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ORCHARD SPRAYING EXPERIMENTS.

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MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.

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BULLETIN No. 198.

ORCHARD SPRAYING EXPERIMENTS.

W. W. Bonns.

INTRODUCTION.

In 1909 the Maine Agricultural Experiment Station came into possession of Highmoor Farm at Monmouth, Maine, the purchase of which had been authorized by the State legislature for experimental work in orcharding and other crops.

Such work was inaugurated in the spring of 1910. Several experiments aiming at the solution of orchard problems were begun at this time. It is the purpose of this bulletin to record only the work and results so far obtained in the plots devoted to spraying experiments with fungicides and insecticides.

It is not the purpose of the Station to plead for the establishment and furtherance of spraying as a common orchard practice in Maine. This must be emphasized by the State agents for agricultural education and extension. Spraying has long ago proved to be a profitable operation when intelligently and thoroughly conducted.* It remains for the experimenter in orchard work to concern himself, so far as spraying is concerned, solely with experiments that attack the problems arising from and proceeding with the extension of the practice.

Nevertheless the data resulting from a continued series of experiments along this line not only throw light upon the questions asked therein, but incidently furnish to the observant orchardist comparative figures whereby he may determine for himself whether the spraying of apple orchards is a profitable operation.

* For a concise account of an experiment dealing with this question see Farmers' Bulletin 479, U. S. D. A., pp. 8-10.
The results of the spraying experiments of the season of 1910 have already been published* and will be but briefly reviewed here.

EXPERIMENTS AT HIGHMOOR FARM 1910.

"The experiment aimed at determining the following points:

1. The comparative efficiency of the lime-sulphur sprays and bordeaux mixture as fungicides, especially for apple scab.

2. A comparison of these sprays in regard to possible injury to foliage and fruit on a variety especially susceptible to spray injury—the Ben Davis.

3. The effectiveness of arsenate of lead in combination with lime-sulphur solutions.

4. The relation of possible leaf and fruit injury to the combination of sulphur sprays with lead arsenate.

An orchard of 140 Ben Davis trees from 20 to 25 years old, of fairly uniform size and condition, and promising a moderate yield per tree, was divided into 12 plots. Plot 1 contained 9 trees. The remainder consisted of 12 each, excepting Plot 9, which contained 11.**

The table on page 3 gives data of treatment:

In making the self-boiled lime-sulphur, hot water was used and an attempt made to secure a large amount of sulphur in solution by making it in a small 10-gallon cask, conserving the heat by a covering during the process, and allowing it to stand for about 45 minutes before using. The lime was high grade and quick acting. Sulphur flour was used.†

The lime of the boiled concentrated spray was slaked with a thin paste made of the sulphur in hot water, more water being added up to a total volume of 10 gallons. This volume was kept constant while the solution boiled for one hour. After cooling

*Bonns, W. W., "Orchard Spraying Experiments," Bul. 180, Me. Agr. Exp. Sta., pp. 33-80, Pl. XII. Inasmuch as the size of the edition proved somewhat inadequate it has been considered desirable to briefly review the account of the work and the results contained therein.

**Two trees in Plot 12 were accidentally sprayed on one side in the second application and were omitted from the final count.

†It should be noted that the above method of making this mixture is in reality not the "self-boiled" preparation of Scott's recommendation, but an intensified modification, whereby more sulphur than Scott advises goes into solution. Concerning the self-boiled mixture see Appendix B of this bulletin, p. 32.
and straining it showed a density indicated in the table and was used at the same dilution as the commercial solutions.

Arsenate of lead was not added in any case until the time of application.

### Table I.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unsprayed</td>
<td>Niagara Sprayer Company</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lime-sulphur</td>
<td>Bowker Insecticide Company</td>
<td>34</td>
<td>1 1/2 gals</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Lime-sulphur</td>
<td>Sterling Chemical Company</td>
<td>34</td>
<td>1 1/2 gals</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Lime-sulphur</td>
<td>Grasselli Chemical Company</td>
<td>31</td>
<td>1 1/2 gals</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lime-sulphur</td>
<td>Jas. A. Blanchard Company</td>
<td>33</td>
<td>1 1/2 gals</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Lime-sulphur</td>
<td>B. G. Pratt Co.</td>
<td>32</td>
<td>1 1/2 gals</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>&quot;Sulfocide&quot;</td>
<td>Sterling Chemical Company</td>
<td>40</td>
<td>3/4 gal*</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Intensified Self Boiled Lime sulphur</td>
<td>Home made</td>
<td>10 lbs. lime, 10 lbs. sulphur</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Boiled lime sulphur</td>
<td>Home made</td>
<td>31</td>
<td>2 1/2 lbs. lime, 5 lbs. sulphur</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Bordeaux mixture</td>
<td>Home made</td>
<td>4 lbs. copper sulphate, 4 lbs. lime</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Bordeaux mixture</td>
<td>Home made</td>
<td>3 lbs. copper sulphate, 3 lbs. lime</td>
<td>2 lbs.</td>
<td>3 lbs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Unsprayed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The third application of "Sulfocide" was 3-16 gallon to 50 gallons water.† Boiled with a constant volume of 10 gallons water and used at same dilution as commercial concentrates.

### Time of Application.

Owing to the nature of the experiment, a hand pump outfit was used. The applications, made with Mistry Jr. nozzles, were exceedingly careful and thorough, and occurred on the following dates:

1st. When fruit buds began to show pink, May 13 to 16.

2nd. After the petals fell, June 7 to 9.

3rd. July 15 to 18."*

Weather conditions at the time of the first and last applications were favorable and remained so for some time thereafter. The second application was made during a period of extremely unsettled weather, with conditions most favorable for the production of spray injury, according to previous experiences with bordeaux. Showers were frequent and changes in temperature, humidity and sunshine intensity were great and sudden.

Results.

In the course of the season, observations showed that injury to fruit and foliage occurred in varying degrees on all sprayed plots. On all the lime sulphur plots such injuries were negligible for practical purposes, compared with the markedly thrifty condition of the leaves and the fine appearance of the fruit.

