plants. As indicated in the discussion of the habits of the nymphs, they work only on the shrubs, while all the reported attacks on the herbaceous plants are directly traceable to the adults only. However, most of the adults must find their way back to the shrubs sooner or later in order to fulfil their destiny in the perpetuation of the species as we shall see in the discussion of the next topics.

Oviposition of the insect.— Nothing has heretofore been recorded regarding the oviposition of this pest. No one has seen the eggs except as they have been taken from the body of the female.

From the time the first adults appeared this year, about June 15, until they disappeared from the bushes about July 15, frequent observations were made to discover if any eggs were laid before fall, and if so, when and where. Egg-laying began about a week after the adults appeared and most of them had been deposited by July 7. The location of the eggs had been discovered in May when the young hatched, so that they were easily found in July.

Unfortunately none of the bugs were caught in the act of laying their eggs. A glance at the ovipositor of the female as shown in figure

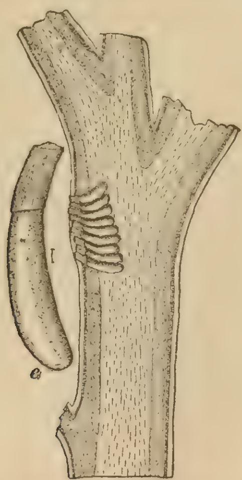

Fig. 10.— Section of currant stem showing eggs in position; *e*, egg, greatly enlarged.

9 is, however, very suggestive. When not in use it lies hidden in a deep groove of the abdomen as represented at *a* in the figure. It can be lifted from the groove as at *c*, and then appears as a thin blade-

like obliquely pointed instrument. Further manipulation with a knife or needle will show that which appears to be a single blade is really made up of two similar blades (Fig. 9, *b*) lying close together. In short, the female is provided with a comparatively long thin two-valved blade-like ovipositor capable of cutting quite a slit in the tissues of a plant; and that is really what does happen.

For the eggs are to be found in slits cut lengthwise into the stems of the plants, extending through the bark, wood, and nearly half way

Fig. 11.— Currant stem showing white egg clusters, considerably enlarged.

through the pith (Fit. 10). The slits vary in length up to one-eighth of an inch, depending upon the number of eggs placed therein. The usual number is 6 or 8; it varies, however from 2 to 14. The eggs lie closely packed together in the slit, as shown in figure 10, with their out ends projecting slightly above the bark.

The eggs, shown enlarged at *c*, figure 10, are 1.65 mm. (.065 inch) in length, smooth, cylindrical, slightly curved or flash-shaped, and of a light yellow color with the upper third capped by a white finely straited portion; the lower end is rounded and the upper irregularly flattened.

With the growth of the surrounding tissue of the stem, the eggs are usually forced out of the slit somewhat, so that about one half or even more of the white portion of the egg projects from the slit as shown much enlarged in figure 12. Later in the season, especially noticeable in the spring, the eggs assume a reddish color doubtless due to the growth of the embryo within.

The eggs are laid only in the soft tender growth made the same season, and almost invariably in the stem. One or two slits containing

FIG. 12.—Portion of currant stem showing three white egg clusters, much enlarged.

eggs have been found in the petiole of a leaf near its base. Eggs are also rarely found six inches from the tip of the shoot. A majority of them are within two or three inches (Fig. 13). In one instance seventy-five eggs were found within three inches from the tip; and sixty-four have been found in one shoot within one and one-quarter inches from the tip.*

* The number of eggs laid by a single female has not been ascertained. Dr. LeBaron records finding from 15 to 24 eggs in the abdomens of females examined. When the egg-laying season was at its heigth, July 7 this year, from 15 to 33 fully formed eggs we found in the females examined.

These egg scars with the white tips of the eggs projecting from them are quite easily seen, and occurring in such a limited portion of the plant have suggested a method of combatting the pest.

Figures 11, 12 and 13 are from photographs of currant stems. In figure 11 several egg clusters are shown considerably enlarged; and in figure 12 are shown three clusters still more enlarged. Figure 13 shows a currant tip natural size and well illustrates the size and position of the whitish eggs in the scars near the center of the stem. The eggs are similarly placed in the stems of gooseberry, flowering currant, and doubtless in its other shrubby food-plants. Eggs were also found in considerable numbers in the stems of wild currant in the field last May. Thus far eggs have been found only in shrubs or woody plants, further indicating, in connection with the fact that these are the only plants on which the nymphs have been recorded, that shrubs are their permanent food-plants.

Number of broods.— Dr. Fitch says: "These bugs which we meet with grown to maturity and paired in the middle of June, lay a crop of eggs from which another generation completes its growth before the end of the season. Thus there are two generations annually." He mentions no observations in support of this statement.

Frequent observations were made in 1892 after the adults disappeared in July, but no indications of the insect were seen until the nymphs appeared this spring. This year, as we have seen, eggs were laid as early as June 25, and these still remain unhatched. Again there are no records of the adults being seen later than July. These facts show that in New York State at least, the insect is single-brooded. Two broods may occur farther south.

Hibernation.— In regard to this phase of the life history of the Four-lined Leaf-bug, all has heretofore been guess work. Dr. Fitch, after admitting that he had not met the insect in its winter quarters, says: "It is evidently in its perfect state, that it passes this period of the year, secreted probably among fallen leaves, or under pieces of boards lying on the ground, in crevices, and other situations where it will remain dry. Coming forth upon the opening of spring, it no doubt lays its eggs upon the young stalks of the dahlia and other vegetation on which the immature bugs afterward appear." Our observations on the oviposition and number of broods just recorded show that this is entirely erroneous. No adults have been seen after July, eggs laid in June now remain unhatched, and nymphs were seen hatching from eggs in May. It is thus obvious that the winter is passed in the egg and not as an adult; the insect thus passes nine months of the year in the egg. This fact renders two of the principal preventive methods that have been recommended practically useless.

Not knowing the manner of hibernation of the insect, its food-plants assume a new interest. A study of the list will show that three-fourths of the plants are herbaceous or die down in the fall, thus offering no shelter for the eggs during the winter. In fact, in only sixteen plants out of the fifty-four species could the eggs pass the winter, these being the shrubs.* Thus only these plants could become the permanent food-plants of the pest. The facts brought out in the discussion of the habits of the nymphs also substantiate this. The wild currants were doubtless among its original food-plants.

Summary of the life-history of the pest.— Briefly stated, our observations upon the life-history of the Four-lined Leaf-bug show that the nymphs appear in the latter part of May upon shrubby plants where they continue to feed upon the tender leaves for two or three weeks, undergoing five moults. The adults appear early in June and often spread to different surrounding succulent plants. Egg laying begins in the latter part of June, the eggs being laid in slits cut in the stems of shrubs near the tips of the new growth. The adults disappear in July and the insect hibernates in the egg. Only one brood occurs each year in our State.

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

The Four-lined Leaf-bug is not an easy pest to control. The new light thrown on the habits and life-history of the pest by our observations during the past two years shows that several of the preventive methods heretofore recommended are practically useless. More caution should be used in recommending remedies or preventives when so little is known of the life-history of the insect. With our present knowledge of the pest the preventive methods to be employed to combat it resolve themselves into two groups — insecticides and mechanical means.

By the use of insecticides.— The food of this pest consists only of the juices of the leaves or buds of the plants upon which it feeds. It is not provided with biting jaws for masticating its food as are many other insects like the potato beetle, grasshoppers and caterpillars. But, as we have seen, its mouth parts are formed into a beak through

* These are the shrubby althea, burning bush, Japanese maple, sumach, rose, currants, wild currant, gooseberry, deutzia, hydrangea, syringa, Hercules' club, weigela, bittersweet and sage; all being ornamental plants except the currants, gooseberry and sage.

which it sucks its food, as does the Pear Psylla, the Squash-bug, Plant-lice and all the other true bugs. As Dr. Lintner has said: "It is evident, therefore, that these insects, living as they do upon the sap of plants, may not be destroyed by means of poisons applied to the surface of the leaves. The delicately pointed sucker would penetrate the poison even when thickly coating the leaf, without imbibing any portion of it." Thus the application of Paris green, London purple or any other poisonous subject would prove of no avail against the Four-lined Leaf-bug.

Some have thought that applications of dust, lime, ashes, soot, soap-suds, tobacco water, carbolic acid washes, etc., might be effectual. Dr. Lintner says, however, that they have on trial been found ineffectual. Walsh and Riley thought that "the plant might be protected against their attacks by a proper use of cresylic acid soap." Experiments have been reported in which a strong solution of this soap was used upon a closely allied insect, the Tarnished Leaf-bug (*Lygus pratensis*); it was entirely ineffectual and would doubtless prove useless against the Four-lined Leaf-bug.

The only insecticide with which we have experimented against this pest is kerosene emulsion, the cheapest and most effectual insecticide yet found for sucking insects.* In June, 1892, an adult was sprayed with the emulsion diluted with twenty-five parts of water. The insect dexterously wiped off with its hind leg a large drop which had accumulated on its back and went its way uninjured. Several adults were then sprayed, care being taken to wet them all over, with the emulsion diluted but five times; some of them seemed "sea sick" for a few minutes but in an hour all were as lively as ever. Adults sprayed with the emulsion diluted with three parts of water were nearly all dead the next morning. Undiluted kerosene killed them in a minute or two.

* To make the emulsion thoroughly dissolve one-half pound hard or soft soap in one gallon of boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool, dark place will keep for a long time. In making a dilution from this cold emulsion it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

This year the emulsion was tried on the nymphs when about one-half grown. When the emulsion was diluted with ten parts of water it had but little effect. But when only five parts of water were used, and the spraying was thorough, the nymphs died in a minute or two.

Prof. Cook reports as follows in regard to the use of kerosene emulsion against the pest in Michigan in 1891: "We sprayed these striped currant bugs on the bushes and in the laboratory with kerosene emulsion made with both hard and soft soap and with pyrethro-kerosene emulsion.* There were almost too few bugs on the currant bushes to make the experiments satisfactory, but in the field and in the laboratory both applications killed the insects, and the bushes in the garden were freed of the blighting bugs."

We have tried no experiments in the field with the emulsion. Our experiments in the insectary as recorded above indicated that the emulsion must be thoroughly applied and must contain at least nine per cent of kerosene (that is, the Riley-Hubbard emulsion diluted with six or seven parts of water) to be effectual against the nymphs, and considerably stronger, diluted not more than five times, to affect the adults.

Prof. Cook's experiments both in the field and the laboratory are, however, quite conclusive and indicate that the emulsion affords a practicable method of combating the pest. As Prof. Cook does not mention the early stages of the insect, it is probable his experiments were made on the adults.

The best and most effectual time to apply the emulsion will be before the insect has reached the adult stage, that is, while they are still nymphs. As the adults begin to appear the first week in June, the spraying should be done the last week in May or as soon as the bright vermilion red nymphs are seen on the bushes. With the insect thus destroyed in its nymphal stage, the buds of dahlia, rose, and the leaves of other herbaceous plants would not suffer from the attacks of the pest if, as the records indicate, the adults alone are responsible for this injury. The insect in all of its stages is so very active that the spraying must be very thorough to be effectual.

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*Professor Cook's emulsions contain one quart of soft or one pound of hard soap dissolved in two quarts of hot water and one pint of kerosene added. This is diluted with an equal amount of water when it is ready for use. This gives nearly seven per cent of kerosene in the dilution as applied; or about the same amount of kerosene that the Riley-Hubbard emulsion has when diluted with nine parts of water. The excess of soap in Cook's emulsions may increase their insecticidal value as used against the Four-lined Leaf-bug. In the pyrethro-kerosene emulsion one gallon of kerosene is filtered through two pounds and a half of pyrethrum powder, and the filtrate is used in the same manner as kerosene in making the emulsion.

We believe that the evidence in favor of the effectiveness of kerosene emulsion is sufficient to recommend it as a practicable method of combating the pest, especially where large areas of an acre or more are attacked. In brief, then, for large areas where some of the mechanical means to be discussed would seem too costly, we would recommend the application of kerosene emulsion (Riley-Hubbard formula) diluted with not more than five parts of water to the shrubs, where the nymphs will be found at work, not later than the last week in May. One thorough application at this time, till it drips from the bushes, will not injure the foliage or fruit and will, we believe, destroy a majority of the nymphs, and thus protect the herbaceous plants from the attacks of the adults. Do not wait until the adults appear before beginning to spray; watch the shrubs for the nymphs.

By mechanical means.—Several methods have been suggested for controlling this pest by mechanical means. These will now be discussed in detail under their respective headings, disposing first of two that our observations have shown to be useless.

1. Burning of garden rubbish.— This was the best method for arresting the depredations of this pest that Dr. Lintner was prepared to offer in 1882. He expected to destroy the adults in this manner. There is no doubt that garden rubbish does harbor many noxious insects and should, therefore, be burned But, as the discussion of the life history of the pest has shown, the adult insect occurs in the rubbish only as an already decaying corpse, if at all; for they arrange for the perpetuation of the species by laying their eggs and disappearing before August. The winter is passed in the egg securely placed near the tip of the bush. Thus the burning of the rubbish would not in the least affect the numbers of the pest the next year.

2. Destroying the females in the spring before ovisposition.— Writing under the supposition that the insect hibernated in the adult state, Dr. Lintner says: "As soon as the leaves of the currants, roses and other early shrubs commence to unfold in the spring -- in all gardens where this insect abounded the previous year, watch should be kept for its first coming abroad from its winter quarters. Nearly all the individuals will be females, with their abdomen swollen with their burden eggs ready to be deposited. They will be found sluggish in their movements, and their conspicuous coloring and marking render them easy to be seen. As an incentive to watchfulness now, it need only to be borne in mind, that for every one captured and killed before oviposition, there will be at least a score less of indefatigable depredators

upon the choicest products of the garden throughout the early summer months, and hundreds less of the augmented later brood."

It is only necessary to again recall the fact that this pest passes the winter in the egg and not as an adult, to see how fruitless would be the watch for the gravid females in the spring.

The two proposed methods of combating this pest just discussed are striking instances of the necessity for more knowledge of the life-histories of some of our insect pests if our farmers and fruit growers are to be taught to intelligently and successfully fight these little foes.

3. Pruning of the bushes to destroy the eggs.— Our discovery of the eggs of this pest in slits in the stems of the shrubs they infest, suggested a new method of combating the pest. All of the eggs are laid before August 1, within four or five inches from the tips of the new growth, and there remain unhatched until the following May. Figure 13 shows a currant tip, natural size, with several white egg clusters plainly visible

FIG. 13. — Tip of new shoot of currant, showing several white egg clusters in the stem near its center, natural size.

near the center of the stem. The eggs are doubtless too well protected to be affected by any insecticide which might be applied, but why not cut back the tips of the new shoots for six inches and burn them?

On bushes which have been infested this year, these egg scars can soon be found, as the whitish tips of the eggs are quite conspicuous. After a few have been found and their characteristics noted, it will take but a few minutes to look over a bush and clip off the tips of the shoots containing the eggs. Burn these tips (the eggs would doubtless hatch in the spring were they left on the ground) and the pest will be effectually checked. Even if the tips of all of the new growth be clipped, the the bush would not suffer more seriously than it would from the pest if present in considerable numbers. On small areas, or with choice plants spend a little more time and cut only those tips containing eggs. The eggs remain in these tips nine months, thus making it practicable to do the pruning during the winter months when other work is not so pressing. The leaves will then also be off and the egg scars can be more easily seen. If currants, gooseberries, or other shrubs have been attacked by this pest, anyone can, by examining the tips of this year's growth for the eggs, at once determine whether to expect it next year or not.

This method of combating the pest is, of course, only applicable to the shrubs, as the eggs will not be found in herbaceous plants. But we believe that this pruning and burning of the tips of the new shoots of currants, gooseberries, and other shrubs attacked by the insect will prove one of the most practicable, and certainly very efficient, method of preventing the ravages of this Four-lined Leaf-bug.

4. The "jarring" method for destroying the nymphs or adults.— On small areas, where choice bushes are attacked, or when the pest appears on ornamental herbaceous plants, the safest, most practicable and efficient way to combat it will be by this method. This can best be done by jarring or knocking the insects into a pan or dish of some kind partially filled with water and kerosene. The bug in all of its stages drops quickly when the bush is jarred. This may seem a rather primitive method but many an acre of potatoes used to be and many garden patches now are saved in this way from the greediness of the Potato Beetle. It will be easier to catch the nymphs of the Four-lined Leaf-bug than the adults in this way, as the latter are more timid, drop quicker, and are apt to fly. Therefore, as many of the nymphs as possible should be destroyed in May and early June.

Nearly all writers on this pest have advised this jarring method for preventing ravages, but always with the proviso that it be done in the cool of early morning while the bugs are comparatively inactive or torpid. Our experience on this point has been given in detail in the discussion of the habits of the insect. A single excursion into the field on a cool June morning convinced us that it is not necessary for one to lie awake nights that they may be on hand early enough in the morning to catch this bug asleep. We have seen practically very little difference in the activity of the bugs at different times during the day, either rain or shine. So that the jarring will be equally as effectual at whatever time of day applied. Catch the nymphs in May if possible and thus preserve the plants, especially the herbaceous ones, from the serious ravages of the adults.

Summary of the preventive methods to be used against this pest.—The arsenites and other poisonous insecticides will have no effect on the bugs, as they feed solely upon the interior juices of the plant. The only other insecticide that promises good results is kerosene emulsion diluted with five parts of water and applied on the nymphs as soon as they appear in May. It will, perhaps, not be so effective on the adults. On large areas we believe it will prove a practicable means of fighting the pest while in the nymphal stages.

The burning of the garden rubbish in the fall will not affect the pest in the least, nor will there be any gravid females to watch for and destroy in the spring, as the pest winters in the egg securely placed near the tips of the new growth of shrubs, as shown in figure 13.

The pruning and burning of these tips in which all of the eggs are laid, will prove a practicable and very efficient means of fighting the pest. The pruning can be done at any time between August 1st and the first of May following.

Probably the best method for general practice, especially against the adults on herbaceous plants, will be to capture the bugs by jarring them into a dish partly filled with kerosene and water. On currants, goosberries, sage and other shrubs one should not wait until the adults appear but capture the nymphs in May.

Thus, there are three practicable methods by which this pest can be controlled: kerosene emulsion for the nymphs; destruction of the egg by pruning; and the capture of the nymphs and adults by jarring into receptacles where they are destroyed. Circumstances will largely determine which method will prove the most practicable in specific cases.

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MARK VERNON SLINGERLAND.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

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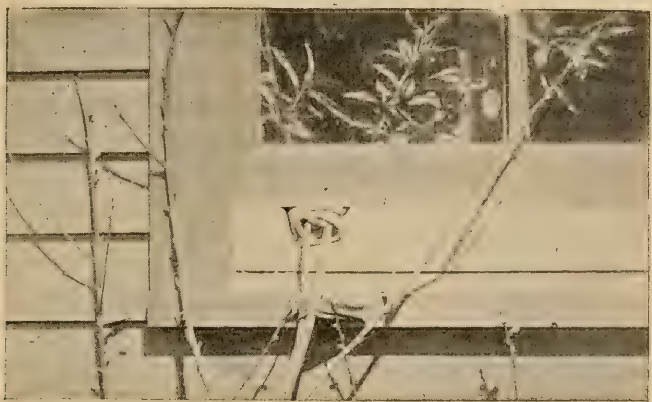

Does Mulching Retard the Maturity of Fruits?

By L. H. BAILEY.

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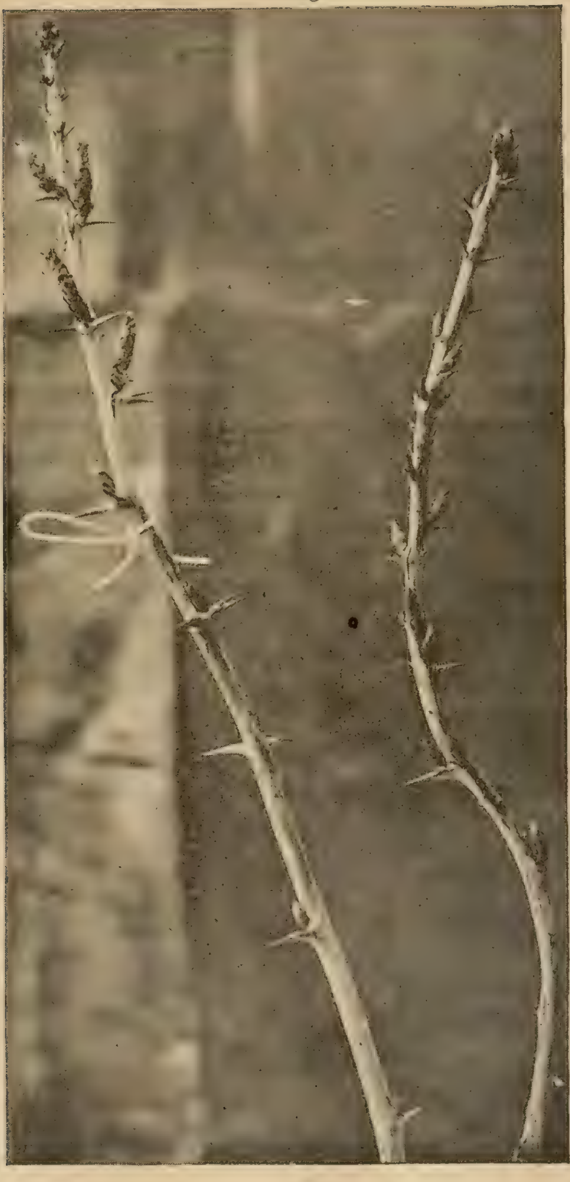
Does Mulching Retard the Maturity of Fruits?

It is a general opinion that a mulch or heavy cover placed upon the soil about plants when it is frozen will retard flowering and the maturing of fruit; yet the practice appears to be often unsatisfactory, and there are reasons for supposing that the philosophy of the subject is not commonly understood. The subject is one of increasing importance, for every effort must be made to reach the market when there is least competition from other sources, and, in New York, at least, this competition comes chiefly from early products, produced in States to the southward. It is also essential that every means be used to escape the late spring frosts which kill the flowers. Careful experiments upon the effects of mulches were made at this Station this year, to the rehearsal of which I also append some general considerations and the opinions of various fruit-growers who have had explicit experience with the practice.

The last winter was severe at Ithaca. The ground froze deep in December, and the frost did not leave it until the middle of March. Upon the 28th of February, 1893, the snow being well settled and a foot and more deep in the open fields, heavy mulches, of coarse manure and litter from horse-stables, were placed about apples, almonds, buffaloberries, blackberries, raspberries, currants, gooseberries, grapes, juneberries, peaches and quinces; and strawberries were mulched later. Observations were also made upon roses which were mulched in the fall for winter protection.

The apples and other tree-fruits comprised trees which were set in the spring of 1889. Half of a large wagon-load of mulch was placed about each tree, covering the snow deep for a distance of three feet or more in all directions. The small fruits were mulched heavily to the middle of the rows, or three and a half to four feet in each direction. A heavy wagon-load of mulch was sufficient to cover about ten feet of row. On the 29th of March, these mulches were examined, and, although the frost had left the fields fully ten days before, the earth under the cover was still solidly frozen and from six to eight inches of snow persisted. Here, then, was an excellent opportunity to study the effects of a cold soil upon the vegetation of plants. On the 13th of April there was still frost and snow under the gooseberry mulches, and yet both mulched and unmulched plants seemed to be starting alike. It was apparent that the temperature of the soil exerted no influence upon the swelling of the buds, for the buds which projected above the mulch were as forward as those upon untreated plants, while the buds immediately under the mulch, upon the same twig, were wholly dormant. The illustration shows two gooseberry twigs arising from a common branch, in which these differences are apparent. The twig upon the right was under the mulch and is completely dormant. That upon the left was covered up to the point indicated by the string. The protruding portion is seen to have pushed its buds forward, save at the very tip, where the shoot was winter-killed. Shoots of which the tips were caught under the mulch, showed perfectly dormant buds at both ends, while the protruding middle portion was as forward as twigs upon unmulched plants. Moreover, the protruding portions of the mulched plants maintained their forwardness, and produced leaves, flowers and fruit at the same time as the contiguous plants which were not treated. Crandall currants, juneberries, roses, grapes, and all the tree fruits, behaved similarly throughout the season. The mulched blackberries, raspberries and Victoria currants seemed to be a day or two behind the others in starting, but they very soon caught up, and there was no difference in season of bloom and maturity of fruit.

With the strawberries the case was far different. General Putnam and Oregon Everbearing were mulched March 25th, when the ground was completely thawed out. The mulch covered the plants and the entire space between the rows to the depth of three inches. On the 15th of May, this mulch was removed. At this time, the unmulched plants were in full leaf and were nearly ready to bloom. The plants under the mulch were just starting into leaf and the growth was weak and bleached. The plants were endeavoring to push themselves through the cover to the light and air. The mulch was forked off the plants, and they gradually assumed a normal color and habit, and bloomed June 1st. The bloom was delayed from ten days to two weeks, according to the depth of the covering. The plants did not seem to recover entirely, however, and the fruitage was somewhat lighter than on the normal plants; but it was delayed about a week.



The Effect of Mulch upon Twigs of Gooseberry.

All this is what the botanist would have expected. It is well known that plants store up starchy matters in their bulbs or branches to be used in the growth of the adjacent parts in early spring. The earliest bloom of spring is supported by this store of nutriment, rather than by food freshly appropriated from the soil. This is well illustrated by placing well matured twigs of apple or willow in vases of water in winter, when the buds will burst and flowers will often appear. It was admirably enforced by a simple experiment which we made last winter in connection with this inquiry, and which is illustrated in the engraving upon the cover. On the fifteenth of February, a branch of a nectarine tree which stood alongside the horticultural laboratory was drawn into the office through a window. This office was maintained at the temperature of a living room. On the 6th of April the buds began to swell, and the young leaves had reached a length of three-fourths inch a week later. The leaves finally attained their full size upon this branch, before the buds upon the remaining portion of the plant had begun to swell. This condition is shown in the illustration. This experiment is by no means a novel one, for essentially the same thing has heretofore been accomplished with the vine and other plants; but it must impress upon the reader the fact that much of the bursting vegetation of springtime is supported by a local store of nutriment, and is more or less independent of root action.

These various experiments and observations show that a mulch can retard flowers and fruit only when it covers the top of the plant as well as the soil. If the ground could be kept frozen for a sufficiently long period after vegetation begins, the plant would consume its supply of stored food and might then be checked from inactivity of the root, but this would evidently be at the expense of injury to the plant; but, in practice, it is fortunately impossible to hold the frost in the soil so long. It is evident, too, that the covering of strawberries and other low plants for the purpose of retarding fruit, must be practiced with caution, for a mulch of sufficient depth to measurably delay vegetation is apt to bleach and injure the young growth, and to lessen the crop. Yet it can sometimes be used to good effect, and fruiting can be delayed a week, perhaps even more. I have obtained the experience of various horticulturists in mulching strawberries to retard bloom and fruit.

C. E. Chapman, Peruville, Tompkins county, N. Y., finds mulching profitable in retarding strawberries.

Because of late spring frosts and the glut of fruit from near Cayuga lake, which is ten days earlier, I was compelled to grow late fruit or quit. The first venture, ten years ago, was to spread a thick mulch of wheat straw over the strawberries during winter, but as there was some timothy in it, next crop was badly damaged by the growing of grass and weeds. Next I used coarse horse manure and that completely ruined them as the horses had been fed hay and the seed all grew.

Next I went into the swamps and cut the long, coarse, wide-bladed grass. There is nothing in it that will seed and grow on dry land. Coarse corn-stalks are best of anything I have used, but I can not get enough of them. I have used the swamp grass for five years, and cut this year about five tons. I spread it on after the ground is frozen hard in early fall. It is thick enough to completely cover the plants from sight and cover the entire surface of the bed. In spring, the plants come up through the mulching unaided, and the mulch is not disturbed or removed until after harvest, excepting in such places as prove too thick for the plants to break through. Such places are stirred a little with a fork, or rather loosened without displacing the mulch. I find spots which have become uncovered during winter, thaw out and the plants begin growing about ten days quicker than those covered. This time varies with the season. A steady, early, warm spell with warm rain, will thaw the soil under the mulch quickly, while cool, cloudy weather will thaw only exposed portions. After plants have begun to grow a few days under the mulch, they must come to the light or become white. I have kept plants back two weeks under the mulch and when uncovered they were white but had full grown leaves. Such plants do not blossom after turning green and are worthless. I should think from six to ten days is the limit of successful retarding of bloom by my plan. Some of this difference in time disappears by the time the fruit ripens, as the plants seem to make an effort to be in season; but the heavier pickings come several days later.

