CIRCULAR No. 67.

UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

URBANA, ILLINOIS, FEBRUARY, 1903.

FRUIT AND ORCHARD INVESTIGATIONS.
BRIEF REPORT OF PROGRESS.

VIEW OF NEOGA HOUSE FROM THE WEST.
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FRUIT STORAGE EXPERIMENTS.

As a result of the appropriation made in 1901 to the Department of Horticulture of the Agricultural Experiment Station of the University of Illinois, several series of experiments along different horticultural lines were planned and outlined. One of the first series inaugurated and put in operation was that relating to cool and cold storage. The conception of these experiments grew out of the apparent needs of the fruit growers for better means of handling the products of their orchards. The grower after bringing his crop to maturity was usually obliged to accept any price offered, because his selling season was very short and he had no means of preserving his crop until market conditions, resulting from the large quantity offered for sale at one time, should improve and remunerative prices prevail. It is true that some of the larger producers have practiced shipping their product to the large storage houses in cities to be sold later in the season by commission men acting under orders from the grower. But there are difficulties encountered in this practice,—chief among which is the transportation for long distances during periods of warm weather when the fruit ripens rapidly, and loses in keeping qualities. Serious delays frequently occur in the transportation and it has been no uncommon experience for fruit to reach storage in very poor condition, so that losses instead of profits have resulted.

These are some of the considerations leading up to the first problem of the experiments:

FIRST PROBLEM.

Can the commercial grower of apples in the apple region of the state, as an individual, or as one of several in a community, afford to construct a cold storage house having capacity of from 2000 to 3000 barrels, depending upon ice and natural temperature for cooling the same?

The advantages of such a house, located either in the orchard, or in proximity to the nearest railway switch, may be briefly stated as follows:

1. The selling period of fruit could be greatly prolonged.
2. Fruit could go from the tree immediately into storage and be cooled to such degree as would arrest ripening processes.
3. Fruit could be stored in temporary packages, and final grading and packing deferred until the hurry of the picking season was over.
4. In the event of scarcity or high price of barrels during the busy season, fruit could be stored in bulk to be packed later when acceptable barrels could be obtained at satisfactory prices.
5. The facilities for handling the fruit would enable the grower to give better attention to the degree of maturity, and pick at just the proper time.

The questions for discussion were: “Will the advantages warrant the necessary outlay?” and, “will the proposed method of cooling operate successfully?”

The first step taken by the Department was in the direction of securing all available information bearing upon the problems of cost, construction and operation. This was accomplished through extended correspondence, search of literature of the subject, and by visiting several storage houses then in operation. Plans were then drawn for a building embodying all features that seemed desirable and applicable to the conditions; care being taken to make the cost as low as possible and at the same time secure the degree of insulation necessary to success.

This building as planned with an approximate capacity of 2000 barrels was erected at Neoga, Cumberland County, at the intersection of two lines of railway—the Illinois Central and the “Clover Leaf.” The latter road extended a siding direct to the building and the location is fortunate both in conveniences for shipping and in being near surrounding orchards.

The dimensions of the building are forty by eighty-one feet, with fourteen foot studding. The fruit room is forty by forty feet. The ice room twenty by forty feet.

The whole aim has been to construct a building of capacity suited to the demands of the commercial grower and at the same time keep the cost within his reach. Full details of construction have been published in Circular 44 from the Experiment Station and also in the reports of the State Horticultural Society for the years 1901 and 1902. These details need not be repeated here and we may proceed at once to consider the results obtained.

It was not possible for the Experiment Station to buy the fruit necessary to test the storage building, nor could it assume any risk of a possible loss of fruit, therefore a set of rules were formulated and distributed early in November, 1901, stating the conditions under which fruit, in lots not exceeding five hundred barrels nor less than five barrels, would be received for storage. Under these rules nearly 2000 barrels were secured from growers in Southern Illinois. This fruit was all received about the same time and the last was in place by October 5. There was no ice in the building until the fruit was
all in, but on that day—October 5th—seventy tons were placed in the refrigerator. The temperature fell rapidly until 33 degrees was reached, and this temperature, or a slightly lower one, was maintained throughout the season of nearly seven months. The success of the insulation is made very clear by the fact that outside temperatures ranging from 75 degrees above to 15 degrees below zero had no appreciable effect upon the inside temperatures. Of the seventy tons of ice placed in the refrigerator October 5th, there still remained ten tons on April 23d, showing the ice requirement for the season to have been sixty tons. This ice cost, delivered, $2.30 per ton, or $138.00 for the amount consumed during the test.

The actual results from this first year's test may be briefly stated as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of storage building</td>
<td>$3430.40</td>
</tr>
<tr>
<td>Interest on cost of building for one year at 6 per cent</td>
<td>205.82</td>
</tr>
<tr>
<td>Cost of icing (60 tons at $2.30 per ton)</td>
<td>138.00</td>
</tr>
<tr>
<td>2000 barrels of fruit stored for six months</td>
<td></td>
</tr>
<tr>
<td>Total amount of interest against each barrel stored</td>
<td>102</td>
</tr>
<tr>
<td>Total cost per barrel for icing</td>
<td>0.69</td>
</tr>
<tr>
<td>Total cost per barrel for supervision and operating expenses</td>
<td>0.02</td>
</tr>
<tr>
<td>Total expense per barrel</td>
<td>1.91</td>
</tr>
<tr>
<td>Total saving per barrel over regular storage charges</td>
<td>0.39</td>
</tr>
<tr>
<td>Net saving per year on 2000 barrels</td>
<td>618.00</td>
</tr>
</tbody>
</table>

Total time required to pay back total amount invested, 5 1-2 years.