An unusual form of injury at the calyx or "bloom" end of the fruit was also noted and was ascribed to the lead arsenate in combination with the lime-sulphur solution. This, with the one exception to be noted, was also small enough in amount to be an unimportant factor.

Only one of the proprietary sprays (advertised as a soluble sulphur and not a lime-sulphur solution), did very severe damage to leaves and fruit, and proved to be the one instance where injury was caused by each application.

No differences great enough to indicate superiority were found among the several commercial lime-sulphur preparations, nor between them and the boiled home made solution. The intensified self-boiled mixture proved less effective as a fungicide. The concentrated lime-sulphur sprays in general showed superiority over bordeaux mixture in regard to the absence of fruit and foliage injury and effectiveness in fungus control. The sole exception in the latter respect was the home boiled solution, and the slight difference here can be accounted for on other grounds.

The conclusions drawn from this year's results were profoundly affected by some unknown factor, generally ascribed to the weather, which produced severe russetting and malformation of fruit on the unsprayed trees. Nevertheless, after taking this into account, the results tended to show the advantages of lime-sulphur sprays, commercial or home made, over bordeaux in a season which put all spray materials to a severe test.
The insecticidal value of lead arsenate was found to be un-
diminished when combined with lime-sulphur sprays.

The following table gives the results of inspecting all the
fruit. Each plot was examined for the scab fungus, (Venturia
Pomi (Fr.) Wint.), which was the only one seen on the trees
in this experiment; for insect injury indicated by curculio
stings or wormy fruit; for calyx injury and for fruit deformity
caused either by natural agencies, spraying, or these factors
combined.

**Table 2.**

<table>
<thead>
<tr>
<th>Plot</th>
<th>Treatment</th>
<th>Density of leaves</th>
<th>Number of apples</th>
<th>Per cent. scabbed</th>
<th>Per cent. scabbed*</th>
<th>Per cent. wrinkled</th>
<th>Per cent. Calyx injury</th>
<th>Per cent. wormy*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Check, Unsprayed</td>
<td></td>
<td>3.102</td>
<td>58.34</td>
<td>41.65</td>
<td>1.96</td>
<td></td>
<td></td>
<td>13.79</td>
</tr>
<tr>
<td>2 Niagara Lime-sulphur</td>
<td></td>
<td>7.736</td>
<td>92.70</td>
<td>7.29</td>
<td>2.22</td>
<td>1.75</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>3 Bowler Lime-sulphur</td>
<td></td>
<td>5.940</td>
<td>93.33</td>
<td>6.66</td>
<td>3.57</td>
<td>1.07</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td>4 Sterling Lime-sulphur</td>
<td></td>
<td>7.783</td>
<td>89.96</td>
<td>10.03</td>
<td>3.37</td>
<td>0.96</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>5 Grasselli Lime-sulphur</td>
<td></td>
<td>9.563</td>
<td>88.53</td>
<td>11.46</td>
<td>4.1\right)</td>
<td>3.21</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>6 Blanchard Lime-sulphur</td>
<td></td>
<td>7.699</td>
<td>91.08</td>
<td>8.91</td>
<td>1.64</td>
<td>0.61</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>7 Pratt &quot;Sulfocide&quot;</td>
<td></td>
<td>3.660</td>
<td>94.42</td>
<td>5.57</td>
<td></td>
<td>44.39†</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>8 Intensified Self Boiled Lime-sulphur</td>
<td></td>
<td>3.161</td>
<td>84.59</td>
<td>15.40</td>
<td>2.13</td>
<td>1.03</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>9 Boiled Lime-sulphur</td>
<td></td>
<td>6.551</td>
<td>85.25</td>
<td>14.74</td>
<td>1.31</td>
<td>0.09</td>
<td>1.23</td>
<td></td>
</tr>
<tr>
<td>10 Bordeaux 4-4-50</td>
<td></td>
<td>7.185</td>
<td>84.29</td>
<td>15.70</td>
<td>6.77</td>
<td></td>
<td></td>
<td>1.51</td>
</tr>
<tr>
<td>11 Bordeaux 3-3-50</td>
<td></td>
<td>5.315</td>
<td>85.96</td>
<td>14.03</td>
<td>5.79</td>
<td></td>
<td></td>
<td>1.97</td>
</tr>
<tr>
<td>12 Check, Unsprayed</td>
<td></td>
<td>6.092</td>
<td>59.24</td>
<td>40.75</td>
<td>2.17</td>
<td></td>
<td></td>
<td>7.33</td>
</tr>
</tbody>
</table>

* On sprayed plots 50 per cent. of respective amounts so slightly scabbed as to have fair
market value.
† Deformity and calyx injury sufficiently coincident to combine in one count.
‡ On sprayed plots practically all fruit under this heading (except Plots 1 and 12), was
injured by the curculio and not by the codling moth. The latter was thoroughly
controlled.

In planning the experiment for 1911, consideration was
given not only to the problems arising from the preceding
results at Highmoor, but also to the facts elicited and the ques-
tions arising from the recent work of other experiments in
this field.

In the course of a number of spraying experiments con-
ducted in several sections of the country, the use of arsenate
of lead alone as a spray material gave results worthy of note.

It appeared from the work of Taylor* and Waite** that

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*Taylor, E. P. "Spraying Peaches for Brown Rot." Western Fruit
**Waite, M. B., "Experiments on the Apple with Some New and
8 (1910).
lead arsenate had some fungicidal properties, or at least was capable of inhibiting fungus attack. Taylor came to this conclusion from work done in Missouri peach orchards where the curculio \((Conotrachelus nenuphar,\) Herbst) and the brown rot \((Sclerotinia fructigena\) (Pers.) Schroet.) were very pernicious. In this instance the control of the rot is largely credited as indirectly due to the insecticidal action of the spray in warding off the insect whose fruit punctures form sources of infection by the fungus. In another instance, however, reference is made to the absence of peach scab following the use of lead arsenate, and this is ascribed to its probable fungicidal properties.

