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REPORT OF THE ENTOMOLOGIST AND PLANT PATHOLOGIST.

OBSERVATIONS ON THE RELATION OF THE HEIGHT OF FRUIT TO APPLE SCAB INFECTION.

By Leroy Childs.

In connection with the research work of the field pathologist there are two very important problems that demand attention if satisfactory results are to be obtained by orchardists in the control of serious plant diseases. The first is the need to accumulate accurate information relative to the seasonal variations and development of the important disease or diseases, the application of which will serve as a basis for control recommendations; and the second is the obligation to see not only that the orchardist understands these recommendations but follows them out to a successful end. This paper deals more particularly with the second problem and is written in order that our observations made relative to the local distribution of apple scab may, if considered by the orchardist, be of assistance in future scab-control campaigns.

The spraying operations carried on in the Hood River Valley during 1916 for the control of apple scab have been much more extensive, not only from the standpoint of the amount of fungicidal materials used, but also in thoroughness of application, than ever before. It was well that this strenuous campaign was inaugurated, since the weather conditions existing during a greater part of spring and early summer were extremely favorable for the development of scab. The resulting infection in neglected or poorly sprayed orchards in many cases reached nearly 100 per cent of the fruit.

Notwithstanding the conscientious work of the orchardists, however, scab infection reached a greater percentage in many sprayed orchards than should have occurred. This condition was brought about through the prevalence of exceptionally rainy weather during June and early July. "Shot fungus," as late infection is locally called, appeared in serious amounts about the middle of July, especially in orchards in which the usual final application of lime-sulfur had not been made thirty days or thereabouts after the petals fell.

At intervals during the summer, while checking up scab experiments under investigation, an interesting observation was made relative to the distribution of scab-infected fruit on the trees examined. Even early in the summer it was observed that the fruits in the tops of the trees were much more scabby than those nearer the ground. It seemed probable, then, that since this condition existed in carefully sprayed experimental plots the condition would be found to be present in a more pronounced form where especially careful oversight had not been given each application of spray. Several orchards were examined to determine the correctness of this supposition. In nearly every case this variation in the amount of scab relative to distance from the ground was found to be present, and often very conspicuous indeed.
In view of the important bearing of this discovery upon the whole subject of spraying practice, it was decided to undertake a careful investigation of actual conditions existing at harvest time in certain trees that had been (as was thought) well and carefully sprayed according to schedules that had been arranged by the Experiment Station.

THE INVESTIGATION.

At picking time twelve large trees were chosen in one of the orchards in which scab control experiments were being conducted. These trees were sprayed at the proper time, though not under the personal observation of the writer, and as thoroughly as the equipment of the owner permitted. Seven of these trees received four scab applications, (Block 1) the 30-day lime-sulfur application being omitted, and five (Block 2) were given five applications of lime-sulfur.

The apples from Block 1 were picked and separated into three divisions (Fig. 1); viz., (1) from the ground to a height of ten feet; (2) from ten feet to fifteen feet; and (3) from fifteen feet to the tops of the trees. After the fruit was picked the percentages of scab were determined for each division in each tree. (See Table I). Only two divisions were made in the case of Block 2 (Fig. 2), the fruit being separated from the ground to ten feet, and from ten feet to the tops of the trees. (See Table II).

In choosing the trees from which the counts were made it was necessary to select those which were bearing a relatively light crop and which stood erect. In the case of trees heavily loaded it was impossibly accurately to segregate the fruits in their respective normal positions, owing to the sagging of the heavily laden branches.
The average height of the twelve trees chosen was 26 feet. (Figs. 1 and 2). The largest reached a height of 28 feet. The average greatest diameter of these trees was 22 feet, the widest being 24 feet. Fruit was found present to an average height of 21 feet; on one tree apples were taken 24 feet above the ground.

Table I shows the total number of apples both clean and scabby occurring on each tree between the heights given. Although considerable variation was found to exist on the different trees studied, the increase

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>Condition of fruit</th>
<th>Distribution of fruit on trees</th>
<th>Percentages of Scab Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-10 ft.</td>
<td>10-15 ft.</td>
</tr>
<tr>
<td>1</td>
<td>Clean</td>
<td>665</td>
<td>653</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>61</td>
<td>308</td>
</tr>
<tr>
<td>2</td>
<td>Clean</td>
<td>415</td>
<td>197</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>65</td>
<td>133</td>
</tr>
<tr>
<td>3</td>
<td>Clean</td>
<td>231</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>Clean</td>
<td>188</td>
<td>201</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>Clean</td>
<td>670</td>
<td>445</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>40</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>Clean</td>
<td>397</td>
<td>769</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>10</td>
<td>69</td>
</tr>
<tr>
<td>7</td>
<td>Clean</td>
<td>431</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>17</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>Clean</td>
<td>2992</td>
<td>2787</td>
</tr>
<tr>
<td>Ave.</td>
<td>Scab</td>
<td>209</td>
<td>800</td>
</tr>
</tbody>
</table>

Table II. Record of Scab Distribution Taken from Trees in Block 2.

The trees in this block were sprayed five times with lime-sulfur.

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>Condition of fruit</th>
<th>Height 0-10 ft.</th>
<th>Height 10 ft.</th>
<th>Percentages of scab infection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-10 ft.</td>
<td>10 ft.</td>
<td>Total scab on tree</td>
</tr>
<tr>
<td>8</td>
<td>Clean</td>
<td>290</td>
<td>739</td>
<td>97.07</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>6</td>
<td>92</td>
<td>2.08</td>
</tr>
<tr>
<td>9</td>
<td>Clean</td>
<td>227</td>
<td>469</td>
<td>97.85</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>5</td>
<td>70</td>
<td>2.15</td>
</tr>
<tr>
<td>10</td>
<td>Clean</td>
<td>149</td>
<td>238</td>
<td>98.68</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>2</td>
<td>58</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>Notes lost.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Clean</td>
<td>563</td>
<td>583</td>
<td>98.78</td>
</tr>
<tr>
<td></td>
<td>Scab</td>
<td>7</td>
<td>213</td>
<td>1.22</td>
</tr>
<tr>
<td>Total</td>
<td>Clean</td>
<td>1229</td>
<td>2029</td>
<td>98.4</td>
</tr>
<tr>
<td>Ave.</td>
<td>Scab</td>
<td>20</td>
<td>442</td>
<td>1.6</td>
</tr>
<tr>
<td>Scab Infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
in every case from the ground to the top was found to be constant, the
difference in degree of infection in each section of each tree being very
pronounced.

From Block 1 which received four applications of lime-sulfur the
following average percentages of scabby fruits occurred in the respective
sections: from the ground to ten feet, 6.52 percent; from ten to fifteen
feet, 22.31 percent; fifteen feet to the top, 45.72 percent. The following
ratio was observed in the most seriously infected tree; ground to ten
feet, 13.72 percent; ten to fifteen feet, 40.30 percent; fifteen feet to the
top, 60.01 percent. The fruit in the least infected tree was found to be
as follows: ground to ten feet, 2.46 percent; ten to fifteen feet, 8.23 per-
cent; fifteen feet to the top, 21.47 percent. The average total scab infe-
tion from Block 1 amounted to 22.52 percent. At first glance an infection
of this extent does not appear serious. However, it is so distributed,
with nearly 50 percent of the fruit in the tops of the trees infected, that
it cannot be thinned out without heavy losses.

Much less scab was found in Block 2. In this group of trees two
divisions only were made in separating the fruit as mentioned previously.

![Fig. 2. Summary of results obtained in Block 2. These trees were sprayed five times.](image)

(See Fig. 2). A decided variation in the relative amounts of scab accord-
ing to height was found to occur here, standing out even more distinctly
than that in Block 1. An average of but 1.62 percent infection was found
on the fruit between the ground and ten feet, while the infection from
ten feet to the tops was 18.03 percent. The average percentage of scab
on these five trees was 12.41 percent, or nearly half that which occurred
on the trees sprayed only four times. The importance of the fifth spray
in this case is easily seen.

Unfortunately no segregation of fruit according to height was made
from apples on the check trees so that the natural distribution of scab
on unsprayed trees was not determined. However, the total infection
present on some of the control trees kept under observation during the past year amounted to 97 percent. This very high percentage of scabby fruits indicates that infection must have been general over the entire tree.

It is interesting to compare the results from two other experiments conducted in the orchard in which the observations just discussed were obtained. In these experiments, lime-sulfur was used in the same strength and in the same number of applications; i.e., in one (Block 3) five applications were given; in the other (Block 4) four applications were used. Equipment, rodmen, and method of application were identical in all four Blocks. Though Blocks 3 and 4 were sprayed earlier in all applications the interval existing between these was about the same throughout the orchard, as the trees were sprayed in their regular turn throughout the season. Two material differences, however, appear to be responsible for the differences in the percentages of scab present. In comparing the average heights of the trees in Blocks 1 and 3, a difference of five and a half feet occurs; in Blocks 2 and 4 but three feet difference in the heights exists. Not only this difference in height occurs but in the case of Blocks 3 and 4 personal inspection of the spraying was given by the writer during each application and parts of the trees missed by the rodman were pointed out and re-sprayed. No inspection was given in Blocks 1 and 2; both men working with the spray rig operated rods; in the case of very large trees a man spraying can not tell the parts of the trees that are not hit with the spray.

The trees in both Blocks 3 and 4 were heavily laden with fruit. On this account the figures given in Figs. 3 and 4 are not entirely accurate, as it was impossible to segregate the fruit in all cases owing to the confusion brought on by the severe bending of the higher limbs. An accurate percentage of infection was obtained, however, from fruits which were actually above ten feet at the time of picking. It was found in

![Fig. 3. Summary of results obtained in Block 3.](image)
Block 3 that top infection amounted to 3.86 percent, while the infection from the ground to the top, which included a good many fruits from the upper division, was .95 percent. An infection of 62.5 percent was present on adjoining check trees.

Figure 4 illustrates the results obtained in Block 4, where the “thirty-day” spray was omitted. The trees in this plot averaged larger than in Block 3 but not as large as those in Block 1 and 2. Though many top fruits are included in the figures given in the lower division, the differences occurring in the two sections are very distinct. An infection of 12.58 percent occurred in the tops of the trees in this Block while the lower fruits possessed 4.03 percent scab. Total average infection in this Block was 7.42; where five sprays were used (Block 3) it was 1.57 percent. The possibilities of using the four-spray schedule will be briefly discussed later in the paper.

**DISCUSSION.**

**Relation of fruit production to scab infection.** In connection with the percentages determined in Block A, it is interesting to take into consideration the significance of the relative bearing areas of the trees as shown in Figure 1, and their relation to scab infection as found in different parts of the trees. The average production of fruit in these areas does not vary greatly. This distribution was as follows; ground to ten feet, 35.29 percent; from ten to fifteen 39.56 percent, from fifteen feet to the tops of the trees 25.13 percent. As would be expected, owing to the fact that trees of this size reach their greatest diameter between ten and fifteen feet, a larger amount of fruit would be found in this section of the tree than elsewhere. The quality of the fruit produced in this section is average of the entire tree. As a rule, however, the larger, physically finer, and more highly colored apples are produced well towards the tops of the trees, while the lower fruits are usually smaller and subject to more injuries, especially those caused by the brown aphids. In referring to the location of the scab on the trees, it is found that 35.29 percent of the poorer quality fruit is subjected to a scab infection of but 6.5 percent while 25.13 percent of fine quality fruit in the upper portions of the trees suffers an average loss of 45.72 percent due to the attack of scab alone. In the case of the former, ordinary thinning will remove all of the scab with no loss; in the upper part of the trees, with nearly half of the fruit infected, the disfigured apples can not be eliminated without a heavy loss.

That the variations which have been discussed are not local or confined to the particular orchard from which these notes were taken was brought out while checking up some twenty odd scab experiments carried on in several orchards. This variation was found to exist, though not so pronounced in many cases, in every one of them.

**Supposed late infections explained.** This analysis of the relation of scab infection to the location of fruit on the trees solves a point with reference to reported late summer infection. During the past two seasons many growers have reported to the writer that apple scab was developing rapidly during August. An examination of these reported orchards, however, failed to disclose any pronounced development of new scab. Large, heavily laden trees usually stand upright, holding their fruit throughout the spraying season in about the same location in which
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bloom occurred, until late July or early August. The fruit on many of the top branches, as shown in the accompanying figures, reaches an average height of twenty-four feet. During late summer and early fall the great weight of fruit on these heavily laden branches causes them to bend strongly downward. By the middle of August the position of fruit on many branches of the trees is largely reversed; i.e., that fruit which during the spraying season was located in the tops can now be found in many cases at a distance of four to eight feet from the ground. This bending of the branches in the latter stages is quite rapid. The orchardist, however, in his weekly or fortnightly inspection, fails to note the changes that have taken place or to realize that different apples are being examined than those watched during the early summer. Instead, the grower is alarmed to find, as indicated in Fig. 1, an apparent increase in the percentage of scab from perhaps 6.5 percent (that which he had been watching earlier) to possibly 45.72 percent, the degree of average top infection found on the trees studied. To the observer unfamiliar with the growth and development of this fungous disease, the phenomenon just described would appear to be that of new development of the disease on the fruit.