From the figures above given the following statement of the possibilities of the building based on working it to the full capacity of 2500 barrels and allowing an increase in the amount of ice of fifteen tons—or a total of 75 tons—may be made:

**STATEMENT OF RESULTS BASED UPON THE FULL CAPACITY OF BUILDING.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum capacity of building—2,500 barrels.</td>
<td></td>
</tr>
<tr>
<td>Total ice required for six months—75 tons.</td>
<td></td>
</tr>
<tr>
<td>First Year—</td>
<td></td>
</tr>
<tr>
<td>Total cost of building</td>
<td>$3430.40</td>
</tr>
<tr>
<td>Interest on cost of building, 1 year at 6 per cent</td>
<td>205.82</td>
</tr>
<tr>
<td>To 75 tons of ice at $2.30 per ton</td>
<td>172.50</td>
</tr>
<tr>
<td>To operating and supervision, one year</td>
<td>50.00</td>
</tr>
<tr>
<td>Ordinary storage charge is, per barrel</td>
<td>0.50 cents</td>
</tr>
<tr>
<td>Cost of ice and operating for this house is, per barrel</td>
<td>0.089 cents</td>
</tr>
<tr>
<td>Saving over ordinary storage per barrel</td>
<td>0.411 cents</td>
</tr>
<tr>
<td>By saving on 2500 barrels at 0.411 cents per barrel</td>
<td>$1027.50</td>
</tr>
</tbody>
</table>
Second Year—
To interest on cost of building ........................................ 205 82
To 75 tons of ice at $2.30 per ton .................................. 172 50
To operating one year .................................................. 50 00
By saving on 2500 barrels at .411 cents per barrel ............ 1027 50
By interest on saving first year, $1027.50, at 6 per cent .... 61 25

Third Year—
To interest on cost of building ........................................ 205 82
To 75 tons of ice at $2.30 per ton .................................. 172 50
To operating one year .................................................. 50 00
By saving on 2500 barrels at .411 cents per barrel ............ 1027 50
By interest on savings, 2 years, $2055.00 at 6 per cent ... 123 30

Fourth Year—
To interest on cost of building ........................................ 205 82
To 75 tons of ice at $2.30 per ton .................................. 172 50
To operating one year .................................................. 50 00
By saving on 2500 barrels at .411 cents per barrel ............ 1027 50
By interest on savings of 3 years, $3082.50 at 6 per cent ... 184 95

Fifth Year—
To interest on cost of building ........................................ 205 82
To 75 tons of ice at $2.30 per ton .................................. 172 50
To operating one year .................................................. 50 00
By saving on 2500 barrels at .411 cents per barrel ............ 1027 50
By interest on savings, 4 years, $4110.00 at 6 per cent ... 246 60
Balance .............................................................. 182 00

$5754 00 $5754 00

The savings with accrued interest on savings have in five years paid the cost of building $3430 40
The icing and operating for five years 1112 50
Interest on cost of building for five years 1029 10
And returned a surplus of 182 00

CONDITION OF THE FRUIT.

The fruit in the building was carefully examined at frequent intervals by representatives of the Department and also by commercial growers. The results of the data collected show that without exception the fruit kept well. There was no scald, no withering. The fruit remained plump and in perfect condition, and the per cent of rotten fruits was very small.

The results exceeded all expectations and plainly show the practical utility of buildings of this construction, cooled by ice. It is probable that in some localities such a building could be located near a body of water from which ice could be obtained at much less cost, but even at greater cost than was paid in this instance, there would still be a favorable showing. Undoubtedly the greatest gain
from a building of this character is the ability to care for the fruit immediately after picking.

The experiment of last year is being repeated this year and the results to date, so far as keeping of fruit is concerned, are fully as encouraging as those of a year ago. There is, however, this difference: While last year, ice was not placed in the building until October 5th when all fruit was in place, this season the refrigerator was filled on the first of September, before any fruit was stored. The ice used was thin and not of as good quality as in the previous year. The mistake was made, in storing the ice, of surrounding it with sawdust; this necessitated additional labor in cleaning before removal to the refrigerator room. This additional expense is a charge against the icing and while the labor could, in all probability, have been performed cheaper by the individual owner than it was possible for the Station to do it with hired labor, the whole addition of labor could have been avoided by omitting the sawdust.

To the above statement the fact should be added that the prevailing outside temperatures during the months of September and October were much higher than in 1901. It follows that the consumption of ice this season has been considerably greater than last year; thus making the showing of profit less for that year.

Exact figures of ice consumption for the season cannot be given at this date, but suppose it to be double the amount used last year. Then the total expense per barrel stored would be raised from 19.1 cents to 26 cents, and the saving per barrel over ordinary storage charges reduced from 30.9 cents to 24 cents. This would reduce the net saving on the 2000 barrels stored the first year from $618.00 to $480.00. But even at this large increase in cost the saving is large enough to warrant the investment.

This problem may be regarded as demonstrated and it can safely be stated that commercial growers of apples can well afford to invest in similar houses and thus add greatly to their profits. Practical fruit men, who have shown great interest in the work and have kept in touch with its progress, freely express the opinion that the work accomplished is worth many times its cost to the fruit growers of the state.

SECOND PROBLEM.