I have saved three crops from frost by having three days' delay in blossoming, and get, always, better prices as my first fruit comes in just behind Ithaca berries. The unmulched portions have fewer and larger berries but not so many quarts per acre as the mulched, and the latter stand drough better. Usually our last picking for market is July 4th. This season first sales were made June 24th and the last July 5th.

I use all the mulching I can get on all kinds of berries to save labor in keeping down weeds and conserving moisture, but as their tops are above the mulch I do not think that they are retarding much.

C. E. Chapman.

J. H. Hale, South Glastonbury, Conn., is able to prolong the season by mulching.

I have never made any careful experiments, as to heavy mulching to retard strawberries, but, in growing and mulching many acres in years past, we have occasionally put on an almost excessive amount and left it on until late in the season, allowing the plants to work their way through, uncovering from time to time the spots where plants were unable to force through the mulch, and, in every instance, this has resulted in retarding the bloom from ten days to three weeks and the fruit from five to ten days. I think it is safe to assume that, by leaving on a heavy mulch of light material just as long as may be, in the spring, without entirely killing the plants, the strawberries may be retarded, on the average, fully a week, in their time of ripening, and, in many instances, two weeks or more.

In this way the season of any one variety may be considerably extended, and, as old plants will produce earlier fruit than young ones, having an old bed to give the earliest fruit and a young bed, heavily mulched, to give the latest fruit, would cause one variety to extend over fully four weeks in picking. Adopting the same practice with the earliest and latest varieties, the strawberry season on almost any farm could be made to cover a period of about seven or eight weeks; in fact, we always have about seven weeks of strawberry fruiting here.

J. H. HALE.

John Little, Granton, Ontario, retarded his fruit a week.

I had a very satisfactory experience this season, along the east side of a willow fence running north and south. There were varieties early and medium: Haverland, Wilson, and Saunders. These were covered with a sheet of leaves which remained on them till the warm days caused the leaves to make their way through them. Michael Early, Bederwood, Crescent and all other varieties were many days ahead of these varieties named.

The early varieties gave some pickings the 4th of June. The three varieties covered with the leaves gave no berries till the 22d. All the other varieties finished giving any berries to speak of the first of July, while those varieties covered with the leaves produced berries till the 12th of July, and a scattering few of Haverland and Saunders for several days afterwards.

JOHN LITTLE.

W. W. Hilborn, Leamington, Ontario, retards his crop from three days to a week.

I have had about eighteen years' experience in mulching strawberries and I find that it does retard them a few days. I mulch several acres every year and would not grow them without. I put on the covering in the fall as soon as the ground freezes about two inches deep, and place most of the covering (which is usually wheat or rye straw) between the rows of plants, putting just enough over the plants to nearly cover them from sight.

In early spring, as soon as growth begins, I rake the straw from the plants and leave it between the rows. If the straw is left on the plants for a time after they begin to grow, it causes a soft, weakly growth of plant that will not produce fruit.

I do not believe they can be retarded more than three days to a week, according to the weather. If they remain covered with snow, as they do in some sections, until near the time growth begins, the covering will retard growth longer. I consider it unsafe to try to retard growth by leaving the covering on immediately over the plants after growth begins.

W. W. HILBORN.

James Edgerton, Barnesville, O., learned too much.

I have had experience to my sorrow. I always commenced picking strawberries in advance of my neighbors till the past season when I came in about three days behind, and know of no cause but that my boys insisted on putting on straw to an extra depth last fall so that they could burn the bed over after harvest. A five days' delay in getting our fruit into Chicago makes a sad difference in our receipts, as Michigan comes on quickly and drives us out.

JAMES EDGERTON.

T. B. Terry, Hudson, O., delays his strawberries a week.

I have retarded blooming-time of strawberries several times about a week, by very heavy mulching in winter when ground was frozen hard. The ground must be deeply frozen and mulch enough to keep it so some days longer than usual. I mulch my seed-potato pit when deeply frozen to keep in frost and delay sprouting, in same way.

I think I have retarded bloom as much as ten days on strawberries, but they hurry up a little after they get started, so that about a week is all the gain we ever get in the way of lengthening the season. I have tried it on raspberries, grapes, etc., and it does not work at all. It did not delay them a particle, the vines being out in the sun and warm air.

T. B. Terry.

Matthew Crawford, Cuyahoga Falls, O., discourages the practice.

I have had some experience in mulching strawberries to retard their blooming and ripening, but am not well pleased with the results. My impression is that, although growth may be retarded somewhat early in the season, it nearly makes up for lost time before the fruit ripens. If the mulch is left on until after growth starts, and is then removed from over the plants, the blanched growth is easily destroyed by a light freeze.

If the mulch is left between the plants until they are in bloom, a frost is far more destructive than it is when the ground is bare. From all that I have seen, I have but little faith in mulching to retard the ripening of the strawberry.

M. Crawford.

R. M. Kellogg, Ionia, Mich., delays his berries two weeks.

I have practiced mulching for the purpose of retarding the ripening of strawberries for several years with gratifying results. My plan is as follows: Select a north incline so as to avoid the direct rays of the sun ; choose the latest variety and delay the mulching until midwinter when the ground is frozen as deeply as possible. Then between the rows put a heavy coat of coarse manure, treading it down as compactly as possible. Care must be taken not to let the manure lie directly on the plants as it will greatly injure or kill them. Immediately on the plants put a coating of chaff, not thick enough to cover the crowns deeply, finishing with a coat of clean straw which may be put on six or eight inches thick, without injuring the plants. This is permitted to remain until fruit of other plants is almost full grown. Growth will sometimes start and foliage be bleached considerably but no injury will result until blossoms are well developed, when enough straw is raked off to see the plants, so they can push up through it. I have often found the ground frozen quite hard after other plants were in full bloom.

I have not only raised some of my largest crops in this way, but the latest pickings were more than two weeks after berries of the same variety not so treated were all gone.

R. M. Kellogg.

George J. Kellogg, Janesville, Wis., delays the bloom a week, but it is sometimes caught by late frosts.

I have for years left the mulching on to keep strawberries back in the spring. Carefully handled, it will keep back the bloom about a week. Last spring we left a heavy mulch of manure on one end of six rows, probably twenty rods long. The plants were so completely covered that we lost three-fourths of the crop where mulched. We thought the plants would push through, but we lost the fruit although the plants lived. The mulch will hold the frost about a week, usually. Sometimes we have found the retarding a detriment. The May frost that does the damage, usually the last week in May (at Janesville, Wis.), is preceded by two weeks of fine weather without frost, so that where the mulch has been removed the fruit may have fully set and passed that point where fruit injures, although nearly all varieties continue in bloom three weeks.

I have repeatedly tried mulching apple trees after the ground has frozen 12 to 24 inches deep, but it does not retard the buds or bloom more than a day or two — there is sufficient sap in the tree above ground to supply the buds and blossoms until the retarded sap from the frozen roots is able to aid the circulation.

George J. Kellogg.

F. W. Loudon, Janesville, Wis., finds that mulch delays berries a week.

Our practice here is to mulch strawberries liberally with straw or marsh hay, for winter protection, as in this region we can not rely upon the snow. In the spring, about the time the plants begin to grow, usually the first week in April, we draw the mulch away from over the plants, just enough to admit the light. By this method, our strawberries are usually a week later than our neighbors' in ripening. I allude to those who take their mulch completely off and haul it away. When they are first in the market, our berries are very much larger and finer. Also we escape the ill effects of the severe drouths that are apt to occur during the fruiting season.

F. W. Loudon.

B. F. Adams, Madison, Wis., delays blossoming a week and thereby escapes frosts.

Mulching strawberries retards blossoming fully one week on an average through a series of years in this climate. My experience covers a period of thirty years in growing this fruit for market. Our danger here comes from late frosts in May, and my practice is to keep this fruit well mulched as late as the season will permit. For years the south has furnished us early berries, some seasons by first of February, and I make no attempt to supply early fruit for this market. The retarding is not quite so marked by heavy mulching other small fruits, but it makes a difference of a few days, say three or four days, in the ripening of raspberries and blackberries. There is still less effect in mulching orchards, but some retarding is perceptible. This heavy mulching of strawberries, which is absolutely essential in this severe climate, consists of marsh hay put on so as to hide the plants completely. In a warm spell, which sometimes comes in April or early in May, it must be stirred or the plants will suffer. Such a spell of weather here is sure to be followed by intense cold, and removal of the mulching would seriously damage the plants.

B. F. ADAMS.

J. S. Stickney, Wauwatosa, Wis., does not approve of it.

I have tried mulching to retard growth of strawberries, but not with satisfactory results. The trouble is that the foilage insists upon growing under the mulch, and suffers seriously when the mulch is removed, so that the very slight gain in time is more than balanced by loss of vigor. My neighbor, Mr. William von Baumbach, the most successful grower I ever knew, removes his winter covering and cultivates thoroughly, not deep, then mulches heavily between the rows, but makes no effort to hold back the time of starting.

J. S. STICKNEY.

I. N. Stone, Sioux City, Iowa, favoring mulching to delay fruit.

I have noticed in different seasons a variation of from five to eight days' later bloom and ripening of fruit where the strawberry bed is mulched as heavily as it is safe to mulch and avoid smothering the plants, that when little or no mulching is used, or when the mulch is all taken off early in the spring and replaced just before ripening. Still there have been years when there was not much difference in the opening of the ripening season on account of a late frost destroying all of the first blossoms of both the mulched and unmulched areas. The bloom on the mulched plants would not be as far advanced as on the unmulched, but it would be affected more by the frost on account of the mulch preventing the radiation of heat from the loose soil. So if a frost hard enough to kill the bloom should come at a time when both the mulched and the unmulched are in bloom, there would be but little if any difference in the time of first ripening of fruit, but the mulched would hold out a few days later than those not mulched. If it is desired to retard the bloom and fruit as much as possible, a light mulch should be put over the plants at the usual time of covering in the fall, and after the ground is frozen deep enough so that there will be no danger of smothering the plants, add enough more to cover the whole surface of the bed three or four inches deep, using light material; do not use coarse manure, except to scatter a little over the light mulching to keep the wind from blowing the mulch from the plants. As soon as warm weather comes, the plants will need close attention and more especially if there is much rainy weather. The mulching should be kept over the plants, but must be stirred up often, and later it will be necessary to work some of the mulch off the plants into the vacant places between the rows, leaving as much over the plants as they will grow through without turning white. Do not take the mulch off the bed until the crop is harvested.

I. N. STONE.

Benjamin Buckman, Farmingdale, central Illinois, finds from two to seven days' delay in mulched strawberries.

We often leave parts of strawberry patches unmulched that we may get earlier berries. It will make from two day's to a week's difference. If the mulch is very heavy and put on after the ground is frozen to the greatest depth, they are more retarded than when the mulch is applied before the ground freezes, for evident reasons. Mulched strawberries have a better color — much more glossy than unmulched. Aside from keeping the ground cooler, the maturity of the berries is retarded by the fact that in a heavy mulch many plants find difficulty in pushing through the straw, and are really late plants with the development all to come in after they get to the light. Frost collects on straw, and I think straw-mulched strawberries are more injured (considering their state of advancement) than those unmulched.

BENJ. BUCKMAN.

A. B. McKay, Agricultural College, Miss., find the fruit of strawberries can be retarded.

Some years ago I mulched a patch heavily with leaves, and the plants were very slow to start on the mulched portion. The crop was later and lighter than on the unmulched portion. I did not repeat the experiment.

A. B. MCKAY.

Parker Earle, Ocean Springs, Miss., has observed a retardation of of four to six days.

I have had no experience in mulching strawberries for purpose of retarding bloom, but have observed that our mulching for cleanliness and to prevent heaving out by frost, has had a retarding effect — I should say, to the amount of four to six days.

PARKER EARLE.

CONCLUSIONS.

1. The early bloom of fruit plants depend very largely upon the appropriation of food stored in the twigs, and it is more or less independent of root action. This is proved both by direct experiment and by study of the physiology of plants.

2. It must follow then, that the temperature of the twig or branch must be reduced if its vegetation is to be much retarded; or, in other words, the top of the plant, as well as the soil, must be mulched, and, in practice, this is possible only with strawberries and other very low plants, or those which are laid down during winter.

3. There is danger of injuring plants by heavy mulch which is allowed to remain late in spring. If it is desired to retard flowers or fruit by mulching, the practice should not be violent and the plants should be carefully watched.

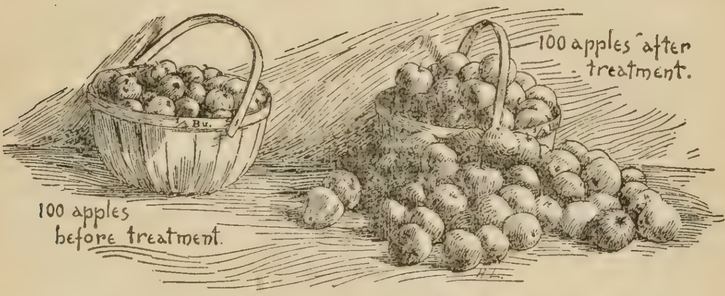
4. Many strawberry growers are able to delay the ripening of fruit, by mulching, from two days to two weeks; but a week's delay is usually about the limit of profitable results.

L. H. BAILEY.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BULLETIN 60 — DECEMBER, 1893.



THE SPRAYING OF ORCHARDS.

I. The Profits of Spraying Apple Orchards.
II. Test of Some Fungicides and Insecticides upon Peach Foliage.
III Some Novel Insecticides and Fungicides.

By E. G. Lodeman.

ORGANIZATION.

Board of Control.—The Trustees of the University.

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.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
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57. Raspberries and Blackberries.
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59. Does Mulching Retard the Maturity of Fruits?
60. The Spraying of Orchards.

I. The Profits of Spraying Apple Orchards.

Spraying orchards to protect the foliage and fruit from the attacks of insects and fungi may now be considered as one of the regular duties connected with the growing of apples. Those who have had experience in this direction are practically unanimous in saying that not only does it pay to spray apple orchards but it generally pays well. Doubts as to the advisability of making applications to orchards are rapidly disappearing, and now arise the questions, what to apply, and how and when to make the applications. The following experiments were designed to indicate as accurately as possible what are the best methods of treating apple orchards so that fruit of the best quality may be obtained with the smallest outlay of labor and money.

Description of the orchard used in the experiments of 1892 *and* 1893. The orchard of John J. McGowen was selected for the work. This orchard covers about two acres and is situated upon a strong clay loam. The land is moderately rolling so that fairly good drainage is afforded. The trees were set out in 1869, making the orchard now twenty-four years old. However, many of the trees first set have died at varying intervals so that the orchard is not uniform. Most of the trees used for filling vacant places are Baldwin, and many of these are now coming into bearing. Nearly one-half of the trees originally set and now in bearing are King; the other varieties in full bearing are Baldwin, Fall Pippin, Maiden Blush, Fallawater, Red Astrachan, Chenango, Strawberry, and Westfield Seek-no-further. The last two varieties were not used in the experiments.

The care which the orchard received from the time of setting has been as follows: During the first three years the land between the rows of trees was used for raising grain and hay. It was then seeded down and sheep were put in. The sod has not been broken since it was first formed. The trees have had an annual dressing of about a quarter of a load of barnyard manure per tree until the year 1890, when the quantity was increased to about a third of a load. The trees as a rule have been regularly pruned, and the old ones are now, with scarcely an exception, fine specimens of the varieties which they represent.

The orchard has borne irregularly. What may be called the first crop was obtained in 1884. The yield was then large, possibly larger than the trees should have been allowed to bear, for on an average, about fifteen bushels per tree were harvested from the King. During the following years the crops were exceedingly light, but this year the orchard produced over three-fourths of a crop.

The orchard was sprayed for the first time in 1890. London purple was then applied at the rate of one pound to two hundred gallons of water. The first application was made about the time the blossoms fell from the trees, and the second about two weeks later. In 1891 only one application was made to the orchard, London purple being used as before. The first experiments carried on under the direction of this station were made in 1892. The entire orchard was then treated with various fungicide and insecticides.* Some of the results obtained indicated the lines of work followed during the present year.

Apple scab.— The apple scab fungus is probably the most serious enemy of the apple grower. It has been determined that this fungus is active even before the leaf buds open, and that the little apples are attacked as soon as the flowers open, and probably even earlier. We have still to learn at what season the growth of the fungus practically ceases, and during what period the apples and leaves are most liable to its attacks. This may be determined in two ways: first, by studying the life history of the fungus, and second, by applying fungicides at intervals to the trees. If the last method is followed very thoroughly the results may be obscured by the more or less complete extermination early in the season of the fungus in the treated orchard. But if a few thorough applications made at the proper time will prove to be sufficient to protect the trees, the fact that the trees are thus protected is of great practical value, whatever the natural life history of the fungus may be.

Points of merit in fungicides.— The relative merits of the most important fungicides now in use still require careful consideration. Cost, ease in preparing and applying, adhesive power, all must enter into any comparison which may be made; and of late a still more important factor has been added, namely, the readiness with which the fungicide may be applied in combination with the arsenites. The fungicide which surpasses in all the above points has still to be discovered, but some now in use possess most of them. Spraying need not be neglected from a want of effective material.

Spraying machinery.— The machinery to use in orchard work is an important item. Spraying is hard work, unless the pump is run by horse power, and this can be used with profit only by owners of exceptionly large orchards. The vast majority of apple growers are necessarily forced to use hand pumps. These are now offered by the trade

* See Cornell Experiment Station Bulletin, No. 48, December, 1892.

in almost endless variety, and selections are often difficult. Pumps of various descriptions have been tried at this station and the following are some of the points which have been emphasized.

The pump should be powerful. It requires double the amount of exertion to apply a given amount of liquid with a small pump than is necessary when one of ample size is used. In general, a pump used for orchard work should have a cylinder at least two and one-half inches in diameter, the stroke being from four to five inches in length. The handle should be long, as greater power can then be obtained. Working parts which are exposed to the action of the materials applied should be of brass, or else brass lined, for iron soon corrodes. The air chamber should be rather small, especially if the pressure of the liquid can be utilized in keeping the nozzle free from obstructions. In such cases, the one who pumps should be able to increase the pressure of the liquid in the nozzle by one or two quick strokes of the handle. A large air chamber defeats this. The pump used in the following experiment was the Gould "Standard" No. 2. It worked satisfactorily, but is open to the objection of being rather small, especially when much work has to be done. It is manufactured by the Gould Co., of Seneca Falls, N. Y.

Many pumps are supplied with agitators, but these have not proved so satisfactory as was hoped. It was found that those which stirred the liquid by means of a stream which was discharged from a return pipe near the bottom of the barrel did not keep the liquid in the entire barrel stirred, but only in that portion of it which came directly under the influence of the current. Another objection to this class of agitators is that too much power is lost. Paddles of various kinds have been recommended. They are attached to the pump handle and with each stroke pass through a certain portion of the liquid. These do better work than the agitators mentioned above, but they also require considerable power. No agitators were used in making the applications mentioned in the following pages. The liquids were stirred with a stick as often as was necessary, which was commonly before each tree was begun.

The Improved McGowen nozzle No. 7 is the one used throughout the season. It is manufactured by John J. McGowen, of Ithaca, N. Y. The spray thrown is fine and forcible, and the nozzle gave no trouble from clogging. The pump was fastened to a barrel which was turned upon its side. The barrel was then placed in a light wagon and filled through a hole about six inches square situated at one side of the pump. The liquid was directed into it by means of a wooden funnel. Two persons worked together in making the application; one drove and directed the spray, while the other pumped.

Distance of planting apple trees.— The trees of this orchard are set forty-two feet apart each way. The advisability of planting those varieties of apples which have spreading tops like King and Baldwin at least forty feet apart can not be too strongly emphasized. Sufficient room for the passage of a wagon must be allowed between the rows when the trees are full grown, and even forty feet is not sufficient for some varieties. A closely set orchard can be sprayed only with great difficulty, and an unsprayed orchard is rarely a profitable one unless it is situated in a peculiarly favorable locality, or unless it consists of varieties which are practically scab and worm proof. The greater ease with which an orchard may be sprayed when in full bearing is of itself a sufficient argument for open planting in apple orchards.

Amount of liquid used.— The amount of liquid applied to the large trees at each application averaged about four gallons. If less liquid was used it was found to be insufficient to cover all parts of the tree as thoroughly as was desired; when more was used, most of the excess fell from the tree to the ground and was lost. The number of trees which may be treated in a day with the outfit described above is about one hundred and twenty-five. In experimental work much time is necessarily lost, but this estimate is not far from the number of trees which may be well sprayed by regular work.

The weather.— The spring and summer of the year 1893 were, on the whole, normal. The departure from the average rain fall of each month was as follows: April + 1.69 inch, May + 2.01 inch, June — 1.57 inch, July + 1.20 inch. April and May show an increase, May particularly so. As the temperature during these months was practically normal, the apple scab fungus met favorable conditions for its development. June was inclined to be dry, although considerable rain fell; but July shows a rainfall above the average. The work done the past season was consequently subjected to practically the same conditions which may be expected any year.

Material used.— The following are the materials applied to the orchard. They were used singly and also in combination.

Bordeaux mixture,
Ammoniacal copper carbonate,
Fosite,
Paris green,
London purple.

The Bordeaux mixture was prepared according to the formula:

Copper sulphate, 6 pounds,
Quick lime, 4 pounds,
Water, 40 gallons.

The sulphate of copper was bought in the crystalline form. It was dissolved by placing the six pounds in a bag of coarse material and suspending it in the top of a pail filled with water. Treated in this manner the crystals dissolve in an hour or two. If hot water is used they enter into a solution much more rapidly. The lime was generally slaked in about a pail of water. Then these two liquids were poured into a keg holding eight gallons, and a pailful of water was added. In this manner six gallons of concentrated Bordeaux mixture were obtained. If the entire amount was to be used, it was poured into a barrel holding forty-five gallons and sufficient water was added to make forty gallons of the mixture. If only a small quantity of the Bordeaux was desired, it was made by taking one part of the concentrated mixture and adding to this nearly six parts of water. In this manner a mixture of very uniform strength was obtained. It was allowed to stand a few hours before using. When prepared according to the above formula, the cost of a gallon of Bordeaux mixture is about one and one-fifth cents.

The ammoniacal carbonate of copper was made as follows:

Carbonate of copper, 5 ounces,
Ammonia 26°, 3 to 5 pints.
Water, 40 gallons.

The amount of ammonia varied, for it could not be obtained of uniform strength. Consequently the above formula was usually modified and the fungicide was made by taking:

Carbonite of copper, 1 ounce,
Ammonia, enough to dissolve the copper carbonate,
Water, 9 gallons.

This formula has proved to be a very convenient one. Although the solution is a trifle weaker than the one first given, it is of the same strength as that recommended by the Division of Vegetable Pathology, at Washington. The cost, when thus prepared, is about one cent per gallon. This fungicide was used during the entire season in combination with Paris green. To forty gallons of the ammoniacal copper carbonate of the strength given above there were added:

Paris green, 2½ ounces.
Quick lime, ½ pound.

The lime was previously slaked in water, and then both ingredients were added to the copper solution immediately before the applications were made.

Fosite is a very fine, bluish gray powder (see page 293). It was applied to the trees by means of a bellows furnished us by C. H. Joosten, 3 Coenties Slip, New York City. The discharge pipe of the bellows was entirely too short to reach the tops of the trees, but a fairly uniform application could be made by climbing into the tree and then blowing the powder at short range. This method is, of course, impracticable for commercial work. Fostite is sold in one hundred pound lots for $6.50, but larger quantities are sold at a lower rate.

Paris green was used at the rate of two and one-half ounces to forty gallons of water, which is about the same as one pound to two hundred and fifty-six gallons of water. London purple was used in the same proportion as the Paris green.

Objects of the experiments.— The above materials were applied with the intention of observing the following points:

1. The number of applications of fungicides and insecticides necessary to produce fair fruit.
2. The comparative values of the fungicides.
3. The comparative values of the insecticides, and the advisability of applying them in combination with fungicides.

Division of the orchard and dates of applications.— The orchard was divided so that some trees should be sprayed two times, others four times, and some even six times. Those sprayed twice received the first application May 19, and the second June 8. On the former date the first blossoms had just opened, only about a dozen being noticed, all upon King trees. At the time of the second treatment a few blossoms still persisted upon the trees. At first the intention was to have a shorter interval between the two applications, but the season advanced so slowly that it was thought advisable to wait. The trees which were sprayed four times were treated April 26, May 19, June 8, and June 22. When the first application was made, the buds upon the trees were swollen and almost ready to burst, but their winter covering still surrounded them more or less completely. In our experiments of last year the necessity for early applications was strongly indicated. On June 22, at the time of the fourth application, the young apples had set and active growth had begun.

The third lot, the one receiving six applications, was sprayed on the same dates as the preceding, but in addition the trees were sprayed July 13, and again August 1. In this manner the fruit and foliage were well protected during almost the entire season.

Combinations used.— The trees upon which fostite was applied were also selected for the comparative test of London purple and

Paris green. The powder was applied with a bellows, which necessitated the separate application of the insecticides. These were applied June 8 and 22, the dates of the first two applications following the fall of the blossoms from the trees. Upon the same dates Paris green was also used in combination with the Bordeaux mixture. Otherwise the Bordeaux was used alone.

The ammoniacal carbonate of copper was invariably applied in combination with Paris green according to the formula given on page 269. Paris green readily dissolves in ammonia and it was hoped to avoid the caustic action of this solution by the addition of lime. Paris green was also applied alone to test its value as a fungicide.

Grading of the apples.— The apples were harvested about the middle of September. The yield from each tree was placed in separate piles so that it could be accurately examined, and the effects of various applications noted. The picked fruit was divided into three grades, the windfalls being so few in number that they were not taken into consideration. The standard for the first grade was high. It was the intention to have this grade composed entirely of fancy fruit, and only strictly first-class apples were put into it. The amount of scab or other fungous injury upon an apple determined its grade, the injury done by worms being rather secondary, for the apples were comparatively little damaged by them. As a rule, large and symmetrical apples possessing good color, were placed among the seconds if several diseased spots could be found upon their surfaces even if the spots were small; for such spots showed that fungi had succeeded in entering the apples, and this was just the result which the applications were designed to prevent.

Consequently, the grading was not done entirely upon a commercial basis, for many of the apples which were counted as seconds might have entered the market as fancy fruit, because the injury done them was not great enough to cause any apparent disfigurement. The apples which constituted the third grade were extra specimens of cider apples, and they are so considered in the table on page 273; but they averaged as good as the ordinary barreling apples of the country.

In counting the number of apples which were wormy, some difficulty was at first experienced. All were not injured to the same extent by the larvæ of the codlin moth, these being the particular ones sought. When an apple had been attacked early in the season the injury done could be seen at a glance. But young larvæ were abundant during late summer and early fall. Many of them had hardly begun their destructive careers, so that practically the apples were uninjured, although the cause for future injury was present. Such apples were nevertheless considered as wormy, and were graded second-class.

For convenience in comparison, all the figures in the following pages show percentages. The first column, and the ones giving the weight of the fruit, are of course excepted.

The results from only three varieties are tabulated. Some of the other varieties contained in the orchard produced no fruit. Others, especially the Red Astrachan, could not be obtained to make comparisons as the fruit was sold as soon as it was fit for market. In general, however, this variety gave nearly as marked results as those obtained from the Fall Pippin or the Maiden Blush. A third reason for omitting certain varieties from the table is that no definite results were obtained. The subject is more fully treated on page 275.

Unsprayed plots.—Two King trees, situated in different parts of the orchard, were used as checks in order to have a substantial basis with which to compare the results obtained from the sprayed trees of this variety. One-half of a Fall Pippin tree was used as a check, there being only four trees of this variety in the orchard. The orchard contains but one tree of Maiden Blush, so that only one-half of this could be used as a check. However, from the appearance of other apples of these last two varieties, borne in the neighborhood, the fruit produced upon the unsprayed portions showed well the comparative value of untreated apples.

TABLE I.—Showing Results Obtained During the Season.

MATERIALS APPLIED.