**Scab development during late summer.** Our observations this year indicate that little scab developed on the apples after the first of August. In a large series of experiments apples were kept under observation and examined monthly to determine the relative increase of scab during the season. During late summer few changes in the percentages were noted. On the leaves, however, apple scab was more or less active during most of the past summer. In notes under date of August 30, the following is quoted: “Leaves examined for apple scab infection indicate that the fungus is still active, as it has been throughout the summer. On trees whose fruit is practically clean there is present much leaf infection,

![Fig. 4. Summary of results obtained in Block 4.](image-url)
especially on the vigorously growing terminal leaves, which in many cases are literally peppered with olive green, mycelium-covered areas. The infection seems to be more conspicuous on trees infested with green aphids, whose leaves have been kept damp with a coating of honeydew.

**Cause of scab variation with height.** The cause for the very pronounced variation in the degree of infection of fruit from the different locations on the trees can be charged to but one fact—lack of thoroughness in making the applications of the fungicide employed. Theoretically more scab infection should be found in the lower portions of the trees, owing to the proximity, during early spring, to the source of ascospores, and later to summer spore infection when the spores are washed down by rains from infections above. Quite the reverse, however, was found
to be true, demonstrating that the fungicides used have been decidedly effective on portions of the trees that have been thoroughly covered.

These difficulties can only be corrected by facing the conditions as they arise. In the young orchard, naturally this variation does not exist for the reason that the tops of the trees are just as easily sprayed as the bottoms. With the aging of the apple orchard, the bringing of protection to the higher fruits becomes more problematical as time goes on. The spray outfit which produced highly satisfactory results five years ago must be made adaptable to the growth in height of the trees, or more modern equipment must be installed in its place; for it does not pay to spray unless it can be done thoroughly from top to bottom.

The successful type of spray nozzle. The type of spray that has been found to give the best results at Hood River in controlling apple scab,
is one that is applied in the form of a fine mist; double nozzles are usually used, since they enable the operator to apply more material in a given time. To effect complete control of the disease, it has been demonstrated that it is absolutely necessary to cover not only the fruit thoroughly in every application, but also both upper and under surfaces of the foliage—in other words, to prevent literally both fruit and foliage infection. The mist spray, accumulating, as it does, in fine globules over the surfaces, produces a much thicker, more complete covering than occurs when a drenching or driving spray is used. The latter, breaking and running upon hitting a surface, draws off much of the spray material, leaving, upon drying, an extremely thin film which lacks the lasting and weathering properties of the thicker mist application.

The actual application of spray, however, should be made adaptable to different weather conditions. Often it is absolutely necessary to continue spraying in windy weather in order that protection from scab be gained. Under these conditions the mist nozzle should be discarded for a coarser type. This change will enable the rodman more nearly to reach all parts of the trees which would otherwise be impossible. A thin film is much better than none at all.

Incomplete protection obtained in many orchards and causes for it.
The average orchardist, regardless of the size or age of his trees, sprays with two leads of hose and from the ground. Considering that the rods are twelve feet long (many growers use ten foot rods) the normal position of the nozzles while in use is at a height of about fourteen feet (see Fig. 5). The rodman, in working around the tree, raises the nozzle at intervals to a height of seventeen to eighteen feet (see Fig. 6). As a long day wears on, the holding of a heavy rod at arm's length becomes very tiresome; for this reason the operator becomes unconsciously careless and the tops are slighted. By referring to the heights of the fifteen-year-old trees that are given in Table I, it will be seen that on the average eleven feet of tree surface occurs between the end of the spray rod when raised to its highest point, and the top foliage. Leaves and fruit in this area, then, are dependent entirely upon the pressure exerted by the outfit and the air, to force and carry the liquid to its proper place. Under absolutely quiet atmospheric conditions it is possible to cover fairly well the under surfaces of the higher foliage and the fruit of these large trees, but a good many top surfaces are missed. With the slightest wind blowing the benefits derived from the air as a carrier are largely reduced, and are completely destroyed by the wind that normally occurs at Hood River during a greater part of the spring. In many instances the writer has observed orchardists spraying in a wind (spraying often has to be done under such conditions) that prevented the reaching of the trees at a greater height than five feet above the end of the rod. The average wind during the spraying season prevents the reaching of the trees at a greater height than six or seven feet above the end of the nozzles, and not very thoroughly at a greater height than four or five feet above. For example, then, considering the tree being sprayed as 28 feet high, the rodman exerting himself to the extent of holding the rod at arms length does not thoroughly cover anything above twenty-two or twenty-three feet. (Fig. 1). This leaves the fruit and foliage, chiefly foliage, over a surface of five or six feet entirely open to infection. The infection which takes place is most advantageously located to further the spread
of the disease over the tree; for with each rain millions of spores are washed down onto the fruit and leaves below, which, if not thoroughly protected by a good coating of spray, become readily infected.

**Is the fifth scab spray necessary?** The secret of growing scab-free fruit lies in the absolute prevention of leaf infection. If this is accomplished, the apples will incidentally be kept clean. With a portion of the trees left open to infection, even though it be only a few leaves in the top, chances of serious fruit infection, taking place early in the summer, are greatly increased, especially if the thirty-day lime-sulfur spray is omitted.

The sixteen days of rain which occurred during late June and early July, produced at least 75 percent of the scab which occurred at Hood River during 1916. Infection could not have taken place if fruit and foliage had been kept clean up to this time. As shown in Block 4, though the results from the standpoint of scab control were not as complete as obtained in Block 3 with five applications, the 7.42 percentage of infection that resulted must be considered a very effective reduction. The trees in this experiment were last sprayed on May 24. On June 17, nearly a month later, rain began falling, continuing some every day until July 3. There is no doubt that a good deal of the protection derived from the last application of spray had disappeared through weathering and expansion of both the fruit and leaves before this favorable scab-infection weather was over. In spite of this long continued rainy spell, infection of but 7.42 percent of the fruit resulted. During this time scab increased on the unsprayed check trees from 20.5 percent to 62.5 percent.

The trees in this plot were known to be practically free from scab at the time the “thirty-day” spray was applied to the other experiments. The infection of fruit at that time was only .39 percent, and since it was so clean to begin with, infection failed to develop in serious proportions regardless of the prevailing weather conditions favorable for scab development.

There is no doubt that the first four scab sprays scheduled by the Experiment Station are necessary; whether the fifth is required (if we dare draw inferences from one season’s work), depends upon the amount of infection present at the time the “thirty-day” spray should be applied. If the trees are absolutely clean at this time, it appears from the excellent results of the test just described that they need no further applications regardless of the weather conditions. At the present time, however, few orchardists are sufficiently competent to determine whether their fruit and foliage are clean. Clean does not mean that one can find a spot here and there. We have called an infection of .39 percent fairly clean, and that means the finding of a little more than three scabby apples in each 1000 examined. Until growers can properly analyze their crop and determine the amount of scab present in actual percentages, it will not be safe to omit the “thirty-day” spray.

**Spray outfit for older orchards.** To overcome some of the difficulties that have been discussed, it is necessary for the orchardist to develop and specialize his spraying equipment along with the demands of his orchard. The small capacity outfit which did splendid work during the earlier years of orchard growth, should be replaced by a machine of high power and larger capacity in order to cope with the expansion of foliage surface which is yearly increasing and which demands just as
speedy attention as did the trees when they were smaller. The machine for the older orchard should possess sufficient power to permit the operation of three leads of hose; two to be operated from the ground, and the third from a tower constructed on the outfit. The rodman in this latter position can not only easily cover the tops of the trees, but he can direct and oversee the work of the other men and inform them of parts of the trees that have been missed. Spraying from the tower insures the covering of the upper leaf surfaces, an accomplishment which is otherwise practically impossible in the case of large trees.

Pruning. Pruning should also prove of much benefit in reducing this tree-top infection. The cutting away of five or six feet, in the case of long straggling branches from which it is impossible properly to pick fruit, would not only reduce the time and cost of spraying but would also remove that part of the tree which is most easily neglected, and which, when neglected scatters more scab spores advantageously than any other part of the tree.

Losses resulting from failure to spray the tops of trees thoroughly are not confined to apple scab infection, but include all insect pests and plant diseases. In the case of most insects, their depredations cannot be tabulated in the same way as those for scab, owing to their movements over the tree. Re-infestations from the fruit-tree leaf-roller, the woolly and green aphis, have been observed by the writer to result from a failure to hit the tops of the trees while spraying for these pests.

**SUMMARY.**

In large trees a much greater percentage of scabby apples was found on the upper portions of the trees than nearer the ground.

At least a quarter of the crop, in the case of fifteen-year-old trees, was found to be produced at a greater height than fifteen feet. Nearly half of this, the best quality fruit produced on the trees, was found to be scabby.

The lower or poorer quality fruit possessed a very slight scab infection, all of which could have been removed by thinning with no loss.

The fifth application of lime-sulfur prevented the doubling, practically, of scab infection in the large trees.

On smaller trees in the same orchard, sprayed in exactly the same way, much better results were obtained. These trees averaged from three to six feet lower than those just discussed. A careful watch was made during each application to see that none of the tops were missed. Missed areas in the tops were “touched up” before the trees were left by the rodmen.

The date of the last application in Block 4, sprayed four times, was May 24. Beginning with June 17 rain fell daily until July 3. This period was ideal scab-infection weather. Practically all fruit and foliage were unprotected during the last two or three weeks of this period. Owing to the fact, however, that the fruit and foliage in this Block, as found on the surrounding trees, were practically free from scab at the time of the last application, further development of the disease was not serious.

Although we cannot draw definite conclusions from one year’s work, it seems safe to say that in the Hood River Valley the “thirty-day” spray of lime-sulfur can be omitted, if the trees are absolutely clean at the time
this should be applied. To determine the condition of the fruit, counts should be made and percentages of scab determined from all sections of the orchard before conclusions are drawn.

The average wind velocity prevailing in Hood River during the spraying season prevents the accomplishment of good work from the ground at a greater height than 22 or 23 feet. In the case of trees as large as those studied, both fruit and foliage in the upper 8 feet of the tops are only partly covered, and in many applications missed entirely. From the infection which takes place here, rains wash down millions of spores onto the fruit and foliage below, which, if not completely protected, become infected. Protection becomes gradually less from the ground to the top of the tree, while the chances of late infection occurring, are much greater from the top to the bottom, owing to the proximity of the summer spores present in the tops of the trees.

For older orchards, the installation of up-to-date spray machinery fitted with three leads of hose and a tower, together with the cutting back of long out-of-the-way limbs, will facilitate spraying and cut down the chances of top infection.

Not only apple scab, but other diseases and insect pests are perpetuated from one season to the other in the tops of larger trees where proper protection is not provided.

The author wishes to acknowledge his sincere appreciation for the many helpful suggestions that have been generously given by Professor H. P. Barss, Botanist and Plant Pathologist, Oregon Experiment Station.
FURTHER OBSERVATIONS ON THE CONTROL OF THE FRUIT-TREE LEAF-ROLLER IN THE HOOD RIVER VALLEY.

By Leroy Childs.

INTRODUCTION.

During 1915, a large series of experiments were outlined in which arsenate of lead was used in different combinations, together with oil emulsions, to determine the most satisfactory method of controlling the Fruit-Tree Leaf-Roller, Archips argyrospilla Walk., in the Hood River Valley. The poison, weak or strong, used in one or several applications failed to approach satisfactory control. Experimental work directed toward controlling the insect by poisoning the larvae was therefore discontinued in 1916.*

The results obtained from the use of miscible oils of the heavier type, however, proved very satisfactory under the conditions which prevailed when they were applied; i.e., late in the spring with settled warm weather existing, and the oils being applied to eggs whose embryonic development was well advanced. It was observed that oils applied at this time, especially in the case of the heavier dosages, caused a foliage and fruit-spur injury of sufficient severity to make the application hardly advisable. On many trees in the experimental tracts practically all of the developing foliage was burned off, as were also many of the more advanced fruit spurs. This condition was much more severe in plots to which oil had been applied at the rate of 7 and 8 gallons to 100 gallons of water. It was much less severe, although noticeable, in the plots receiving 5 and 6 gallons to the 100 gallons of water.

OBJECTS OF FURTHER TESTS.

Experimental work was continued in 1916, the more important points in mind being to determine: (1) the difference in the ovicidal properties of early and late applications of the same strength of oil; (2) the result obtained by applying oil during prevailing unsettled, cold weather; (3) the relative merits of different commercial products in weak and strong dilutions; and (4) the accuracy of the previous season’s investigations.

From the data gathered in the experimental work and from an observation of the general results obtained by orchardists during the past season, it appears that satisfactory results are dependent more upon the existence of proper weather conditions at the time of making applications, and for several days following, than upon any other factor.

In a consideration of the varying “weather conditions;” i.e., heat, cold, rain or snow, and fair, sunshiny days, and their effect on the value of the oils in control, it appears that applications made during unsettled weather are of little or no value. Usually with damp weather during this season of the year (March and early April) cold temperatures exist, making it somewhat difficult to ascertain which of these factors are more im-

portant in limiting the ovicidal value of the oil applications. The results of the experiments carried on during the past year, point out clearly that applications made during rainy or sleety weather are absolutely worthless. On the other hand, applications made during fair weather resulted in practically absolute control of the leaf-roller.

THE EXPERIMENTS AND RESULTS OBTAINED.