The second cold storage problem is this: Can the smaller grower of fruit afford to insulate a cellar and provide it with ice during the early part of the season? For a test of this question three structures, one at Olney in Southern Illinois, one at Savoy in Central
Illinois, and one at Princeton in Northern Illinois, are now in operation. The Princeton cellar was completed only this fall and consequently we have no complete data as yet. The other two cellars have been operated one year and the results are not very encouraging. From the data so far secured, we have a pretty clear indication that the fruit growers in Southern or Central Illinois cannot afford to insulate a cellar for the purpose of storing fruit. Our work in these two places demonstrates beyond all doubt that it is not economy to build a cold storage in the ground. The earth is a good conductor of both heat and cold. Air is a poorer conductor of heat and cold than is the ground. It is cheaper, therefore, to insulate a structure above ground. The amount of ice used in the early part of the season was excessive and would not be profitable. Later when the admission of outside temperature was relied upon, fluctuations that are detrimental could not be avoided. The Olney cellar resisted low outside temperatures better than did the one at Savoy, but neither could resist the higher temperatures.

As a consequence of fluctuating and commonly too high temperatures the fruit did not keep well, the percentage of rot was too high, but a possibly worse feature was that the sound fruit was more or less wilted. The fruit used in these cellar tests was of rather low grade and was picked at varying degrees of maturity. It was found that degree of maturity is an important factor and that fully mature fruit has much better keeping qualities than the immature.

In connection with the tests in progress this year, the maturity factor is receiving special attention with prospect of a definite determination of the exact condition best suited for all storage purposes.

Third Problem.

The third storage problem is an attempt to determine what temperature during the storage period is best suited to different varieties of apples.

For this test, arrangement was made with the Twin City Ice and Cold Storage Company, of Champaign, for the use of four rooms to be maintained respectively at temperatures of 31, 33, 35 and 37 degrees. These rooms were not completed for the reception of fruit until October 1, 1901. It was then too late to secure a large assortment of varieties for the test.

On October 16th the rooms were filled with Ben Davis and Winesap apples. The fruit in all the rooms was examined at frequent intervals and the general conclusion from the data obtained
is that Ben Davis apples keep better and scald less at a temperature of 31 degrees than at a higher temperature. The difference in the case of Winesap is not so marked, but yet there is sufficient difference to show that the fruit did keep better at the lower temperature. In the work this year a large assortment of varieties is stored, which we are confident will give much additional data of value to fruit growers.

**FOURTH PROBLEM.**

At what degree of maturity when picked do apples keep best when placed in storage?

During the past few years there has developed a growing tendency to pick apples early. This is due in part to the competition among buyers and the fear of loss through storms, and in part to the strong desire of the grower to see his fruit safely picked and on the market.

Observations on stored fruit indicate that the practice is a pernicious one; that the immature and under-colored fruit does not keep nearly so well as does fruit properly matured and colored on the trees. For additional data on this question an assortment of fruit picked at different degrees of maturity was carried through last season at Champaign, and this year assortments are being observed both at Neoga and Champaign. The results thus far obtained point to great superiority in the keeping qualities of mature over immature fruit. Mature fruit shows a much smaller percentage of rot; is much less liable to scald; does not shrink as much; has better color, and hence better selling qualities when removed from storage.

As work on the problems outlined has progressed, many supplementary questions have arisen, some of which will require work for several seasons before they can be definitely answered. As has been stated, the first problem regarding the feasibility of constructing cold storage houses by the commercial growers is looked upon as practically settled, but there is the possibility that from continued study of the building and its operation, revised plans can be made that will in some degree decrease the cost without diminishing the effectiveness of insulation and this work the department has well advanced.

The second problem regarding cellars for small growers seems definitely answered only for the southern part of the state. It is possible that the cellar in operation at Princeton may prove satisfactory and show that for the northern part of the state such cellars could be recommended. The problems regarding transportation and
maturity need further study before final conclusions can be announced. The work of one, or even two seasons cannot satisfactorily determine all the secondary questions that have arisen. It is clear, however, that much depends upon weather conditions during the fall. The keeping of fruit subjected to abnormally high temperatures in the period just preceding picking, is an altogether different matter from keeping fruit that has matured under normal or lower than normal temperatures. It follows, therefore, that it is not safe to rest a decision upon the test of one season.

The following are some of the questions upon which additional information is needed:

Storage temperatures best suited to the different varieties of apples.

The degree of maturity at which different varieties will keep best in storage.

In what kind of a package will fruit keep best in storage—box or barrel? ventilated or tight?

To what extent can wrapping the fruit be practiced with profit, and what is the best wrapping material?

What is scald? A study of its effect upon the fruit; determination of the varieties most subject to it; the conditions under which it develops; and the predisposing causes. This has long been recognized as one of the worst troubles with stored fruit and there is great need of exact knowledge regarding it.

The degree of moisture to be maintained in storage rooms, and the amount and kind of ventilation to be given are questions upon which more exact information is needed.

SPRAYING FOR BITTER ROT.

When the work of spraying for the control of bitter rot was inaugurated in 1901, it was generally conceded that the investigations should extend over a period of at least three years in order that the results might be fully established. The results of the first year's work did not warrant the drawing of any very definite conclusions, nor the making of any explicit recommendations regarding the control of the disease. This was largely due to the fact that the season was unfavorable to the development of the fungus, so that it failed to appear at all in two of the orchards in which experiments were being conducted, although it was present in both the preceding year. Ex-
perimental work in the only other orchard under treatment had to be abandoned early in the season, owing to a misunderstanding on the part of the owner. After it became apparent that the bitter rot was unlikely to develop in the other two orchards above mentioned, the operations were extended to an orchard at some distance, in which the disease had already appeared in abundance. This late spraying, after the disease had become well established, resulted in a saving of some of the fruit, but the results were somewhat variable and not entirely conclusive.