In Waite's experiments in Virginia with apples, however, the action of lead arsenate is specifically recognized as fungicidal. Discussing the results obtained on the lead arsenate plot, the author states: “This spray gave excellent results, not only in its absence of injurious effects on the foliage and fruit but in preventing fungous diseases.………………. Furthermore, the spraying seemed to protect the fruits from the fly-speck, the smut fungus, and the fruit spots, just as in the case of the other mixtures.” *

He concluded that “this insecticide seemed to possess considerable fungicidal value, though probably not enough to be depended upon for general use.”

Wallace et al.** have also made extensive field and laboratory studies of the fungicidal value of spray mixtures, and included therein a test of the efficiency of lead arsenate diluted to spraying density, uncombined with other solutions. When so used it was found to reduce apple scab considerably and in mild cases to control it fairly well. Better percentages of control were obtained under field conditions than in the laboratory studies, and in both kinds of tests the addition of lead arsenate to lime-sulphur solutions increased the fungicidal value of the latter. Such increase is regarded by Wallace as due more to

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(Note—The author does not indicate in his report the specific organisms thus controlled. The lead arsenate in question was used at the dilution of 2 lbs. to 50 gallons.)
the changes resulting from the chemical combination of the two substances than to the simple addition of the arsenate.

In connection with the above experiment Wallace advances a theory accounting for the fungicidal action of the arsenate. He suggests that such action may be due largely to physical rather than chemical causes. Assuming that the leaf has been well sprayed and is thoroughly coated with a thin layer of insoluble arsenate, it would be possible for fungus spores to germinate in water on the leaf above this layer and still prevent the penetration of the germ tubes. This protective action might be reduced with the growth of the leaf, when the newer surfaces would be unprotected and the chances of infection greater.

On this hypothesis reliance must be placed on a spray material actually preventing spore germination, rather than on one merely presenting obstacles to germ tube penetration.

Other facts elicited by the work in question were the changes wrought in lime-sulphur used alone or with lead arsenate, in the presence of carbonic acid. This chemical compound is injected into the problem when the carbonic acid gas sprayer is used. It was found that under such conditions the soluble sulphur was precipitated before its application, but the resulting products were no less effective than the solutions applied by means other than the gas sprayer, after changes produced in them by exposure to the air had occurred. This appeared to be true irrespective of the use of the gas sprayer with lime-sulphur alone, or combined with lead arsenate. It was observed, however, that with the use of the gas sprayer in applying the two materials combined, arose the tendency to produce foliage injury, especially to the susceptible leaves of the peach.

For the past two years the work at Highmoor in spraying experiments has of necessity been confined to trees of fairly uniform condition, bearing a reasonable crop. These conditions have limited the work to the Ben Davis variety. Although other standard kinds are growing in the Highmoor orchards they were either scattered in a way poorly adapted to experimental work, or their poor condition rendered them unsuitable material. It was therefore considered very desirable that trials along lines similar to those being conducted in the Station orchard should also be made on other varieties in other or-
chards. Coöperative work under the supervision of the Station horticulturist was therefore begun in three orchards in the nearby town of Greene, owned by Messrs. H. Philbrook, J. Coburn and H. Keyser respectively. The writer wishes at this time to express his appreciation of the interest shown and the aid furnished by these gentlemen. A discussion of the work and results obtained in the Greene orchards will be made separate from the work at Highmoor.

It is a well recognized fact that in using the lime-sulphur preparations instead of bordeaux mixture in orchard spraying we are substituting for a spray that at the time of application is insoluble, one that is soluble and more or less caustic in nature, according to the strength of the solution. The basis, therefore, for the proper use of lime-sulphur sprays has been the determination of the strength of the stock solution, and its dilution for use according to its density. Simple instruments for this purpose and dilution tables graded for a scale of densities have been, and still are the only safe means of using lime-sulphur as a summer spray which, so far as known, will insure both fungicidal effectiveness and freedom from spray injury.

Nevertheless it is a matter of practical interest and importance to determine what may be the limits of dilution for a specific density, in regard to injury and to efficiency: in other words, can a solution of a known density be safely used at a reasonably greater strength than that indicated by its place in the dilution table, or can it be diluted beyond the amount indicated in the table, and still be an effective fungicide?

**EXPERIMENTS AT HIGHMOOR FARM, 1911.**

The experiment for this year, therefore, in addition to securing further comparative notes on the effectiveness of lime-sulphur and bordeaux mixture, aimed at the accumulation of data bearing on the points discussed above.

Both the lime-sulphur and the bordeaux preparations were home made. The latter was of 3-3-50 strength and the lime-sulphur was made according to the boiled stock solution formula.* A reliable commercial brand of lead arsenate was used throughout.

*Explanation of bordeaux 3-3-50 and directions for making and diluting concentrated lime-sulphur solutions are given in the Appendix.
The home made lime sulphur concentrate registered 27 degrees Beaumé density. This, according to Van Slyke et al.* should be used at a summer strength of 1 gallon to 29.5 gallons of water, or 1.69 gallons of concentrate for 50 gallons of spray. In the Highmoor experiment, therefore, 1 2-3 gallons was used upon the block to be sprayed with the recommended "standard" dilution. Two other blocks of equal size were sprayed with the same concentrate at dilutions of 2 gallons to 50 and 1 1-4 gallons to 50 respectively, or 20 percent stronger and 25 percent weaker, respectively, than the standard given according to the dilution table.**

The remaining portions of the experimental plot were divided into three parts. Two of these were treated simply with arsenate of lead, at 2 and 4 pounds to 50 gallons of water, respectively; the other was sprayed with the 3-3-50 bordeaux mixture plus 2 lbs. of lead arsenate. The lime-sulphur solutions also included 2 lbs. of arsenate to 50 gallons of spray.

All applications on all divisions of the plot were made with the Niagara carbonic acid gas sprayer.