A single brand of oil was used in experiments (1) and (2) so as to determine the effect of varying seasonal and weather conditions on the results obtained. By so doing, variations in the penetration and killing properties, dependent upon specific gravity of different oils, were eliminated.

The material used in determining the points cited under (1) and (2) were furnished by the Hood River Spray Company, through the courtesy of Mr. J. C. Bucher. The emulsion was made from Western refined lubricating oil, specific gravity 28 degrees Beaume. When water was added and the solution agitated, saponification took place readily producing a uniform, smooth emulsion.

The trees used in the experimental work were of the Yellow Newtown variety, 13 years of age, bearing a fairly heavy, well-distributed crop. The application of the materials was uniform in all of the experiments. The same outfit and rodmen were used throughout. A tank of the emulsion was used on each plot. “Friend” nozzles with an angled Y attachment, fitted with medium discs, were used. A pressure of 175 to 200 pounds was maintained and the oil was applied in such a manner as to drench every portion of the trees. Approximately 7 gallons of spray was applied to each tree.

To determine the effect of applications of oil in relation to varying weather conditions and seasonal advancement, material of the same strength was applied at three different times, on March 17, March 23, and April 3. These dates give hardly as much range as is desirable, but owing to the fact that the spring was exceedingly wet and retarded, it was impossible to get the sprayer into the orchards before the earlier date. When the trees did start to grow, development was very rapid; and it became necessary to make the later application sooner than desired in order to avoid a possible severe injury.

On March 17, the first block of trees* was sprayed. The emulsion was used at the rate of six gallons to 100 gallons of water, this strength having been found during the previous year's work to be practically as effective as dilutions of greater strength. During the seven days preceding this date and the two days following it, no rain occurred. At the time the oil was being applied the trees were dry and in a good condition to receive the spray. During the two fair days that followed the spraying, the average maximum temperature was 63 degrees F. The warmest day was on the date of spraying, the thermometer registering 65 degrees. The minimum temperature was 33.5 degrees. Beginning with March 19, rain fell continuously for nine days, with the exception of March 23, which was cloudy. Observations relative to the behavior of the oils on the trees, which will be discussed later, seem to point to the fact that beginning with the rain, the oil which is in such a condition as readily to mix with water (other

*Experiment 1.
than that which has penetrated into the bark, roller eggs, etc.) is gradually removed by the rains. In this experiment 30 percent of the eggs hatched, while on the unsprayed trees 97 percent hatched. As was observed in 1915, the percentage of the eggs destroyed has to be relatively high in order to effect satisfactory control. The worms which hatched, caused a fruit injury of 11.6 percent or a little more than a box to the tree. The fruit injury found to exist on the control trees amounted to 19 percent.

The second application, Experiment 2, using the material at the same strength and applied in the same way, was made March 23. On the four days preceding this date rain fell, 2 1/2 inches of snow falling on March 21. Following the application, rain fell for four days, a heavy precipitation of 2.2 inches occurring on the 25th. During the five days that followed the application, the average maximum temperature was 49 degrees, 54 degrees being the highest temperature recorded during the time. The average minimum temperature was 34 degrees, 30 degrees being the lowest.

At the time the oil was applied in this experiment the trees were very damp; although rain did not fall there were times during the day that were quite misty. No excessive run off of the emulsion was observed, and from all appearances the trees received and held at the time just as much oil as those in the other plots.

When the eggs were counted in order to determine the percentage that had been destroyed, it was found that only 27.8 percent had been killed by the oil. Only one egg mass was found in which all of the eggs failed to hatch; in many they all hatched, especially those located on the portions of the trees away from the sunshine. The fruit injury on this plot was found to be in excess of the loss found on the check trees, 21.8 percent being damaged.

The third application, Experiment 3, was made on April 3. The oil was used in the same manner and in the same strength as that described above. For seven days preceding the spraying the weather was fair, and following it, no rain fell until April 11, 8 days later. On this date .13 inch of rainfall was recorded; this was followed by two days of fair weather, and then another week of rain. The average maximum temperature for the eight days following the application was 63 degrees; the highest temperature reached during the time was 70 degrees. The average minimum temperature for this period was 37 degrees, 32 degrees being the lowest temperature recorded. Excellent control was obtained in this plot; 1007 eggs were counted in checking up the experiment, 25 of which were found to have hatched. In the case of one egg mass noted, 15 out of 16 eggs hatched. This was clearly a case of mechanical error in that the mass was missed in spraying the trees. This increase must be charged to experimental error rather than the failure of the oil to do its part. The fruit injury found to exist in this plot amounted to 2.7 percent, while the loss due to leaf-roller on the unsprayed trees was 19 percent.
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<th>Eggs Hatched</th>
<th>% Destroyed</th>
<th>Total Fruit</th>
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COMPARISON OF RESULTS IN DIFFERENT EXPERIMENTS.

The maximum temperatures for the fair days following the applications in Experiments 1 and 3 are practically identical, the average being 62 and 63 degrees respectively; in the case of the former, however, only two days elapsed before a rainy spell of practically 9 days duration occurred, accompanied by much lower temperatures. In this experiment the fruit injury was reduced from 19 percent, as found to exist on the unsprayed trees, to 11.6 percent. In view of the fact that the prevailing average temperatures in the two experiments are practically the same during the period of fair weather following the applications, the only important factor which seems to have direct bearing on the different results obtained is the length of time elapsing before a precipitation of considerable duration occurs. Just how much time must elapse following the spraying in order that satisfactory control may be obtained is not known. It is safe to say, however, that two days of good weather whose average maximum temperatures is 62 degrees or lower, is not sufficient time to give good control. Seven days, on the other hand, as shown in Experiment 3, the average temperature of which was 63 degrees, produced excellent results. With higher temperatures existing the period would probably be considerably reduced.

Herrick and Leiby* in 1915, working on the control of the leaf-roller in New York state, made observations relative to the actions of oils applied under unfavorable weather conditions. The chief object of their experimental work was to determine whether oil sprays applied during freezing weather would cause any injury to the trees. None was observed although a minimum temperature of 25.5 degrees was recorded on the third day after application. Both hail and snow occurred on the second and third day following the application in their experimental work, after which the weather was settled. A higher percentage of the eggs was destroyed in their experiments than in those of the writer under more or less similar conditions, although not sufficient as to be considered entirely satisfactory. However, it must be noted that their work was not carried on under typical orchard conditions. A knapsack sprayer was used and probably more material was applied than is generally used in orchard practice. The authors state “the trees were literally drenched with spray which collected at the crowns and streamed down on all sides of the trees.” In two of the three experiments they conducted, the oil was used at the rate of about 1 gallon to the 100, stronger than was used by the writer, which, together with the fact that they report no heavy precipitation in the form of rain during the days immediately following the application, would indicate that more oil undoubtedly remained on the trees than on those under observation by the writer.

Experiment 2 illustrates the fact that applications made during unsettled and rainy weather are worthless. Many growers in the Valley were spraying at the time the oil in this experiment was applied, and to the unfavorable weather condition which then prevailed can be attributed many of the total failures and part failures reported in attempted leaf-roller control. Rain on many of the days during this period occurred during the night, and owing to the fact that the time for making the semi-dormant scab spray was fast approaching, spraying was continued re-

*The Fruit Tree Leaf Roller, Bulletin 367, Cornell University.
Regardless of the prevailing weather. Precipitation alone cannot be charged as being entirely responsible for the negative results that were obtained. The average maximum temperature for five days following this application was 49 degrees, or 14 degrees cooler than occurred in the other experiments. The presence of moisture, however, undoubtedly played the more important part in reducing the killing properties of the oil, as shown by its effect in a very short time.

**APPEARANCE OF OIL ON TREES SPRAYED AT DIFFERENT TIMES.**

Two weeks from the last date of spraying and thereafter, the appearance of the sprayed trees in the plots made them easily distinguishable. The depth of the brown oily coloring matter upon the trees varied in accordance with the time of application. The color of the trees in Experiment 2, (followed by rainy weather) was found to be many shades lighter than occurred in either of the other two experiments. This brownish discoloration of the trunks and limbs became lighter and lighter, until by the middle of summer little or no traces of the oil remained. The trees in Experiment 1, although several shades darker than those in Experiment 2, lacked to a large degree the blackish brown oily covering noted in Experiment 3. The trees in Experiment 3 were still very dark brown in color on September 5, 1916, standing out in marked contrast to the trees in the other plots. That the material was given sufficient time to penetrate the outer bark on these trees seems to be the only solution of the differences in results and appearance.

**Period of Activity of Oil and Time Required for “Setting” Different from other Orchard Sprays.** In the case of practically all of the other sprays used in the apple orchard, such as lime-sulfur, atomic-sulfur, Bordeaux mixture, arsenate of lead and tobacco, the only prerequisite for good results as far as the weather is concerned is that the materials become dry or set before rains occur. Under ordinary conditions two to six hours is ample time for these sprays to become fixed. This is not true of miscible oils. Oil is effective as an insecticide and must be considered an active agent as long as it lasts on the tree. In Experiment 3, oil, which could be removed by the touch was found as late as seven days after the application. This point was not made an object of observation at a later date. In case of the heavy oils, volatilization and penetration properties are slow. The oil must be given sufficient time before activity ceases in order that it may accomplish penetration, or sufficient coating to the eggs to give the desired results.

**EASTERN VS. WESTERN OILS.**

Several commercial brands of spray oils were used in the Hood River Valley during the past spring, made from both the Eastern or Parafine base oils and from the Western or Asphaltum base oils. In all cases, whether Eastern or Western oil, control was found to be excellent if the material had been applied at a favorable time; at less favorable times very poor results and even total failures occurred with all the brands.

Several growers who used different brands in their orchards report, in nearly every case the emulsion made from the Eastern oil was much more easily applied. A smoother liquid was formed which spread better, making it possible to cover the trees with less material and labor.
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*—Snow, 2 1/2 inches.
T—Trace of rain.
Several different brands of oil were used in an experimental way as well as kept under observation where used by several different growers during the past spring. A great range of variation occurred, not with an individual brand, but with all brands; this variation being dependent entirely upon the weather conditions existing at the time the application was made. Owing to the fact that success and failures occurred with every brand used in Hood River during the past year, no data relative to the advantages one brand have over another were obtained.

VALUE OF THE ADDITION OF SOAP.

Three different dilutions of Soluble Dormant Oil furnished by the General Chemical Co., were used with and without the addition of soap. These experiments were carried on primarily in connection with some work being done on the control of the Woolly aphis, but in view of the fact that leaf-roller was present (Experimental work being carried on in the same orchard as that discussed above) results from the standpoint of leaf-roller control were noted.

Practically no difference was found to exist between the Hood River Spray Co. oil and the Soluble Dormant Oil (Exps. 1 and 4), the oil content in both being the same with 2 gallons of liquid soap added in the case of the latter. In the former, (Exp. 1) 70 percent of the eggs was destroyed; in the latter (Exp. 4) 66 percent of the eggs failed to hatch. The trees in these two experiments were sprayed on the same day. The conclusions drawn here are that the addition of soap is of no importance as far as the killing properties of the oil are concerned. The stronger emulsions gave slightly better results. In Experiment 5, in which 8 gallons of the oil was used together with 1 gallon of liquid soap, 74 percent of the eggs was destroyed. In Experiment 6, the oil used at the rate of 10 gallons to 100 gallons of water with no soap, 76 percent of the eggs failed to hatch. The difference of 4 gallons of oil to 100 gallons of water (Exp. 4 and 6) made a difference of only 10 percent in the destruction of the roller eggs. The destruction of 76 percent of the eggs fails by considerable to approach satisfactory control. The results obtained in Experiment 6, as well as in 4 and 5, again clearly demonstrate that it is not the strength of oil (within certain limits) that is the important agent in bringing about satisfactory results, but rather the conditions under which the oils are applied.

The addition of soap, as far as increasing the efficiency of the oil in destroying leaf-roller eggs is concerned, appears to be of no consequence. The added soap, however, produces a much smoother emulsion which spreads much better and easier on the tree. For instance, in Experiment 6 (oil 10 to 100), a tank of 120 gallons of the emulsion sprayed but 16 trees, or an average of 7.5 gallons per tree. In Experiment 4 (oil 6 gallons; soap 2 gallons; water 100 gallons), 23 trees were sprayed with 120 gallons of the emulsion, or slightly more than 5.2 gallons per tree. The resultant saving is not only 2.3 gallons per tree, but the costly time employed in its application. There are 1300 trees in the orchard in which the experimental work was done. A saving of 2.3 gallons per tree, means a saving of 2990 gallons of spray on the entire orchard, or prac-
tically 14 1/2 200-gallon tanks. One hundred and seventy-four gallons of oil would be saved, and practically two days of labor. The added soap would cost about 40 cents a gallon.

LIGHT TRAPS FOR CATCHING MOTHS.

An interesting observation was made relative to the value of maintaining light traps during the egg-laying period of the moths in orchards infested with the leaf-roller. Two orchardists, Mr. F. W. Radford and Mr. F. Vonnecutt, placed electric (Tungsten) lamps over pans, the bottoms of which were covered with kerosene. These traps were not established until the egg-laying season was well advanced, and for this reason it is impossible to draw definite conclusions as to the possibilities such a procedure offers. Herrick and Leiby (1915) report observations made on the use of lanterns established in infested orchards. With ten lanterns, 6003 moths were captured in ten days, of which only 323 were females. The percentage of "spent" females is not given. Large numbers of the moths were captured by Messrs. Radford and Vonnecutt, as high as 600 moths being taken in a night. The average catch reported by Herrick and Leiby by using lanterns as attractors was not more than 60 moths. In view of the fact that the orchards in which the electric lights were operated at Hood River are not severely infested, it appears that attraction is greatly increased by the increased intensity of the light.