The work for the year 1902 was carefully planned with a view to determining the following points:

1. The value of early sprayings repeated at intervals of ten days up to the time of the appearance of the disease.
2. The value of spraying shortly before the appearance of the disease.
3. The value of three applications of spraying material, at intervals of ten days, beginning after the appearance of the disease.
4. The value of five applications at intervals of ten days, beginning after the appearance of the disease.
5. The value of making applications after every rain, beginning after the appearance of the disease.

Three orchards were selected in which it seemed probable, from past records, that the rot would surely develop. These orchards were located near Tonti, Tamaroa and Flora. In order that the operations might be carried on on a sufficiently large scale to render the results of practical value and leave no uncertainty regarding the conclusions, it was decided to undertake the investigation of only a part of the above enumerated points in each of the orchards. Accordingly, the operations at Tonti were carried on with a view to determining the first two points; the operations at Tamaroa, the third and fourth points; and those at Flora with a view to comparing the relative efficiency of spraying at stated intervals with spraying after every rain, (4th and 5th points.)

The material used in all of the spraying was Bordeaux mixture of the usual strength—four pounds lime, four pounds copper-sulphate, fifty gallons water. In all of the orchards, check plates were left unsprayed for purposes of comparison.

**TONTI ORCHARD.**

In the Tonti orchard the work was confined to the Ben Davis, with the exception of six trees of the Huntsman. The latter variety
is extremely susceptible to the bitter rot, and so it was thought best
to include these six trees (the only ones of the variety in the
orchard), even though their number was small. Unfortunately these
Huntsman trees were on low ground, and one of the most important
applications of spraying material had to be omitted owing to the
presence of standing water on this portion of the orchard.

The sprayed portion of the Ben Davis block was divided into
two plats. Plat I was sprayed May 15, 28, June 7, 17, July 2 and
12. Plat II was sprayed May 15, July 2, 9 and 12. The check
plat received no spraying at any time during the season. Two trees
of the Huntsman (Plat I) were sprayed May 15, 28, June 7, 17
July 9 and 12. Plat II of the Huntsman was sprayed May 15,
July 9 and 12. The bitter rot was first observed in the orchard July
8th. This early infection was confined almost exclusively to the trees
which had not recently been sprayed. The Huntsman was much
worse infected than the Ben Davis, in which but few specimens
showed the rot at this time. Plat I of the Huntsman, however,
showed at this time only one infected apple. The repeated sprayings
were certainly holding the rot in check, even though no applications
had been made to the Huntsman since June 17.

Beginning July 19, all fallen apples on the experimental plats
were gathered, examined and counted, and a record made of the num-
ber of specimens infected with bitter rot as well as the total number
of specimens which had fallen. The fallen apples were gathered at
intervals of a week or ten days until the harvesting of the crop.

September 30th and October 1st the apples were picked from
the trees, examined and counted, and a record made of the number
of specimens showing bitter rot and of the total number of speci-
mens in the crop. The records regarding the fallen apples and
picked apples were then combined, and the percentage of bitter rot
for each plat determined. The results were as follows:

**Ben Davis.**

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Percentage of entire crop infected with bitter rot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Sprayed five times before any rot appeared, once afterwards.</td>
<td>3.93</td>
</tr>
<tr>
<td>II.</td>
<td>Sprayed once shortly before rot appeared and twice soon after its appearance</td>
<td>16.84</td>
</tr>
<tr>
<td>III.</td>
<td>Check, not sprayed.</td>
<td>44.94</td>
</tr>
</tbody>
</table>

**Huntsman.**

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Percentage of entire crop infected with bitter rot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Sprayed four times before rot appeared and twice afterwards.</td>
<td>54.76</td>
</tr>
<tr>
<td>II.</td>
<td>Sprayed twice after the rot appeared.</td>
<td>83.54</td>
</tr>
<tr>
<td>III.</td>
<td>Check, not sprayed.</td>
<td>89.27</td>
</tr>
</tbody>
</table>
The great disparity between the results on the Ben Davis and the Huntsman is due to two facts, namely: (1) The Huntsman is more susceptible to the disease than is the Ben Davis, and (2) the application of spraying material just before the appearance of the rot was unavoidably omitted from the Huntsman. If it had been possible to have sprayed the Huntsman trees July 2, when the Ben Davis were sprayed, the final results would probably have been different.

**TAMAROA ORCHARD.**

The orchard at Tamaroa, with the exception of the check plat, had been sprayed once by the owner, for codling moth and apple scab, on May 1st. No further spraying was done until after the bitter rot, which made its first appearance July 5, had become thoroughly established. Beginning July 16, Plat I was sprayed five times at intervals of about ten days; and Plat II three times, also at intervals of ten days. Records were made regarding the fallen fruit and picked fruit as in the Tonti orchard. The variety was Ben Davis. Results were as follows:

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Percentage of entire crop infected with bitter rot</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Sprayed five times after disease was fully established</td>
<td>48.26</td>
</tr>
<tr>
<td>II</td>
<td>Sprayed three times after disease was fully established</td>
<td>59.06</td>
</tr>
<tr>
<td>III</td>
<td>Check, not sprayed</td>
<td>68.53</td>
</tr>
</tbody>
</table>

That the attack of bitter rot was worse in this orchard than at Tonti is shown by the fact that a much higher percentage of rot appeared in the unsprayed plats. While over 20 per cent of the crop was saved by spraying five times after the rot had become fully established, the contrast of the results obtained on the same variety at Tonti by spraying five times before the rot appeared is very striking.