Number of application.	Bordeaux Mixture and Paris Green.					Ammoniacal Copper Carbonate and Paris Green.					Paris Green.					Fostite (and Paris Green).					Fostite (and London Purple).				
	Per cent 1st class.	Per cent 2d class.	Per cent cider.	Per cent wormy.	Weight in pounds of 100 apples.	Per cent 1st class.	Per cent 2d class.	Per cent 3d class.	Per cent wormy.	Weight in pounds of 100 apples.	Per cent 1st class.	Per cent 2d class.	Per cent 3d class.	Per cent wormy.	Weight in pounds of 100 apples.	Per cent 1st class.	Per cent 2d class.	Per cent 3d class.	Per cent wormy.	Weight in pounds of 100 apples.	Per cent 1st class.	Per cent 2d class.	Per cent 3d class.	Per cent wormy.	Weight in pounds of 100 apples.
King.																									
2	55	43	2	11	37½	45	52	3	9	47¾	48	50	2	5	44½	....	....	....	....	......	....	....	....	....	......
4	53	46	1	6	47½	50	46	4	7	44¾	58	41	1	3	42	...	....	....	....	......	....	....	....	....	......
6	76	19	5	4	44½	57	37	6	5	49½	57	38	5	3	44½	40	53	7	8	48¾	33	60	7	3	42½
None	25	56	19	9	43	25	56	19	9	43	25	56	19	9	43	25	56	19	9	43	25	56	19	9	43
Fall Pippin.																									
6	61	35	4	4	46	23	53	24	2	40	30	47	23	2	42	7	60	33	3	30¼	....	....	....	....	......
None	1	30	69	12	27	1	30	69	12	27	1	30	69	12	27	1	30	69	12	27	....	....	....	....	......
Maiden Blush.																									
4	48	35	17	2	37¾	....	....	....	....	......	....	....	....	....	......	....	....	....	....	......	....	....	....	....	......
None	15	27	58	13	24½	....	....	....	....	......	....	....	....	....	......	..	....	....	....	......	....	....	....	....	......

This table contains in a condensed form the principal results obtained this year in the orchard of Mr. McGowen, and it is the basis for many of the conclusions which follow. But additional tables are necessary in order to realize the full force of many of the figures, and to compare in a more convenient form various results obtained.

Number of applications necessary.— To reply to the question, How many applications can be applied with profit? is not an easy task. Too many factors must be taken into consideration to give an answer which will apply to all apple growers. It can be shown what the results of varying numbers of treatments have been, and from this each grower must decide for himself how many can be made with profit. The percentages of gain in first-class apples of the sprayed over the unsprayed portions are given below:

Table II.— Showing Percentage of Gain in First-class Apples Obtained from Varying Numbers of Applications.

NUMBER OF APPLICATIONS.	King.					Average, omitting fostite plants.	Fall Pippin.					Maiden Blush. Bordeaux mixture.	General average gain.
	Bordeaux mixture.	Am. carb. copper.	Fostite and Paris green.	Fostite and London purple.	Paris green.		Bordeaux mixture.	Am. carb. copper.	Fostite and Paris green.	Paris green.	Average.		
2	120	80	....	....	92	97	....	....	....	....	....	....	97
4	112	100	....	....	132	115	....	....	....	....	....	220	141
6	204	128	60	32	128	150	6000	2200	600	2900	2925	....	1361

This table emphasizes several facts. In the first place, it shows what an enormous range of variations is found in the treated apples of different varieties. The series is most nearly complete in the King, but the Fall Pippin shows the benefits of six applications, and the Maiden Blush of four. The last was more affected by four applications than the Kings by six, and undoubtedly the Fall Pippin would have shown a still greater difference, judging from the effect produced by six applications.

Turning to the King, it will be seen that on the average two applications increased the number of first-class apples ninety-two per cent, four applications 115 per cent, and six applications 150 per cent. In making these averages, only the application of Bordeaux mixture, ammoniacal copper carbonate, and Paris green were considered, for it would be obviously unfair to include fostite under the six applications and not under the others. This fungicide was applied merely for the purpose of determining its value as compared with the others.

It is practically impossible to show by means of figures the exact condition of an apple crop. The averages for the King, and these were the ones particularly selected to determine the benefits derived from different number of applications, show a uniform and marked increase in the number of first-class apples as the number of applications increased. As has already been said, the grading was not done for the ordinary market, but for fancy trade, and since the later applications protected the fruit from attacks of scab which would have produced but slight blemishes, the above figures must not be construed to show that it is much better for the general grower to make six applications instead of four.

The commercial grading of all the Kings as made by the buyer was as follows: The total yield of King was sixty-five barrels. Of these fifty-nine barrels were marked as firsts, four and a half as seconds, and one and a half barrels as thirds. On considering the percentages of the three grades, they constituted respectively ninety-one, seven and two per cent of the total yield. In this grading the wind-falls were also included, which was not the case in the table on page 273. The highest per cent of first-class fruit shown by this table was seventy-six, yielded by King apples sprayed six times with the Bordeaux mixture. Some idea of the high standard set may be obtained by comparing this with ninety-one per cent made in packing.

Value of sprays upon different varieties.— Two important factors must be considered in spraying every orchard. The first and more important one has to do with the varieties grown; the second has reference to the characters of the season. During wet weather more applications are necessary than when the rainfall is slight. Dry seasons do not favor the development of injurious fungi, and the materials applied remain upon the trees much longer, not being washed off by rains.

Some varieties are undoubtedly much more subject to the attacks of apple scab than others. The past season proved this beyond a doubt as regards the varieties grown in the treated orchard. Several trees of Baldwin and Fallawater were included in the experiments, but no detailed report is here made of the results obtained, as there was practically no difference between treated and untreated trees. Although the Fall Pippin and the Maiden Blush apples were nearly ruined when not treated, Baldwin and Fallawater apples growing close by them were hardly injured. I believe it can safely be said that the susceptible varieties mentioned above could have been sprayed with profit four or five times in order to reduce insect and fungous injury, while the comparatively resistant varieties would not have repaid any more applications than those necessary to control the codlin moth, two treatments with Paris green being probably sufficient for this purpose.

Another point bearing upon this subject can not be overlooked. Many varieties are not uniformly attacked in different localities. It may pay some growers of a certain apple to spray it thoroughly, while the same variety in another locality would not warrant the expense of even one treatment for scab. During the summer of 1892, an attempt was made to determine the amount of injury done by the scab to the varieties of apples now in cultivation. The results of the work were published in Bulletin No. 48, of this Station. Although the list given is not so complete as might be wished, it is still of interest in this connection.

From the preceding it will be seen that no rule regarding the number of applications nor the dates upon which they are to be made can be laid down with safety. Each grower must be his own judge. If two, four or six applications are decided upon, they can be applied with safety and profit, in New York, upon dates given on page 270, subject to the condition of the season.

Comparative efficacy of the fungicides.—A fair idea of the comparative values of the various fungicides used can be obtained by examining the number of first-class apples produced by the trees sprayed six times with the fungicide used in each plot.

Table III.—Showing the Per Cent of First-class Apples Produced in the Different Plots.

TREATMENT.	PER CENT OF FIRST-CLASS APPLES OF EACH VARIETY.			PER CENT INCREASE OF EACH VARIETY.		
	King.	Fall Pippin.	Maiden Blush.	King.	Fall Pippin.	Maiden Blush.
Unsprayed	25	1	15	......	....	....
Bordeaux	76	61	48	204	6000	2200
Ammoniacal carbonate copper	57	23	....	128	2200	....
Paris green	57	30	....	128	2900	....
Fostite and Paris green	40	7	....	60	600	....
Fostite and London purple	33	....	....	32	....	....

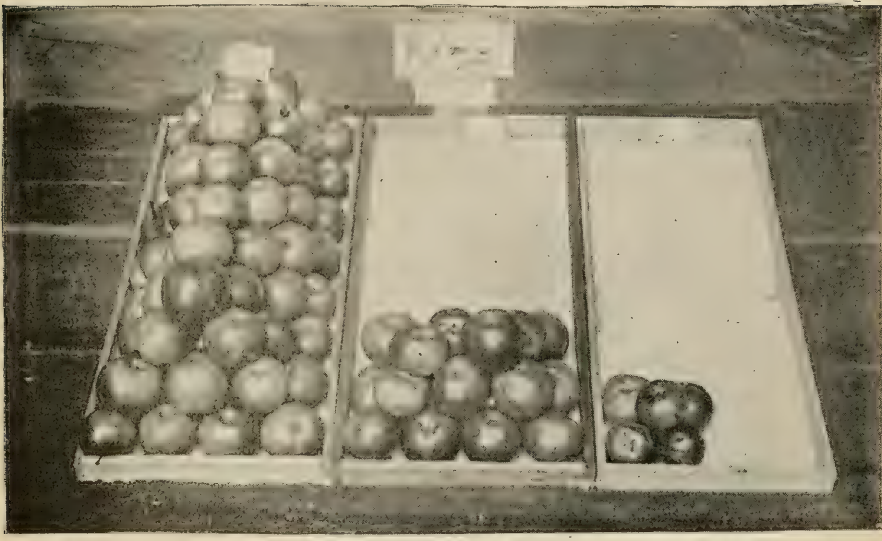

FIG. 1.— King, Sprayed Six Times with Bordeaux Mixture. Showing Relative Proportion of First, Second and Third Grades respectively.

FIG. 2.— King, not sprayed. Showing Proportions of First, Second and Third Grades respectively.

FIG. 3.— Fall Pippin, Sprayed Six Times with Bordeaux Mixture. First, Second and Third Grades.

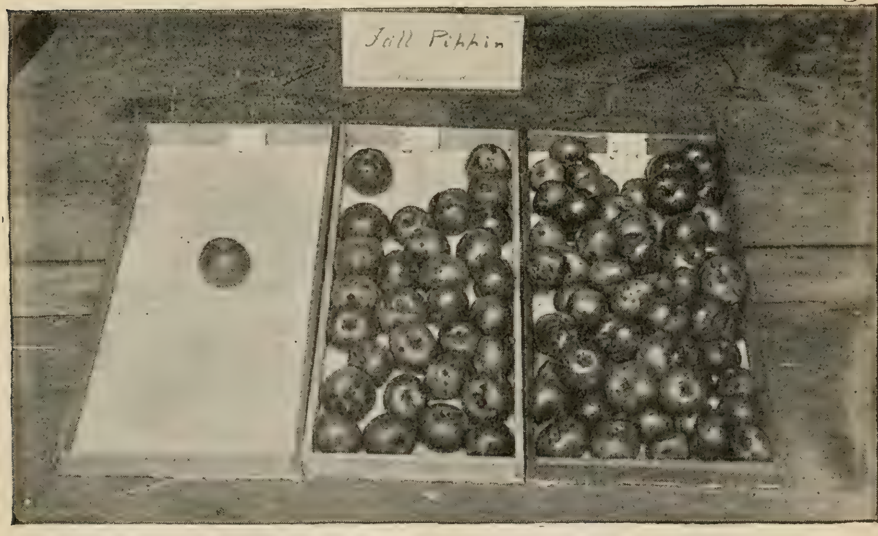

FIG. 4.— Fall Pippin, not Sprayed. Showing First, Second and Third Grades.

The decided superiority of the Bordeaux mixture can be seen at a glance. In no case did any other fungicide give results which approached in excellence those obtained from this mixture. Nor is its value fully shown by the number of apples in the various grades, for the general appearance of these apples was so superior that the fruit of the Bordeaux lots could be identified at sight almost with certainty. This superior appearance was mainly due to the uniform size of the apples, their regular form and the smoothness of the skin. Figure 1 illustrates these points well. The regularity with which the first-class apples could be piled upon the trays is particularly to be noticed. Little remains to be desired as regards uniformity of fruit.

The general effect of six applications upon King and Fall Pippin apples may be obtained by comparing Figs. 1 and 3, these representing treated apples, with Figs. 2 and 4 showing fruit which was not sprayed. With the more susceptible varieties it is evidently a question of crop or no crop, and the answer is in the hands of the grower. In comparing the illustrations it must be borne in mind that among the sprayed lots were a great many apples graded as seconds, which really were first-class apples, only they did not bear the test of sufficient freedom from scab. The general appearance of the seconds of the unsprayed lots was markedly inferior to the same grade of the sprayed lots.

The ammoniacal carbonate of copper most nearly approached the Bordeaux mixture in the value of the results obtained. Although the average increase of first-class apples, 128 per cent, is the same as that given by Paris green, still the general appearance of the apples treated by Paris green and carbonate was plainly in favor of those treated with the ammoniacal solution. The first-class apples of this last were almost equal to the same grade of those treated with Bordeaux, while those treated with Paris green were not. More small spots of scab could be found upon the latter, and the apples were unquestionably inferior. However, in the general market most of them would have been classed as firsts.

Fostite is far behind in the comparison. King trees to which this powder was applied when treated with Paris green for the codlin moth show an increase of 60 per cent of first-class apples. When the London purple combination was used, the increase is but 33 per cent. Since the Paris green undoubtedly assisted in keeping the fruit fair, the entire gain in the other lot may be ascribed to Fostite, for London purple has practically no value as a fungicide. But this test of Fostite is not entirely fair since the apparatus for applying it was poorly adapted to the work.

The following diagrams will assist in showing more plainly the results obtained from six applications of various fungicides upon King and Fall Pippin apples. In diagram II, which refers to Fall Pippin apples, the upper division represents first-class apples, the middle division second-class, and the lower one third-class apples.

DIAGRAM I.—SHOWING THE RELATIVE VALUES OF THE FUNGICIDES APPLIED TO KING APPLES.

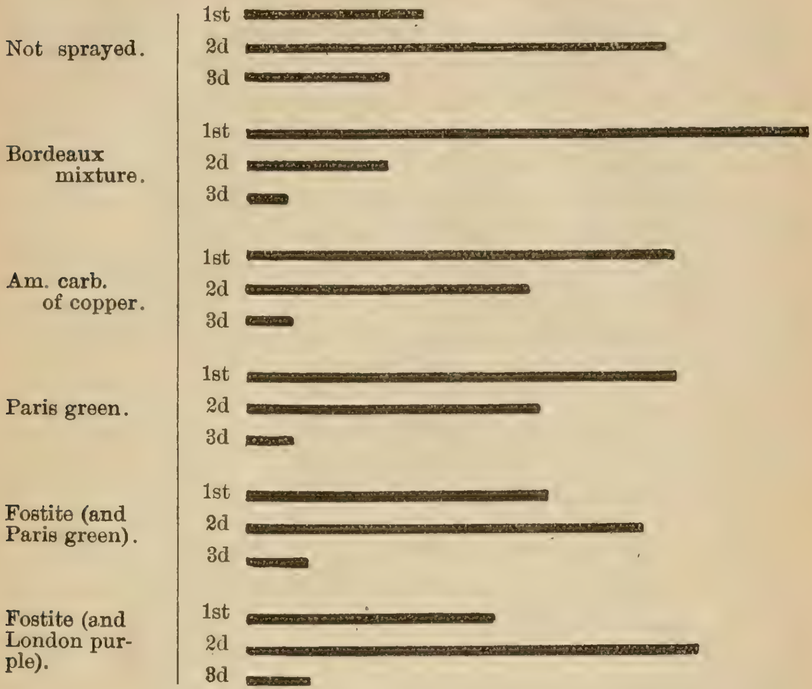

DIAGRAM II.—SHOWING THE RELATIVE VALUE OF THE FUNGICIDES APPLIED TO FALL PIPPIN APPLES.

a *b* *c* *d* *e*

a, unsprayed; b, Bordeaux mixture; c, ammoniacal carbonate of copper; d, Paris green; c, fostite (and Paris green).

None of the apples showed the effects of spraying more plainly than the Fall Pippin. This variety is very subject to the attacks of scab, and diagram II shows clearly the comparative values of the fungicides, as well as the benefits derived from proper applications. By comparing the untreated plot with the Bordeaux, it will be seen that the second one (*b*) is practically the reverse of the first (*a*). The unsprayed Fall Pippin yielded scarcely a first-class apple, the bulk of the crop being third-class. The apples treated with Bordeaux are mostly first class apples, while the proportion of thirds is exceedingly small. Certainly it pays to spray this variety.

Insecticidal values of the arsenites.— Although the London purple and Paris green used in these experiments contain about the same amounts of arsenic, still it is held in different forms. Applications were made to determine their comparative values.

Table IV.— Showing the Results Obtained from Applications of the Arsenites.

	King.				Fall Pippin.			Maiden Blush.	
No. of treatments......	1	2	6	0	2	6	0	2	0
MATERIALS APPLIED.	Per cent of wormy fruit								
Bordeaux mixture......	11	5	...	9	4	....	12	2	13
Am. carb. copper.......	9	7	5	9	....	2	12	....	....
Paris green............	5	6	3	9	3	2	12	....	....
London purple.........	....	3	....	9	....	....	....	....	....

The apples were on the whole very free from worms, whether sprayed or not, yet the above table indicates some of the effects of the applications.

The per cent of wormy apples among those sprayed but once with Bordeaux, is large when compared with the apples which were not sprayed. In one case, the number is larger, but on the average a small gain was made. This application was made June eighth, as soon as the blossoms had fallen from the trees.

All varieties show a considerable decrease in the number of wormy apples when the trees were treated twice. The second application was made June 22, two weeks after the first. These two treatments protected the apples so well that any additional ones would hardly have been profitable. June was comparatively dry (see p. 268), but the rain-fall during July was considerably above the average, so that the poison stood a good chance of being washed from the trees. It would scarcely seem to be advisable to apply Paris green or London purple more than twice in a season for the codlin moth, unless the rainfall is very heavy or continuous. Late applications protect the fruit from larvæ which hatch late in the season, but their numbers are comparatively few, and the damage done is so insignificant from a financial standpoint that the returns will scarcely warrant the expense.

On the whole, it appears to be immaterial in which form or combination the arsenites are applied. The table shows that when only one application was made Paris green gave better results when applied alone than when applied in combination with Bordeaux. But when two applications were made this result is reversed. This coincides practically with the results obtained in 1892,* when it was also found that the action of the poison was not materially affected by the presence of the Bordeaux mixture.

Paris green and the ammoniacal solution did not give such favorable results, but as the difference is comparatively slight, conclusions adverse to the combination can scarcely be drawn.

Two applications of London purple made upon the King gave more sound apples than two of Paris green, only three per cent being found wormy But Paris green equals this in two applications made upon Fall Pippin, and surpasses it by one per cent in the Maiden Blush. Consequently, no preference can be given to either poison as regards its insecticidal value. It is probable that if each contains the same amount of arsenic, the value of the two is the same. In one respect, however, Paris green has been disappointing. It was found last year, and again this summer, that the foliage of apple trees is more or less injured by its use. When many applications are made using one pound of the poison to 256 gallons of water, the injury may become serious. After the fourth application had been made to the orchard, it was found advisable to use about a quarter of a pound of quick lime, first slaked in water, to every forty gallons of the poison mixture. This apparently stopped the caustic action of the Paris green. Samples of Paris green from several manufacturers are now being analyzed by the Station

* See Cornell Experiment Station Bulletin No. 48, December, 1892.

chemist, and from incomplete data it would seem that all Paris green now sold in the market contains more or less soluble arsenic. If trouble is experienced in its use, the addition of lime will be sufficient protection to the foliage. London purple also injured the foliage, even to a greater extent than did the Paris green, but the injury was partially obscured by the action of fostite, which was applied upon the same trees.

Action of fungicides upon foliage.— Fostite was applied to the trees in liberal quantities, in order to give it a fair trial. The lower branches of the trees received their full share, which was not always the case with the upper ones. Later in the season the leaves upon the lower branches showed decided injury, so that if this powder still proves to be of value for combatting apple-scab, it must be used with caution.

The ammoniacal carbonate of copper, to which was regularly added Paris green and lime as described on page 269, proved very satisfactory as regards injury to foliage. Throughout the season the leaves of trees treated with this combination were healthy and the trees looked vigorous. The Bordeaux mixture also protected the foliage so well that scarcely a diseased leaf could be found. This effect was particularly noticeable on the Fall Pippin. The difference in foliage between the sprayed and unsprayed trees could be seen very plainly. The foliage of this variety is naturally much attacked by the apple-scab fungus, and this characteristic allowed the beneficial action of the fungicide to become apparent. The foliage of a Fall Pippin tree that was sprayed with Paris green was also noticeably more healthy than the unsprayed.

Size and color of the sprayed fruit.— The size of the apples was in some cases very plainly affected by the applications, and possibly also the color. On this latter point there was a difference of opinion, just before the apples were picked. The apples were sold while still upon the trees and the buyer very soon discovered an unsprayed tree and wanted to know what was the matter with it. It was his opinion that the color of the sprayed fruit was deeper and brighter, and others affirmed the same, but the point is open to doubt. Many varieties of apples will color beautifully if the sun is allowed to shine upon them even after they are picked.

But there can be no question of increased size of the sprayed apples. The Kings did not show it so plainly from the fact that the entire trees received the same treatment. By referring to the table on page 273 it will be noticed that the weight of one hundred apples sprayed twice with Bordeaux mixture was 37½ pounds, sprayed four time 47½ pounds, sprayed six times 44½ pounds. There is apparently no connection between the weight of the fruit and the treatment of the trees, and the other weights given under this variety are equally disconnected. An accurate comparison can be made in case of the Pippins. In the table mentioned, the numbers in the division which refers to the portion treated with Fostite and Paris green were obtained from trees treated only upon one side, the other half remaining as a check. The gain in weight is shown to be 3½ pounds, although the treated apples were by no means the best. But the Maiden Blush apples showed what could be done. There is only one tree of this variety in the orchard, and this year it bore a fair crop. One-half of this tree was sprayed with Bordeaux and the other half was not touched. When harvested, 100 average apples of the unsprayed side weighed 24½ pounds, while an equal number similarly chosen from the other half of the tree weighed 37¾ pounds; a gain of over 54 per cent. This difference was forcibly shown in another way; in fact, so plainly and conclusively did it show the value of spraying apples susceptible to the attacks of the scab that it alone would convince the most skeptical that the operation is a paying one. One hundred average unsprayed apples filled a half-bushel basket evenly full, as shown on the cover page; one hundred of the average sprayed apples filled a bushel basket evenly full. Thus the bulk of the crop of Maiden Blush was practically doubled. At the same time the energy of the trees was taxed but little more, as the production of the seed in the apple is more exhaustive than the production of the flesh. It is true that but few commercial varieties of apples will respond so generously to treatment, but still some will, and there can be no doubt that all varieties attacked by fungus are more or less checked in their growth. In addition to this, healthy foliage assists in making a healthy and vigorous tree, resulting in the deflection of a greater amount of food to the fruit.

Keeping qualities of apples as affected by sprays.— A few Fall Pippin and Maiden Blush apples were selected from the sprayed and also from the unsprayed portion of the trees about September 20. Bordeaux mixture had been used upon the former. They were stored in a cool, dry cellar. On the 15th of October the unsprayed apples began to show signs of shriveling. The scabby portions were depressed and some days later showed signs of decay. November 18, the unsprayed apples were much shrivelled and somewhat decayed. The sprayed apples, which were exceptionally fine specimens, were still plump and fit for market. It is possible that the keeping qualities of apples may be considerably affected by the proper applications.

It will undoubtedly be interesting to follow the apples from this orchard into the markets, and thus determine what relation the spraying of the fruit bore to the price received for it. Through the kindness of the buyer, J. H. Gail, commission merchant in Buffalo, N. Y., I am able to give his report on this point. His statement regarding the appearance of the fruit in the orchard was as follows:

"Without question, the showing of the fruit, before harvesting, in the apple orchard of John J. McGowen was one of the finest it has ever been my pleasure to see. The fruit, having been picked and barrelled for extra fancy trade, did not show over two or three per cent of culls; and the culled fruit when packed made a very good grade of second quality. There was practically no fruit usually known as cider apples in the orchard."

The following letter relates to the sale of the apples in Buffalo:

"The apples were as fine as anything I ever saw in the shape of Kings, even those rated as 2nd's or No. 2's being as good as the ordinary run of No. 1 fruit; in fact, they sold at the price of other No. 1's. We commenced the trade on them as soon as they arrived here, to some of our buyers of fancy fruit, at $4.50 per bbl. in job lots. I think had we put the price at $5.00 we should have got it; in fact we did get it for a portion of them while the ordinary run of Kings and so-called No. 1's sold in single barrel lots at the same time at $3.75 to $4.00. We think they went out fully $1.00 per bbl. better than the average run of Kings, and all who had them were anxious for more."

Buffalo, N. Y., Nov. 14, 1893. J. H. Gail.

The following letters indicate the attitude of leading fruit growers of this state regarding the spraying of orchards:

"In my opinion, spraying is a work of inestimable value; indeed I believe no man engaged in growing apples can afford to dispense with it. He should spray both with reference to the work of insect life and fungi. It should be done at least twice in the season and *every year*. The operation is inexpensive, and will pay a larger percentage on the investment than any other outlay of an equal amount."

Geneva, N. Y. S. D. Willard.

"After five years' experience in spraying with insecticides and fungicides, I am sufficiently satisfied to plan for the future to do the work more thoroughly than it has yet been done.

"I have found that Paris green not only avoids a large per cent of the Codlin moth's depredation, but it also has the effect of destroying the tent caterpillars and other leaf-eating insects that destroy much of the foliage during the period when it is most needed to perfect the development of wood and buds for the following year, as well as the fruit of the present.

"There is no doubt but that much of the failure of the orchards of New York for the past ten years has been due to the insects that have annually denuded the trees of a large amount of foliage, and there has been a formation of fruit-buds of low vitality.

"The same effect has been produced by a steady increase in attacks of apple-scab fungus upon both fruit and foliage which the trees have not been able to resist, and I have seen fruit over entire counties in Western New York fall to the ground within a week after blooming, from the effects of apple-scab fungus; and the young foliage was as sear as if a frost had injured it.

"When using Paris green alone, I apply one pound to 250 gallons of water. If used with Bordeaux mixture, one pound to 200 gallons.

"A very thorough, even distribution of the mixture is more essential than quantity.

"I have used four pounds of copper sulphate and three pounds of lime to 50 gallons of water with satisfactory results on apples and particularly so on quince the past season, as also with grapes. These were sprayed three times, with twelve and fifteen days intervening; the fruit was clear in color, and improved in quality.

"No fixed time can be set for the spraying. The fruit grower most study the conditions which vary with each season.

"Some varieties are more susceptible to fungus attack than others, as the Spitzenburg and Cranberry Pippin, among apples, and the White Doyenne and Flemish Beauty among pears, and these require more thorough treatment than others."

Ghent, N. Y. GEO. T. POWELL.

"I made one experiment in which about one-sixth of a R. I. Greening tree was sprayed with Paris green, using 1 pound of the poison to 200 gallons of water. As no rain fell soon after this application, a second one was not deemed necessary. When the apples were harvested the sprayed portion yielded 534 sound apples, or 4 bushels; and 48 wormy apples, or about ¼ bushel. The unsprayed portion yielded 216 sound apples, or 1½ bushels; and 92 wormy apples, or ¾ bushel. Many wormy apples fell from the unsprayed portion during the season, and as this was not the case with the part sprayed, the above figures are very partial to the side that was not sprayed. The sprayed apples were larger, of better color, and showed less scab. The man who came to buy my crop saw the sprayed side of the tree first, and actually gave me 5 cents a barrel extra for *all* my fruit, although most of my orchard consists of green instead of red varieties."

Peruville, N. Y. C. E. CHAPMAN.

II. Test of Some Fungicides and Insecticides Upon Peach Foliage.

Peach trees were treated with the following materials for the purpose of determining the extent to which each would injure the foliage:

Bordeaux mixture.— This was prepared according to the formula given on page 268.

Bordeaux mixture and London purple.— The arsenite was used at the rate of 1 pound to 250 gallons of the mixture.

Ammoniacal carbonate of copper, prepared as described on page 269.

Ammoniacal carbonate of copper, Paris green and lime. These materials were used in the proportions stated on page 269.

Paris green, used alone at the rate of 1 pound to 250 gallons of water.

London purple, used at the rate of 1 pound to 300 gallons of water.

Fostite, applied with bellows.

The above materials were applied to the trees three times, and upon the following dates: July 18, August 3, and August 22. The ingredients of the combined insecticides and fungicides were mixed immediately before the applications were made. The table shows the extent of injury resulting from each.

Kind of Treatment After Three Applications had Been Made.