From one night's catch, 100 moths were dissected under the binoculars. The following information was obtained: 95 of the moths were males, 3 were "spent" females, and 2 were females containing eggs. Several catches were examined later with the hand lens, and in no case observed was there present any number of gravid females. It is clear that the operation of light traps, as far as catching the females is concerned, is worthless. Some advantages might be derived by capturing the males before mating takes place; but again, light might have no attraction for them before mating time.

CONCLUSION.

Together with thoroughness in making applications of oil, the most important feature required in destroying leaf-roller eggs is the existence of fair, settled weather for several days following the spraying. The exact period of time required for the oil to penetrate sufficiently to prevent the hatching of the eggs has not been determined; it would undoubtedly vary under different temperatures. Continued rainfall for four days following spraying destroyed the effectiveness of the oil. Two days of fair weather followed by continued rains permitted incomplete control. With seven fair days following the application, complete control was obtained.

A great variation in the degree of control occurred with all brands of oils used in Hood River during the Spring of 1916. This was observed not only in an experimental way, but was found to be true in many orchards kept under observation. This variation was not due to inferiority of materials, but to the weather conditions prevailing at the time of application.
Emulsions made from Eastern or paraffin-base oils spread better than the Western or asphaltum-base oils.

The addition of one to two gallons of liquid soap to 100 gallons of emulsion greatly increased the spreading properties of the spray.

Oil sprays do not “set” with the rapidity of other applications used in the apple orchard. Oil which could be removed by rains has been found on the trees as long as a week after application—it must be considered active while in this form. The other orchard sprays set within two to eight hours and effectiveness from that time on is only slightly reduced by continued rains.

A Tungsten electric light trap caught as high as 600 moths during a single night; of these 95 percent were males; 3 percent spent females, and 2 percent were female moths containing eggs. The light was operated for several nights. The catch was usually very large, but the sex ratio was observed to be about the same as that given. Whether the males caught were unmated was not determined; this is a consideration worthy of further observation.

Miscible oils used at the rate of 6 to 100 during 1915 and 1916, though causing considerable foliage injury when used after the fruit buds begin to show, have not injured these buds in numbers sufficient to reduce the crop or to cause an injury to the tree other than slightly retarding its development. In both years a very high percentage of the eggs was destroyed when the oils were applied at this time.

Oils applied late can usually be applied during a period of warm settled weather.

The author wishes to thank Professor A. L. Lovett, Entomologist of the Oregon Experiment Station, for many helpful suggestions, and Mr. A. J. Graff, orchardist, whose careful assistance during the spraying season has made possible the accumulation of these data.
SUGGESTIONS FOR THE CONTROL OF THE MORE SERIOUS PLANT DISEASES OCCURRING AT HOOD RIVER.

By Leroy Childs.

THE APPLE.

Apple Scab. At the present time no more satisfactory recommendation can be given for the control of apple scab than that outlined for the past season, which includes five applications of lime-sulfur, dilutions of which are reduced as the season progresses.

Several new features were included in experimental work directed toward the control of scab during the past year. These include the experiments pertaining to the following: first, the dusting of trees instead of spraying for the control of both scab and codling moth; second, the consideration of greater dilutions of lime-sulfur than at present used in the many sprays for controlling scab; and third, substitutes for lime-sulfur in the latter spray, in order to avoid injury from burning. Considerable time has also been given to the study of the life-history of this disease, and its relation to our present control measures. Much valuable data have been obtained in these various fields of endeavor. The work is not sufficiently completed or tested, however, to warrant drawing conclusions at this time.

The following program will not only be found effective in controlling this disease, but it is so arranged that by combining other ingredients with the lime-sulfur powdery mildew, codling moth, brown and green aphids can be readily controlled at the same time. Of the list of sprays that are included in this program it will not be necessary in all cases to use the materials present, as some of the orchards are free from some of the pests mentioned. Before it is time to put on the applications recommended, the orchardist should determine whether his orchard contains the pest or not.

Powdery Mildew. From the experimental work which has been in progress now for a year, and which is still not completed, it is safe to say that up to the present time control measures in Hood River have not been attempted early enough to bring about entirely effective results. The disease becomes active shortly after the semi-dormant period, blighting from that time on, fruit spurs, terminal growths, and foliage. In the work which has been conducted, several combinations have been used during the past season, the most effective of which has been found to be iron sulfide-mixture used at the rate of 10 gallons of the mixture to 100 gallons of water. Atomic sulfur, used at the rate of 12 pounds to 100 gallons, was observed to be fairly effective, but did not reduce the disease to the extent that did the iron sulfide mixture.

Last year the disease was kept under control with four applications, iron sulfide being used in the first four scab sprays. These are the recommendations given in the spray program. (Page 29). The iron sulfide mixture is made as follows: Take 10 pounds of iron sulfate (copperas), suspend it in a sack well towards the top of a 50 gallon barrel, which contains about 40 gallons of water and allow it to dissolve. As soon as the copperas becomes dissolved, add about 3 gallons of lime-sulfur solution. A black precipitate immediately forms. The solution should be
<table>
<thead>
<tr>
<th>Application</th>
<th>Insect and Plant Disease</th>
<th>Materials and time of application</th>
</tr>
</thead>
</table>
|                        | **Leaf Roller**                         | **For Scab.** Lime-sulfur 32°, 1-20 (1)  
(2) **For Mildew.** Add Iron Sulfide mixture 10-100 (2)  
For Brown Aphis. Add Tobacco (Nicotine Sulfate) 1-1200.  
This spray should be applied at time first 
leaves are unfolding about the bud 
clusters on the fruit spurs. |
| 1. Miscible Oil        | **Apple Scab**                          | **For Scab.** Lime-sulfur 32°, 1-25.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
This application should not be made until 
the fruit has separated in the clusters, 
otherwise the entire surface of the 
young developing apple cannot be 
completely covered. |
| Delayed Dormant        | **Mildew**                              | **For Scab.** Lime-sulfur 32°, 1-25.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
For Codling Moth. Add Lead Arsenate 4-100.  
(Paste). Use 2-1/2-100 of powder 
Apply after the petals fall. |
|                        | **Brown Aphis**                         | **For Scab.** Lime-sulfur 32°, 1-40.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
This should follow the calyx application 
within ten days or two weeks. |
For Mildew. Add Iron Sulfide mixture, 10-100.  
For Codling Moth. Add Lead Arsenate 4-100.  
(Paste). Use 2-1/2-100 of powder 
Apply after the petals fall. |
|                        | **Mildew**                              | **For Scab.** Lime-sulfur 32°, 1-40.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
For Codling Moth. Add Lead Arsenate 4-100.  
(Paste). Use 2-1/2-100 of powder 
Apply after the petals fall. |
|                        | **Codling Moth**                        | **For Scab.** Lime-sulfur 32°, 1-40.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
For Codling Moth. Add Lead Arsenate 4-100.  
(Paste). Use 2-1/2-100 of powder 
Apply after the petals fall. |
|                        | **Green and Woolly Aphis**              | **For Scab.** Lime-sulfur 32°, 1-40.  
For Mildew. Add Iron Sulfide mixture, 10-100.  
For Codling Moth. Add Lead Arsenate 4-100.  
(Paste). Use 2-1/2-100 of powder 
Apply after the petals fall. |
| 8. Third Codling Moth   | **Codling Moth**                        | **For Codling Moth.** Arsenate of lead, 4-100.  
For Anthracnose. Add Bordeaux 3-4-50.  
The date of this application is dependent 
upon the seasonal development of the 
codling moth and will be recommended 
from the local experiment station. |
|                        | **Anthracnose**                         | **For Codling Moth.** Arsenate of lead, 4-100.  
For Anthracnose. Add Bordeaux 3-4-50.  
The date of this application is dependent 
upon the seasonal development of the 
codling moth and will be recommended 
from the local experiment station. |
| 9. Fall Application     | **Anthracnose**                         | **For Codling Moth.** Arsenate of lead, 4-100.  
For Anthracnose. Add Bordeaux 3-4-50.  
The date of this application is dependent 
upon the seasonal development of the 
codling moth and will be recommended 
from the local experiment station. |

(1) See Dilution Table for lime-sulfur at different degrees Beume.  
(2) See method of preparation of this mixture, page 28.
TABLE VI. DILUTION FOR LIME-SULFUR AT DIFFERENT DEGREES BEAUME*

(This table is prepared considering lime-sulfur at 32° Beaume as a standard. Concentrates testing higher or lower are arranged so that they will contain the same amount of sulfur in the diluted spray.)

<table>
<thead>
<tr>
<th>Deg. - Beaume</th>
<th>Delayed dormant Spray</th>
<th>Pink Spray</th>
<th>Calyx Spray</th>
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<td>1 to 19.0</td>
<td>1 to 23.0</td>
<td>1 to 28.2</td>
</tr>
</tbody>
</table>

*This table was kindly prepared by Mr. R. H. Robinson, Assistant Chemist, Oregon Experiment Station.

allowed to settle for 2 to 6 hours. In order to determine whether all of the sulfide has been precipitated, place a little of the clear liquid from the top of the barrel in a tumbler, and add a few drops of lime-sulfur concentrate. If a black residue forms by adding the lime-sulfur, then add about one-half gallon more lime-sulfur concentrate to the barrel and stir again. After it settles, test again, and add more lime-sulfur to the barrel if a precipitate is formed when lime-sulfur is added to the clear liquid. If no further precipitation occurs upon addition of the lime-sulfur, drain this top liquid off by siphoning down to the black muck.

(The clear liquid is of no use and should be thrown away.) Fill the barrel containing the black muck and allow it to settle. Again drain off the clear liquid, fill the barrel full of water and stir. This is now ready for use. Ten gallons of this black liquid will make 100 gallons of diluted spray. In view of the fact that the sulfide settles very rapidly, always stir up the materials in the barrel before dipping out the material to make the diluted spray.

**Anthracnose.** The handling of the large crop of apples during this past year, combined with the early rain, prevented the greater majority of orchardists from applying the anthracnose spray during the fall of 1916. This disease will therefore probably be prevalent in the Hood River Valley during the coming year. No orchard in which Bordeaux Mixture was omitted in 1916, should go unsprayed this fall, for the results may become very serious.

Quite often as was the case this year, it is practically impossible to get the spray on the trees after the harvest, owing to the occurrence of early rains. For this reason Bordeaux 3-4-50 should be added to the last codling moth spray, the date of application depending upon the develop-
ment of the insects. This should usually be made between August 10 and 25. Experimental work carried on during the past two years has demonstrated that this material can be used at this time with safety to the apples. If applied thoroughly, it is of great value in preventing early anthracnose infection, which may result from rains occurring before the fruit is picked. Under ordinary conditions this spray will keep the disease well in hand in orchards comparatively free from the trouble. Seriously infected orchards, however, should not only receive this summer application, but the regular fall Bordeaux Mixture 6:6:50 which should be applied as soon as the fruit is picked.

PEAR DISEASES OF INTEREST TO HOOD RIVER GROWERS.

Fire Blight. The outbreak of fire blight which occurred in several sections of the Valley last year should serve as a very distinct warning to all orchardists that they be on the alert for a return of this disease in the future.

The value of maintaining a careful watch for this most serious trouble cannot be over-emphasized. Unless orchardists take more interest in the future than they have shown in the past, the disease will cause more trouble than all of the rest of the insect pests and plant diseases that demand attention at the present time. This disease is caused by a bacterium which attacks all parts of the tree; blossoms (known as blossom blight), twig blight, (that of killing and blackening of vigorously growing terminals), and body blight. The disease in the latter form attacks the limbs and trunks, forming large cankers, and ultimately girdling and killing the tree.

All suspected cases of blight should be reported to the county fruit inspector before control is attempted. This will assist the proper authority to determine areas of infection and enable him to eradicate the trouble with greater ease. Fire blight can only be controlled by cutting out the injured parts. Tools should be disinfected before and after making each cut in order to avoid the further spreading of the disease by these instruments. Corrosive sublimate, which can be obtained at any drug store, should be used at a dilution of 1 part to 1000 parts of water.

Pear Bark Blister. During the past year many pear trees were observed possessing more or less well-defined cankers upon the larger limbs and body. The cause of this destruction of tissue has not been determined, but winter freezing is suspected to be the chief cause for the formation of these injured areas. No disease has been isolated from these places. Anthracnose has been found in several cases, but infection from this disease is not as a rule prevalent upon the pear. Spraying for the control of this disease upon pears is the same as for apple.

The writer has examined many cankers during the past fall, and has found that a great majority of them are rapidly healing over. These so doing should be left alone until recovery is complete. In the case of large body wounds, where a large amount of heart wood is exposed, the application of a good coating of white lead paint is suggested, in order to reduce the possible entrance of heart rot organisms to a minimum until the bark is completely healed over. This application should be repeated two or three times a year. The use of white lead and raw linseed oil is recommended.
Pear Scab. Though a different organism pear scab closely resembles apple scab in appearance and method of attacking the fruit. Its control is much the same as that of apple scab. In orchards which have suffered losses from this disease, the program given for the control of apple scab (page 29) will be found effective.