**FLORA ORCHARD.**

The block of Willow Twigs reserved for the experiment at Flora had, with the exception of the check plat, been sprayed twice by the owner for the codling moth and apple scab. A general infection of bitter rot appeared in this orchard July 10, so that the disease was quite well established when the spraying was commenced July 14. It was the intention to spray Plat I after each rain, and Plat II every ten days regardless of rain. It happened that rain occurred about every ten days, so that the two plats received exactly the same treatment, namely, five applications at intervals of ten days, beginning July 14. The fallen apples were gathered as in the other orchards,
and the record thus secured was combined with the record of the hand-picked crop to determine the percentage of the crop lost by reason of bitter rot. The results were as follows:

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Percentage of entire crop infected with bitter rot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Sprayed five times after disease appeared</td>
<td>57.82</td>
</tr>
<tr>
<td>II.</td>
<td>Sprayed five times after disease appeared</td>
<td>62.34</td>
</tr>
<tr>
<td>III.</td>
<td>Check, not sprayed</td>
<td>83.81</td>
</tr>
</tbody>
</table>

The average percentage of bitter rot for the two sprayed plats is 60.08. This shows that an average of 23.73 per cent of the crop was saved by spraying five times after the appearance of the disease; that is, the percentage of the crop saved was about the same as in the case of the Ben Davis receiving similar treatment at Tamaroa. The percentage of rot in the check plat shows that the Willow Twig at Flora was attacked worse than the Ben Davis at Tamaroa or Tonti, and nearly as bad as the Huntsman at the latter place.

CONCLUSIONS.

The results of the past season's work, which included the examination of over two hundred and eighty thousand (280,000) apples, warrant the following conclusions:

1. It was possible by the use of Bordeaux mixture to reduce the amount of bitter rot to less than 4 per cent of the crop, in an orchard where nearly 45 per cent of the fruits from unsprayed trees were infected.

2. Applications made shortly before the first appearance of the disease were of greatest value.

3. Applications after the rot had become established were of some value.

4. The securing of a thorough coating of Bordeaux mixture on the apples before the first appearance of the disease is far more important than is spraying at stated intervals with reference to time or rains.

5. This thorough coating cannot be secured by one application, or by two. Three or four applications are necessary.

6. Since the bitter rot appeared earlier than usual the past season, when the first and most general infection took place between June 26th and July 2d, it would seem that if the coating of Bordeaux on the apples is secured by making three or four applications between June 1st and 25th, and maintained by later applications if necessary, the best results will be assured.
The investigations in spraying for bitter rot should be continued during 1903, and larger areas devoted to the work in each orchard so that the various points under investigation may all be exploited at each place, thus assuring conclusive results.

FRUIT DISEASES—BOTANICAL INVESTIGATIONS.

The vegetable pathologist, or botanist making the diseases of plants a specialty, has very much to do with parasitic fungi. These are all too small to be seen, except sometimes in masses, by the unaided eye. His work is therefore to a considerable extent with the compound microscope and is mostly by laboratory methods. It is his business to trace any given disease to the agent which causes it, to find out how this latter grows, what favor and what hinder it in its development, what natural or artificial means can be adopted to destroy it or to prevent its attack.

This work is altogether different from that which the agriculturist or horticulturist is usually called upon to perform and can only be successfully accomplished by a specialist who has the time and equipment necessary for this very particular and difficult business. But it is necessary work. Without it one fights in the dark. He never can be sure that he has hit his enemy or indeed that the enemy is even present when and where he strikes. Hence in practical experimental work upon the diseases of plants the trained botanist and the well-informed horticulturist or agriculturist need to work together, each contributing his share to the results hoped-for.

Recognizing this, one man has been kept busy most of the time since the first of July, 1901, when House Bill 315 went into effect, upon the strictly botanical part of the work planned in Section 4—Orchard Treatment. This man has of necessity been an expert in his line and he has worked under the direction of the Head of the Botanical Department of the University of Illinois, who has himself kept in close touch with the work. So far this has been almost wholly upon diseases of apple trees and their fruit, which are far more numerous than is commonly supposed and are destructive almost beyond belief.

Most prominent attention has been given to bitter rot, because of the exceeding destructiveness of this disease. On the first day of July, 1901, when this work began there was practically nothing known concerning the life history, or the manner of development of the fungus, which had been recognized as the cause of this trouble.
No one knew where it came from in the earliest infections of a season. It was not known by any one where or how the fungus lives over winter, nor by what means the spores are distributed. Since it had been observed that when an orchard or even a certain tree was once infected it was very liable to remain so year after year, the argument was often received with favor that it was a disease of the sap, and that the fruit rotted because of something carried to it through the twigs and stems. This idea still holds in some quarters, though we now know that it cannot be true.

During the summer and autumn of 1901 it was demonstrated that the spores issuing from an infected fruit could not be carried by the wind but that they were sometimes distributed when moist by small flies; it was also proved that these spores could penetrate the skin of apples with or without puncture and could cause again the disease. Further, it was ascertained that the fungus often lives over winter on old shrunken apples, either hanging upon the tree or left upon the ground, and that from these an outbreak of the disease sometimes might occur the following season.

In 1902 it was discovered that the fungus also grows in certain spots called cankers on the living limbs. From these spots spores are produced in June and later and reach the fruit by being washed down by rain. This was an entirely new and most important contribution to knowledge upon the subject and satisfactorily clears up many previously perplexing observations upon the origin and spread of the disease. From the fact that the spores seem not to be carried by the wind it is difficult to see how the disease can start on the young fruit from the old infected apples on the ground. Further investigation is needed upon this point, but it is now certain that the fruit on the tree may be infected from such old apples which still hang upon the tree and from the cankers on the branches. Both of these sources of infection can be destroyed and apparently without much expense, but further study is needed to find the easiest method of doing this. The results of investigations already made in connection with the spraying experiments are sufficient to show clearly enough that this dreaded scourge of the apple orchard can be efficiently and practically controlled.