The same block of Ben Davis trees used in 1910 served for the work under discussion. It was divided and treated as indicated in the following figure.

** Plan of Experiment. **

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

A. Arsenate of Lead, 4 lbs. to 50 gallons.
B. Lime-sulphur, 2 to 50 gallons, +2 lbs. lead arsenate.
C. Lime-sulphur, 1½ to 50 gallons, +2 lbs. lead arsenate.
D. Lime-sulphur, 1¾ to 50 gallons, +2 lbs. lead arsenate.
E. Lead Arsenate, 2 lbs. to 50 gallons.
F. Bordeaux mixture, 3-3-50 +2 lbs. lead arsenate.


** The third application was made from a fresh stock solution registering 24 degrees Beaumé density, and was diluted on the above plan for the three blocks.
Time of Application.

The applications were made as aforesaid with the gas sprayer at 100 to 125 lbs. pressure. The machine was thoroughly washed out between use on each plot. Friend, Mistry Jr. and Scientific nozzles were used during the several sprayings, which occurred on the following dates:

1st. May 12 and 13. Flower buds half grown and showing pink at tips. Leaves fairly well developed.
2nd. May 30. After petals had fallen.
3rd. July 7 and 8.

Weather Conditions.

In regard to absence of rain or excessive humidity, the conditions for spraying were excellent. The season was one of exceptional drought. No rain fell from about April 1 until May 24. On May 29, one day preceding the second application, there was a precipitation of .2 inches. On July 6, again one day preceding the last application, .24 inches of rain fell.

The first rain following the first application occurred 11 days afterward: following the second, 2 days thereafter, and 7 days after the final spraying. The small amount of rain preceding the last application occurred during periods of high temperature.

The third application was made during two days of a week of exceptional heat: the relation of such extreme temperatures to spraying and its effect on fruit will be discussed later.

The following table gives the rainfall from the beginning of the record in April to the middle of the harvest.

Table 3.
Precipitation at Highmoor Farm. April 1-October 1, 1912.

<table>
<thead>
<tr>
<th>Date</th>
<th>Inches</th>
<th>Date</th>
<th>Inches</th>
<th>Date</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 24</td>
<td>.7</td>
<td>July 17</td>
<td>.6</td>
<td>Aug. 28</td>
<td>.65</td>
</tr>
<tr>
<td>May 29</td>
<td>.9</td>
<td>July 18</td>
<td>.26</td>
<td>Aug. 31</td>
<td>.17</td>
</tr>
<tr>
<td>June 1</td>
<td>.15</td>
<td>July 20</td>
<td>.18</td>
<td>Sept. 6</td>
<td>1.29</td>
</tr>
<tr>
<td>June 12</td>
<td>1.53</td>
<td>July 22</td>
<td>.05</td>
<td>Sept. 9</td>
<td>.14</td>
</tr>
<tr>
<td>June 13</td>
<td>.18</td>
<td>July 24</td>
<td>.62</td>
<td>Sept. 12</td>
<td>.02</td>
</tr>
<tr>
<td>June 14</td>
<td>.60</td>
<td>July 25</td>
<td>.25</td>
<td>Sept. 22</td>
<td>.47</td>
</tr>
<tr>
<td>June 15</td>
<td>.07</td>
<td>July 31</td>
<td>.40</td>
<td>Sept. 25</td>
<td>.32</td>
</tr>
<tr>
<td>June 16</td>
<td>.88</td>
<td>Aug. 9</td>
<td>.04</td>
<td>Sept. 27</td>
<td>.22</td>
</tr>
<tr>
<td>June 20</td>
<td>.03</td>
<td>Aug. 11</td>
<td>.46</td>
<td>Sept. 29</td>
<td>.65</td>
</tr>
<tr>
<td>June 28</td>
<td>.03</td>
<td>Aug. 17</td>
<td>.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 6</td>
<td>.24</td>
<td>Aug. 18, 19</td>
<td>.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 15</td>
<td>.11</td>
<td>Aug. 26</td>
<td>.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total         15.14
The maximum and minimum shade temperatures of the weeks in which the spraying was done are here given in degrees Fahrenheit, the days of application being considered as the middle of the week. This will indicate the conditions immediately before and after the operations.

Table 4.
First Application, May 12, 13, 1912.
Maximum and Minimum Shade Temperatures May 10-16, Inclusive.

<table>
<thead>
<tr>
<th>May 10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>75.5</td>
<td>74</td>
<td>89</td>
<td>76</td>
<td>69</td>
<td>65</td>
</tr>
<tr>
<td>Min.</td>
<td>46</td>
<td>46</td>
<td>51.5</td>
<td>55.5</td>
<td>41.5</td>
<td>41</td>
</tr>
</tbody>
</table>

Table 5.
Second Application, May 30, 1912.
Maximum and Minimum Shade Temperatures May 27-June 2, Inclusive.

<table>
<thead>
<tr>
<th>May 27</th>
<th>28</th>
<th>29</th>
<th>30</th>
<th>31</th>
<th>June 1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>78.5</td>
<td>87</td>
<td>83</td>
<td>78</td>
<td>68</td>
<td>74</td>
</tr>
<tr>
<td>Min.</td>
<td>50.5</td>
<td>52</td>
<td>59</td>
<td>58</td>
<td>47.5</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 6.
Third Application July 7, 8, 1912.
Maximum and Minimum Shade Temperatures July 4-10, Inclusive.

<table>
<thead>
<tr>
<th>July 4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>103</td>
<td>93</td>
<td>99</td>
<td>86.5</td>
<td>81</td>
<td>94.5</td>
</tr>
<tr>
<td>Min.</td>
<td>79</td>
<td>70</td>
<td>66</td>
<td>63</td>
<td>55</td>
<td>59</td>
</tr>
</tbody>
</table>

It is also desirable here to note the temperatures for the following week of July 11-18 inclusive, given below, in the light of observations and deductions made from the experiment.