DISEASES OF THE PEACH.

California Peach Blight. During the past two or three years California Peach Blight has become very prevalent at Hood River and the surrounding country. This disease, together with peach leaf curl, is killing many peach trees. The fungus attacks twigs, buds, foliage, and fruit. In the case of the old branches and twigs, irregular cankers are formed, from which a thick gum exudes. Infections on the newer growth are at first red, or reddish brown in color, changing with the destruction of the tissues to a dark brown color, eventually forming a small black canker. These cankers often completely girdle small twigs, resulting in their death. Infection also very often occurs on the fruit, and if sufficiently extensive, destroys the marketability of the product. Reddish brown spots occur upon the skin of the fruit from which exude long, semi-transparent threads of gum. The fruit of the apricot is often attacked and becomes badly deformed, owing to the infection caused by this disease. On trees badly infected large numbers of the fruit and foliage buds are destroyed during the fall and winter.

Peach blight can be controlled by pruning and proper spraying. In the case of the older trees, a large portion of which is diseased and partly dead, heavy cutting should be resorted to, in order to develop new wood and bearing surfaces. In connection with this work, the trees should be sprayed at least three times a season in order completely to protect the new wood from infection. The fungus is active during a greater part of the year. On this account it is necessary to spray in the fall in order to protect the trees from infection, which occurs during the rainy weather. Either Bordeaux 6-6-50 or lime-sulfur 1-15 will be found effective in combating the disease at this time. The first application in the spring should be made just before the buds burst. This application will control leaf curl as well. Lime-sulfur 1-10 is suggested. It has advantages over Bordeaux; since, if there are any scales present, these will also be destroyed. The second spring application should be applied to the affected trees when the fruit is about the size of a pea. Atomic sulfur, used at the rate of 8 pounds to 100 gallons, is suggested for this application, or self-boiled lime-sulfur used at the rate of 8 pounds of lime, 8 pounds of sulfur to 50 gallons of water. Lime-sulfur concentrate should not be used at this time, as it will cause a decided defoliation.

Peach Leaf Curl. Peach leaf curl, when it is left unattended, does a great deal of damage in the Hood River Valley. A parasitic fungus causes this disease. The leaves become over-sized, thickened, twisted, and eventually drop prematurely without performing their proper function. Quite often the trees are defoliated two or three seasons in succession, with the result that the trees become greatly devitalized. This disease is easily controlled by spraying with lime-sulfur 1-10 before the buds burst in the spring. Infections occur as soon as the leaves begin to show, and sprays applied after that date are useless.
SUGGESTIONS FOR THE CONTROL OF THE MORE SERIOUS INSECT PESTS OCCURRING AT HOOD RIVER.

By Leroy Childs.

Leaf Roller. At the present time the distribution of the leaf roller does not include the entire Hood River Valley. The area of chief infestation includes the Pine Grove section, and generally speaking is found in serious numbers within a radius of not more than a mile and a half or two miles from the Van Horn station. The first spray of the season, consisting of an application of a miscible oil, is directed toward the control of this insect. It should be applied subject to the conditions that are given in this bulletin for the control of the leaf roller (page 29). Oils applied at this time have been observed satisfactorily to control the brown aphis. However, at Hood River it is believed at the present time that with the exception of the leaf roller other insects can be more effectively and economically handled by the use of other sprays.

Brown Aphis. This is the insect that is responsible for the development of “aphis apples”—small, gnarled clusters of apples that are usually found on the fruit spurs in the lower parts of the trees. If the leaf roller is present in the orchard, spray with miscible oil, as recommended for this insect. If the leaf roller is not present, add tobacco at the rate of 1 to 1200 to the delayed-dormant application of lime-sulfur. (See program for scab control, page 29).

Woolly Apple Aphis. Experimental work carried on for the control of this insect has up to the present time been productive largely of negative results. This has included fall and spring applications of miscible oils. These findings eliminate oils of the heavier type from being of any decided service in controlling this pest. The insect must be combated in the summer. Tobacco added to the thirty-day spray in 1916 was observed to check the development of this insect. It must be remembered, however, that the thirty-day lime-sulfur spray must be applied with extreme care in order to prevent burning. This means that a thin, even application must be given the trees. To destroy the woolly aphis, a drenching and driving spray has to be employed in order to reach the insect, and for this reason the gaining of one end may defeat the other, and vice versa. Growers who can make these applications separate should do so. In applying the tobacco alone, add 3 or 4 pounds of soap to each 100 gallons of the spray. The woolly aphis at the present time offers more complications relative to its control than any other insect pest present in the Hood River Valley.

The infestations as a rule do not become very pronounced until toward the middle of the summer, and some time after the scab sprays have been applied. For this reason, contact insecticides used during the early season, have proved of little value in reducing the numbers of this pest. This period of extreme infestation occurs at a time when orchardists are very busy thinning, irrigating, cutting their hay, and doing many other little duties that have been neglected during the long spring siege of spraying. It is very clear, however, that this pest, as far as we know at the present time, can only be handled during the summer time. For this
reason it will be necessary to apply at least one extra summer application of tobacco and soap that the pest be kept under control.

**Green Aphis.** During the past two season the green apple aphis has been very prevalent in the Hood River Valley, and especially during 1916, at which time more injury was caused by this insect than probably any other single insect pest or plant disease present. This injury was not only due to the "smutting" of the apple, which prevented the proper coloring of red varieties, but produced an injury on account of their feeding on the fruit themselves. In severe cases this injury resulted in a gnarling which resembled somewhat that caused by the brown aphis. On yellow varieties red spots were produced, which resembled in color those caused by the San Jose scale. It was found that if these spots were produced early in the summer, they largely disappeared before the apples were harvested.

No experimental work has been attempted in the control of this insect at Hood River. In 1915 and 1916, however, it was observed that no contact insecticide applied before the first of June was of any pronounced benefit in controlling this pest. If the observations made in these two years are a criterion, it will be necessary to fight this insect in the summer, along with the woolly apple aphis. It was observed during the past year that orchards sprayed with the thirty-day application with tobacco 1-1200 were much freerer from the green aphis than adjoining unsprayed orchards.

**Codling Moth.** For control see outline spray calendar (page 29). Pears as well as apples should be sprayed if the insect has been found attacking this fruit.

**Pear Leaf Blister Mite.** This mite overwinters under the bud scales of the pears. In the spring as soon as the leaves appear, they burrow into the newly developing tissues, causing the foliage, and in some cases the fruit, to become spotted with puffy red areas. These latter turn black, and the leaves usually drop prematurely. This organism is easily controlled by the use of lime-sulfur 1-10 just as the buds are bursting. Applications made later than this time will do little or no good.

**San Jose Scale on Pear.** Owing to the fact that it has not been necessary to use much lime-sulfur in the pear orchards up to the present time some have become infested with San Jose scale. These orchards should be sprayed just as the buds are bursting with lime-sulfur 1-10.
REPORT OF THE HORTICULTURIST FOR 1916.

By Gordon G. Brown.

ACKNOWLEDGMENT.

Special thanks are due Professor C. I. Lewis and Professor V. R. Gardner for many kindly and valuable suggestions offered from time to time.

INTRODUCTION.

The work completed or under way may be subdivided as follows:

1. Apple Fertilizer Work. This refers to a series of complete fertilizer experiments that were begun, in 1914, in the Hood River orchards, upon which observations are still being made and two reports given. Owing to the great importance of this work, much time and painstaking care have been expended in determining results. Six experiments of this nature have been conducted, covering nearly fifty individual plots in different parts of the valley. The results for the preceding two years have been so satisfactory that it was deemed advisable to determine to what extent the beneficial effects would last.

2. Strawberry Fertilizer Work. Owing to the importance of the industry and the absolute lack of experimental data bearing on the subject of the relation of fertilizers to yields, grade of fruit, duration of plants, amounts required, etc., six different experiments are now under way, each of which involved eleven different treatments. It is hoped soon to gather such information as will enable the station to make more definite recommendations. Later the work of selection and breeding will be considered.

3. Fertilizer Work for Alfalfa. Owing to the greatly improved stands secured in Southern Oregon by the use of such fertilizers as sulfur and land plaster, three experiments of this nature were started at Hood River this year. Results have been very satisfactory and show greatly improved yields and vigor from their use. These experiments were conducted in the open field this year but in the future it is hoped to conduct them in the orchard, where this fertilizer may be studied from the standpoint of shade crops in relation to tree growth and development.

4. Shade Crop Studies. Owing to the fact that in many parts of the Northwest alfalfa has been found the most economical and efficient shade crop covering a long series of years, the desirability of determining its influence under local conditions is obvious. There are many problems yet to be solved: How long may we leave this crop in our orchards? What are the best methods of caring for this crop in order that it may remain vigorous under its somewhat unnatural environment and perform the work for which it was seeded? The question of the relation of fertilizers to this crop has already been raised. One distinct experiment of this nature has been running for two years. Two of the fertilizer experiments referred to (3) involve a study of this kind. The relative importance of this crop as a fairly permanent one, as com-
pared with the use of clover which may be turned under, is a mooted question on which there is indeed much to be said.

5. Hog Pasturing Studies. Two experiments of this nature have been running this year. In both cases economical gains have been made by pasturing the orchard with swine. The experiments are not intended to demonstrate the advisability of orchardists going into the business on a wholesale scale but rather to stimulate interest in production at least for home consumption and incidentally to utilize much of the materials going to waste around the ranch. The fertilizing effect of hog pasturing has been often referred to and should not be lost sight of.

6. Pruning. There is probably no problem confronting the orchardist in the Hood River Valley of more importance than that of pruning. This is particularly so with the owner of mature trees. The problem of keeping alive and productive an extensive fruit spur system is a big one, and the difficulty of making many young trees come into bearing is an acute one. There are now five distinct pruning experiments running that have been started in 1916. These refer to the principal varieties such as Newtowns and Spitzenbergs, and the objects sought are studied on both old and young trees.

7. Other Work. Other work being conducted by the Horticulturist applies to extension work, exhibition work, lectures showing the results secured from time to time, newspaper articles which contain timely information relating to the more important problems in the orchard and field. Over 150 orchardists were visited during the year.

Plans for the Future. All of the lines of work started are important and should be conducted for a number of years in order to secure evidence of definite nature. Most of the work is just started. Who can say what are the far-reaching effects of the fertilizer applied to date on the mature apple tree, or the influence of alfalfa if left in the orchard as long as many of our orchardists hope to leave it? Greatest attention will probably be paid to the subjects of Shade Crops, Irrigation, and Pruning. The aim will be not necessarily to discover new principles so much as to demonstrate already known facts in a practical way. The other work started will receive as much attention as time will permit.

Obviously space allowance will not permit a complete report. All that can be hoped for is to discuss the main problems involved and the general result secured. Definite recommendations covering several subjects will be included also and based upon the merits of the facts as discovered to date. Many subjects of experimental nature will not be included at this time partly because of the lack of space, partly because of inconclusive evidence as yet secured. This is particularly true of the strawberry work; but it is hoped to give a complete report at a later date. Station records are filled with complete records in detail regarding many of the problems so far discussed and are available to anyone sufficiently interested to study them. As in the past, it is hoped to continue during 1917 the newspaper articles that cover many subjects not treated here.
INFLUENCE OF COMMERCIAL FERTILIZER UPON THE BEARING APPLE TREE.

By C. I. Lewis and Gordon G. Brown.

A few years ago a very serious soil problem forced itself upon the apple grower in various sections of the Hood River Valley. It had to do with vigor of trees and fruit production. Many orchards formerly productive to a marked degree began to fail. This was true not only of neglected orchards, but also of orchards apparently receiving the very best of care as judged by the standard practices of the time. Tree growth was reduced to negative proportions, fruit-spur development was weak, the ability of spurs to set fruit subnormal, as evidenced by small crops of fruit following very heavy blossoming. The leaves formed were thin and sparse and, failing to function early in the summer, consequently dropped. Fruit, while possessing good color, was so small as to throw big percentages in the secondary market values.

Coincident with these facts, two important general features regarding care predominated: the first was that previous irrigation had not been given; the second, long-continued clean cultivation has been the general rule.

Regarding the latter feature: it is now a rule long since established by experience that clean cultivation practiced exclusively tends to destroy the organic matter of the soil. The relation of organic matter, bacterial action, water-holding capacity, and good tilth are widely known and will not be enlarged upon here. The relation of nitrogen to wood growth and fruit production is also widely understood but often not appreciated in a practical way. The soils in these orchards might be regarded as "run out." They lacked water-holding capacity, they baked or puddled-early, and on hillsides were given to erosion. In many cases, they were so badly depleted of organic matter as to make the introduction of leguminous shade crops such as clover and alfalfa which depend upon an abundance of moisture, a problem of extreme difficulty.

The fertilizers used in the four fertilizer experiments started in 1914 may be classed as mixed fertilizers and nitrate fertilizers. Each may be considered as a series representing two orchards. By the former classification is meant the application of the principal ingredients, nitrogen, phosphoric acid and potash as carried by nitrate of soda, superphosphate, and sulfate of potash. These were applied either alone or in the different combinations possible. An orchard on the East Side was chosen for one experiment and one on the West Side for the other. The former represents a light silt soil and the latter a clay. One is now nineteen years of age and the other, twelve. Both, especially the former, represented a phase of the undesirable conditions already referred to.