Other diseases of apple fruits have also been studied and progress has been made in learning something of their nature and of possible means of fighting them, viz.: "black rot," "brown rot," and a previously undescribed disease now called "fruit blotch." This last
especially must be further investigated. It sometimes does great damage, though attention has not before been called to it.

Considerable time has been spent, not without some results, upon a kind of destruction in many orchards called "rotten root." Trees die after they arrive at bearing age, when paying crops should be expected from them. Sometimes whole orchards are practically destroyed. Our information now is that this results from a fungus which usually starts upon old wood in the ground or from dead

A CANKERED LIMB WITH DISEASED APPLES BENEATH IT.
stumps. A cure ought to be found, but no one now knows of any effective treatment.

Another disease becoming more and more prevalent is that called crown gall, which affects many kinds of trees and vines and which causes severe losses in many localities. Almost nothing has been ascertained as to the nature or cause of this malady, but this state of things should not continue long to be so.

Still another apple tree disease has been identified and its cause has in this case been worked out. The name "Illinois Canker" has been given to it, because though occurring abundantly elsewhere it had not before been described and it differs from a disease common further eastward known as the New York canker, and from one in the far west called Oregon canker. Methods of prevention have not been satisfactorily ascertained, but a hopeful beginning has been made.

Studies have also been made upon diseases of cucumber and melon vines. Many thousand dollars worth of these crops are annually lost on account of what are no doubt preventable diseases. Our results show that the main trouble is not the same as that described in the states of the Atlantic seaboard, where serious losses also occur. It is probable that prevention can be secured through the use of a proper spray.

That these studies upon the diseases of orchard trees and their fruit might be more effectively carried on a laboratory was established in the spring of 1902 and maintained during the summer at Salem, Illinois, where direct and abundant observations could be made and from which the regions having the largest orchard interests could be easily reached. Further progress in these investigations demands the continued employment of specially prepared investigators furnished with the best possible equipment for their work. A laboratory is a necessity and there are many advantages in locating this where the workers can have easy access to the fields and where the closest connection can be maintained with the other experimental operations. Other fruits and trees beside the apple have diseases upon which such investigations are likely to help momentously in the practical endeavors to control them and in furnishing the taxpayer the means by which he can meet the obligations forced upon him. The results of the two seasons' work are worth 1000 times their cost.
SPRAYING FRUIT TREES IN BLOOM.

The experiments with reference to spraying fruit trees in bloom have thus far been confined to the apple. The results of the investigations made during the past season warrant the following statements: Spraying during the blossoming period prevents the setting of fruit in the case of blossoms which have but recently opened when the spray is applied. It kills the stigmas and prevents the germination of pollen. A tree which blossoms full, however, produces several times as many flowers as it should mature fruits; and there is so much difference in the time of opening of the flowers, even in the same cluster, that spraying once while the tree is in bloom does not seem to prevent the setting of sufficient fruit for a full crop. The first spraying for the codling moth is fully as effective, if not more so, when applied after the petals fall, rather than while the tree is in bloom.

There was no opportunity to test the effect of spraying in bloom upon the apple scab, or upon the yield or size of fruits, since no scab developed,—not even on the check tree,—and a severe storm blew off so much of the fruit that none of the trees matured a full crop. The investigations should be continued in 1903 with a view to determining these points.

SPRAYING FOR THE CODLING MOTH—FIRST BROOD.

An attempt was made to determine the best method of applying the spraying material for controlling the first brood of the codling moth and also to determine the relative efficiency of different numbers of applications. The variety used for this work was the Whitney No. 20. The best results were obtained by applying a large amount of material, through a fine nozzle, under high pressure. It was possible to force spraying material into a much larger percentage of the calyx cavities when a large amount, than when a small amount was used per tree. As to the number of applications, the best results were secured when two heavy applications, as described above, were followed by two other applications made with the same nozzle and pressure, but with less material, the spraying being stopped before the small drops ran together. Of the fruit picked from a tree sprayed as indicated, only eighty-one hundredths of one per cent was injured by the first brood of the codling moth, and if the windfalls which dropped after July 2 are also included, the percentage of the whole crop which was injured by the codling moth was only two and fifty-seven hundredths. The dates on which the above tree was sprayed were May 8, 16 and 23, and June 5. Three heavy applications, made May 8, 16 and 22, gave almost as good results.
The great advantage of thoroughness in applying the spraying material is shown by the fact that even one heavy application (made May 8th, just after the petals fell) resulted in a crop of apples only 4.07 per cent of which was wormy; while one light application, in which only a small amount of material was used, resulted in a crop 13.81 per cent of which was wormy. From the trees left unsprayed as checks, an average of 24.61 per cent of the crop was wormy.

During the progress of this investigation it was incidentally found that the heavy spraying, where two or more applications were made, also very greatly reduced the injury from the plum curculio. Further investigations should be made touching this point.

SPRAYING FOR THE CODLING MOTH—SECOND BROOD.

Investigations regarding the possibility of controlling the second brood of the codling moth by means of a poisonous spray have been carried on during the past two seasons. The first season’s work resulted in three important discoveries, namely:

1. Spraying late in the season reduces the percentage of apples visibly attacked by the second brood of the codling moth.