Table 7.
Maximum and Minimum Shade Temperatures, July 11-17, 1912, Inclusive.

<table>
<thead>
<tr>
<th>July 11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>97</td>
<td>93</td>
<td>86</td>
<td>82</td>
<td>83</td>
<td>79</td>
</tr>
<tr>
<td>Min.</td>
<td>72</td>
<td>70</td>
<td>61.5</td>
<td>56</td>
<td>58</td>
<td>57</td>
</tr>
</tbody>
</table>
The humidity records, owing to inaccuracies in the self-recording hygrograph, are omitted. The precipitation and temperature tables given above, when considered in relation to the dates of spray application, will show that atmospheric humidity may be considered a negligible factor.

No dew formed in the night following the extremely hot days above recorded, so no consideration of lens action of intense light through drops of water need be included in a later discussion of fruit injury.

Results.

Effect on Foliage.

No injury whatever was noted on any of the trees in plots A to E, inclusive. The foliage, despite the unusually hot summer, coupled with insufficient rain, was most thrifty in all respects. Especially noticeable was the growth not only of the foliage as a mass, but of the size of the individual leaves. Evidently neither the strength of spray applied nor the existing conditions at time of application affected the foliage of these plots in any perceptible way.

In this connection it may be said that three or four trees in a row of about 20 Baldwins on the farm showed a moderate amount of leaf scorch. These trees were sprayed with the same solution and at the same strength as block C in the experiment,—i.e. in dilution table proportions. The injury was mostly marginal, scattered and in no way serious. The remainder of this variety in this row showed no evidence of having been affected. Considering that the Baldwin is regarded as less susceptible to foliage spray injury than the Ben Davis of the experimental plot, and that stronger applications did not affect the foliage of the latter variety in any way, the injury to the few Baldwins in question may be accounted for on the ground of individual susceptibility.

In plot F distinctly different results appeared. No spots that could be reasonably ascribed to bordeaux injury were in evidence up to the end of the second week in June. At that time the characteristic circular dead areas began to become noticeable * and increased very gradually throughout the sea-

* See Fig. 47. Me. Agr. Exp. Sta. Bul. 189.
son up to the middle of July. By August 11 the leaf injury on
this plot, although by no means comparable with that of the
preceding year, was still considerable in amount, and some yel-
lowing and leaf fall had already occurred.

The occurrence and development of this leaf injury when
viewed in relation to Table 3 clearly shows the well estab-
lished connection between bordeaux injury and rainy weather.

Effect on Fruit.

On June 1, about two weeks after the second application,
several of the small fruits on trees in plot B appeared distinctly
russeted. None were found at that time in plots A, C, D, and
E. In plot F very early stages of bordeaux injury flecks were
beginning to show.

Following the rains of the first two weeks in June there
appeared to be evidence of a slight increase in russetting in all
plots. Here again none of this was sufficient in amount to be
a serious matter from the commercial standpoint, even in a
large orchard, as the data will show. A few rare instances
occurred in all the plots where the apples were not only rus-
seted, but the russeted surfaces were grotesquely distorted with
irregular, corrugated and warty projections. So far as such
malformations are concerned, it may be said that in no con-
ceivable way can they be reasonably made to appear related to
spray injury. Such malformation was entirely different in
appearance from that accompanying the russeted fruit on the
trees sprayed with lime-sulphur in the preceding year's work.

As might be expected, the injury to fruit of plot F increased
with the rainfall of the two months preceding harvest. The
injury this year, however, was characterized less by the well
known bordeaux russeting than by an increased amount of the
earlier stages of injury, so that at picking time the fruit ap-
peared to be either well mottled with dull brown flecks a few
millimeters in diameter, or speckled with minute dots. This
gave to the fruit a general soiled, dull brown hue.

The coloring of the fruit from this plot, aside from the
effect just noted, was far below that of the apples on any of
the others. This is noteworthy in view of the fact that the
seasonal conditions were such that apples everywhere in this
State, regardless of treatment or lack thereof, were of especial-
ly fine color.
The fruit of the other experimental plots, benefited by the rains of later summer and the prolonged periods of sunshine, grew to unusual size for the variety and was of exceptionally high quality and color. The harvest occurred the third week in September.

In examining the fruits of all these plots it was found impracticable, on account of the presence of a crop far beyond the anticipated yield, together with lack of storage facilities, to set aside and examine individually each fruit from the entire experiment. The three smaller plots were examined in full. Of the three large plots B, C and D, one-half the number of barrels from each was selected at random, and thoroughly examined for the points indicated in the following table. It will be seen that the number counted in these three plots is roughly 50 percent of the totals and is a reliable index of the general run in each plot.

Insect Injury. Under the column "stung" are included apples stung by the curculio and fruits affected by some factor which caused isolated wart-like developments, sometimes russeted and sometimes entirely smooth. The cause of this deformity is not known.—at least it has not yet been proved to be of insect origin. There also exists the possibility that some of the stings and "dimples" produced are the work of the tarnished plant bug (*Lygus pratensis*), or some insects similarly affecting the fruit; but as no definite data regarding the presence of these insects in the orchards is available, all such deformed fruits have been included in the column for wormy apples. In connection with this it may be stated that at Highmoor the curculio-injured apples constituted not more than half of the respective percents in the column. Thorough cultivation is proving highly effective in reducing the injury from these beetles.

Leaf and bud eating insects were not numerous after the first application in any of the orchards, being well controlled by the arsenate of lead. The browntail moth (*Euproctis chrysorrhoea*), became much in evidence during the summer, but so far has done no damage in the orchard worthy of note. The tent-caterpillar (*Clisiocampa americana*) was very prevalent in the vicinity of Highmoor and did great damage to adjacent property, but none to the Station orchards.
Figs. 1 and 2. Sunscald on young Baldwins. Fig. 3. Section through 2, showing depth of injury. Fig. 4. Calyx injury on Ben Davis.
Of the small number of fruits classed as "wormy" practically none from the experimental plots were affected by the codling moth (*Carpocapsa pomonella*). The fruit so recorded had the appearance of having been attacked from the outside by some insect, but the injury itself was not sufficiently characteristic to enable the Station entomologists to determine the cause, since no insect was caught at work. These "worm holes" were in the nature of feeding punctures,—small, round perforations of the skin about the size of a pin head. The injury was little more than skin deep; no great cavity had been eaten beneath the skin. There was no trace of insect life in such apples when examined, and little that is definite can be stated regarding the cause of this trouble. Thus far it is, as indicated in the table, of very slight importance.