The results of two years' work previous to 1916 indicated no response of a practical nature by the use of potash or phosphoric acid. On the other hand, encouraging results were secured from the introduction of nitrogen. However, in order to complete the work, a third application in both orchards was made this year. In the one orchard, one-half of each plot which had received fertilization each year (1914 and 1915)
<table>
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<tr>
<th>Orchard Number</th>
<th>Plat Number</th>
<th>Pounds per tree</th>
<th>Treatment</th>
<th>Average per tree yields loose boxes</th>
<th>Terminal growth inches</th>
</tr>
</thead>
<tbody>
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<td>5.2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2.b</td>
<td>5.2</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.c</td>
<td>5.2</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.a</td>
<td>6.75</td>
<td>6.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.b</td>
<td>6.75</td>
<td>6.75</td>
<td></td>
<td></td>
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<td>3.c</td>
<td>6.75</td>
<td>6.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Fertilizer broadcast on ground.
b. Fertilizer sprayed on ground as liquid.
c. Fertilizer sprayed on ground and tree as liquid.

(Above table refers to Spitzenbergs only)
received a third application this year, so as to check the two-years application against the third. Owing to the fact that in both orchards the negative results of former years were repeated no other report will here be given except to state that it is impracticable to use fertilizers of this kind, as there is no evidence to show that the soils in this valley are lacking in other plant foods than nitrogen at this time. For further evidence, see station records.

Owing to the fact that during the past three years very satisfactory results have been secured, on the other hand, by the use of nitrate of soda, this article will hereafter concern itself with work along this line. For the nitrate work two typical Spitzenbergs orchards about sixteen years of age were chosen in the spring of 1914. These orchards represented practically all of the undesirable conditions of growth and fruit production heretofore enumerated. In order more closely to identify the orchards with results and make comparisons easy, a number will be assigned to each experiment. One experiment at Pine Grove will be referred to as Orchard No. 1, and another as Orchard No. 2. The former experiment is subdivided according to variety, there being both Newtowns and Spitzenbergs present upon which separate checkings were made. Experiment No. 2 is composed entirely of Spitzenbergs. Table VII shows the pounds of nitrate applied according to plot number. These experiments may be considered duplicates in all respects other than in the amount of fertilizer applied. In Orchard No. 1, 5.4 pounds per tree formed the basis of the work, and in Orchard No. 2, 6.75 pounds. Plot No. 1 in each experiment received its fertilizer in the form of crystals broadcast under the tree; plots No. 2, in the form of a liquid sprayed on the ground around the tree, and plots No. 3, in the form of a liquid sprayed both upon the trees and ground. Plots No. 4 in both cases, as will be noted, have never received any commercial fertilizer and will hereafter be referred to as the Check.

When these fertilizers were applied, some doubt existed as to the best methods, there being some experiments conducted elsewhere which seemed to show beneficial effects from applying the fertilizer as a liquid to the buds just before opening. The results for the first two years together with separate experiments conducted along this line in 1916, show emphatically that there is no advantage to be gained in the more expensive application such as spraying. The cost of such fertilizer at normal prices, $60 per ton, would approximate $10 an acre on the one hand and $15 on the other. Note that these applications were made during 1914 and 1915 only, no fertilizer being applied during 1916.

During the first year, the applications by the different methods were not all made at the same time. This fact served one very important purpose: for example, it was noticed that nitrate applied in May scarcely exerted any marked influence on tree growth and production until nearly the end of the growing season, whereas that applied in early March exerted an influence almost immediately and throughout the entire growing season on both factors. Consequently the second application of fertilizer on all plots indicated in both experiments was made in early March, 1915.

It is important to note the culture given these orchards to date. In Orchard No. 1 irrigation was applied for the first time in 1914. Since that time an ample supply has been available. It was clean cultivated during
the early season of that year and seeded to clover. A good stand was secured. In 1915, this clover was pastured by hogs and young cattle. Early in 1916, this clover with its manurial content was turned under. Orchard No. 2 was clean cultivated in 1914 and seeded to a mixture of clover and alfalfa. Beginning with and since 1915, irrigation has been given.

In 1916 two more orchards were chosen to afford further study of this problem. These orchards are called Orchards No. 3 and 4 and in most respects resemble the two preceding. They are about sixteen years of age and are located on a Hood Silt soil. Long, continued, clean cultivation and lack of irrigation had been the general rule, resulting in depleted soil conditions, poor physical condition of trees, and consequent- ly poor crops. The purpose in starting these experiments, which also may be considered duplicates, was to determine further the best and most economical amounts to apply, best time of application, and further whether nitrate of soda has any part in a permanent rotation in the orchard. Time only can answer this last question. Each experiment is composed half and half of Newtonts and Spitzenbergs of similar age. Several good crops have been in promise in these orchards, but the extremely weak character of the blossoms prevented the trees from setting the fruit or retaining it to full maturity. The quality of fruit has been good, but on the average the sizes for Spitzenbergs have been too small. In these orchards the nitrate was broadcast in early March or April, being followed by abundant rains. Plots No. 1, 2, and 4 received 7.3, 5.00 and 3.00 pounds nitrate per tree respectively. Plots No. 3 in both cases received no fertilizer and will also be referred to as the check. See Table VIII. Both orchards were this year seeded to clover. In Orchard No. 4 a good stand was secured.

RESULTS.

Influence of Nitrogen on the Character of Blossoms. No difference was observed in the time when the blossoms on the respective plots opened. In Orchards No. 2, 3, and 4, the number of blossoms to the spur was considerably more than on the spurs in the check trees. They were also larger and more highly colored. Many of the buds in Orchard No. 4 did not open. This has been a feature of the nitrate work for the past two years.

Influence of Nitrogen Upon the Set of Fruit. On all plots receiving nitrogen, percentages have been taken to determine the extent of fruit set, both in June and again at picking time. There appears to be no relation between the method of application and the percentage set. Blossoms retaining at least one fruit each were credited with 100 percent set. It is significant that the blossoms on the fertilized trees have retained on an average 70 to 80 of all their fruits during the early season, as compared with 35 percent for the check. Owing to the natural drop and other conditions prevailing during the remainder of the season, these averages were reduced about one half. However, the ratio given, 2 to 1 in favor of the fertilized plots, remained constant during the entire growing season.

Influence of Nitrogen on Leaf and Terminal Growth. Previous to the applications of nitrate in these orchards, yields had been negative.
Results, however, were almost immediate. Figures show that no matter in what form the nitrate is applied, it exerts a beneficial effect on the trees in question. If there were any practical differences existing as between the different methods of application in the first two orchards, those facts were not established by any of the careful methods of checking employed. In all cases the fertilized trees became green and vigorous and yielded heavily in marked contrast to the unfertilized trees nearby.

Differences were marked almost from the opening of the buds this year in Orchards No. 3 and 4. In these cases the difference was marked from the opening of the buds and remained so during the entire growing season. Strong contrasts were furnished about picking time when the yellow leaves especially on Newtowns in the checks were rapidly de-foliating, in marked contrast to the still bright, green, vigorous appearance of leaves on the fertilized trees. On August 20, moisture determinations were made on all plots to see what influence nitrate had on functioning at that date. In most cases high percentages were found associated with nitrate plots and low percentages with the checks. Referring further to Orchard No. 1, last year there was an abundance of dark green foliage on all the nitrate trees. Possibly it may be said that foliage was slightly excessive to insure the best color of all fruits, this in view of the fact that no thinning was done. However, all trees in the check were very naked in this respect, the leaves being small and sparse. Fertilized leaves average 2.8 inches long, representing an increase of 24
### TABLE IX. RELATION OF SIZE OF FRUIT TO COLOR, ETC.

<table>
<thead>
<tr>
<th>Orchard Number</th>
<th>Plot Number</th>
<th>Pounds Nitrate per tree</th>
<th>175-150 per box (small)</th>
<th>138-112 per box (medium)</th>
<th>100 and larger</th>
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<td>13.8</td>
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<td></td>
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<td>27.8</td>
<td>48.3</td>
<td>23.9</td>
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<tr>
<td></td>
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<td>(check)</td>
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<td>24.9</td>
<td>11.55</td>
</tr>
<tr>
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<td>3.00</td>
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<td>26.20</td>
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</table>

The figures substantially represent results for the same year in Orchard No. 1.

Next, turn to Orchards No. 3 and 4. See Table VIII. Note that all the nitrate plots show great differences over the checks. Here again the beneficial effects as indicated by color of foliage were visible for long distances. Leaves of the Spitzenbergs in the Checks averaged 1.99 and 2.34 inches long respectively, versus such figures as 2.95, 2.93 inches, representing fairly constant averages for the nitrate plots. It will be noted that there is shown practically as much vigor as expressed in leaf growth by the plots receiving the lighter applications of nitrate as those receiving more than double that amount. Newtown leaves in the checks average 2.32 and 2.27 inches long respectively, versus such averages as
2.93, 2.79, and 3.44 inches for the various nitrate plots. With both varieties average widths shown vary closely with lengths expressed. The importance of these facts is obvious. If the lighter and more economical applications of nitrate are able to produce practically equivalent response in vigor as the heavier, a saving of over 50 percent in material is effected.

This year a change has come over Orchard No. 1. Leaf development on all plots regardless of previous fertilization has been very vigorous. Recall that no fertilizer was applied this year to either Orchards 1 or 2, but that clover and its manurial content was turned under in early spring in the former and that alfalfa and clover are now well established in the latter. Note also that irrigation and rainfall this year have been ample. The leaves on Check Spitzenbergs in the former orchard averaged 2.95 inches long and 1.78 inches wide; Newtowns, 2.95 inches long and 1.93 inches wide. The differences as compared with the plots formerly fertilized are negligible. In some cases the Checks show to better advantage than the fertilized. The striking similarity in vigor of growth of Spitzenbergs for 1916 is clearly illustrated in Figure 1. In Orchard No. 2 the invigorating influence of nitrate has extended into 1916 and gives good promise for 1917. Leaves on all fertilized plots averaged slightly larger than for 1916. This is also true for the Check, but considerable advantage is still possessed by fertilized plots.

Influence of Nitrogen on Terminal Growth. As would naturally be expected there is a vast difference in Orchards No. 3 and 4 in this respect. Table VIII shows this clearly. Note that the fertilized Spitzenbergs in some cases show increases of 400 to 500 percent. Approximate results are approached by the Newtowns. Here again figures show little difference in vigor as related to amount of nitrate applied. Figure 2 shows clearly differences in vigor of Newtowns between Plots 2 (5 pounds nitrate) and the Check in Orchard No. 3.

The great uniformity of vigor for 1916 in Orchard No. 1 is again clearly shown in terminal growth. Truly it may be said that the check has “come back.” Despite the disparity in this respect for 1914 and 1915, 1916 shows a complete reversal of form. Table VII (last column) shows a terminal growth of 19.9 inches for the Spitzenbergs in the Check. This exceeds two of the fertilized plots and is practically equal to the other. Note that this measurement is nearly three times that of its own yearly average growth for the years 1914 and 1915. This relation is also true for the unfertilized Newtowns in this orchard, which made an average growth nearly equivalent to that of the fertilized plots. These figures should also be studied in the light of yields, the influence of which is appreciated.

Influence of Nitrogen on Size of Fruit. As might be expected, nitrate influences the size of fruit greatly. This year, however, little effect was noted with Newtowns, sizes running quite small in all orchards. This was true regardless of yields. See Table IX. Note that most fruit averaged around 175 to 160 to the box. The only appreciable difference noted was that the Newtowns from the checks in all orchards showed greater maturity at picking time as evidenced by seeds, color and greater ease with which detached from the spurs. The comparatively small sizes for this variety can be largely attributed to the lateness of blossoming and the short growing season for 1916.
Last year Spitzenbergs from the nitrate plots in Orchards No. 1 and 2 showed a tendency to large sizes. In sizes there was not a close relation between the nitrate plots in Orchard No. 2. One plot showed as much as 68.10 percent larger than 100 to the packed box versus only 5.43 percent for the Check. The nitrate plots averaged 50 percent large fruit. This was also true of Orchard No. 1, but to somewhat less extent. Here we have two extremes of undesirability. Big percentages of large fruit on the one hand and small on the other. However, the former feature is not so serious when it is understood that practically all of the oversized and undercolored specimens from the nitrate plots might have been thrown away and the balance would still be vastly in favor of the nitrate plots.

Attention is briefly called to sizes for 1916. Most of the fruit falls within the medium and small sizes as contrasted with last year. Note that the Checks show extremely small percentages of large fruit. On the other hand there were very few oversized specimens from any of the fertilized plots. Here, again, light is thrown on the subject of the relative influence on size of heavy versus light applications of nitrate. Figures disclose little practical differences for this year and encourage the more economical amounts. Thinning was practiced in Orchards No. 1 and 3. The heavy crop in Orchard No. 2 was not thinned but was subject to considerable "June Drop." Thinning was not warranted in Orchard No. 4 because of the light bloom.