2. It is possible to kill many of the larvae by spraying after they have entered the fruit, but before they have penetrated sufficiently far beneath the surface to do serious damage.

3. Fruits in which worms have been killed close to the surface will keep almost as well in cold storage as will fruit without a blemish.

These discoveries mean that spraying for the second brood of the codling moth will make No. 1’s and 2’s of many apples that would otherwise be culls. However, a serious obstacle was encountered in that the application of Paris green late in the season resulted in injury to the foliage and excessive dropping of the fruit. Therefore, the second season’s work was directed especially to determining what material would be best adapted to late summer spraying, and at what strength it could be used without serious damage to the foliage or fruit. The season’s work corroborated the results of the previous year and also established the fact that arsenate of lead is a much safer material for late spraying than is Paris green even when used in connection with lime. The arsenate of lead did not cause an excessive dropping of the fruit even when used in enormous quantities.

The work should be continued in 1903 with especial reference to determining whether or not Paris green will cause an excessive dropping of the fruit if used in combination with Bordeaux mixture.
EXPERIMENTS IN ORCHARD DRAINAGE AND FERTILIZATION.

Owners of orchards near Flora have complained that certain orchards bloom abundantly but set no fruit, and that this is the case year after year. Examination of these orchards in the spring of 1902 disclosed the fact that the soil was cold and saturated with water. The whole root systems of the trees were confined within fifteen inches of the surface, few roots going deeper. The trees have made very little growth and the character of the vegetation under and between the trees showed indications of soil acidity. After careful study of the situation it seemed apparent that the difficulty was attributable to soil conditions. Drainage and the application of fertilizers to correct chemical deficiencies were suggested as possible remedies.

The orchard of the Flora Fruit Company was selected as a place for the proposed work and approximately one acre was tile drained; using five-inch tile placed three and one-half feet below the surface. The laterals were all connected with a silt basin at the corner of the plat and an outlet provided from the basin to lower ground.

In addition, six plats of twenty trees each were marked off, leaving check rows between the plats, and to these plats were applied definite quantities of lime, kainit, superphosphate, superphosphate and potash and stable manure. The fertilizers applied were worked into the soil by disk harrow, and these plats, together with the drainage plat, have been kept cultivated during the season. It is proposed to watch the behavior of these plats during a period of three years or longer if necessary, making careful notes regarding all observed
changes. The accumulated data should determine whether there is any virtue in the tiling and which of the fertilizers effects the greatest improvement.

A further fertilizer experiment on similar plats and for a similar purpose has also been established in the orchard of Schwartz Bros. near Salem.

While this work is being prosecuted in accordance with a pre-arranged schedule, progress in the work may suggest desirable modifications, and anything that promises to secure desired ends will be adopted. The entire aim is to find the quickest and best means of correcting existing faults and making unprofitable orchards profitable.

COVER CROPS.

Cover crop experiments were started in the fall of 1901 in the orchards of G. H. Perrine & Sons, Centralia; H. M. Simpson & Sons, Parkersburg, and E. C. Green, Clay City. There was difficulty in obtaining seed and the plats were not sown until late. The possibilities of failure from late sowing were fully appreciated, but it was determined to go ahead with the work in order to secure data regarding the growing qualities of the different crops under trial during the cool weather of autumn.

It was demonstrated that it is not possible to secure growth enough for sufficient cover when seed is sown after the first of September and fall rains are deficient. The seed sown germinated and the plants came up well but growth was very slow, because of the drought, and no adequate body of vegetable matter for cover was obtained.

Of the kinds planted rye made the best growth of any, but even this did not serve the purpose of winter cover. The rye started early in the spring and soon furnished a thick mat of plants to be turned under.

Cow peas were killed to the ground before the plants were large enough to be of use.

Canada field peas did better than cow peas, making enough growth to materially aid in holding fallen leaves. This plant does not live through the winter to furnish green matter to be plowed under.

Hairy vetch. While this plant did not make sufficient growth for good cover, it seems certain that planted about the first of August it will serve the purpose admirably. It is worthy of more extended trial.
Oats and Canada peas give promise of working an excellent combination, especially effective in holding fallen leaves.

Rye and vetch were also tried in combination, but the vetch made so little growth that it was no better than rye alone. Further trial under earlier sowing with more moist conditions would undoubtedly give more satisfactory results.

This work with cover crops should be continued over a series of years.

RUSSETING OF APPLES.

Experiments were undertaken to determine the cause of the russetting of the skin of the fruit by the application of spraying materials. A large number of experiments were made, using different proportions of the spray mixture and applying under different conditions. When lime alone was used no russetting effect was produced under any circumstances or with any amount of the material. When copper sulphate was used alone the effect was usually very pronounced. In many cases russetting was avoided by the use of a greater proportion of the lime with the copper sulphate than common, but this depended in part, also, upon the weather conditions. During damp weather, or with rain, the russetting is much more likely to result than during dry weather. It seems, however, that the damage done to the fruit can be pretty nearly avoided by suiting the proportions of lime to the copper with reference to the climatic conditions.

The results of these experiments will be fully presented in a forthcoming bulletin.

DUST AND LIQUID SPRAY OBSERVATIONS.

A growing tendency in favor of the dust spray as a means of combating the orchard pests, and the employment of this method to some extent in one or two apple-growing sections of this state, led the Horticultural Department of the State Experiment Station to make some careful examinations of areas sprayed by this method, areas sprayed by liquid spray, and areas unsprayed, for the purpose of determining as far as possible the comparative value of the two methods.