In regard to codling moth in all the orchards at Highmoor it may be stated that of the large crop of 2450 barrels not enough fruit attacked by this insect was found to fill 2 barrels.

*Fungus Control.* It will also be noted that apple scab was found on but one of all the fruits examined. A conservative estimate places the amount of scabby fruit in the Highmoor crop of 1911 at less than 500 fruits out of the crop previously mentioned. The chief cause for the absence of fungi will be discussed later.

*Sunscald.* An unusual factor in the growing season of 1911 was the intense heat wave lasting from July 4 to 13 (see tables 6 and 7), coupled with clear skies and intense sunlight. As a result of these almost phenomenal conditions, fruit was sunburned or scalded on the trees. The surfaces affected, in the case of small green Baldwin apples at Highmoor, turned a light tan brown; the epidermis became wilted and wrinkled (Figs. 1 and 2), and the tissues below discolored and shrunken (Fig. 3).

On Ben Davis and Greening fruit less wilting or shrinking of skin and softening of tissues was observed in early stages. The first indication of injury was a yellowish brown wash sometimes tinged with red, of fairly well defined area, although the margin was not in every case definite (Fig. 7). Later in the season the color of such areas took on a darker, blackened hue with more definite outline, and as the expansion due to

*This term is not to be confused with a winter injury of the same name affecting trunk and limbs.*
growth of the adjacent healthy tissue continued, it ultimately tore apart the dead areas and prominent splits or clefts appeared (Figs. 5 and 6).

The discussion of sunscald and spraying is considered later.

The table on page 17 gives the data according to the respective observations.

**Discussion.**

*Calyx Injury.* Only one instance of the calyx injury observed quite generally in last year's plots was found the past summer. This was seen in a few fruits of one or two Ben Davis trees belonging to another experiment, and which are and have been in sod for an unknown period. In this soil environment they have been naturally quite unthrifty, with poor and small amount of foliage. Their fruits in 1911 were remarkable for small size. Fully fifty percent were no larger than the larger crab varieties. (Fig. 4).

The fact that such injury was confined to these few unthrifty trees, whereas none whatever was to be seen during the season on several thousand trees of the same variety in vigorous condition; and the further fact that the trees showing such injury last year were in that year experiencing their first season of renovation, and were to a large degree bearing good fruit in 1910 more in spite of preceding neglect than as the result of any direct response to that year's treatment, raises the question whether or not such calyx injury was not indirectly due as much to the lack of vigor as indicated by the tissues of the fruit, as to the caustic action of the spray.

In a discussion of this calyx injury in an earlier publication * the writer attributed it largely to chemical reaction between the lead arsenate and lime-sulphur when combined. It has been found that such combination tends to release arsenic in soluble form, and this would in itself furnish the grounds for an explanation of such injury.

The fact, however, that the same spray materials were used this year, would present the same conditions, so far as formation of soluble arsenic is concerned. Furthermore, on the basis of Wallace's results, previously mentioned, we might expect a more serious injury when lime-sulphur and lead arsenate were

*Pub. 189, Me. Agr. Exp. Sta. (1911).*
Fig. 5. Scurfscald on Greening. Sprayed once, before buds opened.

Fig. 6. Scurfscald on unsprayed Ben Davis.
### Table 8.

Data of Spraying Experiments at Highmoor Farm, 1911.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.994</td>
<td>25.0</td>
<td>35</td>
<td>0.5</td>
<td>85</td>
<td>1.2</td>
<td>67</td>
<td>0.9</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>A</td>
<td>Arsenate of Lead, 4 lbs., 50 gals. water</td>
<td>9</td>
<td>6,773</td>
<td>6,773</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>2 gals. Lime-sulphur, 2 lbs. Lead Arsenate, 50 gals. water</td>
<td>35</td>
<td>35,471</td>
<td>14,451</td>
<td>2,361</td>
<td>16.3</td>
<td>644</td>
<td>4.4</td>
<td>194</td>
<td>1.3</td>
<td>216</td>
<td>1.7</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>C</td>
<td>1½ gals. Lime-sulphur, 2 lbs. Lead Arsenate, 50 gals. water</td>
<td>35</td>
<td>35,530</td>
<td>15,102</td>
<td>1,512</td>
<td>10.0</td>
<td>168</td>
<td>1.1</td>
<td>209</td>
<td>1.3</td>
<td>166</td>
<td>1.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>D</td>
<td>1½ gals. Lime-sulphur, 2 lbs. Lead Arsenate, 50 gals. water</td>
<td>35</td>
<td>35,530</td>
<td>15,102</td>
<td>1,512</td>
<td>10.0</td>
<td>168</td>
<td>1.1</td>
<td>209</td>
<td>1.3</td>
<td>166</td>
<td>1.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>E</td>
<td>Arsenate of Lead, 2 lbs. Lead Arsenate, 50 gals. water</td>
<td>12</td>
<td>10,323</td>
<td>10,323</td>
<td>1,828</td>
<td>17.7</td>
<td>100</td>
<td>0.9</td>
<td>209</td>
<td>1.3</td>
<td>166</td>
<td>1.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>F</td>
<td>Bordeaux Mixture, 3-3-50, 2 lbs. Lead Arsenate</td>
<td>12</td>
<td>6,833</td>
<td>6,833</td>
<td>679</td>
<td>9.9</td>
<td>38</td>
<td>0.5</td>
<td>166</td>
<td>2.4</td>
<td>4835</td>
<td>70.7</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>139</td>
<td>193,294</td>
<td>67,619</td>
<td>9,636</td>
<td>14.2</td>
<td>1,420</td>
<td>2.1</td>
<td>1,064</td>
<td>1.5</td>
<td>5,764</td>
<td>8.5</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

* The grouping of apples under these headings is explained on pp. 14 and 15 respectively.
† Fruit spotted, not much russeted. Early stages of bordeaux injury.
‡ It must be noted that the high total per cent. of russeted fruit is due to the inclusion of the great amount of bordeaux injury. Omitting fruit injured by bordeaux mixture the percentage of russeted apples is 1.3.
applied with the carbonic acid gas sprayer, as in the work of
the past season.