**Influence of Nitrogen on Color.** In all orchards fruit from the Checks showed a much better color than those from the nitrate plots. Last year within certain limits there was a relation between the size and color, the larger specimens being less desirable in this latter respect. The fact that in some orchards no thinning was done and heavy foliage predominated, largely influenced this result. This year, in Orchard No. 1 there was practically no relation between the size and color.
on any of the plots, all running about the same. High color was not especially pronounced as there was a slight overshadowing of greenish yellow which obscured the deep red characteristic of the Spitzenberg. In Orchard No. 2 better color was in evidence, despite the large crop and heavy foliage, the trees being more open in structure, permitting better distribution of sunlight. This variety matured approximately at the same time in all plots.

**Influence of Nitrogen on Yields.** Table VII shows the yearly distribution of yields. Owing to the lateness of application of fertilizer in Orchards 1 and 2 in 1914, the yields are somewhat inconsistent and small. Results in both orchards for 1915 were excellent. They were correspondingly poor for both Checks. This year the fertilized plots in Orchard No. 2 are even better than for 1915. The Check shows a slight gain over the abnormally poor results for the preceding two years.

![Fig. 8. Unfertilized Yellow Newtown tree in foreground (Check) compared with the vigorously growing fertilized trees in the background.](#)

Attention is again called to the great uniformity of results in Orchard No. 1 for 1916. This factor has been discussed with reference to vigor as expressed in leaf and terminal growth. Notice that of 1916. Yields are fairly good in all plots, but strong contrasts are lacking. Compare the Check's yield of 8.8 boxes per tree also with the .2 and .31 box yields for the two preceding years. Attention is also called to the fact that the unfertilized Newtowsns in Plot 3 produced 13.3 boxes per tree this year scarcely less than one-half box behind the average for the nitrate plots. These factors should be studied in the light of shade crop treatment about which comments will be made later.

Turn to yields for Orchards 3 and 4, Table VIII. The bloom in the former for both varieties was particularly heavy. The comparatively high percentage of fruit set on the nitrate plots and the correspondingly low set on the Check very largely explains the great disparity in yields. In this case there is a direct relation between yields and the amount
of nitrate applied, the larger yields being associated with the heavier applications. This fact obtains for both varieties. Owing to the small bloom in Orchard No. 4, yields are small but nevertheless indicate the trend.

Crop Prospects. On the fertilized plots in these two orchards for next year, crop prospects are excellent, as indicated by an abundance of fruit buds formed. The Checks have produced many fruit buds but of weak character. Prospects are also good for next year for both varieties in Orchards 1 and 2, the Check in the latter being the only exception. The physical condition of this plot is improving gradually under the stimulus of better irrigation and the influence of the shade crop.

RECOMMENDATIONS.

The grower desires to know to what extent the results discussed may be applied to his own trees. Do my trees need fertilization, and of what kind? How much and how often shall I apply the same? Has nitrate of soda any part in a permanent rotation with shade or cover crops, and, if so, to what extent? These and many other questions of similar import will be raised.

In general, it may be said that the probable demands for nitrate of soda in the Valley for apple trees will be light. This does not infer that the demands for nitrogen upon the soil will be less than in former years. Reasoning tells us that because of increasing age of trees and larger crops in prospect, the demands should correspondingly enlarge.

It is certain that recommendations covering this subject can be made only in relation to the presence of shade crops which occupy the ground either for a long or short period. It must be viewed in the light of soil, age of trees, variety, pruning practices and irrigation. No set rules can be laid down, each orchard presenting problems of its own.

We are all familiar with the fact that shade crops induce bacterial action and by liberating nitrogen, stimulate tree growth. There are many evidences to show that alfalfa, left permanently in the orchard, does not stimulate wood growth as rapidly as where placed in a shorter rotation with clean tillage. The same rule to some extent applies to clover. In the former case, unless receiving an abundance of water, often not the case, and care such as renovation and cultivation in its somewhat unnatural environment, this shade crop does not make its best growth and becomes soddy, a condition not only inimical to its own welfare, but to that of the trees as well. On the other hand, when organic matter such as clover or alfalfa are turned under frequently, say once in every three or four years, and followed by clean tillage, disintegration of organic matter and bacterial action are greatly accelerated inducing great vigor of tree, especially in "off" years when the crop is light. In this connection the astonishing results pointed out in Orchard No. 1, Figure 1 are cited. Owing to the previous soil conditions, such as lack of irrigation and clean cultivation, it is obvious that the soil was "run down" and that the reintroduction of organic matter in large quantities plus its manurial content largely explains the rapidity with which devitalized trees recover.

These are old subjects about which too much cannot be said. Upon the proper interpretation of the well-known principles just enumerated depends the success or failure of the apple orchard as a business propos-
tion. The aim should be to avoid extremes. Clean cultivation exclusively was one extreme; cover and shade crops combined with fertilizers may become another extreme.

It will be recalled that nitrate of soda was applied a few years ago to serve a special need. Trees were extremely weak physically and the soil depleted of its nitrogenous plant food. That shade or cover crops could restore nitrogen and humus was recognized at once. That the beneficial effects of such crops are not immediate was also understood; hence the restoration of nitrogen in the artificial form. A careful study of the two orchards in which nitrate was applied for two years (1914 and 1915) gives no evidence whatever that further applications of nitrate are necessary. This applies not only to Orchard No. 1, where the shade crop was turned under, but also to the other, where alfalfa and clover have been for two years established. That nitrate has accomplished a special mission is evident. The beneficial effects of shade crops should be understood. Should nitrate be found useful in the rotation, it is evident that the smaller amounts will be most economical and satisfactory. The reader's attention is again called to this fact about which much has already been said.

May alfalfa be left for a long period in the orchard? Possibly so, if properly cared for. If this crop is to remain long in the orchard it must receive at least passing care along the lines suggested. Plainly, a weak, shallow-rooted leguminous plant cannot go deeply and loosen up the subsoil, the purpose for which seeded. On the contrary, it becomes a surface feeder in direct competition with the roots of the tree, both for plant food and water. In addition to the care suggested, applications of 100 pounds of land plaster per acre, or small amounts of sulfur, both of which have given splendid results in the open field, may be worth while.

Whether this crop should occupy the soil for a long or short period must also be viewed in the light of economical irrigation distribution and from the standpoint of labor supply. Avoid extremes, no matter to what phase of orchard practices applied. Trees producing the best and most fruit are those making but a moderate growth only. This is especially true with Spitzenbergs, upon which a premium must be placed for color as well as size. Trees over stimulated with fertilizer, shade crops, pruning, or irrigation cannot produce fruit of the quality sought.

Special thanks are also due Messrs. Lage, Dragaeth, Mason, Radford, McCully, Stone, and Pierson for sympathetic interest shown, and practical assistance given, from time to time. The Station also feels indebted to Messrs. Shannon, Jensen, Howell, Smith, Millard, and others who have also done much to promote the work.
PRUNING PROBLEMS IN THE HOOD RIVER VALLEY.

By Gordon G. Brown.

There are many pruning problems in the Hood River Valley which have not been solved either in an experimental way or to the satisfaction of most growers. These become numerous and complicated owing to the different soils, varieties, elevations, growing season, and age of trees. The problem of pruning young trees yet in the formative stage has by no means passed by. The increased plantings in the Upper Valley have increased the acreage of this class considerably. As land clearing and tree planting continues, this problem will accompany it. It is true that many of the main principles regarding the pruning of these trees have been quite thoroughly worked out, especially with apples. This is less so with pears and other tree fruits. Because of these facts, it seems desirable that some experimental work be done along this line.

The problem of pruning trees beyond the formative period, but not yet in the commercially productive period is also a very important one. These problems not only refer to principles of correct body building but principally to the fruiting habit. Referring to our two main varieties, Newtowns and Spitzenbergs, the problem at this stage refers more acutely to the former and less to the latter, which, unless abnormally stimulated to wood growth, naturally comes into bearing moderately early. With the Newtown this is often not the case. Extreme care is often necessary with reference to its culture to prevent this variety from running into excessive wood growth, rather than to fruit production, beyond the ninth and tenth year, at which time big crops should begin to be the rule. Several experiments bearing on this subject are under way.

In connection with pruning practices, a very important principle has been recently cited by Prof. V. R. Gardner of the Oregon Experiment Station, who has done extensive work along this line. This work has involved a study of fruit-spur formation as related to kind and time of pruning, and the location of the lateral buds from which they spring. A general rule has been laid down: that with the exception of the very few which develop laterally on the current season's wood fruit spurs develop on the one-year-old wood only. In other words, buds formed laterally during one growing season grow into spurs during the following summer. Failing to do this during the time mentioned, they never form fruit spurs except indirectly by being pushed out into wood growth under the stimulus of heavy pruning or fertilization, on which growth, spurs in turn may later be formed. The importance of this idea as related to the pruning of young trees is obvious. The aim, then, should be to prune the tree so as to insure correct body building and induce early fruiting.

The relation of fruit-spur formation to position of lateral buds has been suggested. Close observation by the above named authority discloses the fact that only the upper, plump vigorous and well-matured buds formed on the current season's growth may be expected to form spurs. It has also been found that under the stimulus of good light and air position, a much larger percentage of all buds on the current season's wood is likely to be of this desirable character. Orchardists have noted that a great
tendency exists on the part of shoots of both Newteowns and Spitzenbergs, especially the former under densely shaded conditions, to make weak lateral buds on the lower one-half or one-third of their entire length, and that during the following growing season they remain inactive. Consequently such wood on which they are carried serves no other purpose than that of supporting terminal growth of later years, which often becomes excessive and must be removed with consequent loss of fruit spurs.

This fact bears an all-important relation to the kind of pruning given. With young trees especially, is it not possible to conserve a big percentage of energy expended in the production of wood growth annually removed in regular heading back and at the same time ensure a proper type of structural growth?

In early summer pruning lies at least one remedy. Thinning out and heading back about July 1, depending upon the season, at which time the shoot has made about two-thirds of its normal growth, is recommended. In addition to offering better light conditions for basal buds, it has been found that most buds on secondary growth develop later (the same season) into spurs. Such a practice conserves energy wastefully expended in terminal growth. Secondary growth does not become excessively long and consequently winter heading back is light, in which case few of the valuable buds are removed.

The disadvantages of winter pruning only is obvious. The thinning out removes all buds which may later form spurs, and the heading back required, because of excessive terminal growth made during the previous summer, removes also a big percentage of valuable upper prospective fruit-spur buds, the percentage of which to the total lateral buds formed is already low because of a failure to thin out and promote better light conditions the season before. The result is a constant removal of fruit-spur wood, the production of more wood promoted by heavy cutting, to be handled usually the same way as before.

There is still another serious problem in the Hood River Valley with reference to pruning either variety mentioned. This refers particularly to trees which have been in bearing a number of years, trees fifteen years of age or older. This appears to be especially true in those orchards where no definite and regular pruning policy has been consistently followed. In some cases little or no pruning has been done for a number of years. This period of inactivity is often followed by heroic efforts to accomplish at one time what normally should have been distributed over a number of seasons. In other words, so-called "bulk" pruning, which involved a comparatively few big cuts as compared with the other type, which is more carefully and thoroughly done. Often the pruner attempts, at a big disadvantage, to correct bad physical defects resulting from such lack of care. This problem, however, is not confined entirely to such orchards, but more or less to all orchards in which trees of these two varieties are grown.

Let us refer first to Spitzenbergs. Observers have noticed that this tree exhibits an alarming tendency for fruit spurs on lower parts of trees to die or remain inactive as far as fruit production is concerned, a few years after fruiting has become established. The pruner may, however, take courage in the absolute knowledge that such unproductivity is due not to age, because old spurs when properly handled are just as capable of producing good fruit as the young. This fruiting habit becomes con-
spicuous on even moderately young trees, as far as the main limbs are concerned. In other words, the fruiting area is confined to the upper and younger wood (most advantageously placed with reference to light and air), while a large, altogether too large, area below is rendered inoperative. The problem, then, is not necessarily to produce a more elaborate fruit-spur system, but to maintain that already established and prevent excessive terminal growth. This strongly suggests that regular thinning out of superfluous branches and heading back to strong laterals so as to prevent sucker growth where strong cuts are necessary will be the most likely to produce the best results. The desirability of keeping the tree reasonably compact, thus avoiding expensive climbing, spraying, and propping is obvious. The remedy appears easy, but its practical application is not so easy. How is this tendency to be overcome? How may we again restore this barren area to a productive one? Some growers do not agree that it should be the aim to grow fruit on the lower portions of the tree, because it is claimed poorer colored and inferior fruit only can be obtained from such sources. Possibly so. The opinion is ventured, however, that with proper light and room for expansion, a high class of fruit may be grown on the lower portions of the tree, indeed, sufficiently high grade and in such quantity as to make the effort to do so well worth while. If such is not the case, and the grower can produce good fruit on the upper portions of the tree only, much climbing will be necessary to secure the fruit, to say nothing of spraying difficulties; and the productive area will represent a very much smaller percentage of the total tree area than is the case with most varieties where color is placed at a premium.