Careful observations and examinations, including over one hundred counts, in three orchards, gave the following results and per-
centages: An area that was sprayed twice with dust, showed about 13 per cent of wormy fruit and practically no scab; an area that was sprayed twice with liquid, showed a slightly less percentage of wormy fruit and a little scab, but not enough to be of any consequence. An area that was sprayed three times with dust showed from 12 to 14 per cent of wormy fruit and practically no scab. An area that was sprayed three times with liquid showed about 12 per cent of wormy fruit, and no scab. An unsprayed area showed from 15 to 16 per cent of wormy fruit and from 2 to 3 per cent of early infection of scab, while practically all the fruit had two or more late infections.

The dust used was a commercial mixture manufactured in Kansas City, Mo., and just what its composition was we do not know. The liquid used was the standard Bordeaux with Paris Green for the arsenite. From the above it will be seen that there is a slight difference in the percentages in favor of the liquid sprayed area. There is a difference of 2 to 4 per cent in favor of the sprayed areas over the unsprayed, as concerns the worminess and early infection of scab, while there is a difference of 100 per cent in the late infection of scab. From these results, however, we can conclude nothing definite. The region from which these records were obtained had no scab this year, even in the unsprayed orchards. At the time of its development in the spring, weather conditions in this immediate vicinity seemed to be peculiarly unfavorable to its spread, and as a result the infection was very slight. Further, in getting these records in different orchards, as was necessary, the different conditions encountered in each would perhaps exert enough influence on the results to account for the difference in them. For instance, the two sprayed orchards were well cared for and cultivated, and the fruit was highly colored and the trees were retaining their foliage well, while the unsprayed orchard was neglected and had no cultivation and the fruit was less highly colored and the leaves dropping badly.

During the coming season the Experiment Station proposes to undertake a series of experiments with dust spray in several commercial orchards, providing sufficient funds are available for the work.

POWER SPRAYING.

In the great apple regions of the state, where apple orchards ranging from forty to one or several hundred acres in size are the rule rather than the exception, the task of spraying is by no means a
small one. How to apply the mixtures effectively and at the same time quickly and cheaply is an important consideration. It is, therefore, apparent that in many orchards at least the hand pump operated by human energy must soon be replaced by a pump that derives its energy from some other source. With this in view the Department of Horticulture has been experimenting with power spraying outfits this past season looking to the perfection of them for Illinois conditions.

Power sprayers may be classed under two general heads: Those for which the power is furnished by an engine or motor, and those for which the power is obtained from the running gear of the wagon and motion ceases as soon as the wagon stops. In this latter style it is necessary to have a large air chamber in which the air may be compressed sufficiently to keep up the pressure, when the wagon stops, to spray a tree. This style has been used, with encouraging success, by two large growers this last season. It is with the former style that the Department has been carrying on its operations. With it we have demonstrated, first that it will do more effective work, and second, that it will do it quicker and cheaper than a hand pump, items of vital importance in spraying. A high even pressure is maintained forcing the liquid from the nozzle in a finely divided mist-like spray, that will carry some distance and which quickly and thoroughly covers the leaf or apple surface. More area can be covered in a day than with a hand pump, and two men will do the work that formerly required three.

In another year we hope to have important data for publishing along this line, but our investigations have not yet gone far enough to warrant further definite statements at the present time.

PUBLICATIONS.

The following publications have been issued by the Experiment Station as a result of the work undertaken, with fruit and in orchard, since receiving special state appropriations for such investigations:

    By T. J. Burrill and J. C. Blair.
    By A. V. Stubenrauch.
    By J. C. Blair and A. V. Stubenrauch.
  By A. V. Stubenrauch and J. W. Lloyd.
  By A. V. Stubenrauch.
  By J. W. Lloyd.
  By W. S. Hotchkiss.
Feb. 1902. Circular No. 44. Fruit Storage Experiments.
  By J. C. Blair.
  By G. P. Clinton.
  By H. Hasselbring.
  By T. J. Burrill and J. C. Blair.
  By T. J. Burrill and J. C. Blair.

The following bulletins are in course of preparation and will shortly be published.

  Bitter Rot Investigations.
  Fruit Storage Experiments.
  Picking, Packing and Marketing of Fruit.

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INVESTIGATORS.

The following statement with respect to the several investigators connected with the fruit and orchard work of the Experiment Station may be of general interest:

Dr. T. J. Burrill, Chief in Botany; directing all investigations of a strictly botanical nature.

J. C. Blair, Chief in Horticulture; directing all horticultural investigations.

John W. Lloyd, Chief Assistant in Olericulture, conducted experiments on spraying in bloom and spraying for the codling moth.

A. V. Stubenrauch, Assistant in Horticulture, had direct charge of field investigations in horticulture, including the spraying for bitter rot, from July, 1901, to June, 1902.
A. W. Bryant, Assistant in Horticulture, had direct charge of field investigations in horticulture including spraying for bitter rot, from June, 1902, to December, 1902.

G. P. Clinton, Assistant Botanist, had charge of the botanical phase of the bitter rot investigation during June, July and August, 1901.

H. Hasselbring, Assistant in Vegetable Pathology, had charge of the Salem laboratory and carried on studies touching the life history of bitter rot, apple root rot, crown gall, russetting of apples, etc., from August, 1901, to December, 1902.

FINANCIAL STATEMENT.

It is not possible in a brief report of this character to give a comprehensive statement of all money transactions connected with these investigations. The original bills which have been paid as a result of this work are on file in the Office of the Business Manager of the University of Illinois, and are open to inspection at any time by those wishing to avail themselves of this privilege. A financial statement touching all such expenditures is published biennially by the Trustees of the University and can be had upon application to the Secretary of the Board of Trustees.