On the contrary, no such effect was noted at Highmoor or
in one of the coöperative experiments where a like sprayer and
the same ingredients were used. In the present state of knowl-
edge we may therefore admit the possible presence of soluble
arsenic in the lime-sulphur-lead arsenate combination and still
suggest as a plausible explanation of calyx or similar injuries
the strength of such soluble arsenic in relation to the health of
the tree, as indicated by its physiological resistance expressed
in the apple tissues at time of spraying.

Effectiveness in Fungus Control. No conclusions can prop-
erly be made from this season's work, either in regard to the
relative effectiveness of the several lime-sulphur sprays in
various dilutions or the comparative efficiency of them and
bordeaux mixture. The cause of this is the unusually hot, dry
summer, preceded by a very warm dry spring. Under condi-
tions such as these the spores of fungi parasitic to the apple
could neither germinate to any degree nor make much growth
after germination. This is shown by the presence of only one
scabby apple in the entire experiment.

For the fruit grower such a season adverse to the dissemina-
tion and propagation of fungi is a great boon. To the worker
in experiments with fungicides the contrary is true, for with-
out the presence of parasites in considerable amount the experi-
ment fails utterly in this respect.

Fungicidal Efficiency of Lead Arsenate. The explanation
just given holds here for lack of data on this point. Work of
this nature must be repeated until a sufficient number of sea-
sons with conditions favorable for the accumulation of experi-
mental data have passed. In this respect the work of 1911 well
demonstrates the futility of making well defined deductions
from the results of one or a few years' work.

Relation of Russetting to Lime-Sulphur. Nothing in the
results of this year indicates any relation between the small
amount of russetting found on the several plots and the nature
of the spray applied. The table of results shows that the plot
sprayed with lime-sulphur at dilution-table strength yielded
practically the same percent of russeted apples as the plot
sprayed with a strength 20 percent stronger than the table
Fig. 7  Sunscald on Ben Davis, showing relation of sunscald to exposure.
recommends. Again, arsenate of lead used at the rate of 2 lbs. to 50 gals. yielded double the percentage of russeted apples when compared with the plot sprayed with 4 lbs. to 50 gals.

A fair percent of the russeted apples in the several plots, with the exception of plot F, were affected to a degree no greater than is frequently found on unsprayed trees. We are here again confronted with the question of physical and natural causes vs. chemical ones in attempting a solution of this question of russetting. This point will again be referred to.

_Lime-Sulphur Plus Lead Arsenate Applied with the Gas Sprayer._ If any conclusions might legitimately be drawn from the results obtained this year it would appear that the effect of carbonic acid gas upon the spray was, when the latter was applied in fair weather, entirely negligible. Fortunately this is not a critical question, as it seems that the gas sprayer for several reasons is being increasingly supplanted by other power machines.

_Sunscald._ That the injury so designated was in reality a scald produced by sunlight, there is no room for doubt. In the first place, it was, with practically no exceptions, found only on fruit upon the south and southern sides of the trees, and in general only where such fruit because of its relation to adjacent foliage was directly exposed to the sun. (Fig 7). Secondly, the injury on such apples was always confined to the surfaces exposed to light at the hottest periods of the day.

As previously stated, no lens action of intense sunlight through drops of dew can here account for any such injury, owing as aforesaid to the absence of dew formation at this period and to the great areas of the injured surfaces.

_Relation of Spraying to Heat._ Did spraying during this season bear any relation to the primary nature of the injury? This question is readily disposed of. Fruit on trees that have never been sprayed exhibited the characteristic burned surfaces. Trees on Highmoor Farm that received only the first application showed no injury to fruit until after the hot weather, when typical sunscald was found.

Did spraying affect the extent or degree of injury? This seems to be a debatable point. In order to obtain the views of
other observers, the writer sent a circular letter to Station botanists, horticulturists or pathologists of the several apple growing states that had been subjected to the heat wave of July.

Practically every reply confirmed the Maine experience in regard to the injury, its relation to the side of tree and fruit exposure, and all were unanimous in crediting the injury to sun and heat. Some also included drought as a factor.

In regard, however, to the relation of spraying to sunscald of fruit, these observers are of divided opinion. Of 12 replies 8 state that spraying during the heated term increased the degree of damage. The others consider the injury due to sunburn pure and simple.

The writer inclines to the belief of the majority of his correspondents, to the extent that spraying during the hot weather appeared to increase the severity where injured areas were present before this last spray was applied. Whether or not the chemical nature of the spray has any influence in raising the degree of injury produced is still an open question. As the data for 1911 shows, the amount of scald varied directly with the strength of lime-sulphur spray used. On the other hand the injury on the lead arsenate plots, although considerably less in amount, was qualitatively equally serious, as Figs. 3 and 9 indicate. Unsprayed trees suffered no greater injury than shown in Figs. 5 and 6.

The distinguishing characteristics of spray injury as separate from sunscald, given by one of the aforementioned correspondents who attributes the injury of the past season entirely to sunscald, tends to confirm our opinion as just stated. His statement is as follows:

"The sunscald with us (fruit of apple), appeared as discolored sunken spots or maculations with a sharply defined margin. In the case of spray injury the tissues are never sunken, nor is the margin well defined, and the epidermis is scurfy, not smooth as in the case of sunscald. The epidermal tissues are brown and the discoloration more marked immediately beneath the epidermis in the case of sunscald, but in the case of spray injury they present no abnormal appearance."