A remedy for this has been suggested for the average tree of the Spitzenberg type; namely, thinning out and heading to laterals. However, there are other methods which must be resorted to. There are in this valley many trees of mature age of this variety which will not apparently stand further thinning out. This is due to the fact that the tree was started with but few branches, and, no inducement having been given the branches to subdivide into laterals, as would have been the case if heading back had been judiciously practiced during the early years of growth, they have made excessive and continuous terminal growth both to the disadvantage of structure and economy of handling. For such trees heading back into two branches and probably much older wood, to induce lateral growth, appears practical. Further thinning out would scarcely be practical, as it is assumed there are no more main limbs or branches than are required to insure a well-constructed tree. The remedy of heading back appears easy, far easier than the attainment of the ends sought by such practices.

With Spitzenbergs, it is obvious that there is a middle ground with reference to desirable amount of wood growth and vigor of tree, on the one hand, and first class fruit production, on the other. This variety seldom produces high-class fully-colored fruit when accompanied by excessive wood and leaf development. Indeed, it may be said that oversized fruit and poor color seems to be the rule whenever the tree's vigor exceeds the point of moderate wood and leaf growth. I have seen no better colored Spitzenbergs anywhere this year than those observed on a very devitalized tree, which had scarcely any foliage and which was making practically no wood growth. The quantity of fruit was, of course, small and the prospects for future crops exceedingly poor, because of the weak spur
development. It must also be said that the fruit this year was but moderate sized.

Attention is called to this fact to illustrate a point of great importance in the pruning of this variety. Heading back and thinning out have been suggested in certain cases where tree structure will permit. How much? Shall it be light or heavy? Shall it extend into the second-, third-, or even fourth-year-old wood? Possibly so. This depends largely upon the natural vigor of the tree, crop prospects for next year, soil treatment, irrigation, etc. As an illustration of what excessive cutting back will do, let us again refer to the devitalized trees above mentioned. (Figure 9, tree in background). Just opposite the row in which these trees are situated, there is another row of Spitzenbergs of the same age and under identically similar soil conditions. Both are on a Hood Silt soil, long since depleted of organic matter by clean culture. In the spring of 1915, these trees

![Fig. 9. Showing results of excessive cutting applied to a Spitzenberg tree. Tree in background received little pruning and is making practically no growth. Both trees represent undesirable extremes.](image)

(those in foreground) were pruned very heavily. Many of them were practically “dehorned” the shears penetrating into four-year-old wood. Today there is a marked contrast in all respects between the trees in the two rows. In the former case, as suggested, the trees are merely the framework of the tree without the outer covering, so to speak. In the latter case the trees act in a general way as though heavily fertilized. There has been a good deal of new growth over the entire tree. Sucker growth is abundant, especially in the region of the heavier cuts. The identity of former fruit spurs has been swallowed up in many cases by this new growth. Leaf development has been green and vigorous. Fruit prospects for next year are but fair. This is true because of the disturbed equilibrium of fruit spurs, many of which will have to readjust themselves before fruiting again. The future production of these trees, however, depends not so much upon old spurs, but upon the formation of many new ones on the newer growth. It is noteworthy that for these trees there is
abundant opportunity for the formation of fruit spurs. In the case of the lightly pruned trees in the background, this is much less so because of their failure to make sufficient new growth. This year the trees in the background bore an average of only six boxes per tree. The fruit was of moderate size and excellent color, as mentioned. The heavily pruned trees, on the other hand, produced on the average, less than one and one-half boxes each. The fruit was large, averaging about 88 to 100 to the packed box. Color was extremely poor. Evidently the amount of cutting has been excessive. This illustrates what may occur as a result of heavy pruning even on a poor soil and suggests strongly what such work will lead to if practiced on a rich soil where natural or artificial fertilizers may have been used.

And yet it is altogether possible to avoid this undesirable feature caused by heavy cutting. This refers more to corrective pruning than to annual pruning of properly balanced trees when the cutting may be distributed over a number of years. Lighter cutting suggests itself. However, it must be borne in mind that the response in varieties naturally given to terminal growth will be near the cut. Things being equal, it follows that the lighter the cut, the further extended will be its influence upon the fruit spurs in the lower portions of the tree, that portion which presents the undesirable fruiting conditions and which we are most anxious to assist. Heavy cutting when the trees have many fruit buds will be done with greater safety than when the trees are filled mostly with leaf buds. In the latter case, overstimulation to wood growth would likely occur and throw the tree out of balance for a year or so. It is evident that in such aggravated cases, the pruner must choose between the two extremes, in other words, take the happy medium. This does not refer to the problem of summer or winter cutting, but to the fact as a well-established principle. It is possible that other conditions may be established to solve the problem. Small applications of fertilizer such as nitrate of soda, different systems of culture, irrigation, etc., may extend a helpful influence. There are, however, distinct problems in themselves and will not be considered here.

Newtowns also present a distinct pruning problem. Last summer the writer cut from the center and lower parts of a seventeen-year-old Newtown tree a number of long, pencil-like branches or switches that were from three to five feet long. (Figure 10). These were the continuation of growth of shoots which originally were about twelve to fifteen inches long and on which fruit had been borne. These long shoots were largely devoid of vigor. Lateral buds, as will be noted during the active growing season, have failed to make lateral growth or even fruit spurs. Many have remained absolutely dormant for several years and small weak terminal growth only has been the rule. Near the end of these long branches, swaying in the wind, the only fruit borne on this part of the tree was found. It was of poor quality and size. This, then, is a distinct case of terminal growth in a tree which is naturally inclined to make lateral growth. This in spite of the fact that the tree was making a good growth, especially in the upper and outward portions of the tree. Here we have a case of many possibilities (lateral buds referred to) which gave promise but have failed to justify their existence. Theoretically, every bud represents the possibility of becoming a future spur. It is of course not possible or even desirable that an undue number of fruit spurs should be
formed. However, the other extreme represented shows altogether too high a percentage of buds that are unproductive. Owing to the dense shade prevailing on the lower and inner parts of the tree, the result has been a natural elimination of the spurs and shoots of a productive nature. The terminals, as will be noted, have continued to struggle for light and air.

What may be done to overcome this condition? How may these unproductive areas be reclaimed? How, also, may we prevent the shorter, now productive shoots from becoming the same? The possibility of a light application of fertilizer has been suggested for Spitzenbergs. This idea loses force in this regard when it is recalled that many trees exhib-

Fig. 10. Small branches taken from densely shaded portion of a Yellow Newtown tree of mature age. Inferior fruit only was found here. Note the percentage of buds remaining mature. Trees should be kept partly open to admit air and light. Leaves became withered before picture could be taken.

iting most of the undesirable tendencies referred to are already making a vigorous growth. Trees are not lacking vigor as a whole, but in the center portions.

From the foregoing, it is evident that this is a distinct pruning problem. It is also evident that pruning practices adopted to overcome this tendency will be either distinctly corrective, the idea being quick recovery, or a practice which designs to distribute the work of corrective pruning over a longer period. The pruning may be of three distinct sorts: heading back, thinning out, or a combination of the two. Of these three practices only two, that is, thinning out, or thinning out and heading back, may be considered as distinct practices in the sense as representing a definite pruning policy which may be consistently followed for a number
of years. This is much less so with heading back depending upon the lightness or heaviness of cutting.

Having considered pruning methods, which of them may be followed to best advantage in restoresing the productive area and maintaining it in that condition? It is evident that considerable thinning out of the upper branches, which cause excessive shading, must be resorted to, no matter what other practice, in conjunction with this one is used. Again, it will be recalled that the Newtown bears considerable fruit on the terminal buds. It must also be remembered that those buds borne terminally or near the upper half of new growth are those from which future spurs will be formed. Heavy cutting beyond those buds into the leaf buds usually results in lateral growth and does not immediately influence the formation of fruit spurs. It is evident that heading back will remove these buds and consequently the fruit borne or to be borne in this manner. Yet it is evident that this must be done at least cautiously to stimulate the dormant buds below. Whether this be light or heavy depends largely upon the length of undeveloped growth and the number of new laterals desired. A 30% cutting may be considered light. This means removing the upper three buds of a shoot containing ten buds. A removal of 60% of the buds, on the other hand, would be considered heavy cutting and consequently more laterals probably would be the result. It is evident, therefore, that if this is practiced exclusively by the grower whose fruit is largely developed at or near the end of the terminal growth the following fruit crop will be lost. If this kind of cutting is to be done, then, it must be distinctly for corrective purposes only, rather than as an annual practice, in cases where the trees of this variety are making a poor growth, and are accompanied by the tendencies illustrated in Figure 4. The possibility of heavy winter thinning out and heading back to stimulate an abundance of wood growth, this to be followed by thinning out of excess growth the following summer to permit the upper axillary buds on the new growth an ample amount of light and air, offers many possibilities in view of the principles already laid down regarding the relation of fruit-spur formation to the location of such buds. At first sight, it may seem inconsistent to advocate thinning out of wood in order to secure more to take its place, but it must be remembered that we are seeking to rid the tree of hundreds of thousands of buds which no longer give any possible promise of forming fruit spurs and consequently occupy valuable space, and to replace them with buds of another character from which we may expect future crops.
ALFALFA FERTILIZERS.

By Gordon G. Brown.

Three experiments conducted in the open field during 1916 were closely watched to determine the relative influence of land plaster and flowers of sulfur. Owing to the fact that excellent results from both fertilizers have been secured at the Southern Oregon Experiment Station, it was deemed advisable to give them a thorough trial under Hood River conditions. By land plaster is meant a treated form of raw limestone commonly used to correct acidity of the soil. This distinction is made in order that the different forms in which calcium appears may not be confused. Land plaster is chemically indicated by the symbol CaSO₄·2H₂O, otherwise known as gypsum. The other is indicated by the symbol, CaCO₃. Other forms in which calcium is carried are known as burned lime, CaO, (that which is capable of slacking) and air-slacked lime. Careful distinction between these different forms should be made. The common assumption is that land plaster will correct acidity. Chemists tell us, however, that this is not the case. As a matter of fact, the acid radical contained in this compound is capable of combining with water to form sulfuric acid. Limestone, however, will correct acidity.

Careful determinations made by the Southern Oregon Station indicate that the sulfur content of alfalfa is very high. Where especially good stands of this crop have been secured, chemical tests show that the soil is also well supplied with sulfur in one or many of the different chemical forms by which it is capable of being absorbed by the plant. Many different kinds of fertilizers have been applied to this plant with various degrees of success. Iron sulfide, superphosphate, land plaster, flowers of sulfur, sulfate of potash, and other compounds carrying sulfur have all produced increased yields. On the other hand, when calcium, potassium, and iron, which are carried in the compounds mentioned, were applied singly or in combination, results were negative. Putting all this evidence together, points unmistakably to the fact that sulfur is a valuable fertilizer for alfalfa. It has also caused good results when applied to clover and the other leguminous crops.

Results from applications of land plaster and flowers of sulfur at Hood River this year have been very satisfactory. Air-slacked lime was also used, but results were negative. All were applied in March by broad-casting. Land plaster was used at the rate of 100 pounds and 200 pounds per acre. Another plot represented a 200-pound total application, one-half of which was applied at the time mentioned, the remainder being applied after the first cutting before irrigation. Applications of nitrate of soda failed to produce additional yields.

One interesting feature is found in the fact that a 100-pound application of land plaster per acre to plants which were unthrifty for a number of years produced even better yields than that recorded for an application double that amount. The latter plot producing a total of 5660 pounds cured hay per acre versus 7522 for the former, compared with 2104 pounds for the non fertilized. In this experiment air-slacked lime failed also to produce increased yields, but when followed by a 100-pound application
of land plaster at the end of the first cutting the plants immediately took on renewed vigor and easily surpassed the unfertilized plot, on a total season's yield by the end of the last or third cutting. This despite the fact that the first cutting showed 1168 pounds for the check versus only 480 pounds for the other.

A 16.6-pound application of sulfur (this amount being the sulfur equivalent carried in 100 pounds of land plaster) in another experiment, produced a total yield of 7650 pounds or a gain of 890 pounds over the check. On the other hand, a 200-pound application of sulfur produced 9880 pounds or an increase of 3120 pounds over the check. In this case land plaster applied at the rate of 100 pounds per acre showed a total yield of 11300 pounds per acre. As is apparent these fertilizers were applied to a very thrifty and uniform stand of plants. In this experiment, there was also a plot which represented a total of 200 pounds applied, one half applied early and one half after the first cutting. In this case, a slight gain of about 400 pounds per acre per cutting is the result. Despite these figures, which do not show any great margin in favor of the second or heavier application of land plaster, it would seem that the lighter applications are the most economical when applied each year.

Another experiment on which records for the first two cuttings only were secured showed that a 200-pound application of sulfur produced a total of 6500 pounds per acre and a 100-pound application of land plaster, a total of 8300 pounds. The second cutting was not so large as the first cutting. The third cutting showed the two fertilized plots far in the lead over the check, which at this time had scarcely enough to warrant the cost of harvesting. At this time, apparently, the sulfur and land plaster plots were about even. As would naturally be expected, the stand in these plots was not as heavy as for the first cutting at which the former produced 4100 pounds and the latter 6000 pounds. The total yield for the check was but 234 pounds.

In connection with these experiments it is worthy to note that sulfur is quite insoluble in water, for which reason it does not become immediately available for plant growth. It is recommended that this be applied, if at all, in the fall or not later than January or February. Land plaster should be applied as early as March to produce good results. As long as the latter produces good results and is less expensive than sulfur, its use is to be advised, for the present at least.

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