VARIETY TREATED.	TREATMENT AND PER CENT. OF LEAVES DROPPED.						
	Bordeaux mixture.	Bordeaux and London purple.	Ammoniacal carbonate of copper.	Ammo-carbonate of copper and Paris green.	Paris green.	London purple.	Fostite.
Old Mixon	0	0	75	....	......	....	....
Crawford	....	....	....	10	75	90	0

The above notes were taken September 12, or 21 days after the last application had been made. Notes were also taken August 22, or only after two treatments had been made.

The Bordeaux mixture did not injure the foliage, whether London purple was added or not. As above prepared it is a perfectly safe fungicide to use on peach trees and the addition of London purple does not render it caustic.

Fostite did no injury to the foliage. The reason for this may be that the leaves of the peach are so smooth that the powder will not adhere to them. At least it was difficult to make what may be called a heavy application, as the powder blew through the trees, very little apparently being retained by the leaves. It is also possible that peach leaves are not affected by the caustic action sometimes shown by Fostite.

The ammonical copper carbonate, when used alone, seriously injured the foliage after three applications had been made, fully 75 per cent. of the leaves dropped from the trees and the remainder showed injury, more or less serious.

When Paris green and lime were added to the ammoniacal solution two applications showed considerable injury to the foliage. Three applications caused from five to ten per cent of the leaves to fall, about ten per cent of them were yellow, but the remainder showed comparatively little injury. Possibly this decrease in the extent of injury may in part be due to the variety treated, but it is scarcely probable that this influence was very great.

The action of Paris green was exceedingly caustic. Two applications caused nearly a fourth of the leaves to drop from the trees, while soon after the third application about 75 per cent fell to the ground. It is unsafe to use Paris green upon peaches, unless the mixture be made very weak.

London purple did still more damage than Paris green. Fully 90 per cent of the leaves dropped from the tree after the third application. This result coincides with those previously obtained by various experimenters, particularly those published from this station in 1890.*

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*See Cornell Experimental Station Bulletin XVIII, July, 1890, for detailed accounts of London purple and Paris green upon peach foliage. Analyses of these arsenites are also given.

III. Some Novel Insecticides and Fungicides.

Various substances have been sent to this station for the purpose of having them tested in regard to their value as insecticides and fungicides, and other materials have been suggested by growers who believed that beneficial results have followed their use. In addition to these several other substances were applied the past season, both singly and in combination, in the hope that something might be found that would prove of value. Some of the substances compared had already been used at this station* in similar experiments; those materials which appeared most promising in 1891 were tested a second time this year. But in the majority of cases it was not known what would be the action of the substance upon foliage, so many of the formulas used are not necessarily the best ones for the proper action of the materials mentioned in them. Some applications were too weak and others decidedly too strong, but all indicated more or less distinctly their value as fungicides or insecticides. Many of the materials were believed to possess caustic properties and to these lime was added. The lime was slacked in a small quantity of water, and required amounts of this milk of lime were used. The applications were, as a rule, prepared immediately before being used.

All liquids were applied with a knapsack pump manufactured by W. & B. Douglass, of Middletown, Conn., and a vermorel nozzle with lance. Powders were applied by means of Josten's magazine bellows.

Difficulty was experienced in making a uniform application of those mixtures which contained much sediment. This was particularly noticeable in the case of the Bordeaux mixture, for this showed very clearly whether it had been applied properly or not. Such mixtures cannot be well agitated in a knapsack pump, so generally the first applications contain the material in a more concentrated form than later ones. As only small quantities of the various mixtures were applied no serious variations took place in the following experiments.

The following are the kinds of plants treated. When but one variety was used the name is given here; in other cases the name of

*Cornell Experimental Station, Bulletin No. 35, December, 1891.

the variety will be mentioned in the tables or text: apple; blackberry, *Agawam*; dewberry, *Lucretia*; gooseberry, *Industry*; raspberry, *Cuthbert*; and quince. At least one plant was used for each application except in the case of the apple, when only one-half of each tree was treated; the other half served as a check.

Unless otherwise stated, the number of applications is six. These were made on the following dates: May 31, June 14, June 29, July 18, August 1, and August 22. Notes on the action of the materials applied were taken July 14 and Sept. 12. This allowed the effects of few and many applications to be compared. The condition of the weather during this time is mentioned on page 268, and in addition it may be said that the rainfall during August was about normal.

The fungi against which the applications were particularly applied were as follows: During the summer of 1892 most of the varieties of apples had suffered from the attacks of the apple scab (*Fusicladium dendriticum*), for this fungus attacks the leaves as well as the fruit. The quinces have also regularly shown the presence of leaf spot (*Entomsoporium maculatum*), while raspberries, blackberries and dewberries have been attacked by anthracnose. This year anthracnose could scarcely be found except on the dewberries. The leaves and canes of these plants were quite seriously attacked by this fungus (*Glœosporium necator*). The Industry gooseberry is an English variety and is very susceptible to the attacks of mildew (*Sphærotheca Morsuvæ*). It attacks both foliage and fruit, generally rendering the latter unfit for market.

The numbers in the first column of the following tables show approximately the degree to which the foliage was injured by fungi. All the sprayed plants were carefully compared with the unsprayed and the relative degree of injury from this cause noted as accurately as possible, in order to determine the effect of the application. The second column of the tables shows the gain in per cents of freedom from fungous attack of the sprayed over the unsprayed portions. In the third column are placed the numbers which show the per cent of injury done by the applications.

As a rule, the amounts of injury shown by the tables are based upon the results of six applications. When they refer to a fewer number the fact will be mentioned.

No. 1.— *Bordeaux mixture.*— This was prepared according to the formula on page 268. Its value as a fungicide has been so often proved that its use here is merely for the purpose of comparing the results obtained from other applications with some which may be considered as standards. The comparative value of the materials can thus be more accurately considered.

PLANTS USED.	Unsprayed. Per cent injury from fungi.	Sprayed.	
		Per cent reduction of fungi.	Per cent injury from applications.
Apple (Baldwin)	15	85	0
Blackberry	0	0	0
Gooseberry	20	75	0
Dewberry	10	75	0
Quince (Rea's Mammoth)	15	80	0
Raspberry	0	0	0

The dewberries and the quinces showed most plainly the value of the treatments. Most of the other plants were not so seriously attacked, yet the difference between the treated and the untreated plants could be seen.

The Bordeaux mixture when properly applied practically protects the foliage of plants from the attacks of the fungi mentioned on page 290.

No. 2.-- *Copper Chloride.*— This fungicide gave good results in 1891, although it was then used too strong. It was used the past season as follows:

(a) Copper chloride, 1 ounce.
Water, 25 gallons.

(b) Copper chloride, 2 ounces.
London purple, 1½ ounces.
Lime, 1 pound.
Water, 25 gallons.

PLANTS USED.	Unsprayed. Per cent injury from fungi.	Sprayed.			
		Formula A.		Formula B.	
		Per cent reduction of fungi.	Per cent injury from application.	Per cent reduction of fungi.	Per cent injury from application.
Apple (R. I. Greening)	10	0	5	50	0
Blackberry	0	0	5	0	0
Dewberry	20	50	0	65	0
Quince (Fall Orange)	15	35	0	80	0
Raspberry	0	0	5	0	0

Copper chloride possesses some value as a fungicide. It can not be used alone, however, without injuring foliage, and lime must be added to destroy its caustic properties. It is probable that two or three ounces in twenty-five gallons of water is sufficiently strong to give good results. When used at the rate of an ounce to twenty-five gallons of water it reduced the injury from fungi 50 per cent upon the dewberries, and 35 per cent on the quinces. When used twice as strong the injury was reduced 75 per cent and 80 per cent respectively. At the same time the foliage was uninjured by the application, even though London purple had been added. These results are encouraging for if a fungicide can be found which will equal the Bordeaux mixture, and still be easy of application, much of the trouble which now accompanies spraying will be avoided.

Copper chloride can not be used as a fungicide to advantage unless the solution is so strong that lime is required to neutralize its caustic action. On the whole it is a promising fungicide.

No. 3.—*Iron Chloride.*—The chloride of iron was applied to the same varieties of plants mentioned under No. 1. The following is the formula used:

Iron chloride,	3 ounces.
London purple,	1½ ounces.
Lime,	1 pound.
Water,	25 gallons.

The beneficial action of this chemical was so slight that no definite improvement in the foliage could be seen. The quinces were apparently not benefited, but upon the dewberries the leaves of the sprayed plant seemed to be a trifle more free from fungous attack than the check plants. The combination possessed no caustic properties.

The experiments of the past season show no practical benefit derived from applications of iron chloride.

No. 4.—*Zinc chloride.*—This chemical was applied both alone and with lime and London purple.

(a)	Zinc chloride,	1 ounce.
	Water,	25 gallons.
(b)	Zinc chloride,	3 ounces.
	London purple,	1½ ounces.
	Lime,	1 pound.
	Water,	25 gallons.

Formula (a) was used for the first four treatments, the last two containing three ounces of the chloride instead of but one. The same varieties of plants mentioned under No. 3 were used, except that the apple tree was a Westfield Seek-no-further.

No beneficial results seemed to follow the use of formula (a), possibly from the fact that the solution was at first too weak. None of the foilage was injured.

Formula (b) gave little better results. The quince and dewberry plants seemed to have healthier foliage where they were sprayed, but injury from fungi was scarcely reduced more than 25 per cent at the most.

Zinc chloride, when used according to the formulas given above, is not a fungicide which can be applied with profit.

No. 5.— *Zinc sulphate.*— The following formulas were used:

(a)	Zinc sulphate,	3 ounces.
	Water,	25 gallons.
(b)	Zinc sulphate.	3 ounces
	London purple,	1½ ounces.
	Lime,	1 pound.
	Water,	25 gallons.

The varieties of plants treated were the same as the preceding, but the apples used were Mc Intosh Red. The advantages derived from the applications were so slight as to be practically of no value. It is probable that greater quantities of the sulphate are necessary. None of the foilage was injured.

Zinc sulphate has thus far proved of no practical value as a fungicide.

No. 6.— *Lead acetate.*— The formulas according to which this material was used were similar to the preceding.

(a)	Lead acetate,	3 ounces.
	Water	25 gallons.
(b)	Lead acetate,	3 ounces.
	London purple,	1½ ounces.
	Lime,	1 pound.
	Water,	25 gallons.

In this variety of apple was Maiden Blush for formula (a), and Ben Davis for formula (b). The other varieties were the same as those previously mentioned. No marked results followed the treatments.

Lead acetate did not materially reduce the injury done by fungi to the foilage of the treated plants.

No. 7.— *Fostite.*— Analysis of this power made by Mr. Cavanaugh, the assistant Station chemist, shows it to contain about 2 per cent of copper, but the form in which it is found has not yet been determined. The bulk of the powder is composed of soapstone, or steatite, which certainly has the power of adhering to foilage a long time, especially if it is applied while wet. It is the intention to give a complete analysis of the substance in the near future.

Fostile was applied in dry form, and also in water. In the former case Joosten's magazine bellows was used, and the distribution was made as even as possible. When mixed with water it was used as follows:

Fostite, 8 ounces.
Water, 2 gallons.

Two applications were made according to the above formula, but the remaining four treatments were made with a mixture one-half as strong. The following table shows the results:

PLANTS USED.	Unsprayed, per cent injury from fungi.	SPRAYED.			
		DRY FORM.		IN WATER.	
		Per cent reduction of fungi.	Per cent injury from application.	Per cent reduction of fungi.	Per cent injury from application.
Apple (Ewalt)	5	25	0	20	25
Blackberry	0	0	0	0	15
Dewberry	20	60	0	25	0
Gooseberry	10	25	0	40	15
Quince (Rea's Mammoth)	15	75	0	75	0
Raspberry	0	0	0	0	0

This table shows that fostite possesses marked fungicidal properties. The quinces show the greatest difference between the treated and untreated parts, the injury from fungi being reduced about 75 per cent; dewberries were also benefitted, and to a less extent gooseberries and apples. When the powder was used in the dry form apparently no injury was done to foilage of any kind. But when it was mixed with water, apples, blackberries and dewberries were more or less burned. This injury was in no case very serious, although it is undesirable.

In addition to the plants above mentioned, fostite was also tested upon roses, forcing cucumbers, and forcing musk melons.

During August the roses of Mr. Arthur Boole, of Ithaca, were severely attacked by the common white mildew (*Sphærotheca pannosa*). Fostite was applied to about 500 plants consisting of Bride and Mermet roses.

The powder was first applied August 14 and daily applications were made, so that soon all the older leaves were more or less discolored. This treatment was continued until August 26. During this time the plants were growing rapidly and new foliage was quickly formed. In spite of the powder the young rose leaves were attacked to such an extent that it was doubtful if any beneficial results followed the applications. It was Mr. Boole's opinion, after using fostite during the period mentioned, that the benefits derived did not pay for the material and the labor of applying, for the young leaves showed spots of mildew almost as soon as they unfolded. This result may be partially explained by the fact that young rose leaves do not as a rule assume such a horizontal position as do the old ones; they have a wilted appearance. Their surfaces also seem to be more smooth and glossy. It is very probable that the powder failed to adhere to the young leaves, and these were then open to the attacks of the mildew. In this trial the time was short but the roses were growing so rapidly that the fungicide had a fair chance to protect the young foliage.

Another experiment upon roses was carried on in the rose-house of this station. About twenty-five of the leading market varieties of tea roses were under treatment. When the plants were set in the house some of them showed considerable amounts of mildew, but most of the varieties were free from the disease. Fostite was immediately applied and the foliage was treated every other day. The powder could be seen very plainly upon the older leaves. When the plants started into growth the condition of the new foliage was watched with interest. Mildew appeared upon the young growth to a considerable extent; and although applications were continued for about four weeks no decrease in the amount of mildew could be observed. In neither of these experiments was any distinct injury from the use of fostite noticed.

During the past summer a crop of cucumbers was grown under glass. The varieties grown were Telegraph, Sion House, Duke of Edinburgh, Blanc Hâtif, and White Spine. In July, mildew (*Oidium erysiphoides* var. *Cucurbitarum*) was observed upon some of the foliage, but especially upon Blanc Hâtif and Telegraph leaves. The house was shut up, the plants syringed, and fostite applied by means of a bellows. The amount applied was supposed to be ample but not excessive. No apparent injury following this treatment, it was repeated in a few days. Three days later some of the leaves showed signs of injury and soon all the foliage showed a greater or less amount of scorching. No further applications were made.

In order to test more carefully the exact amount of injury done to the foliage of cucurbitaceous plants Individual plants of forcing musk-melons were dusted by means of a can having a perforated cover. The varieties treated were particularly adapted to forcing and were as follows: Melon de Malte, Brodé de Malte, Brodé d' Antibes blanc, Brodé olive, Brodé vert. The applications were made about October

1, upon young plants which were growing vigorously. Enough of the powder was used so that it could be plainly seen; the plants were wet at the time. Two days later some signs of injury were observed, and this continued to increase to such an extent that some of the treated leaves were killed, and one plant died. Some of the other plants show the effects of the application to this date, November 20.

The insecticidal value of fostite was tested on a small scale by W. J. McNeil, a student doing advanced work in entomology. He dusted thoroughly some chrysanthemum plants which were infested with plant lice, distributing the powder carefully over the entire plant. In addition to this, some of the lice were removed from the plant, and rolled about in the powder. They were then placed upon a plant which contained none of the pest. The day following these operations the lice were examined collectively and individually, and no trace of injury was shown by any of them.

Fostite possesses some fungicidal value. This was most clearly shown by Rea's Mammoth quince, Lucretia dewberry, Ewalt and King apples.

It must be applied with caution as the leaves of apples, blackberries, dewberries, forcing cucumbers, and forcing musk-melons have been injured by its use.

When dry, it possesses no value as an insecticide which kills by contact.

No. 8.— *Boron compounds.*—

(a)	Borax,	2 ounces.
	Water,	2 gallons.
(b)	Borax,	2 ounces.
	Lime,	½ ounce.
	Water,	2 gallons.
(c)	Boracic acid,	2 ounces.
	Lime,	½ ounce.
	Water,	2 gallons.

These formulas were used in making solutions, which were applied to the same plants mentioned under No. 7. In no case could any decided benefit which was due to the application be found nor were the plants particularly injured.

Neither borax nor boracic acid appear to possess any fungicidal value.

No. 9.— *Iodine.*— The use of this material for fungicidal purposes was suggested by a correspondent. Some of it was also sent us. A watery solution of the iodide of potassium was used for dissolving the iodine crystals, and this solution was so diluted with water that it resembled weak black tea in color. The proportions used were :

Iodine solution, 1 pint.
Water 2 gallons.

All the plants to which this solution was applied were injured by it, the quinces probably more than any of the others. Fully 25 per cent. of the quince leaves were burned. This injury to the foliage obscured the fungicidal action of the iodine; and although it was thought that some advantage had been gained from its use upon dewberries and quinces, still further trial is necessary to determine its value in this respect.

The application of dissolved iodine crystals is unsafe and it is of doubtful value.

No. 10.— *Nitrate of soda.*— This substance was suggested by Joseph Harris. It was applied in solution.

Soda nitrate, 2 ounces.
Water, 2 gallons.

Applications were made to the same plants mentioned under No. 7, but the variety of apple here used was the Baldwin. All the plants were injured. Fully 20 per cent of the Baldwin leaves were affected, and 10 per cent of the quince foliage. The other plants suffered but slightly. No reduction in the amount of fungous injury could be noticed following these applications.

Nitrate of soda when applied in water has a caustic action upon foliage and possesses apparently no fungicidal properties.

No. 11.— *Caustic potash.*— During the month of May, 1892, Mr. W. C. Archibald of Wolfsville, Nova Scotia, sprayed a large number of apple, peach and plum trees with a solution of "rock or caustic potash, diluted to about the proportion of 1 pound to 2 gallons of water." The buds on the trees had not yet burst although they were swollen. Regarding the result, Mr. Archibald writes: "By accurate observation my plums and apples, where the potash was so used on the buds, are pronounced one-eighth larger than those borne in previous years."

As tested at this station during the past season, caustic potash was used in the form of sticks obtained from a druggist. It was used as follows:

Caustic potash, $\frac{1}{2}$ ounce.
Water, 2 gallons.

The potash dissolves readily in water and the solution was applied to the varieties of plants mentioned under No. 7. The application appeared to reduced the amount of leaf-spot on the quince about 30 per cent and the dewberries were protected from about 25 per cent of the injury visible on the check plants. The other plants which were sprayed showed no effects of the application. No foliage was injured.

Caustic potash may have some fungicidal value.

No. 11.— *Pine products.*— In April, 1892, we received from S. L. Goodale, of Saco, Maine, some abretic acid, and some kreolin, two substances derived from pines. As the amounts received were small the following formulas do not include so much of the materials as might be desired. Two ounces of kreolin were dissolved in one pint of water.

(a)	Abretic acid solution,	1 tablespoonful.
	Water,	1 gallon.
(b)	Kreolin solution,	2 tablespoonfuls.
	Water,	1 gallon.

None of the treated plants, these being the same as those mentioned under No. 7, showed any effects of the application. No foliage was injured, and fungi were as abundant as upon the check plants.

The application of pine products appeared to be without effect.

No. 12.— *Antinonnin.*— This substance is sold as an insecticide and was sent us by the manufacturers, Friedr, Beyer & Co., of Elberfeld, Germany. It is said that this compound was discovered by Prof. O. Harz and W. von Miller, of Munich, Germany. Antinonnin is a solid having about the same consistency as fresh cheese. It is bright golden-yellow in color, very easily soluble in water, and when dry is highly explosive. Consequently it must be kept in a moist place for if fire reaches it when once dry it will ignite almost as readily as gunpowder and it burns very much in the same manner. The station chemist has not yet completed its analysis, but it is supposed to be an organic compound. It was used at the rate of

(a)	Antinonnin,	$\frac{1}{4}$ ounce.
	Water,	1 gallon.
(b)	Antinonnin,	$\frac{1}{4}$ ounce.
	Lime,	$\frac{1}{4}$ ounce.
	Water,	1 gallon.

The applications were made to Longfield apple trees, Champion quince, and to the same varieties of plants mentioned in addition under No. 7. After the first application it was immediately seen that the above formulas gave a too concentrated solution, so the same amount of the insecticide was used in two gallons of water. Even when thus diluted, formula (a) did considerable damage, destroying from 35 to 75 per cent of the foliage to which it was applied; its use was discontinued. Six applications were made of the solution containing lime. This still possessed caustic properties, but the injury done was not serious. Apple and quince foliage suffered most, the injury amounting to perhaps 10 per cent. The other plants appeared to be unaffected.

The introducers of antinonnin claim that it is of value in destroying both leaf-eating and sucking insects. The quince tree to which the material was applied was badly infested with the common green plant louse. After the applications the number of insects was not visibly reduced. The poison would not adhere to their bodies but the drops rolled away and the insects were uninjured. Its effect upon chewing insects was not tested.

Antinonnin must be kept moist else it becomes a dangerous substance to handle.

Its action upon foliage when used alone is extremely caustic, and its solution must be applied weak.

Lime reduces the caustic action of this poison.

It possesses apparently no practical value as a destroyer of sucking insects.

SUMMARY.

1. Pumps used in spraying orchards must have a large capacity in order to be economical of labor. (Pages 266, 267.)

2. Automatic agitators have not given satisfactory results. (Page 267.)

3. That spraying may be facilitated, the trees in an orchard should be planted far enough apart to allow of the passage of a wagon when the orchard is in full bearing. (Page 268.)

4. The amount of liquid required to spray a full grown apple tree is about four gallons. (Page 268.)

5. The number of applications necessary to protect apples from the scab fungus can not be definitely stated. As a rule, it may be said that a fungicide should be applied at least once before the trees blossom, and two applications are necessary after the falling of the blossoms, upon those varieties which are habitually injured by scab to any serious extent. Upon many susceptible varieties, one or two additional treatments are advisable. Only one or two applications may be applied with profit to resistant varieties. (Pages 274, 275.)

6. The advisability of making more than one or two applications of fungicide to Baldwin and Fallawater apples is doubtful. King, Maiden

Blush, and Fall Pipin apples will repay, four and possibly six applications. Red Astrachan can also be profitably treated three times. (Pages 275, 276.)

7. Bordeaux mixture proved to be by far the most effective fungicide of those used. Following the Bordeaux in the order of their value are, the ammoniacal solution of copper carbonate, Paris green, fostite. (Page 277.)

No preference can be given Paris green or London purple in regard to their insecticidal value, provided they contain an equal amount of arsenic. (Page 281.)

9. Two applications of the arsenites are sufficient to control the ravages of the first brood of codlin moth larvæ. The financial gain derived from later application may be doubtful. (Page 281.)

10. The arsenites and the fungicides used in the apple orchard appear to be equally effective whether applied alone or in combination. (Page 281.)

11. Paris green and London purple, if applied more than once or twice to foliage, may do serious damage unless their caustic action is neutralized. (Page 281.)

12. Lime greatly reduced the caustic action of Paris green. (Page 281.)

13. The foliage of varieties of apples susceptible to the attacks of apple scab was kept in a healthy condition by applications of fungicides. (Page 282.)

14. The size of Fall Pippin apples was practically doubled by protecting them from the attacks of the apple scab fungus. (Page 283.)

15. The use of fungicides may intensify the color of apples. (Page 282.)

16. The keeping qualities of Fall Pippin and Maiden Blush apples were apparently greatly augmented by the applications of Bordeaux mixture which were made to reduce injury from scab. (Page 283.)

17. The market value of sprayed apples was increased at least $1.00 per barrel by the applications made during this season. (Page 284.)

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18. Bordeaux mixture, when applied to peach trees alone, or in combination with London purple, did not injure the foliage. (Page 288.)

19. The ammoniacal carbonate of copper is very injurious to peach foliage, but the solution may be rendered less caustic by adding lime. The addition of Paris green can then also be made with comparative safety. (Page 288.)

20. Neither Paris green nor London purple should be used upon peach trees unless the mixtures are very dilute, or lime is added to neutralize the caustic action of the arsenites. (Page 288.)

21. Fostite gave only negative results when applied to peach foliage. (Page 288.)

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22. The Bordeaux mixture, when properly applied, practically protects the foliage of apples, quinces, dewperries, raspberries, blackberries, and gooseberries from fungous attack. (Page 291.)

23. Copper chloride can be used as a fungicide to advantage when the solution is so strong that lime is required to neutralize its caustic action. On the whole, it is a promising fungicide. (Page 292.)

24. The experiences of the past season show no practical benefits arising from applications of iron chloride. (Page 292.)

25. Zinc chloride, as used the past season, cannot be applied with profit as a fungicide. (Page 293.)

26. Zinc sulphate has thus far proved of no practical value as a fungicide. (Page 293.)

27. Fostite contains about two per cent of copper. (Page 293.)

28. Fostite possesses some fungicidal value, but its application to trees is difficult and the beneficial action so moderate that it cannot be generally recommended. (Pages 277, 294.)

29. Fostite has proved injurious to the foliage of apples, blackberries, dewberries, forcing cucumbers and forcing musk-melons. (Pages 294, 295, 296.)

30. When dry, fostite possesses no value as an insecticide which kills by contact. (Page 296.)

31. Neither borax, nor boracic acid and lime appear to possess any fungicidal value. (Page 296.)

32. The application to the foliage of dissolved iodine crystals is unsafe and of doubtful value. (Page 297.)

33. Nitrate of soda, when applied in water, has a caustic action upon foliage, and it possesses apparently no fungicidal properties. (Page 297.)

34. Caustic potash may have some fungicidal value. (Page 298.)

35. Abretic acid, and also kreolin, were applied for fungicidal purposes but no beneficial results followed their use. (Page 298.)

36. Antinonnin must be kept moist, else it becomes a dangerous substance to handle. (Page 299.)

37. The action of antinonnin upon foliage, when used alone, is extremely caustic, and the solution must be applied very dilute. (Page 299.)

38. Lime reduces the caustic action of antinonnin. (Page 299.)

39. Antinonnin possesses no practical value for destroying insects by contact. (Page 299.)

40. On the whole, therefore, I recommend that growers adhere to Bordeaux mixture in combatting fungi; or ammoniacal carbonate of copper may be used as a second choice, in case the Bordeaux cannot be applied with facility. Paris green and London purple are still the best general insecticides; and the greater value seems, in general, to reside in the Paris green.

E. D. LODEMAN.

Cornell University Agricultural Experiment Station.

ALL DIVISIONS.

BULLETIN 61—DECEMBER, 1893.

SUNDRY INVESTIGATIONS OF THE YEAR.

ORGANIZATION.

Board of Control.—The Trustees of the University.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.— Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55 Greenhouse Notes.
56. The Production of Manure.
57. Raspberries and Blackberries.
58. Four-Lined Leaf-Bug.
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Botanical Division

CRYPTOGAMIC BOTANY AND PLANT PATHOLOGY.

ŒDEMA OF APPLE TREES.

During the month of July specimens of diseased apple twigs were received from Mr. E. A. Crow, of New York city. The soft outer tissue of the limbs was in a state of decay and occupied by a fungus, some species of *Fusarium*, which resembled *F. arcuatum* B. & C., which was described from the bark of Pirus malus in South Carolina. Mr. Crow had supposed this fungus to be the cause of the trouble, and had tried the use of the Bordeaux mixture after having scraped off the bark from the diseased places. Since so many of the species of the genus *Fusarium* grow only in tissues which have been injured by some other agent, and all of the material which was first received was in such an advanced state of decay, I requested Mr. Crow to send me some fresh specimens which would represent the entire progress of the trouble from its inception. From this material, which was received in good condition, the external peculiarities of the disease may be described as follows:

Minute elevations appear on the surface of the branches or trunks, which gradually increase in size from one-eighth to one-fourth of an inch long and nearly as wide. They are usually quite close together and frequently by increase in size, become confluent when a large number extend over quite a large surface and appear as one of very irregular form. These elevations present the appearance of blisters, and they are well shown in figure 1, which is from a photograph of three of the specimens received. Two of them show the appearance of the twigs when the blisters are most prominent, while one of them shows the collapsed condition of the tissues which always results after the tissues are broken down from decay.

Microscopic sections through the parts of the twigs where the trouble is recent, shows that no fungus is present, and in fact there is no ground for the casual connection of any parasitic organism. Immediately beneath the periderm the young phellogen tissues at the points of the blisters is seen to be very greatly elongated radially. This radial elongation of the phellogen causes the periderm to be raised in the form of a blister. Beside the radial elongation of the phellogen cells they are also very much distended. This distension continues until the cell walls are no longer able to stretch because they become so thin that they break and the cells collapse. This collapse of the phellogen cells causes the collapse of the blisters and in drying these affected areas are depressed below the normal surface of the twig. Also the dying tissue forms a nidus for such saprophytic fungi as the Fusarium which was in many cases present. The dropseal swelling of the tissues is of the same nature as that which occurs sometimes with tomatoes when grown under conditions which favor rapid and continuous root absorption and at the same time hinder transpiration, or growth. A thorough study of this trouble with the tomato was made last winter by the author and published in bulletin No. 55, May, 1893, of the Cornell Station. To this the reader is referred for a full discussion of the unequal operation of the physiological laws which induce the trouble, and for the bibliography.

In the case of the tomato œdema the unequal operation of the physiological laws was due to certain unfavorable conditions of greenhouse lighting and heating. This would not apply to the case of the apple trees which were grown out doors. But since the trouble was like in kind, the cause would probably be found in some condition of soil, cultivation, or pruning of the trees, which would favor root absorption and hinder transpiration, or growth, at a sufficient number of points on the tree to take charge of all the water which the roots absorbed. Inquiry of the owner developed the fact that the soil in the young orchard was very fertile and well worked, and that the conditions, so far as soil was concerned, were very favorable for rapid root absorption and growth. In fact the trees grew very luxuriantly and were the marvel of the neighborhood. But during the winter and early spring they were very severely pruned. According to the owner they were pruned very close, leaving only the main limbs and twigs and a few secondaries, and the new growth was cut back one-third. This left but few growing points. When root absorption and growth began in the spring, there being no leaves to discharge the excess of water through transpiration, the few growing points could not dispose of the excess. Consequently the thin-walled phellogen tissue could not stand the strain. Figure 2 represents a portion of a cross section of one of the blisters; *a*, periderm; *b*, phellogen; *c*, inner layer of cells developed from phellogen; *d*, bast fibers; *e*, cambium; *f*, medullary

Fig. 1.—Œdema of Apple Trees.

FIG. 3.— Melanconium Fuligineum.

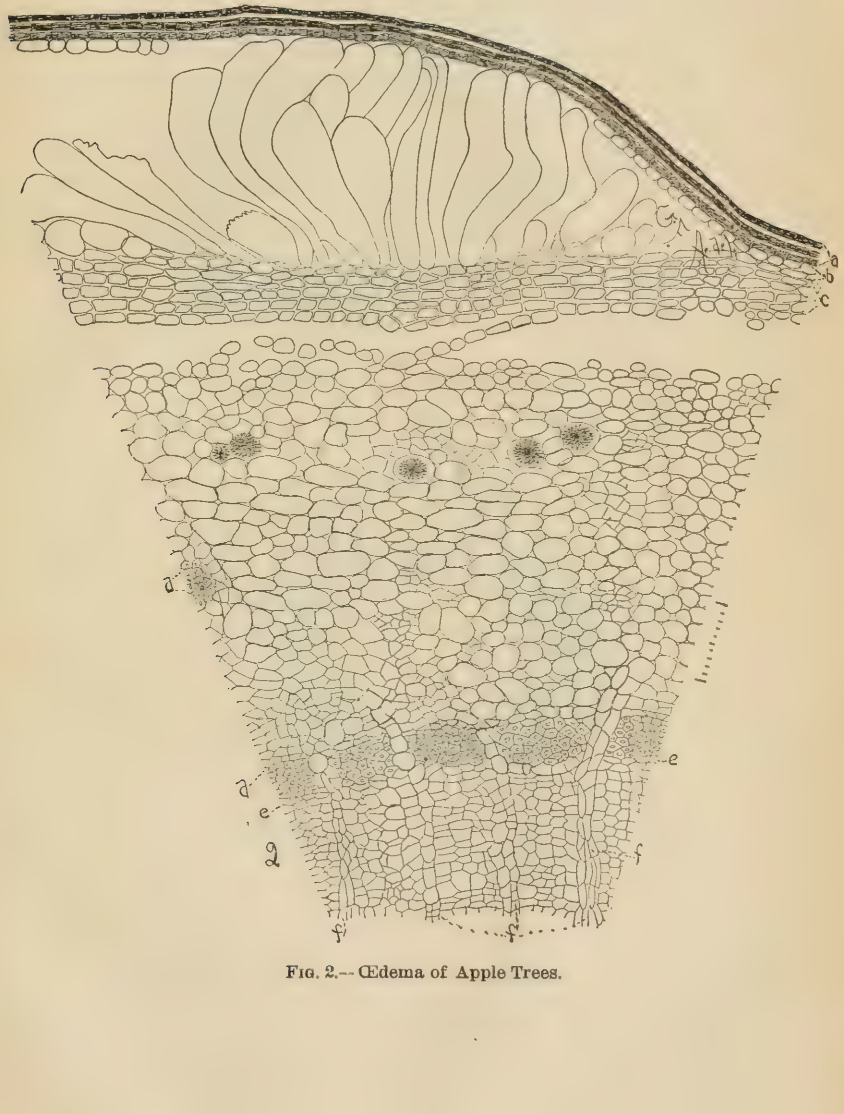
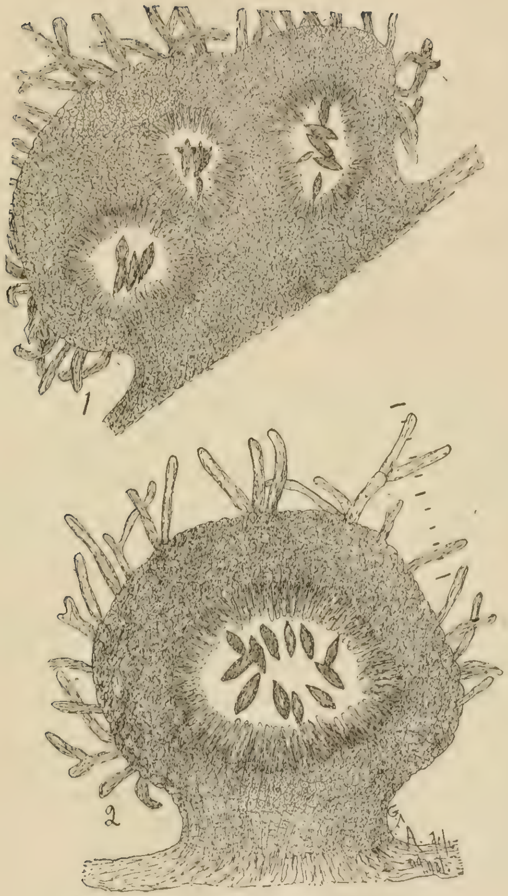


FIG. 2.—Œdema of Apple Trees.



FIGS. 1 AND 2.— Melanconium Fuligineum.

rays. Scale = 1 mm.; object magnified 10 times more than the scale. Drawn with aid of camera lucida.

The cause being known the remedy would be suggested to all, that too vigorous growth should be guarded against and too severe pruning should not be indulged in.

GEO. F. ATKINSON.

ARTIFICIAL CULTURES OF MELANCONIUM FULIGINEUM.

The suggestion made by Miss Southworth* that the *Melanconium fuligineum* (Scrib. et. Viala) Cav., should be placed in the same genus with the Ripe Rot of grapes and apples (*Gloeosporium fructigineum*, Berk.) led me to make artificial cultures of the fungus for the sake of comparison with cultures of the genus *Gloeosporium* of the same type as the *fructigenum*. Material was obtained from Mr. F. S. Earle of Ocean Springs, Miss, who was kind enough to take the trouble to collect some fallen grapes during the month of February, 1893, from a vineyard which had been affected with the fungus the previous season. A few of these grapes possessed numerous pustules characteristic of *Melanconium fuligineum* and which were filled with spores. With these dilution cultures were started in Petrie dishes using ordinary nutrient agar.

In 24 hours the spores were germinating. One to several germ tubes may arise from the spore, usually several. The spores remain continuous, and at first the threads develop septa scantily or indistinctly. The hyphae soon branch and usually profusely quite close to the spore, so that a rudimentary stroma appears to be developed quite near the center of growth. The spores germinate quite readily in the nutrient agar and growth continues readily for a few days, but no spores were developed in the plate cultures even after a period of three weeks. Even after the first few days the fungus no longer grew vigorously. The nutrient agar did not supply the needed kind of nourishment for it, or lacked favorable physical properties.

A few of the colonies of the threads known to have originated from spores of the Malanconium fuligineum were transplanted to culture tubes of nutrient agar, but in a month's time seemed to make no growth or but very little. At the same time several colonies were transplanted to sterilized bean stems in culture tubes. This medium proved to be very favorable for the organism, for in a few days a profuse growth appeared

*Journal Mycology, Vol. VI., No. 4, 1891, p. 171.

at the point of the transplantings. The threads of the fungus grew both within the tissues and upon the surface of the stems. In macroscopic appearance the surface growth first formed a scant downy, whitish weft with a number of ascending and procumbent threads at the advancing edge of the weft. From the center of growth this was soon succeeded by a darkening of the fungus, brought about chiefly by the discoloration of the threads lying close to the substratum, and the appearance of stroma or stools scattered over the surface which gave the stem a punctiform appearance. This growth spread until the entire surface of the stems so far as the moisture extended presented a blackened or charred aspect, studded with numerous black points. The fungus also grows out upon and in the infusion in which the stems are partly immersed, and in time form a thick weft.

The elevated stools when magnified simulate in form a pezizoid stroma, being attached to the substratum by a very short stem, and presenting a plane or convex surface, their perpendicular diameter being less than their horizontal diameter. These stools perform the same function in the artificial cultures that the pustules on the berries do, and produce myriads of fuliginous navicular spores. The superficial position of the fruiting stroma is probably due to the difference in the substratum. Sometimes the spores are borne upon the surface of the dark stroma, or very frequently the stroma forms a pseudo-pycnidium covered with loose threads some of which bear spores, but the center is occupied by a hymenium from which numerous basidia converge toward the center of the cavity and bear multitudes of the characteristic spores, as shown in figures 1 and 2. When the stroma attains some size there may be several cavities at different relative depths.

When the cultures in the Petrie dishes were about one month old the plates were photographed and plate No. 3 is reproduced in figure 3. Since this was a dilution culture for the separation of the fungus the culture is a mixed one and other colonies than those of the *Melanconium fuligineum* appear in the plate. Up to this time in the agar the colonies remain colorless. The growth in dilution culture No. 3 where the fungus had more room did not exceed 1 cm. in diameter, and while the growth was not quite compact, radiating threads are shown on the margin of the colony. In the photograph the colonies of *Melanconium fuligineum* are those of the medium size and the places from which the transplantings were made can readily be seen. In the illustration beside the *Melanconium* are common moulds, bacteria, and a dark yeast form which produces deep black points in the medium.

Compared with cultures of the type of *Gloeosporium fructigenum* which has fallen into my hands, the *Melanconium fuligineum* seems to be generally distinct as shown by the characters of germination, the growth in the agar plate, and the characters of fructification on a more solid artificial substratum like sterilized bean stems. A full comparison it does not now seem best to make, reserving it for the study of the *Gloeosporiums* which are now in progress. Figures 1 and 2 drawn with aid of camera lucida; scale = 1 mm.; object magnified 30 times more than scale.

GEO. F. ATKINSON.

POWDERY MILDEW OF CRUCIFERS.

A powdery mildew of certain cultivated cruciferous plants is probably of common occurrence in America, but thus far it does not seem to have attracted much attention. This may be because it is not very injurious. At present this mildew is known only in the conidial stage, on crucifers, and I do not remember ever seeing any reference to its occurrence on these plants in the United States. It frequently becomes very injurious to turnips in England where it has been known for some time. W. G. Smith records it in his little book: "Diseases of Field and Garden Crops" under the name of *Oidium balsamii*, Mont.

Oidium is a form genus which includes several species that are known to be the conidial stages of some pyrenomycetous fungus especially of the group *Erysipheæ*. According to Saccardo several of the microsporous species are probably more properly referable to the genera *Ovularia* and *Ramularia*.* Several of the larger species of *Oidium* have already been correllated with their ascosporous form.

Oidium balsamii, Mont. was named from specimens of the mildew on *Verbascum montanum* collected at Milan by Balsamo and referred by him to *Oidium tuckeri*. Berkeley † first published the species using Montagne's manuscript name, and recorded its occurrence in England on *Verbascum nigrum*, and also to this species referred the mildew which was at one time abundant and injurious upon the Culhill's Black Prince Strawberry in the Kew Gardens.‡ In 1880 it appeared in abundance in England on turnips § for the first time though it had been observed there before that time.

During the autumn of 1893 the present writer observed it on turnips, Japanese cabbage and Scotch green curled kale at Ithaca, N. Y., and in the autumn of 1889 at Auburn, Ala., upon ruta bagas.

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*See Syll. Fung. Vol. IV, p. 41. † Ann. Nat. Hist., Vol. XIII, 1854, p. 463.
‡Gard. Chron. Apr. 15, 1854, p. 263. § Gard. Chron. XIV, 1880, p. 392.

The turnips did not seem to be very much injured though in several cases large areas of the surface of the leaves were white with the mildew. In many cases the Scotch kale leaves were completely covered on both surfaces with the growth, and in such cases must produce considerable injury. The Japanese cabbage which was affected was going to "seed," and not only were the leaves affected but several of the fruiting stems were completely covered by the fungus. Several *Erysiphe* which fruit shyly on the leaves of their hosts frequently do so abundantly on the stems and it was hoped that in this case the perfect form of this Oidium might be obtained, but thus far no sign of the ascosporous stage has been seen. It would be difficult to properly correllate the form without the evidence to be derived from this stage, but there is some evidence to be gained which at least suggests relationship to some species. As I have found, the haustoria on the mycelium are lobed. It is quite possible that the form is ultimately to be referred to some of the species of the genus Erysiphe. As DeBary* has pointed out, the haustoria on the mycelium of *Erysiphe galeopsidis* are lobed and this character is useful in differentiating this species from *Erysiphe cichoracearum*. No species of *Erysipheæ* have as yet been recorded upon any of the cruciferous family. If the *Oidium* on turnips has been properly referred to the *Oidium balsamii* on *Verbascum* then there would be some probability at least that this was the conidial stage of *Erysiphe galeopsidis*, since that species has been found upon a genus of the *Scrophulariaceæ* (*Chelone*). In size and form the Conidia of *Erysiphe galeopsidis* agree very well with those of the turnip mildew. But this evidence can only suggest, not determine, the true relationship.

GEO. F. ATKINSON.

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*Morp. und. Phys. d. Pilze, III, p. 49.

Agricultural Division.

WHEAT CULTURE BY THE JETHRO TULL OR LOIS-WEEDON SYSTEM.

Since to the investigations and practices of Jethro Tull is due more than to any other cause the superior culture given to roots and grain crops in England, it may not be out of place to state briefly the chief points of his system.

Jethro Tull, an English landlord educated for the bar, visited Italy and the South of France at the close of the sixteenth century in order to regain his health. In these countries he learned that many successive crops were taken from the land without any apparent diminution of yield. He says, "Vines kept in the condition of low shrubs are constantly plowed (cultivated) in the proper season ; these have no other assistants, but by hoeing, because their heads and roots are so near together that dung would spoil the taste of wine they produced, in hot countries."

From what he had seen and learned during his visits he conceived the following propositions:

1. "That interculture among the growing crops is a necessary preparation in well conducted farming."

2. "That adequate tillage is not only an economic substitute for manure, but"

3. "Thorough tillage is also competent, with or without the aid of manure, to secure the profitable growth of any given species of cultivated plants, year after year, in succession." He began to raise wheat much as we raise corn, in drills, with intervals wide enough for the passage of the horse hoe. The rows of each succeeding crop of wheat were planted in what had been intervals the year before.

Up to the time of his death, in 1741, he had grown thirteen unmanured wheat crops without intermission, and without decrease, in the same ground. In the latter years of his practice he frequently grew a hundred acres of wheat in one season by his improved method of horse hoeing.

Rev. Samuel Smith adopted Tull's plan with some improvements and modifications at Lois-Weedon, Northamptonshire. He was extremely successful and hence the system of horse hoe culture for wheat and other similar grains is often known as the Lois-Weedon system.

Smith succeeded in growing twelve successive crops of wheat without the application to the soil of any manure whatsoever, and he claimed that no degeneration or diminution of quality ensued. Many experiments similiar to those conducted by Smith and Tull have been carried on in the United States always with satisfactory results so far as the yield was concerned, but with high priced labor, and cheap virgin soil it has been found in most cases unprofitable to practice, in any large way, the Lois-Weedon system of wheat culture in its entirety.

LOIS-WEEDON SYSTEM OF AGRICULTURE MODIFIED.

The experiments were begun in 1874. The previous year the land had raised a crop of oats, without manure, and in 1872 and for several years previous to that date had been in blue grass pasture.

The land after removing the oat crop of 1873 was in a bad lumpy condition. It was summer fallowed in 1874 and not manured. The plots were $20\frac{2}{3}$ rods long and the entire area was cut into 8 strips of $\frac{172}{1000}$ of an acre, each strip being $5\frac{1}{2}$ feet wide.

The first year of the experiment every other strip was drilled to wheat, and the intervals cultivated, the following year the treatment was alternated; the ones having borne a crop of wheat the previous year being under summer fallow. Clawson seed wheat at the rate of two bushels per acre was used in all cases.

Yield 1st yr.,	1874-5,	season poor,	158 lbs.,	at the rate of	10.31 bu.	per acre.
" 2d "	1875-6,	" fair,	369 "	"	"	35.77 "	"
" 3d "	1876-7,	" sup'r,	694 "	"	"	67.23 "	"
" 4th "	1877-8,	" fair,	637 "	"	"	61.42 "	"

It should be noted that the strips are very narrow, only one width of the drill being used, the intermediate spaces between these drilled plots were cultivated four or five times each season.

The effect of using such narrow plots was to allow the wheat to virtually occupy the whole land, as the culture between these narrow plots was by the common single one-horse cultivator, this permitted the roots to extend and feed upon the plots which were left vacant. At harvest time the whole area had the appearance of a continuous field of wheat, as the heavy heads leaned over into the spaces, and shaded and covered the whole ground. Note that these experiments were conducted somewhat differently from those which are reported below.

No manure or fertilizers of any kind were used during the four years of the experiment. If it is allowed that the wheat occupied all the ground, the yield would be just half as much per acre as is stated above. Even then the yield was large considering the quality of the land. Each year as the experiments went on the land became more friab'e and in better condition physically than it was at the beginning. The wheat was removed from the field as soon as it was cut, and the ground plowed the same or the following day. This gave the plots which had produced the wheat a short summer fallow from the middle of July until fall the same year; a summer fallow from the last of May to the first of September the following year. This, as it will be seen, was really "maneuvering" the land, thus causing it to increase in production by culture.

In 1888 a system of experiments similar to those recorded above, with additional plots treated with fertilizers and farm manures were begun.

These plots were located in the same field, but not on the same ground used in the preceding experiments, upon ground where for some seven or eight years experiments had been going on in the cultivation of Indian corn. The plots of Indian corn were narrow and laid lengthwise of the field, so when the field was laid off for conducting the experiments in wheat it was seen to be best to lay the plots crossways of the corn plots, because there had been variable and different treatments in the cultivation of the corn. Some plots had received nothing, others liberal applications of fertilizers. By laying out the plots at right angles to the old ones it at least made them all alike, though one portion of the plot might be quite different in fertility from another portion. The plots contained one-tenth of an acre each, and were separated by strips of grass $3\frac{1}{2}$ feet wide. Later the grass was plowed up and the unoccupied strips were kept clean throughout the summer by frequent cultivations.

The primary object of the experiment was to show the value of superior culture on rather poor clay land, such as is frequently found in the wheat districts of New York, and to determine if possible how much of the plant food of the land can be secured profitably without adding any fertilizers. The fitting of the land for most crops is done so badly that it was thought best to not only emphasize the value of culture, but to discover if in some part at least, culture might be substituted for expensive commercial fertilizers.

These being the chief objects of the investigation, it will be necessary to speak but briefly of the manured and fertilized plots.

The manured plot received the first year two tons and in all subsequent years one and one-half tons of mixed horse, cow and sheep manure, which had been kept in a covered yard during the winter and until the last of May, when it was removed to a rotting pit in the open field, from whence it was taken in September to the plots and spread on the surface of the plowed ground. The manure contained a high per cent of nitrogen owing to the liberal use of cotton-seed meal in feeding the animals. After the first year the wheat had a tendency to lodge, which tendency became so bad in the last year of the experiments that in the fall of 1892 no manure was used. On plot 3, 60 lbs. of Bradley's superphosphate were drilled in with the seed in the first three years, in the fourth, 60 lbs. of Small's superphosphate, and in the fifth, 15 lbs. of double superphosphate, 15 lbs. of sulphate of potash and 10 lbs. of sodium nitrate. Briefly stated, it may be said that the plot received annually 45 lbs. of phosphoric acid, 15 lbs. of potash, and 15 lbs. of nitrogen per acre.

Plot 4, which was in wheat without any "rest" by means of a summer fallow was plowed, as were all the plots immediately after harvests, harrowed, rolled and cultivated several times, making indeed a short summer fallow.

All plots contained one-tenth of an acre each. Two plots were used in the Tull or summer fallow system, so a crop was harvested on each every other year, while in all other cases a crop was harvested every year.

YEAR.	SUMMER FALLOWED.			FARM YARD MANURE.			FERTILIZER.			NOTHING.		
	TULL SYSTEM MODIFIED											
	Wheat, lbs.	Straw and chaff, lbs.	Bushels per acre.	Wheat, lbs.	Straw and chaff, lbs.	Bushels per acre.	Wheat, lbs.	Straw and chaff, lbs.	Bushels per acre.	Wheat, lbs.	Straw and chaff, lbs.	Bushels per acre.
1889	213	397	35.35	218	372	36.33	193	367	32.16	196	374	32.66
1890	208	553	34.66	176.5	552.5	29.41	194	446	32.33	215	533	35.83
1891	213.5	856.5	35.58	159	719	26.5	123	207	20.5	139	246	33.16
1892	132.5	....	22.08	103	....	17.16	121.5	....	20.25	139	....	32.16
1893	175.3	274.7	29.21	82.2	187.8	13.7	88.9	201.1	14.81	79.8	108.2	13.3
Totals	942.3	2,063.2	....	738.7	1,831.3	....	720.4	1,221	....	768.8	1,261.2	....
Average	188.46	515.8	31.41	147.76	457.8	24.62	145.08	305 3	29.01	153.76	315.3	30.75

CONCLUSION.

From these and many other similar experiments conducted in Europe, it is believed that on strong or clayey lands it is often more economical to secure available plant food by culture than by the purchase of fertility.

That in strong wheat soils there is more plant food than the variety of wheat grown can utilize, though enough may not be available to produce a maximum crop.

That in our changeable climate the wheat plant is so handicapped at times for want of suitable climatic conditions, that it is unable to appropriate much of the available plant food in the soil and hence is often not benefited by additional nourishment.

That the plants were unable to elaborate more food than the amount furnished by the soil under the superior culture.

That under certain conditions even a moderate amount of manure or fertilizers may not only fail to increase the yield but may be positively injurious to the crop to which they are applied.

I. P. ROBERTS.

CORN — DETASSELING.

July 14, 1893, three plots were marked out in the University corn fields for experiments in detasseling. Plots I and II were side by side in a field of well drained gravelly loam and the corn early and uniformly good. Plot III was on a clay knoll in a field of late corn that suffered severely from the drouth during the latter part of the season. All plots were surrounded by corn that had not been detasseled. Plots I and II contained sixteen rows each and plot III nine rows; each row contained fifteen hills. In plots I and III the tassels were removed from alternate rows, while in plot II every fourth row was left with tassels on, that is the tassels were removed from the first three rows, left on the fourth, removed from the next three and left on the eighth row and so on throughout the remaining rows of the plot.

The tassels were removed by hand by pulling them out as soon as they appeared. This operation was performed quite rapidly as comparatively little force was necessary to cause the stalk to break just above the upper joint and without any injury to the leaves whatever, if done before the tassels had become fully expanded. From the experiments in detasseling made at the station it is thought to be of prime importance to completely remove the tassel before it has expanded and commenced to shed pollen. As the tassel at this time is partially protected, within the folds of the leaves, it can only be completely removed by grasping the top of the tassel and giving it an upward pull which causes it to break off as described above. Experiments in detasseling have been made at other experiment stations where the practice has been to remove the tassels by cutting them off with a corn knife which would either cause an injury to the leaves or a delay until the tassels had become fully expanded and had shed pollon, as some tassels will shed pollen while yet partially protected within the folds of the leaves. In either case a benefit ought not to be expected from the practice. Our experiments show that the object of removing the tassels is not accomplished if they are allowed to remain until fully expanded and become polleniferous.

The following tables give the results of the practice from each of the three plots:

PLOT I.

ROW.	Tassels.	No. of stalks.	No. of abortive ears.	No. of good ears.	No. of poor ears.	Weight of good ears.	Weight of poor ears.	Weight of stalks.
1	Off	65	20	40	23	17.5	5.5	36
2	On	61	13	36	14	14.5	4	35
3	Off	67	16	29	31	13	7.5	38
4	On	63	20	26	18	13	5	40
5	Off	72	27	30	29	14	7.5	38
6	On	80	21	28	23	13.5	6	41
7	Off	65	17	28	28	13	6	32.5
8	On	73	22	25	26	10.5	6.5	38.5
9	Off	70	17	39	12	17	3	34
10	On	69	18	36	16	16	4.5	38
11	Off	67	19	32	29	15	7	33
12	On	66	19	38	17	18	4	39
13	Off	68	25	30	28	14	7	40
14	On	66	17	29	17	12.5	4	35
15	Off	63	21	30	23	13.5	7.5	38.5
16	On	82	18	30	27	12	5.5	40
Total off	....	537	162	258	203	117	51.	290
Total on	....	560	148	248	158	110	39.5	306.5
Average off	....	67.1	20.2	32.2	25.4	14.6	6.3	36.26
Average on	....	70.	18.5	31.	19.75	12.7	4.9	38.31

Yield per acre, tassels off, 5,000 pounds.

Yield per acre, tassels on, 4,449 pounds.

Gain by removing tassels, 12.4 per cent.

PLOT II.

ROW.	Tassels.	No. of stalks.	No. of abortive ears.	No. of good ears.	No. of poor ears	Weight of good ears.	Weight of poor ears.	Weight of stalks.
1	Off	66	25	27	31	12.5	8	39
2	Off	61	22	39	17	17.5	5	37.5
3	Off	72	18	43	23	18	6.5	39.5
4	On	71	14	34	18	14	4	35
5	Off	62	17	36	18	17.5	4.5	35
6	Off	66	18	45	20	20.5	5.5	40
7	Off	69	20	33	30	14.5	6.5	39
8	On	72	19	30	26	12	5	33
9	Off	73	25	31	31	13	8	41
10	Off	75	20	34	33	15	8	46.5
11	Off	74	29	36	32	15.5	7	45.5
12	On	60	22	28	19	12.5	4	39.5
13	Off	64	20	35	25	15.5	6.5	42
14	Off	60	21	37	20	16.5	5	37
15	Off	69	23	29	31	13	8.5	42
16	On	61	10	28	24	12.5	4.5	40
Total off		811	258	425	311	189	79	484
Total on		264	65	120	87	51	17.5	147.5
Average off		67.6	21.5	35.4	25.7	15.7	6.6	40.3
Average on		66	16.2	30	21.75	12.7	4.4	37.4

Yield per acre tassels off, 5,316 pounds.

Yield per acre tassels on, 4,077 pounds.

Gain by removing tassels, 30.3 per cent.

From the accompanying tables it will be seen that in each plot there was a greater yield of corn from the detasseled rows than from the rows where the tassels were left on. Not only from the total yield of corn but also a gain in the weight of both the good and poor ears. From each plot the weight of good ears from detasseled rows was greater than the weight of good ears from the rows with tassels; the same is true concerning the poor ears from each plot. The average weight of the ears from rows with the tassels on, correspond very nearly with the weight of the ears from detasseled rows, showing that the increased yield is from a greater number of ears rather than larger ears. There is also shown a tendency toward greater ear production on the detasseled rows by the increased number of abortive ears. All "sets" bearing silk, but without grain, were classed as abortive ears.

PLOT III.

ROW.	Tassels	Number of stalks.	Number of abortive ears.	Number of good ears.	Number of poor ears.	Weight of good ears.	Weight of poor ears.	Weight of stalks.
1	On	64	7	19	24	6	4	25
2	Off	57	21	21	29	6	4.5	25
3	On	61	25	15	25	3	4.5	23.5
4	Off	60	14	19	24	5.5	4	25
5	On	54	19	16	25	5.5	4.5	25
6	Off	70	15	21	36	7	5	26
7	On	63	21	15	32	4	3.5	24
8	Off	67	21	28	28	7.5	3.5	27.5
9	On	74	17	28	26	7.5	3	33
Total	On	316	89	93	132	28	19.5	130
Total	Off	254	71	89	117	26	17	103.5
Average	On	63.2	17.8	18.6	26.4	5.6	3.9	26
Average	Off	63.6	17.9	22.25	29.25	6.5	4.25	25.87

Yield per acre tassels off, 2,559 pounds.
Yield per acre tassels on, 2,262 pounds.
Gain by removing tassels, 13 per cent.

The report of a recent experiment in detasseling is published in Bulletin 25 of the Nebraska Experiment Station, where the tassels were removed by the use of a *corn knife*, and the results are summed up in the following conclusions:

1. "The detasseling of corn seems to be a positive detriment and loss, as shown by the results in two years' trial. This is not conclusive evidence, but strongly indicative of what we may expect from the practice.

2. "The expense is about $1.25 per acre and would require an increased yield from three to five bushels of corn to pay for the labor involved, thus depending on the price of corn in any given locality.

3. "Although the results of the experiment in 1892 are so strongly contrasted and so widely divergent, yet we do not deem them decisive. We propose to repeat the experiment on still larger areas and with different varieties of corn and note the results before we announce the positive rule that 'detasseling does not pay.'"

Although not conclusive the experiments made at this station indicate that there is more pollen produced by the corn plant than is necessary to produce a maximum crop and that this over-production is an exhaustive process.

The following are the results in brief of detasseling practiced at this station for four years:

In 1890 a gain in total yield of corn of 50.6 per cent.

In 1891 a very slight gain.

In 1892 a gain in total yield of corn of 21 per cent.

In 1893 a gain in total yield of corn of 19.3 per cent.

GEO. C. WATSON.

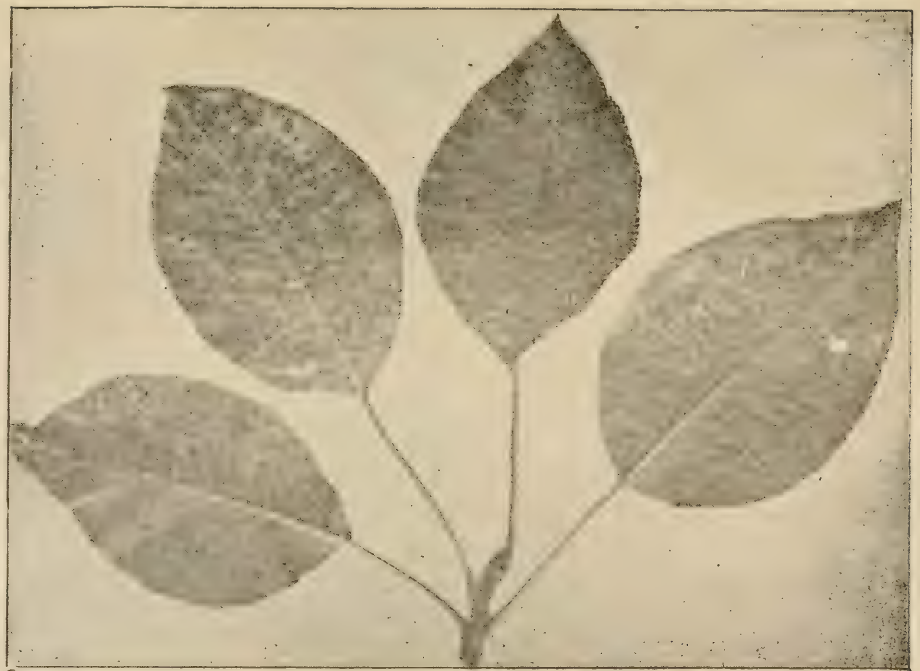

FIG. 1.—Cluster of Infested Leaves representing the Disease in its Brown Stage, as seen from below on Three Leaves and from above on One Leaf. (From a Photograph of Leaves collected in August. Natural size.)

Entomological Department.

THE PEAR LEAF BLISTER.

Phytoptus pyri.

Order ACARINA; family PHYTOPTIDAE.

Reddish blister-like spots an eighth of an inch or more in diameter appearing on the pear leaves in the spring and changing to black corky spots in July, each with a minute opening in it.

In Bulletin 23 of this Station, issued in December, 1890, this disease of pear leaves was discussed at some length. It was then realized that the only methods of checking the disease which could be suggested were too laborious to be practicable, except where the trees were young or few in number. This need of a cheaper and easier method of fighting this pest has been the subject for experimentation during the last two years. Some of these experiments have been strikingly successful, and we are now confident that this disease, which is alarmingly on the increase in the United States and Canada, can be easily and cheaply controlled.

As the disease has been studied during an entire season, other phases of it, not before recorded, have been seen. The disease has also appeared in several other localities, and is causing considerable alarm among pear growers, judging from the reports of correspondents. It is the purpose of this article then to record these new facts, and to tell pear growers how the pest can be easily and cheaply combated. As Bulletin 23 is now out of print, it has also seemed best to again discuss the disease in detail.

Symptoms of the disease.— The disease appears on the pear leaves before they are fully expanded from the bud, in the spring, in the form of red blister-like spots an eighth of an inch or more in diameter. During this red stage of the disease, the spots are more conspicuous on the upper surface of the leaves. About June 1, the spots gradually change to a green color hardly distinguishable from the unaffected portions of the leaf; this change takes place on the lower side of the leaf first, and the spots may thus be red above and green below. In this green stage, which seems to have been heretofore overlooked, the badly diseased leaves present a slightly thicker, corky appearance; otherwise the disease is not readily apparent, especially where not severe. This green stage lasts about a week or ten days; and about June 15 the spots may be found changing to a dark brown color, beginning on the lower side of the leaf. The tissue of the diseased

FIG. 2.—Part of an infested leaf, seen from below, showing several of the galls considerably enlarged. (From a photograph.)

parts or spots then present a dead, dry, brown or black, corky appearance. The spots are also more conspicuous on the lower side (Fig. 1), and remain unchanged until the leaves fall in the autumn. They occur either singly, scattered over the surface of the leaves or often coalesce, forming large blotches which sometimes involve a large portion of the leaf (Fig. 1). The disease often appears on the young leaves of the new growth during the summer. The spots are then also first red and pass through the green stage to the brown. No variety of pears seems to be exempt from the attacks of the disease.

The disease is not known to attack anything but the pear in this country.*

This Pear Leaf Blister is sometimes mistaken for a common fungus disease, the Pear Scab, which attacks the pear, also forming blackish spots on the surface of the leaves which have a slight resemblance on the blisters. The fungus, however, does not produce the blister-like corky appearance; nor is there scarcely any thickening of the leaf where it is attacked by the fungus.

These diseased portions of the leaf are termed galls, as are the various abnormal vegetable growths produced by true insects. Figure 2 represents several of these galls, or blisters as they are sometimes called by fruit growers; the galls are magnified about six diameters and well illustrate their blister-like corky appearance. In figure 3 is shown a section of a pear leaf through one of the galls, made doubtless while the gall was in its red stage. Here the leaf is seen to be greatly thickened at the diseased part. And in addition to the swelling of

FIG. 3.—Section of a leaf; *g*, gall in its red stage; *n*, *n*, normal structure of the leaf; *o*, opening of the gall; *e*, eggs. (After Sorauer.)

both surfaces of the leaf, its internal structure is seen to be modified. In some parts there is a multiplication of the tissue cells, and in others a large part of the cells have been destroyed.

As the season advances and the galls become dry and brown, the thickening of the leaf becomes less marked, especially on the upper surface. Figure 4 represents a section of a leaf collected and studied in October. Here the tissues in the diseased spot are dead, and there has been a shrinkage of the affected parts until the gall is but slightly thicker than the uninjured portion of the leaf.

If these galls be examined from the lower side of the leaf with a hand lens (an instrument which every fruit grower should own) there can be seen near the center of each a minute round hole. It can be discerned in some of the galls represented in figure 2. This hole leads

* Mr. Crawford records the finding of similar diseased spots on a fern (a *Gleichenia*) growing among infested pear trees in Australia. Although the inhabitants of the spots differed in color from those on the pear, he believed this to be due to the difference of the food and concluded that the disease was the same on the fern and pear.

into a cavity within the substance of the leaf (Figs. 3 and 4, *o*) and in this cavity reside the creatures that cause the disease.

Appearance of the Inhabitants of the Galls.— The minute creatures that attack the tissues of the pear leaf in such a manner as to cause the

FIG. 4 — Section of leaf showing structure of gall in autumn; *g*, gall; *n*, uninjured part of leaf; *o*, opening of gall.

abnormal growths — the galls — which form their homes, are what are popularly known as mites. They are exceedingly small, being practically invisible to the unaided eye; and even with a good lens they appear as minute whitish specks. In fact, the best of microscopes is necessary in order to study their structure satisfactorily. So small are they that it would take 150 of them placed end to end and 600 placed side by side to measure an inch. They are usually whitish in color, sometimes with a slight red or brown tinge. The body is cylindrical in form, tapering slightly towards each end (Fig. 5). It is ringed throughout the greater part of its length with about 100 very fine rings. Its four legs are placed near the head end of its body, so that when the mite walks it drags its body after it. The head is in the form of a conical snout, within which are two sword-like jaws. The body and legs are furnished with a few hairs which are constant in number and position.

Classification of the Pest.— The cause of this Pear Leaf Blister is not a true insect, but a mite. (The mites are more closely allied to

FIG. 5.— The adult mite, greatly magnified.

the Spiders and Scorpions than to the true insects.) The southern Cattle-tick, the Itch-mite and the Red Spider are well-known members of the same order (*Acarina*) of animals to which this pear pest belongs. As a rule, newly-hatched mites have three pairs of legs and a fourth pair is added during growth. The members of the genus

Phytoptus, to which this pear pest belongs, differ, however, from all other mites in that they never possess but two pairs of legs.*

The popular name for this pear pest that has come into general use is the Pear Leaf Blister Mite. Crawford called it the Pear Phytoptus, the Anglicized form of its scientific name *Phytoptus pyri.*

The Distribution and Past History of the Mite.— The cause of this peculiar affection of pear leaves was discovered by Scheuten, a German, in 1857; doubtless the disease itself had been observed many years previously. Later German writers, Sorauer in 1873 and 1886, Kaltenbach in 1874 and Frank in 1880, speak of the disease as common in Europe. In 1877 Murray records it as common in England and on the continent. Crawford states that public attention was first called to the pest in South Australia in 1881. In 1891 French found it had gained a foothold in Victoria orchards. In 1888 Fletcher received specimens of the disease from Nova Scotia, and in 1891 he found it was very widespread and serious throughout Canada. These are all the references to the occurrence of the pest in other countries that we have seen.

The first record of the appearance of the disease in the United States is in 1872, when Glover found it common in Maryland. In 1880 Burrill said the disease was widespread in this country. Osborn found the mite in large numbers on some Russian pear trees in Iowa in 1884. He thought the pest had probably been introduced with the scions of the trees recently imported from Europe. In 1890 specimens were sent to Dr. Lintner from Charlotte, N. C., with the report that the disease was very prevalent there. In 1891 we received the mites from a correspondent in Fayetteville, Ark., who said his trees were badly affected. At the meeting of the Association of Economic Entomologists in 1892 Webster of Ohio and Smith of New Jersey reported the pest as very abundant in their respective States that year. This year McCarthy has found the disease very prevalent in the orchards of North Carolina.

In 1889 and 1890 the pest was abundant in pear orchards in western New York. We received specimens from Oswego in 1891; and Dr.

* These curious four-legged mites seem to have been first observed in 1834. For seventeen years they were thought to be immature forms of some eight-legged species. In 1851 Dujardin (An. des Sci. Nat., 3d Ser., vol. 15, p. 166) showed why he believed them to be adult forms and proposed the generic name *Phytoptus* for such four-legged forms. In 1857 Scheuten, who described the Pear Leaf Blister Mite, criticized Dujardin's work and adhered to the theory that they were but immature forms. During the succeeding twenty years several observers studied the four-legged mites, and since 1877 it has been the prevailing opinion that they are adult animals forming a distinct family among the mites.

Lintner reported it as excessively abundant in eastern New York in 1892. The disease is very common in pear orchards near Ithaca, and has very noticeably increased within the past three years. It doubtless occurs in a majority of the pear orchards in the State. This completes the recorded history of the disease in our own State and other States.

These data indicate that the disease is of European origin. It had become established in the United States in 1872, and had reached Australia in 1881, and Canada in 1888. It is widely distributed over the northern, eastern and southern portions of the United States, and has doubtless been introduced into other sections on stock bought in the east or in Europe.

Its Destructiveness.— The destruction wrought by the mite thus far has not been very serious except in a few cases where it was excessively abundant. The infested leaves fall from the trees sooner than the others, thus depriving the tree of its breathing organs and materially weakening it. Without its leaves the tree cannot store up the necessary food in its winter buds to insure a healthy vigorous tree and a full crop the next season. The freer from disease the leaves can be kept during the summer and fall, the more vigorous will be the tree and the better will be the quality and the greater the quantity of the fruit the next season. Pear growers should therefore be on the watch for the Pear Leaf Blister, and not let it get a foothold in their orchards.

The Life History of the Mite.— According to German observers, the exceedingly minute oval grayish eggs are laid by the females in the spring within the galls that they have formed, and here the young are hatched. How long they remain within the gall of their parent has not been ascertained. But sooner or later they escape through the opening in it, and seeking a healthy part of a leaf or more often crawling to the tenderer leaves of the new growth, they work their way into the tissue and new galls are thus started. In this manner the galls on a tree are often rapidly multiplied during the summer. The mites live within the galls, feeding upon the plant cells, until the drying of the leaves in autumn. They then leave the galls through the openings and migrate to the winter buds at or near the ends of the twigs. Here they work their way beneath the two or three outer scales of the buds where they remain during the winter. Fifteen or twenty may often be found under a single bud scale. In this position they are ready for business in the spring as soon as growth begins; and they doubtless do get to work early, for their red galls are already conspicuous before the leaves get unrolled.*

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* Mr. Crawford says: "There are two ways in which the mite survives the winter when all the leaves are shed — first, by hibernating among the hairs of and in the leaf bud, and, secondly, by forming colonies under the tender bark of last year's growth, as I have found them in both situations."

The mites instinctively migrate from the leaves as soon as the latter become dry. Whenever branches were brought into the insectary, as soon as the leaves began to dry, the mites left them and gathered in great numbers in the buds. It is impossible to accurately estimate the number of mites that may live in the galls on a single leaf. Sections of galls made while in their red stage would seldom cut through more than two or three mites; but sections of the brown galls often showed four or five times as many. Thus on a badly infested leaf there is without doubt at least a thousand of the mites.

Methods of Destroying the Mites.— Owing to the fact that the mites live within the tissues of the leaves during the growing season, they are then beyond the reach of ordinary insectides. It is obvious that they would not be affected by any poison dusted or sprayed upon the surface of the leaves. In 1890 we demonstrated that the mites could not be reached by an application of kerosene emulsion to the leaves. It was hoped that a sufficient quantity of the liquid would pass into the galls through their open mouths to injuriously affect the mites, but it did not.

Thus the only practicable method of combating the pest while in the galls is to gather the infested leaves, either by picking or pruning, and burn them. This method is a sure one, and is practicable where the pest is just starting in an orchard, or where the trees are small or when but a few large trees are attacked. It can be done at any time before the leaves dry and fall in the autumn, but the earlier in the season the better. In May, while the galls are red, would be the best time to do it.

The most vulnerable point at which the disease can be attacked on a large scale is when the mite is in its winter quarters in the terminal winter buds. Doubtless the pest receives a considerable check in many orchards at the annual pruning to which the trees are subjected. In this manner many of the winter buds containing the mites are removed and the burning of the brush soon after destroys the pest.

The methods just discussed are sure means and are practicable within certain limits. But a method which is cheaper, easier, more practicable, and one that is effective and applicable to large orchards, has resulted from our experiments during the last two years. One winter while experimenting to learn the effects of kerosene oil on dormant wood, it was noticed that the oil penetrated every crevice of the wood with surprising thoroughness; and it was at once suspected that kerosene might be used with effectiveness against this mite while in its winter quarters under the bud scales.

In the fall of 1891, before the leaves fell, several badly infested trees were labeled; and in Februry, 1892, two trees were treated with undiluted kerosene, one tree with kerosene emulsion diluted with two and one-third parts of water, and one tree was left untreated as a check.

In the spring the mites appeared in force on the check tree, but upon the treated trees not more than a dozen galls appeared during the season, the pest having thus been nearly exterminated. The trees treated with the undiluted kerosene were nearly killed, so that in this form kerosene can not be used with safety on the pear. The only apparent effect upon the trees treated with the emulsion, however, was a slight retardation in the unfolding of the leaves in the spring. This experiment was of course only an indicator but it gave the clue. The result was not given to fruit growers at the time for it needed further verification on a larger scale, and it was desirable to know what percentage of kerosene it was necessary to apply to do the work successfully.

In September, 1892, we found sixteen quite badly infested trees in the Horticultural orchard here at the Station. These were then labeled, and March 10, 1893, all but two (which were left for a check) were sprayed with kerosene emulsion diluted with from three to ten parts of water. The trees were standards varying from six to fifteen feet in height, but it was found that it required only about one and a half quarts of the diluted emulsion and about two minutes of time to spray a tree thoroughly from all sides with a knapsack sprayer.

July 10, 1893, trees were examined and it was found that the four sprayed with the emulsion diluted with three parts of water were practically free from the disease. The four trees sprayed with the emulsion diluted five times, and the four on which the emulsion diluted with eight parts of water was used showed a very few galls, not one per cent of the number on the trees the preceding year. Two trees which had been sprayed with the emulsion diluted with ten parts of water showed nearly as many galls as before. The two check trees were as badly infested as they were the year before.

These results showed that the emulsion was effective when diluted with not more than eight parts of water, or containing about eight per cent of kerosene. The remarkable success of these experiments could be fully realized only by one who had seen the diseased trees in the fall and again a year later. To illustrate it graphically one need but imagine the four leaves shown in figure 1 (which were taken in the fall and are typical specimens of the leaves on many branches of the trees before they were treated) passed through some process by which all of the galls could be removed except one or two on each leaf; this comparison does not exaggerate the difference between the trees before and after treatment with the emulsion. In all of our work with preventive methods against insect attacks, we have never met with more striking success than we obtained by the use of the emulsion against this Pear Leaf Blister Mite.*

The emulsion can be applied with equal effectiveness at any time after the leaves have fallen in autumn and before the buds have begun to swell in the spring. Dilute the emulsion † with not over five to seven parts of water. Spray the tree thoroughly from every side, taking especial care to hit every terminal bud, for this is where most of the mites congregate. There is no danger of injuring the tree with this dilution of the emulsion.

In this manner the Pear Leaf Blister Mite can, we believe, be nearly exterminated in an orchard by a single thorough spraying. The method also has the great advantage of being cheap, easy to apply and practicable on a large scale. This spraying of the tree in winter with so strong an emulsion may also destroy some of the adults of that pest most dreaded by all pear growers — the Pear Psylla — which is then in hibernation in the crevices of the bark on the trunk and large limbs; therefore spray the tree all over.

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*Mr Crawford doubtless first suggested the use of kerosene emulsion against this pest in winter. He said: "The habits of the mite in the winter time afford a clue to one method of treating it. For this purpose I would recommend three washes to be experimented with, viz.: Kerosene emulsion, one to fourteen; caustic soda, say four, eight and twelve ounces to the gallon; and sulphuretted lime."

He tried no experiments and our results show that to dilute an emulsion would be of little avail. Mr. Crawford's recommendation was unknown to us until after we began to write this article.

Other authors have recommended the use of the emulsion when the mites are eaving the buds or while migrating to the buds. It would be effective if the mites could be hit at this latter time, which would, however, necessitate very careful watching with a good lens to determine the exact time to make the application. They do not leave the buds in the spring, but attack the leaves while yet in the bud; and the mites are out of reach in their galls before the leaves unroll.

† To make the emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may be now readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

To summarize briefly, our experiments strongly indicate that the Pear Leaf Blister can be nearly exterminated in a badly infested orchard by a single thorough spraying of the trees in winter with kerosene emulsion diluted with from five to seven parts of water.

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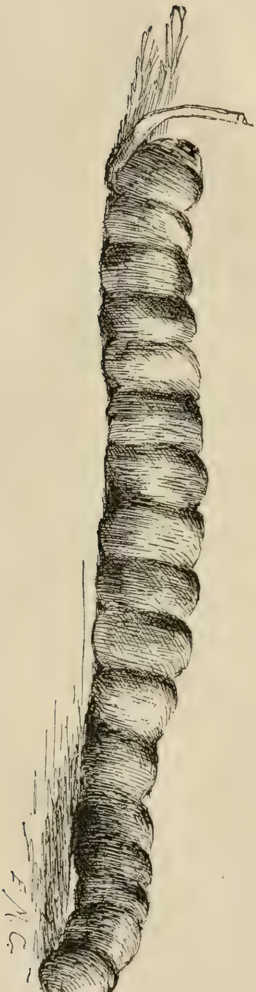
MARK VERNON SLINGERLAND.



Tuber of Stachys Floridana.

Horticultural Division.

A NEW FOOD PLANT.—*Stachys Floridana.**

Two years ago, Dr. Erwin F. Smith, of Washington, sent us a curious tuber which he picked up on the sea coast in Florida. For two years an interesting progeny has been grown from this tuber, which proves to be *Stachys Floridana*, a plant not before introduced to cultivation, so far as I know. In general appearance, the plant is much like the Chorogi or *Stachys Sieboldii* which is sold as an esculent by the seedsman, and a detailed report of which was made from this station two years ago.† It differs from the Chorogi, amongst other things, in its more slender habit, smoothness, and its long-stalked cordate leaves. The tubers are produced as freely as in that species and are generally somewhat larger. The illustration shown herewith is a life-size picture of the greater portion of a tuber, which, however, was rather above the average size. The tubers commonly reach the length of four to six inches, and the joints are of nearly uniform thickness. The flavor is fully equal to the Chorogi, and we sometimes think it better, being perhaps, somewhat more crisp and brittle. The plant has not yet been grown in the open ground, but we now have sufficient stock to make the experiment the coming season. I expect that the plant will be able to endure our winters with the protection of a mulch, for tubers that have been frozen grow readily. There is every prospect that this interesting species will add another attractive vegetable to our gardens.

Stachys Floridana is known to occur only in eastern Florida, and it is one of the comparatively little known plants of the genus. Chapman, in his Flora of the Southern United States, calls it an annual, but Gray describes it as producing "a moniliform tuber of two or three inches in length."

Gray says that the plant is "barely a foot high" but under cultivation it grows to the height of two feet.

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* *Stachys Floridana*, Shuttleworth, MSS.; Bentham, D. C. Prodr. xii. 478 (1848).

† Bulletin 37, p. 394.

THE MOLE-PLANT.—*Euphorbia Lathyris.**

The horticultural community was interested last spring in the announcement of Samuel Wilson, of Mechanicsville, Penn., that he had a plant which will drive moles from the garden. This plant, although said to be biennial, was called the Mole-Tree, and the account was verified by the picture, which shows a diminutive tree beneath which lies the corpse of a mole. Nothing is said by the introducer about the origin, nativity or botanical affinities of the plant. We were able to secure but one plant of the Mole-Tree, and we were so choice of it that it has been grown in the greenhouse. It turns out to be an interesting old garden plant, which has a continuous history of at least three hundred years, and which was known as a medicinal plant to Galen in the second century. It is the Caper Spurge, *Euphorbia Lathyris.* The name Spurge is applied to many related plants, in reference to their purgative qualities, and this particular species is called Caper Spurge from the fact that the little seed-like fruits are sometimes used as a substitute for capers. The plant is known chiefly as a household medicine, although it is used in materia medica and is figured by Millspaugh in his recent work upon American Medicinal Plants. Its use as a food plant seems, fortunately, to have ceased. Johnson, in Sowerby's Useful Plants of Great Britain, 1862, speaks of this use of it as follows: "The three-celled capsules are about the size of a large caper, and are often used as a substitute for that condiment, but are extremely acrid, and not fit to eat till they have been long macerated in salt and water and afterwards in vinegar; indeed it may be doubted whether they are wholesome even in that state."

This plant is a native of Europe, but it has long been an inhabitant of old gardens in this country, and it has run wild in some of the eastern states. Its use as a mole repeller is not recent. Pursh, in writing of the plant in 1814, in his Flora of North America, says that "It is generally known in America by the name of Mole-plant, it being supposed that no moles disturb the ground where this plant grows." Darlington makes a similar statement in Flora Cestrica, 1837: "This foreigner has become naturalized about many gardens,—having been introduced under a notion that it protected them from the incursions of moles." In later botanies it is frequently called Mole-plant. I do not know if there is any foundation for these repeated

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* *Euphorbia Lathyris*, Linnæus, Sp. Pl. 655 (1753).

Stachys Floridana. (5/8 natural size.)

A Young Mole-plant   End view

statements that the Caper Spurge is objectionable to moles, but the fact that the notion is old and widespread raises a presumption that the plant may possess such attributes. The statement occurs only in American works, so far as I know. It would be interesting to know the experiences of those who have grown the plant for a number of years, for the subject is worth investigation. But we cannot too strongly deprecate the practice of introducing plants to the public without giving purchasers definite knowledge of their history and nature, and without having detailed proof that the plants possess the virtues which are claimed for them. It would have been better in the present example, no doubt, to have submitted the plant to a botanist before introducing it, in order that its proper name and history might have been determined; and if the public is at all inclined to buy a mole-plant it would have been persuaded much more by the long tradition of its virtues than by any consequential statement of its value.

The Caper Spurge is apparently biennial, although Boissier, a celebrated monographer of the euphorbias, calls it annual. The plant is very unlike in its early and flowering stages. Until it begins to branch and flower, the leaves are long linear-lanceolate, opposite, and arranged in four perfect rows down the thick, smooth stem. As this stage of the plant is rarely illustrated or described, I have introduced here a photograph of our Mole-plant as it appeared eight months after its receipt from Mr. Wilson. It was placed horizontally and an end view was taken in order to show the serial arrangement of leaves. The plant is exceedingly curious and interesting, and we shall grow it in our greenhouses as an ornamental subject. Few plants have a more novel or striking appearance. In its second or flowering stage, the leaves are ovate and shorter. Mr. Wilson writes me that he knew this plant in old gardens more than fifty years ago, where it had a reputation for expelling moles, but he lost sight of it until a short time since, when he again met with the plant. It was then propagated and introduced to the public.

ORCHARD COVERS.

A year ago* a report was made upon the use of the European vetch (*Vicia sativa*) as a plant for growing in orchards, — to afford a cover for the soil in late summer, fall and winter, and to provide fertilizer when plowed under, the following spring. Observations have been

*The Vetch or Tare as an Orchard Plant, Bull. 59, Cornell Exp. Sta. 354.

continued upon the vetch this year, and experiments have been tried with common field peas, cow peas, and other plants, as covers for orchard lands.

The vetch is an annual leguminous plant which continues its growth long after frost and which mats down with the snow into a perfect, carpet-like covering. In the spring the vines are so well decayed that the cover can be plowed under easily. The vetch can be sown late in June or early in July in this State, and the plants will cover the ground with a dense tangled mulch two feet deep when winter sets in. Last year (1892) we sowed the vetch June 16. This year we sowed one area June 20, and another June 28. Both made an ideal mulch, and the plants were green and still growing late in November. They produced no seeds, and but very few flowers. About a bushel of seed should be sown to the acre. The seed is large and germinates readily, and is likely to catch at almost any time during the summer. Some idea of the dense growth of the vetch this year may be obtained when I say that one patch overcame and obscured a heavy growth of horse radish which had been in the ground two years. I am confident that upon fairly good soil, good results can be obtained with vetch sown as late as the middle and possibly the last of July. We have obtained our seed from J. M. Thorburn & Co., of New York, who sell it for $3.50 per bushel. Other dealers probably keep it. An analysis of the vetch, as given in our report for last year and repeated below, shows that it is rich in fertilizer value.

There has been very considerable inquiry concerning the value of cow peas for northern orchards. Sixteen varieties were grown at the Station this year for the purpose of ascertaining which one will mature in this latitude; and over half an acre was sown to the Black pea, which Professor Massey, of North Carolina, thought likely to prove the best variety for our purpose. These black peas were obtained of L. R. Wyatt, Raleigh, N. C., and were sown June 20. The land was clay and variable in contour, comprising two dryish knolls, with a moist vale lying between them. The peas were slow in starting, owing to the hard soil, but they made a fair growth in August and early September. In the vale, the plants grew nearly two feet high and covered the ground well, but on the knolls the soil was not covered. The plants had just begun to flower when they were killed by the first frost. The leaves fell off, and the bare, stiff stems now afford very little protection to the soil.

The varieties of cow peas grown for the purpose of ascertaining the earliness of the various kinds, were sown May 31 in rich garden loam. These peas were obtained from the experiment stations of North

Carolina, Arkansas and Louisiana. The varieties ripening seeds are ten, as follows:

Black, from N. C.
Black Eye, N. C.
Blue, La.
California Bird's Eye, Ark.
Clay, N. C.
Gray Prolific, N. C.
Large White, La.
Whipporwill, N. C., Ark., La.
Yellow Prolific, N. C.
Yellow Sugar Chowder, Ark.

The varieties which did not mature seeds are the following:

Black, from La.
Brown Eye, Ark.
Clay, La.
Conch, N. C.
Indian, La.
King, La.
Lady, La.
Purple Hull, La.
Stewart, N. C.

The varieties which seemed best adapted to this latitude were the Black and Whipporwill. The latter I fruited also at Lansing, Michigan, in 1887. It will be seen that there appears to be a difference between samples of the same variety coming from different sources. The Black pea from North Carolina seed matured well, but that from Louisiana stock was too late. The same difference occurred in the Clay. This is what might have been expected, and it emphasizes the importance of securing seed from the northernmost station, when choosing stock for growing in the north. On the whole, the Black cow pea seems best adapted to growing in Central New York. A small patch of this was sown on a rich, loose soil July 17, and the plants made as heavy growth as those sown upon the clay soil nearly a month earlier. But the cow pea affords so much less winter protection to the soil than the vetch, without any counterbalancing advantages, that it can scarcely be recommmnded for an orchard cover in the north.

The ordinary field pea was also grown this year as a winter cover. One lot was sown August 18. Although the tips of the plants were somewhat shriveled by frost, the plot was still green and growing the middle of November, but no flowers had appeared. The vines were two to three feet long and they covered the ground completely, and made an excellent mulch. Peas sown September 20 reached a height of about six inches and were not large enough to afford a satisfactory cover ; yet, if sown very thick, peas could be put in at this time with fair result, in cases where the ground could not be used earlier.

Aside from these covers, various kinds of clovers were sown in mid-season for purposes of comparison, but they made a poor stand and afforded very little protection to the soil. Rye sown late in August or early September made a fair cover, but it is no better than common field peas, if as good, and its fertilizing value is small.

The following analyses show the fertilizer values of the various plants here discussed. The vetches and peas were analyzed at this Station. The analysis of cow peas is taken from Professor Teller's recent studies in Arkansas,* and that of clover is compiled from reliable sources for comparison.

	Original substance.	Dry substance.
Vetch, ready to bloom, roots and tops.		
Nitrogen	.65 per cent.	3.10 per cent.
Phosphoric acid	.146 "	.70 "
Potash	.475 "	2.28 "
Water	79.15 "	
Peas, 2 to 3 ft. high, no flowers, roots and tops.		
Nitrogen	.451 "	2.33 "
Phosphoric acid	.113 "	.58 "
Potash	.361 "	1.86 "
Water	80.61 "	
Peas, 6 in. high, roots and tops.		
Nitrogen	.34 "	2.43 "
Phosphoric acid	.086 "	.62 "
Potash	.179 "	1.28 "
Water	86.05 "	
Cow Peas (Whipporwill), in blossom, straw only.		
Nitrogen		3.09 "
Phosphoric acid		.50 "
Potash		1.98 "
Red Clover, average of several analyses.		
Nitrogen		2.05 "
Phosphoric acid		.66 "
Potash		2.24 "

* Bull. 24, Ark. Exp. Sta. July, 1893.

Spinage Dock.

Belleville Dock or Sorrel.

It will be seen that the vetch ranks highest in fertilizer value although it is not greatly above cow peas. But cow peas afford little protection to the soil during winter and can therefore scarely be recommended for an orchard cover in this latitude. Next to the vetch in value is the common field pea, and as it affords a good cover when sown as late as the middle or last of August, it may often be more useful than any other plant.

GARDEN DOCKS.

Various species of docks and sorrels have long been cultivated as pot-herbs. Some of them are very desirable additions to the garden because they yield a pleasant food very early in spring, and, once planted, they remain for years. We have grown two of the French docks for years and find them to be very good. One is the Spinage Dock (*Oseille Epinard*), the other the Large Belleville (*Oseille Large de Belleville*). The former is the better of the two, perhaps, and it has the advantage of being a week or ten days earlier. The broad crisp leaves appear early in April when there is nothing green to be had in the open garden, and they can be cut continuously for a month or more. This dock is the Herb Patience, or *Rumex Patientia* of the botanies. It has long been an inhabitant of gardens, and it has sparingly run wild in some parts of this country. It is a native of Europe. The Belleville is also a European plant, and is really a sorrel. It is *Rumex Acetosa* of botanists. It has also become spontaneous in some of the eastern portions of the country. It has thinner, lighter green and longer-stalked leaves than the Spinage Dock, with spear-like lobes at the base. The leaves are very sour, and will probably not prove to be so generally agreeable as those of the Spinage Dock ; but they are later, and afford a succession. In some countries this sorrel yields oxalic acid sufficient for commercial purposes. The Round-leaved or true French sorrel (*Rumex scutatus*) would probably be preferable to most persons.

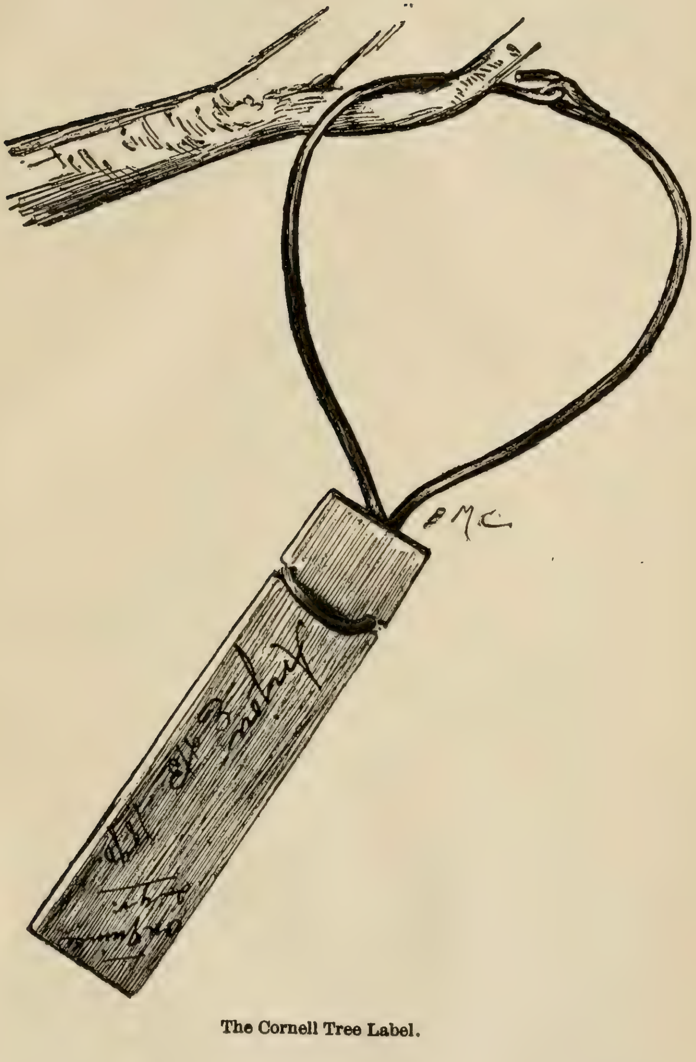
All these docks are hardy perennials, and are very acceptable plants to those who are fond of early " greens." Some, at least, of the cultivated docks can be procured of American seedsmen.

LABELS.

Anyone who has had experience in gardens knows that the methods of labelling plants and trees are nearly always unsatisfactory in some particular. A great variety of labels has been recommended for trees, but we do not seem to have found the ideal label, although the one which is here described seems to satisfy more needs than any other which we have been able to secure. We first tried zinc labels, cut in narrow strips from a sheet of the metal. The record is made upon the zinc with a soft lead pencil and the label is then wound about a branch. Very often the record is indistinct upon the zinc label, but the chief fault is its inconspicuousness. It requires much searching to find a zinc label upon a large tree, and this objection holds with every practicable tree label which has been introduced, even with the three or four-inch pine labels which are common in the market. We next tried patent zinc and copper labels which are cut from very thin metal so that the record can be made by the impression of a sharp point or style. These pretty and so-called indestructible labels are furnished with an eyelet through which the wire passes. We were much pleased with these labels when we put them upon our orchard trees one fall; but the next spring we found that the metal had broken away from the eyelets and nothing remained of them but a hole hung upon a wire.

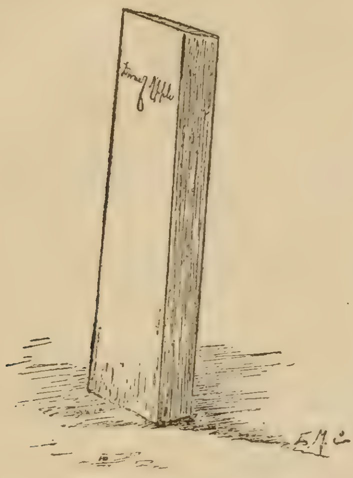
We now label our trees with the device shown in the illustration. We buy the pine "package label" which is used by nurserymen, and which is 6 in. long and $1\frac{1}{4}$ in. wide. These labels cost, painted, $1.30 per thousand. These are wired with stiff, heavy galvanized wire, much like that used for pail bales and not less than eighteen inches is used upon each label. Hooks are turned in the ends of the wires before the labels are taken to the field. A pail of pure white lead, well thinned with oil, is taken to the field with the labels. The record is made with a very soft pencil, the label is dipped into the paint, the wire is placed about a conspicuous limb and the hooks are joined with a pair of pliers. The paint at first almost completely obscures the writing, but some of it drips off and the remainder dries in, so that the record becomes bright and the soft pencil marks are indelibly preserved, while the label remains white. If the paint is brushed on, the soft writing will be blurred. If in the future the wood becomes grey, the label can be brightened by immersing it in a pot of white lead, without removing it from the tree. The large loop of wire allows of the growth of the branch and the label hangs so low that it can be seen at a glance. The heavy, stiff wire insures the safety of the label against boys and workmen. It cannot be removed without a pair of pincers. The label is large enough to allow of a complete record of the name of the variety, the place of purchase, age, and other matters; and it is readily found.

For temporary or annual plants, where little horse work is done, we like the commercial garden stakes, $12 \times 1\frac{1}{4}$ in. These cost us,



The Cornell Tree Label.

when painted and made of soft clear pine, \$4.55 per thousand. For more permanent stake labels, we use the one shown in the picture, and which is sawed at the nearest mill. This is cut from clear pine and is 2 ft. long, 3½ in. wide, 1½ in. thick, and sawed to a point. These are given two thin coats of white lead, care being taken not to pile them upon their faces until thoroughly dry, to avoid a rough surface for the pencil. The record may be made by a large soft pencil, like a carpenter's pencil, or by a brush and black paint; but for all annual crops the pencil will be found more serviceable. At the end of the season or when the record becomes dim, a thin shav-



A good Stake Label.

(24 x 3½ x 1½ in)

ing is planed off the face of the label, it is repainted, and used again. We gather up these labels from the vegetable garden each fall and dress them up during winter. The label is thick enough to allow of many annual dressings, while the lower portion is not reduced and it therefore lasts for many years and is strong enough to resist the shocks of cultivator or whippletrees. For ornamental bushes this large label is too conspicuous, and for this purpose we use a pine label 1½ inch wide, ½ inch thick, and 18 or 20 inches long, and the lower half is soaked in a strong solution of sulphate of iron (copperas), and, after drying in lime water, to preserve it.

RECENT VARIETIES OF TOMATOES.

The year 1893 was prolific in new tomatoes. It is impossible to make an extended report upon the tomato experiments of the year at this time, but the following brief running notes of the newer varieties may be of value:

Aristocrat Dwarf (Livingston). Habit of Dwarf Champion. Fruits red, small but very even and uniform and round, solid and attractive. Apparently a valuable amateur variety.

Baltimore Prize Taker (Landreth). A purple tomato of medium size, round and smooth. Attractive, but seemed to possess no superior merits.

Buckeye State (Livingston). A very large and productive round, heavy, purple smooth tomato. Seems to be the best novelty of the year on our grounds, and apparently worthy of general use.

Comrade (Gregory). A small and round early tomato, red, like Prelude in shape, valuable for its earliness, although here it did not equal Advance in this respect.

Early Michigan, or *Early Red Apple* (Ferry). Red, of medium size, round and regular. A good, handsome variety, but scarcely large enough to compete with other tomatoes in the general crop. It was not very early here.

Earliest of all (Salzer). A red, angled tomato of medium size, with a tendency to be flattened. It was not early here, and it seemed to have no striking qualities.

Extra Early Advance (Burpe). Our earliest tomato this year. A small red tomato of uniform size and shape, not very far removed from the Cherry type. Valuable only on account of its earliness.

Gold Ball (Livingston). Much like the old White Apple, except a little longer and of a bright lemon color. Early.

Hubbard's Early (Jerrard). A curled-leaved variety of the old angular type, red, appearing to be identical with the old Hubbard's Cnrled Leaf.

La Crosse Seedling (Salzer). Mixed, part of the plants like Dwarf Champion, and others slender growers with red angular fruits. Of no value with us.

Lemon Blush (Thorburn). Fruit of medium size, bright lemon with a faint blush, early. A good variety, and apparently worth general dissemination.

Logan's Giant (Everitt). An irregular, very late tomato, of no value here.

May's Favorite (R. D. Hawley & Co., Hartford, Conn.). A medium red tomato, uniform, regular and good. Seems promising.

Salzer's First Prize (Salzer). A flattish red variety of medium size, and apparently valuable for home use.

Salzer's Giant Tree (Salzer). Much mixed. Most of the plants bore a smallish red tomato with no pronounced attributes.

Salzer's Morning Star (Salzer). We could not distinguish it from Mikado.

Salzer's New Pot (Salzer). Mixed. Mostly like Dwarf Champion.

Semperfructifera (Pitcher and Manda). A red tomato of the Plum type, but somewhat angular or cornered in form. It was not early with us. One plant bore a large round fruit and was evidently a "rogue." Valuable only for domestic use.

Shenandoah (May). Large red flattish tomato of uniform size and regular. Very promising.

Storm King (Buckbee). Seems to be indistinguishable from small forms of the old White Apple.

Ten Ton (Landreth). Fruits medium to small, red, apparently not valuable here.

Terra Cotta (Thorburn). A medium to large buff-red regular tomato, of novel color. Interesting, and apparently valuable.

Topound (Huntingdon). Very much like Shenandoah. Good.

World's Fair (L. H. Reed, Grand Rapids, Wis.). A red flattish tomato with small foliage and evidently an offshoot of the old angular or cornered type of tomatoes. It seems to have no particular merits here.

TOMATO-POTATO GRAFTS.

Frequent statements go the rounds of the press describing some mysterious or extravagant results which have been obtained by intergrafting tomatoes and potatoes; and one correspondent has reached the point of naming his mongrel the "Potomato," and from it he expects to reap compound crops of tomatoes and potatoes. The truth is that the grafting of the tomato on the potato, and *vice versa*, is no new thing; and it is equally well known that no economic results come from the union. Yet the subject is an interesting one to those who are curious concerning the habits of plants, and it is true that potato tubers will grow without potato tops and tomato fruits will ripen without tomato roots. In order to set the matter right, it has seemed best to make a report of some of these grafts which we made three years ago, although a brief account of them has already been published.*

The grafts comprised tomatoes on potatoes and potatoes on tomatoes. Plants for the purpose were grown in pots, and the grafting was done in the greenhouse when the plants were but a few inches high.†

All sprouts were promptly removed from the stock below the union, and when the plants were set out of doors the parts were strongly knit together. Nevertheless, it was necessary to set the plants in a protected place to avoid injury from winds. The illustrations show a representative plant from each lot. It will be seen that the tomato-on-potato plant bears a handful of tubers, together with a fair crop of tomatoes. The products of the two parts looked to be perfectly normal, although the potatoes did not grow when planted, and the tomatoes seemed to develop the full tomato flavor. In this case, there was not a potato leaf allowed to develop the entire season. The potatoes were manufactured by tomato foliage. But the plant which bore the best crop of tomatoes bore no tubers on the potato roots — the strength seemed to have gone entirely into the tomato top.

The potato-on-tomato plants were infertile; that is, the tomato roots had no tubers and the potato tops, while they bloomed freely, produced no balls. The failure of the potato top to produce balls is probably not due to the fact that it had a tomato root, however, for comparatively few modern varieties of potatoes go to seed, even if they flower freely. There are records of potato tops on tomato roots having produced potato-like tubers in the axils of the leaves, and this curious circumstance has been thought to indicate a sort of graft-hybridism between the potato and tomato. I am ready to believe that such tubers have been produced, but they occasionally appear upon normal potato plants, and we have frequently produced them when propagating potatoes from cuttings of the growing shoots. Auxillary aerial tubers, while rare, are perfectly well known, and it would not be strange if, when the plant is prevented from making tubers in the ground, it should spend its energy elsewhere.

But however interesting these experiments may be to the plant physiologist, it is well for the reader to know that there is nothing mysterious in the operation of grafting the plants, and that there is no likelihood that any economic results will follow.

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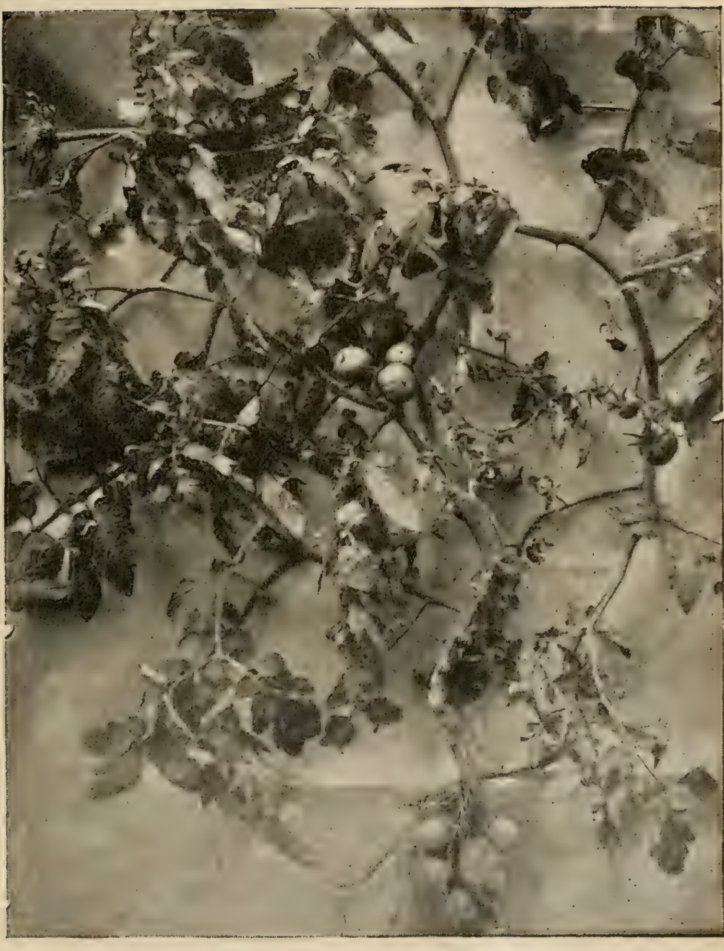
*Carman, The New Potato Culture, 151.

†For an account of the methods of grafting herbs, see Bull. 25, Cornell Exp. Sta. 175.

Potato-on-tomato Plant.



Tomato-on-potato Plant. Tomatoes above, Potatoes below.

HARDY CARNATIONS.

There is comparatively little known in this country about hardy or what the English call border carnations. The energy of American carnation growers has been directed almost entirely to the winter or house type. This winter or forcing type is a modern evolution from the hardy carnation, and there seems to be no reason why the two types should not succeed equally well in this country. Gardeners of foreign birth usually dismiss the hardy carnations by saying that our climate is too hot and dry for them. While there may be much truth in this position, it is also true that many and perhaps all of the border varieties can be grown here with little trouble. Some persons have grown them with perfect satisfaction for years, and visitors to the World's fair in early August must have noticed a glowing bed of them upon the wooded island.

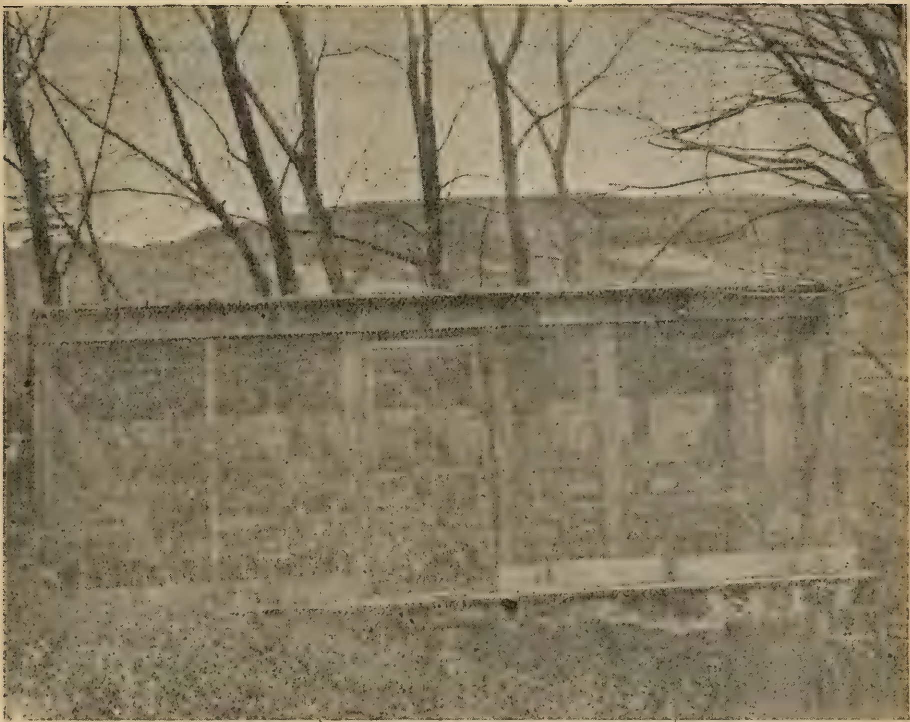
In order to determine if these plants can be successfully grown with only ordinary care, such as any person can give, we secured seeds, in the spring of 1892, of the following strains: Early Margaret, Self Colored, Early Dwarf, Mixed Vienna, Red Grenadine, Splendid Rose-leaved, Picotee and some others. These were sown in boxes in the greenhouse on the 8th of March, but they might just as well have been sown out of doors when the season opened. The plants were set in the field as the season advanced. A few of them bloomed in the fall. They were allowed to go through the winter wholly unprotected, although they grew upon bald hill-top; and the last winter was severe at Ithaca. They all wintered well, and they began to bloom about the middle of June and gave an uninterrupted display of bright colored and interesting forms until late in August. Although the lot was a mixed one, having come from seeds, all the varieties were interesting, particularly the single flowers. If any one strain were more pleasing than another, it was probably the Vienna, which bore single and semi-double little flowers of very pure and dainty colors, ranging from ivory-white to rose-red. Some of the plants had been taken up in the fall and removed to the house for winter bloom, and here, too, the Vienna was very pleasing. These hardy carnations will live on from year to year, although so good results cannot be expected from the subsequent seasons of bloom, and it is best to raise new plants from seeds.

SHED FOR STRATIFIED SEEDS.

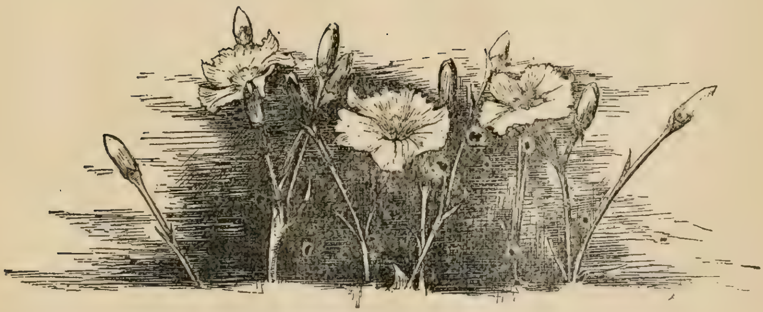
Seeds of fruits and nuts and many hardy herbs usually germinate best when placed in moist soil and subjected to frost. It is the practice of gardeners to place such seeds in boxes between layers of sand, and to expose them to the weather. Such seeds are said to be stratified. If more than one layer of seeds is placed in the box it is with the intention that they shall be sifted out the next spring and sown; but for all small parcels of seeds, such as usually fall to the lot of the experimenter, it is better to sow them regularly in boxes, and then expose them during the winter, allowing them to germinate without re-sowing. Some hard seeds will not germinate under two years, and occasionally they require even more time; but the boxes are kept clear of weeds, and the gardener abides his time.

With experimenters and others who have choice and often hybridized seeds to grow, it is a serious question what to do with these boxes of seeds, and how to keep a record of them. If kept in a building, they become too dry during winter, or if the seeds grow, the young plants are likely to die for want of light. If put out of doors, shade must be provided to keep the boxes moist and to prevent the young plants from becoming scorched by the sun; and the boxes are likely to get upset, the labels broken off or blown out, or the rains may wash out the seeds. We have been in the habit of placing these boxes under trees, where they make a convenient sitting place for workmen, and the labels afford entertaining whittling; and, more than all, the birds drop seeds into the boxes and destroy the value of experiments. We were much delighted with curious results which we got from boxes of hybridized raspberry and blackberry seeds; but when one raspberry box came up to strawberries we began to think that someone or something had taken an interest in our investigations.

But we are no longer troubled. The picture shows the shed in which we keep our stratified seeds, under lock and key. We call it a Seminarium. The roof is tight, but the sides are covered only with galvanized wire netting. The meshes in this netting are never more than a half inch, so that mice are excluded. The rains and snows beat into the place, and when the seeds germinate, the plantlets find light enough for their purpose. A record-book goes with this Seminarium, with columns for the entry of the following items: Name of sample; where from; date of sowing; number of box or pot; by whom sown; when transplanted; permanent quarters. The house is used also for the storing of cuttings, which are planted in boxes, the same as seeds. Such quarters are indispensable to any institution where many seeds of hardy plants are sown, and especially where experimental inquiry is attempted.



A Handy Seed Shed.



Border Carnations — The Vienna.

WHITEWASHING WITH THE SPRAYING PUMP.

The use of Bordeaux mixture in the spraying pump suggests that the machine can be used to good purpose in spraying whitewash upon greenhouse roofs, barn basements and fences. We now apply all the whitewash upon our larger glass roofs by means of a pump and nozzle. The whitewash is made in the ordinary manner, of lime and water, and is diluted to about the consistency of thin cream. If a large surface is to be covered, especially if it is difficult to reach, a direct delivery nozzle, like the Boss or a common discharge nozzle, is used, and the operator stands several feet away. But if it is desired to cover the surface evenly and neatly, the McGowen nozzle is most satisfactory.

A POTATO PRESERVER.

Last spring a prominent seedsman sent us a sample of potatoes, cut for planting, in very small pieces, and thickly coated with a white powder. These tubers were obtained from a dealer in potato novelties in the west, who said that he had discovered a material which would prevent the pieces of tuber from shriveling, thus allowing the seedsman to cut away most of the flesh of the tuber and to send the lightest possible bulk through the mails. A chemical examination of the material, however, showed it to be only ordinary land-plaster (calcium sulphate). Farmers often dust plaster over freshly cut seed-potatoes for the purpose of absorbing the moisture and rendering the tubers easier to handle ; and it is possible that the coating of plaster, when it dries upon the tuber, may prevent the loss of moisture and delay shriveling, but its advantage in this respect must be small.

L. H. BAILEY.

APPENDIX II.

DETAILED STATEMENT

OF THE

Receipts and Expenditures of the Cornell University Agricultural Experimental Station, for the Fiscal Year Ending June 30, 1893.

RECEIPTS.

From Agricultural Division.

1892.			
Oct.	17.	Two hogs	$32 17
Nov.	11.	Wool sold	20 00
1893.			
Jan.	5.	One hog	21 24
Feb.	14.	Three lambs	14 00
	21.	One lamb	9 15
March	13.	Two lambs	14 22
	27.	Eight pigs	91 17
April	4.	Sundries	14 70
	26.	Three lambs	13 50
May	31.	Four lambs	21 80
June	10.	Eleven sheep	40 00
		Total for agricultural division	$291 95

From Horticultural Division.

1892.			
July	25.	Sundry vegetables sold	$35 00
Aug.	5.	Sundry vegetables sold	32 00
1893.			
Jan.	7.	Sundry vegetables sold	33 92
	1.	Hauling coal	53 65
Feb.	1.	Hauling coal	10 02

1893.			
Mar.	1.	Hauling coal	$58 13
	31.	Hauling coal	32 16
April	3.	Sundry vegetables sold	33 00
May	2.	Sundry vegetables sold	5 00
		Total from horticultural division	$292 88

EXPENDITURES.

For Salaries.

1892.			
July	31.	I. P. Roberts, director, one month	$125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, entomologist, one month	83 33
		L. C. Corbett, assistant horticulturist, one month,	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
Aug.	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month	83 33
		L. C. Corbett, assistant horticulturist, one month	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
Sept.	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month	83 33
		L. C. Corbett, assistant horticulturist, one month	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66

1892.			
Oct.	31.	I. P. Roberts, director, one month............	$125 00
		H. H. Wing, deputy director, one month......	166 66
		L. H. Bailey, horticulturist, one month........	166 66
		Geo. F. Atkinson, cryptogamic botany, one month..	83 33
		G. C. Watson, assistant agriculturist, one month....................................	83 33
		M. V. Slingerland, assistant entomologist, one month..	83 33
		L. C. Corbett, assistant horticulturist, one month..	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
Nov.	30.	I. P. Roberts, director, one month............	125 00
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		L. C. Corbett, assistant horticulturist, one month..	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
Dec.	31.	I. P. Roberts, director, one month............	125 00
		H. H. Wing, deputy director, one month......	166 66
		L. H. Bailey, horticulturist, one month........	166 66
		Geo. F. Atkinson, cryptogamic botanist, one month..	83 33
		Geo. C. Watson, assistant agriculturist, one month....................................	83 33
		M. V. Slingerland, assistant entomologist, one month..	83 33
		L. C. Corbett, assistant horticulturist, one month..	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
1893.			
Jan.	31.	I. P. Roberts, director, one month...........	125 00
		H. H. Wing, deputy director, one month......	166 66
		L. H. Bailey, horticulturist, one month........	166 66

1893.			
Jan.	31.	Geo. F. Atkinson, cryptogamic botanist, one month	$83 33
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month	83 33
		L. C. Corbett, assistant horticulturist, one month	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
Feb.	28.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. F. Atkinson, cryptogamic botanist, one month	83 33
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month.	83 33
		L. C. Corbett, assistant horticulturist, one month,	62 50
		G. W. Cavanaugh, assistant chemist, one month,	66 66
March	9.	L. C. Corbett, assistant horticulturist, one-third month	20 83
	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. F. Atkinson, cryptogamic botanist, one month	83 33
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month	83 33
		Geo. W. Cavanaugh, assistant chemist, one month	66 66
April	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. F. Atkinson, cryptogamic botanist, one month	83 33
		Geo. C. Watson, assistant agriculturist, one month	83 33

1893.			
April	30.	M. V. Slingerland, assistant entomologist, one month	$83 33
		G. W. Cavanaugh, assistant chemist, one month,	66 66
May	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 66
		L. H. Bailey, horticulturist, one month	166 66
		Geo. F. Atkinson, cryptogamic botanist, one month	83 33
		Geo. C. Watson, assistant agriculturist, one month	83 33
		M. V. Slingerland, assistant entomologist, one month	83 33
		Geo. W. Cavanaugh, assistant chemist, one month	66 66
June	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, deputy director, one month	166 74
		L. H. Bailey, horticulturist, one month	166 74
		Geo. F. Atkinson, cryptogamic botanist, one month	83 37
		Geo. C. Watson, assistant agriculturist, one month	83 37
		M. V. Slingerland, assistant entomologist, one month	83 37
		G. W. Cavanaugh, assistant chemist, one month,	66 74
Total for salaries			$9,570 84

For Buildings.

1892.			
July	12.	A. A. Terrill, repairs on barn	17 64
Total for buildings			$17 64

For Printing.

1892.			
July	6.	Adams Express Co., expressage	50
	12.	W. F. Humphrey, 9,000 copies Bulletin No. 38,	$333 00
	5.	Geo. A. King, drawings	12 00
	11.	Rural Pub. Co., engravings	25 50
	13.	L. V. R. R., freight	75
	16.	Adams Express Co., expressage	75

1892.			
Aug	5.	Adams Express Co., expressage..............	$0 25
	3.	W. F. Humphrey, 10,000 copies Bulletin No. 39,	100 00
	3.	W. F. Humphrey, 10,000 copies Bulletin No. 40,	60 00
	3.	W. F. Humphrey, 9,000 copies Bulletin No. 41,	117 00
	4.	Rural Publishing Co., engravings.............	8 65
	29.	John Allen, drawings........................	3 93
	3.	Philadelphia and Reading railroad, freight....	1 00
Sept.	6.	National Express Co., expressage.............	50
	12.	W. F. Humphrey, 8,000 copies Bulletin No. 42,	65 75
	12.	W. F. Humphrey, 8,000 copies Bulletin No. 43,	48 00
	16.	Rural Publishing Co., engraving	9 30
	10.	Andrus & Church, circulars..................	5 25
	19.	Adams Express Co., expressage...............	35
	14.	Philadelphia & Reading railroad, freight......	1 78
	28.	Rural Publishing Co., engraving..............	9 10
	22.	Geo. A. King, drawings......................	2 00
Oct.	...	Adams Express Co., expressage...............	55
	20.	Geo. R. Chamberlain, drawings...............	4 50
	24.	Effie E. Slingerland, drawings................	9 00
	26.	Rural Publishing Co., engraving..............	5 60
	27.	U. S. Express Co., expressage................	25
	31.	Adams Express Co., expressage...............	1 35
	26.	Lovejoy Co., electrotypes..................	32
	28.	Rural Publishing Co., engravings.............	30 08
Nov.	1.	Western Union Telegraph Co., message.......	25
Oct.	24.	National Express Co., expressage.............	25
Nov.	24.	Philadelphia and Reading railroad, freight....	75
Oct.	29.	National Express Co., expressage............	75
Nov.	...	Adams Express Co., expressage..............	75
	1.	W. F. Humphrey, 8,000 copies Bulletin No. 44,	112 00
Dec.	12.	Anna B. Comstock, drawing.................	5 00
	13.	W. F. Humphrey, 8,000 copies Bulletin No. 45,	128 50
	8.	Rural Publishing Co., engravings.............	11 35
	16.	Effie E. Slingerland, drawings...............	1 50
	15.	Adams Express Co., expressage..............	95
	20.	Philadelphia and Reading Railroad Co., freight,	80
	27.	U. S. Express Co., expressage................	25
	17.	W. F. Humphrey, 8,000 copies Bulletin No. 46,	96 00
	24.	Rural Publishing Co., engravings.............	18 50
	29.	Rural Publishing Co., engravings.............	6 00

1892.			
Dec.	30.	Rural Publishing Co., engravings.............	$39 30
	29.	Lovejoy Co., electrotypes....................	1 07
	16.	Adams Express Co., expressage.............	1 15
	15.	Rural Publishing Co., engravings............	8 00
	30.	National Express Co., expressage............	90
1893.			
Jan.	16.	Adams Express Co., expressage...............	65
	16.	Rural Publishing Co., engravings	2 00
	17.	Hilda Lodeman, drawings	4 00
	19.	Philadelphia & Reading railroad, freight......	50
	19.	W. F. Humphrey, 8,000 copies Bulletin No. 47,	80 13
	19.	P. & R. railroad, freight	50
	19.	Rural Publication Co., engraving..............	4 25
	23.	W. F. Humphrey, 8,000 copies Bulletin No. 48,	144 00
Feb.	6.	W. H. Dole, drawing	2 50
	6.	Lehigh Valley railroad, freight................	50
	6.	National Express Co., expressage.............	25
Mar.	1.	United States Express Co., expressage	30
Feb.	25.	Rural Publishing Co., engravings	24 20
	27.	W. F. Humphrey, 9,000 copies Bulletin No. 49,	280 38
	28.	P. & R. railroad, freight	75
Mar.	4.	National Express Co., expressage.............	30
	9.	National Express Co., expressage.............	30
	14.	Effie E. Slingerland, drawings	4 00
	13.	Rural Publishing Co., engravings	1 00
	18.	United States Express Co., expressage	55
	21.	United States Express Co., expressage	85
	22.	National Express Co., expressage.............	25
	25.	Rural Publishing Co., engravings.............	22 90
	27.	United States Express Co., expressage.........	1 00
	27.	Western Union Telegraph Co., messages......	1 25
Jan.	3.	B. F. White, photographs	2 00
Mar.	23.	Rural Publishing Co., engravings	26 20
April	17.	W. H. Dole, drawings.........................	2 50
	15.	W. F. Humphrey, 8,000 copies Bulletin No. 50,	128 00
	15.	W. F. Humphrey, 8,000 copies Bulletin No. 51,	90 00
	18.	Rural Publishing Co., engravings.	8 00
	17.	P. & R. railroad, freight	3 30
May	10.	United States Express Co., expressage.........	35
	15.	Rural Publishing Co., engravings.............	14 40

1893.			
May	18.	W. F. Humphrey, 10,000 copies Bulletin No. 52,	$172 00
	24.	W. F. Humphrey, 8,000 copies Bulletin No. 53,	206 50
	23.	P. & R. railroad, freight	4 31
June	1.	Hilda Lodeman, drawing	2 00
		Total for printing	$2,527 90

For Office Expenses.

1892.			
July	21.	Bush & Dean, towels	$0 46
	29.	Enz & Miller, 43,000 envelopes	77 40
	28.	New York & Pennsylvania Telegraph Co., message..................................	40
Aug.	5.	Postmaster, 250 stamps	5 00
	11.	Andrus & Church, 1,000 letter-heads	5 00
	8.	Andrus & Church, 44,500 envelopes	80 10
	12.	Andrus & Church, stationery	4 35
Sept.	1.	E. N. Ehrhart, labor.........................	1 35
Nov.	30.	Western Union Telegraph Co., message.......	25
	4.	New York and Pennsylvania Telegraph Co., message..................................	40
Dec.	8.	Andrus & Church, 2,000 envelopes............	4 75
	6.	E. G. Hance, cartage	25
	20.	James B. Parker, labor......................	1 20
	23.	United States Express Co., expressage	90
	23.	H. H. Wing, stamps..........................	5 00
	15.	Andrus & Church, stationery	1 00
	30.	Nellie G. Works, labor......................	29 00
1893.			
Jan.	9.	Postmaster, stamps..................	13 00
	19.	Andrus & Church, paper	95
	18.	Andrus & Church, binding	75
	30.	Andrus & Church, stationery	4 10
Feb.	15.	G. C. Watson, stamps	11 00
	15.	Andrus & Church, 1,000 letter heads...... ...	3 88
	18.	United States Express Co., expressage	40
	18.	National Express Co., expressage.............	25
	18.	Andrus & Church, stationery	1 55
	21.	Geo. F. Lasher, postal guide.................	2 53
	22.	Andrus & Church, dictionary	4 70

1893.			
Mar.	2.	Andrus & Church, 1,000 letter heads	$3 25
	18.	Postmaster, 500 stamps	10 00
	18.	Andrus & Church, stationery	2 91
	28.	Felt & Tarrant Mfg. Co., comptometer	125 00
	22.	Association American College and Experiment Station, membership	10 00
	30.	Andrus & Church, paper	2 50
April	6.	Andrus & Church, pamphlet cases	5 00
	8.	W. O. Wyckoff, repairs to typewriter	5 23
	8.	Franklin Phon. Institute, note books	1 50
	24.	Andrus & Church, stationery	12 50
	29.	Nellie G. Works, labor	31 25
	25.	Western Union Telegraph Co., message	29
May	17.	Postmaster, stamps	15 00
June	1.	Postmaster, stamps	8 00
	15.	United States Express Co., expressage	30
	17.	Andrus & Church, stationery	88
	14.	W. O. Wyckoff, typewriter ribbon	1 00
		Total for office expenses	$673 95

For Agricultural Division.

1892.			
July	8.	Treman, King & Co., sundry hardware	$8 17
	8.	D. H. Roe & Co, Babcock Milk Tester	13 35
	16.	Andrus & Church, stationery	3 75
	19.	J. Carbutt, photographic plates	6 25
	20.	United States Express Co., expressage	70
Aug.	22.	Emil Greiner, milk pipettes	85
Aug.	13.	D. H. Roe & Co., one gear wheel	30
July	16.	D., L. & W. R. R., freight	92
Aug.	29.	Vermont Farm Machine Co., Cooley cans	1 17
Sept.	23.	National Express Co., expressage	25
	6.	American Carbonate Co., twenty pounds carbolic acid	3 00
Aug.	25.	Baker & Adamson, one carboy sul. acid	5 20
Sept.	21.	W. U. Tel. Co., message	25
	24.	D., L. & W. R. R., freight	25
	30.	Geo. Whipple, labor	35 00
	30.	Geo. Bush, labor	35 00
	30.	Geo. Westcott, labor	35 00

1892.			
Sept.	30.	Wm. Cummins, labor	$34 32
	30.	R. D. Roberts, labor	18 90
	27.	D., L. & W. R. R., freight	45
	24.	American Carbonate Co., twenty pounds carbolic acid	3 00
	23.	Leavitt M'f'g Co., dehorning clippers	6 00
Oct.	1.	A. B. Bogardus, fourteen sheep	21 00
	4.	Emil Greiner, Babcock test bottles	5 15
	17.	W. L. Bean, labor	5 00
Sept.	30.	Driscoll Bros., cement	13 50
Aug.	8.	White & Burdick, asphalt varnish	11 50
Sept.	28.	National Express Co., expressage	1 00
Nov.	4.	Jamieson & McKinney, rubber hose	2 55
	7.	Treman, King & Co., galvanized iron pans	4 00
	28.	E. McGillivray, photographic plates	2 50
	18.	American Carb. Co., express charges paid	1 00
Dec.	3.	National Express Co., expressage	95
1893.			
Jan.	2.	D. H. Wanzer, feed	2 31
	16.	National Express Co., expressage	25
	5.	American Glucose Co., feed	36 00
	6.	Ithaca Gas Light Co., coal tar	1 50
	20.	Baker & Adamson, one carboy sul. acid	5 44
	18.	Kelloggs & Miller, feed	54 00
	23.	E., C. & N. R. R., freight	4 80
Feb.	3.	P. & R. R. R., freight	66
Jan.	26.	Pottstown Iron Co., odorless phosphate	1 50
	11.	W. L. Mitchell, service boar	9 00
Feb.	10.	Emil Greiner, milk pipettes	1 23
	13.	U. S. Express Co., expressage	1 60
	14.	Bowker Fertilizer Co., meat scrap	34 00
	21.	J. M. Thorburn & Co., tobacco seed	90
	18.	P. & R. R. R., freight	1 28
	18.	E., C. & N. R. R., freight	4 70
	24.	Chas. H. Dodge, milk strainer	50
	23.	Schuyler Grant, one cylinder of gas	4 00
	28.	D., L. & W. R. R., freight	61
March	1.	Otto Benecke, fertilizer	3 80
	16.	Emil Greiner, Babcock test bottles	7 65
	27.	W. Atlee Burpee & Co., tobacco seed	44

1893.			
April	1.	D. M. Ferry & Co., rape seed	$0 30
March	30.	Treman, King & Co., oil can	30
April	20.	J. M. Thorburn & Co., crimsom clover seed	50
	22.	R. A. Pearson, labor	19 40
	19.	P. & R. R., freight	61
	21.	Treman, King & Co., sundry hardware	95
	14.	Moro Phillips Chemical Co., sul. of am	10 15
May	15.	United States Express Co., expressage	50
June	7.	United States Express Co. expressage	45
	8.	Peter Henderson & Co., cow pea seed	73
	27.	H. H. Wing, tobacco plants	1 00
	5.	D. H. Wanzer, feed	5 16
		Total for agricultural division	$496 45

For Horticultural Division.

1892.			
July	8.	E. and H. T. Anthony & Co., photographic supplies	$1 85
	8.	E. C. Cleaves, blue print paper	8 32
	8.	Judson & Co., stakes	10 31
	8.	C. J. Rumsey & Co., sundry hardware	65 17
	13.	United States Express Co., expressage	1 00
	16.	John Reidy, picking berries	3 01
	16.	Thomas Reidy, labor	3 46
	16.	C. J. Sheehan, picking berries	2 90
	16.	F. S. Sheehan, picking berries	45
	16.	Albert Shaw, picking berries	1 60
	18.	S. Vandevere, three bushels potatoes	75
	6.	Farmers' Fertilizer Co., bone flour	11 00
	19.	J. Carbutt, photographic plates	9 00
	16.	Bernard Gallagher, picking berries	2 02
	20.	United States Express Co., expressage	75
	22.	Thomas Reidy, picking berries	3 00
	1.	J. H. Stannion, repairs	75
	25.	Alfred Bridgeman, seeds	2 45
	25.	Edward Gillette, plants	1 75
	22.	H. A. Williams Manufacturing Co., nozzles	75
	26.	J. M. Thorburn & Co., seeds	2 01
	29.	F. W. Rane, labor	35 74
	30.	Thomas Reidy, picking berries	2 60

1892.			
July	30.	Wm. Westcott, labor	$35 00
	23.	National Express Co., expressage	2 65
	26.	Henry A. Dreer, seeds	15
August	2.	Thomas Reidy, picking berries	1 30
	8.	F. W. Card, labor	3 30
	11.	Thomas Reidy, picking berries	26
	8.	United States Express Co., expressage	40
	12.	Dan. Sullivan, picking berries	1 66
	6.	National Express Co., expressage	2 20
	5.	L. H. Bailey, traveling expenses	26 65
	1.	E. & H. T. Anthony Co., negative preservers	1 13
	22.	James Fay, labor	2 50
	8.	Dennison Manuf'g Co., fish glue	1 17
July	15.	L. C. Corbett, photographic plates	3 75
	12.	Andrus & Church, mounting paper	5 75
June	27.	Andrus & Church, blank books	1 60
Aug.	1.	Fish & Hulett, berry baskets	2 75
Sept.	1.	William Westcott, labor	35 00
Aug.	27.	J. Carbutt, photographic plates	4 85
	24.	National Express Co., expressage	30
July	27.	White & Burdick, chemicals	3 24
Aug.	27.	E. & H. T. Anthony Co., photographic plates	1 17
Sept.	13.	Samuel Raub, labor	12 00
	1.	A. B. Seymour, economic fungi	6 10
	20.	Adams Express Co., expressage	70
Oct.	1.	William Westcott, labor	35 00
	1.	Ira Grover, labor	34 50
	10.	U. S. Express Co., expressage	50
Aug.	31.	James Seamon, moving boiler	6 74
Oct.	11.	Dennison Manuf'g Co., stationery	3 00
	11.	John A. Scolley, putty buds	2 00
	7.	J. Carbutt, photographic plates	2 93
	15.	U. S. Express Co., expressage	45
	12.	Adams Express Co., expressage	1 40
Sept.	30.	James Seamon, window frame	4 00
Oct.	22.	F. W. Card, labor	75
	27.	H. Mitchell, hay	27 40
	25.	U. S. Express Co., expressage	75
	29.	Adams Express Co., expressage	1 25
	31.	William Westcott, labor	35 00

1892.			
Nov.	2.	U. S. Express Co., expressage	$0 60
	4.	L. V. Main, sundries	1 15
Oct.	17.	Pritchard & Son, wagon repairs	12 55
Nov.	1.	Dennison Manuf'g Co., glue	1 75
Oct.	29.	L. J. Farmer, strawberry plants	5 35
Nov.	6.	National Express Co., expressage	4 70
	5.	Ithaca Gas Light Co., gas bill	19
	11.	Bloomington Phœnix Nurseries, trees	1 35
	1.	R. G. Chase & Co., grape vines	32
Aug.	2.	A. F. Fay, picking berries	40
Nov.	11.	U. S. Express Co., expressage	35
	7.	National Express Co., expressage	95
	22.	Adams Express Co., expressage	6 65
Dec.	1.	William Westcott, labor	35 00
	15.	E. G. Lodeman, postage stamps	8 00
	31.	William Westcott, labor	35 00
1893.			
Feb.	1.	Wm. Westcott, labor	35 00
	6.	Ithaca Gas Light Co., gas bill	2 28
Mar.	4.	Wm. Westcott, labor	40 40
Apr.	1.	Ira Grover, labor	35 00
	1.	C. J. Foulkes, labor	4 52
	5.	P. H. Moore, labor	16 00
	5.	J. C. Blair, labor	7 80
	21.	Treman, King & Co., galvanized wire	46
	29.	C. J. Foulkes, labor	25 00
	29.	Ira Grover, labor	35 00
March	3.	Andrus & Church, stationery	1 55
	28.	J. M. Thorburn & Co., seeds	4 31
	23.	Andrus & Church, 300 postals and printing	3 75
	24.	Peter Henderson & Co., seeds	14
April	4.	J. M. Thorburn & Co., seeds	90
Feb.	9.	S. J. McKinney, plumbing	1 65
April	5.	Samuel Wilson, seeds	2 50
May	2.	United States Express Co., expressage	1 85
April	5.	W. A. Morrison, spraying nozzle	1 25
	14.	M. Jones, desiderata	3 00
	7.	C. Eisley, plants	2 00
	26.	J. Lydiatt, sand	1 00
	12.	Delaware, Lackawanna and Western railroad, freight	60

1893.			
May	11.	National Express Co., expressage	$0 40
April	25.	E. C. & N. R. R., freight	1 08
May	5.	United States Express Co., expressage	1 55
	6.	P. & R. R. R., freight	1 08
	10.	J. Carbutt, photographic plates	8 33
	12.	United States Express Co., expressage	1 65
	5.	E. C. Powell, fifty stamps	1 00
June	1.	C. J. Foulkes, labor	25 96
	1.	Ira Grover, labor	36 35
	1.	P. & R. R. R., freight	4 05
May	23.	J. Carbutt, photographic plates	3 31
June	7.	C. J. Foulkes, labor	5 30
May	22.	I. H. Rogers, drawing	5 00
June	10.	National Express Co., expressage	50
	10.	E. Snyder, sixty bushels oats	27 00
	13.	Delaware, Lackawanna and Western railroad, freight	1 30
	26.	Ira C. Grover, labor	15 38
	26.	Ira S. Grover, labor	35 00
		Total for horticultural division	$996 06

For Entomological Division.

1892.			
July	12.	Robt. Leitch & Sons, repairing pump	$2 00
	14.	Adams Express Co., expressage	55
Aug.	1.	W. E. Rumsey, labor	8 20
July	7.	National Express Co., expressage	55
	30.	Andrus & Church, stationery	35
	9.	E. McGillivray, photographic plates	90
Aug.	9.	Bausch & Lomb Optical Co., microscope reproductions	1 88
Sept.	1.	W. E. Rumsey, labor	15 60
Aug.	29.	Andrus & Church, stationery	84
	29.	Arthur B. Brooks, sundries	4 45
Sept.	13.	White & Burdick, sundries	88
	10.	Andrus & Church, stationery	86
	26.	Treman, King & Co., hardware	92
Oct.	1.	W. E. Rumsey, labor	22 70
	13.	J. D. Eagles, photographic plates	3 30

1892.			
Oct.	19.	N. Y. & Pa. Tel. & Tel. Co., rent	$10 00
	20.	Treman, King & Co., hardware	3 16
Nov.	1.	W. E. Rumsey, labor	17 00
	10.	P. & R. R. R. Co., freight	1 18
	9.	Hammond & Willard, trees	16 00
	22.	P. & R. R. R. Co., freight	1 29
Dec.	1.	W. E. Rumsey, labor	16 00
	3.	J. D. Eagles, photographic plates	1 50
	3.	Andrus & Church, stationery	4 40
	17.	Andrus & Church, stationery	3 15
Nov.	1.	A. B. Brooks, sundries	17 20
1893.			
Jan.	5.	Andrus & Church, stationery	65
	2.	Treman, King & Co., hardware	1 75
	23.	Andrus & Church, stationery	70
Feb.	13.	Andrus & Church, stationery	50
	24.	J. D. Eagles, photographic plates	3 95
March	13.	Andrus & Church, stationery	39
	22.	G. W. Herrick, labor	4 50
	27.	Treman, King & Co., hardware	2 35
April	11.	Treman, King & Co., hardware	2 53
	29.	G. W. Herrick, labor	6 83
	21.	Andrus & Church, letter-heads	8 25
May	4.	Postmaster, 500 stamped envelopes	10 90
	5.	Silas Wilson, sundries	5 00
	6.	P. & R. R. R. Co., freight	50
	6.	D. B. Stewart & Co., one barrel oil	1 77
	20.	J. D. Eagles, photographic plates	2 85
	6.	Treman, King & Co., hardware	2 50
June	4.	G. W. Herrick, labor	3 08
	28.	R. H. Pettitt, labor	17 00
	28.	G. W. Herrick	15 00
		Total for entomological division	$248 86

For Botanical Division.

1892.			
Aug.	1.	Gustav E. Stechert, books	$11 18
Oct.	28.	Andrus & Church, stationery	10 73
	31.	E. Steiger & Co., apparatus	201 37

1892.			
Nov.	2.	Gustav. E. Stechert, books	$1 44
	23.	White & Burdick, two gallons alcohol	5 00
Sept.	1.	A. B. Seymour, books	7 22
Dec.	9.	The Bool Co., furniture	52 00
	12.	Andrus & Church, stationery	1 50
Oct.	7.	White & Burdick, chemicals	20
	26.	Enz & Miller, paper	32
	7.	Treman, King & Co., tin work	20
Sept.	30.	Bush & Dean, cloth	1 14
	28.	J. B. McAllister, sundries	10
Dec.	27.	Larkin Bros., sundries	16
Nov.	9.	R. A. Heggie & Bro., platinum work	50
Dec.	24.	Franklin Educational Co., apparatus	14 64
	13.	Gustav E. Stechert, books	4 88
1893.			
Jan.	3.	Platt & Colt, chemicals	11 79
	18.	Andrus & Church, stationery	6 30
Mar.	25.	White & Burdick, rubber tubing	50
Jan.	1.	Barr Bros., granite pitcher	1 25
		Total for botanical division	$333 14

For Chemical Division.

1892.			
July	16.	Andrus & Church	$5 25
1893.			
Mar.	1.	James Seaman, repairs	89
		Total for chemical division	$6 14

For Columbian Exposition.

1893.			
Jan.	4.	R. A. Pearson, labor	$12 20
	5.	National Express Co., expressage	65
	17.	Andrus & Church, one copy Cornellian	1 00
	23.	Whitall, Tatum & Co., show bottles	2 80
Feb.	3.	P. and R. R. R. Co., freight	62
Jan.	27.	E. C. and N. R. R., freight	55
Feb.	28.	D., L. and W. R. R., freight	50

1893.			
Mar.	20.	P. and R. R. R. Co., freight	$1 88
	27.	H. H. Wing, sundries	1 40
	29.	United States Express Co., expressage	25
	30.	National Express Co., expressage	3 50
	30.	United States Express Co., expressage	2 00
	27.	Western Union Telegraph Co., messages	50
	29.	E. C. and N. R. R. Co., freight	4 33
	30.	Eimer & Amend, glass jars	21 00
May	2.	United States Express Co., expressage	85
	1.	National Express Co., expressage	75
	29.	B. F. White, enlarged photos	75 00
June	3.	V. T. Wilson, making chart	27 00
Mar.	20.	E. J. Fort, making charts	10 00
		Total for Columbian Exposition	$165 78