An examination of Figs. 5 and 6 and Figs. 10 and 11 will lead one to conclude that if such distinctions hold, we have in the illustrations just referred to, sunscald as evidenced by the discolored, more or less sunken spots with rather well defined mar-
Figs. 8 and 9. Ben Davis, sprayed with arsenate of lead. Injury confined to sunscalded areas.
gins; in addition, the epidermis is scurfy, which, according to our correspondent, is a sure sign of spray injury. Furthermore, our observations in 1910 as well as in the past season showed that the tissues beneath the epidermis became discolored and depressed as well from spray injury alone as from the sunscald of the past summer.

In comparing the amount of scald on trees sprayed with lime-sulphur and bordeaux mixture, it is seen that the percent of injury in the latter plots is very small indeed. This is in accord with the consensus of observation of other men. In short, while lime-sulphur inflicted a very moderate percent of damage in connection with the sunscald, bordeaux seemed to effect far less; and the same holds true for lead arsenate when used alone. The degree of injury, however, was as severe on the two last named as on the lime-sulphur plots.

The most feasible explanation of the past season's fruit injury (except, of course, the well known bordeaux injury) is, in the writer's opinion, that which regards the spray as an injury producer only on those tissues already affected by sunscald. This may be accounted for, according to the results at Highmoor Farm and at Greene, by the fact that on trees subjected to the first application only, (Fig. 5) and on unsprayed trees observed elsewhere, (Fig. 6) the injury, while sufficient to throw the fruit out of market class, was nevertheless much less accentuated than the scalded spots on fruit sprayed during the extreme heat.

The chief point to be emphasized is, that the excessive injury upon the sprayed fruit was distinctly confined to the previously or contemporaneously sunscalded areas. Figs. 10 and 11 show two extremes of injury on sunscalded apples from the lime-sulphur plots, selected from a series of photographs showing gradations in order of severity. Figs. 8 and 9 illustrate similar injury on fruit sprayed with lead arsenate alone.

COOPERATIVE EXPERIMENTS. AT GREENE.

The Philbrook Orchard.

This is a Baldwin orchard pastured to sheep. The trees are fairly high headed, and give evidence of being in tolerably good condition. Judicious pruning might well be carried out here, for some of the trees had too much growth in the center of their tops.
The material used was supplied by the Station and consisted of the lime-sulphur concentrate and arsenate of lead used in the first two sprayings at Highmoor. It was, therefore, used at the same dilution as in plot C (p. 9). This also holds true for the other experimental plots in Greene.

The first application on May 16 occurred before blossoming, although closer to that period than would generally be recommended. Two or three days earlier would have been more seasonable, had conditions permitted. No damage, however, resulted to the buds just ready to open. The second application was on May 31 and the third on June 16.

The spraying in this experiment could not be carried on under circumstances approaching ideal conditions. Power was obtained from the ordinary hand-pump barrel sprayer, and the short spray rods and hose did not permit easy access to the large trees or allow such effective work as was desired.

Results. No spray injury was noted in this orchard at any time during the season. The same conditions that made for healthy foliage and clean fruit at Highmoor obtained here. Some slight insect injury was noted, and this was more severe on the unsprayed than on the sprayed trees. On the former browntails were decidedly in evidence.

A very slight amount of scalded fruit was first noted on August 30. This orchard, as well as the next one to be considered, was markedly free from this injury. This is doubtless due to the fact that the tops were fairly dense and the fruit well protected from the sun.

The data for this orchard was taken under handicaps: no assistance was available to the writer, owing to the great scarcity of labor at this particular time. In view of this fact, and of the absence of scab and sunscald, coupled with the limited amount of time, indicative rather than exact data had to be taken. For this over 2000 apples from the sprayed plot and an almost equal number from the unsprayed trees were selected at random from different parts of the barrels. These were examined solely for insect injury.

The results as given in the combined tables for the cooperative work (p. 25) will show a ratio of sprayed to unsprayed fruit of 9 to 24 percent respectively. The percent of the sprayed fruit is higher than need be, even considering the pos-
sible errors in methods of examination. It could doubtless have been reduced two-thirds with adequate equipment and more open growth of tree.

The Coburn Orchard.

Here were selected 12 scattered trees of four varieties, 4 McIntosh, 3 Baldwin, 3 Greening and 2 Ben Davis. With the exception of 2 McIntosh trees standing in the corner of an oat field, the trees were in sod.

The applications here also were made with a hand pump, but with longer leads of hose and longer spray rods than in the case aforementioned. The barrel was mounted on a stone boat, which allowed a closer approach to the trees, and the applications were in consequence somewhat more satisfactory than in the Philbrook plot.

The application before petal fall had to be omitted here, as the period of bloom was too near at hand to warrant risk of injury to the flowers. The first application, therefore, was after petal fall, on May 31. The second and last was on June 16.

Results. No spray injury to foliage or fruit was observed during several inspections throughout the season. A very moderate amount of sunscald was noted on Baldwin and Greening apples and considerably less on McIntosh and Ben Davis.

On August 30 the fruit in general was excellent in appearance; foliage likewise, except that there was increasing evidence of the blister mite (Eriophyes sp.). On one or two fruits of McIntosh, an exceptionally susceptible variety, scab was noted in small amount.

The Keyser Orchard.

Twenty-four vigorous bearing trees in two rows of 12 trees each were here selected, consisting of 19 Baldwins, 3 Greenings, and 2 Ben Davis. The aisle between these rows had been used as a garden and cultivated for 7 years; the bounding aisles had been cultivated every other year during the same period and seeded to clover. The year of the experiment the entire block was plowed about June 1 and cultivated up to July 6.

The first application occurred on May 31, as here also the early spraying before buds opened had to be omitted. Both this application, as well as the last on July 21 were made with
the Niagara carbonic acid gas sprayer and were very thorough in every respect.

The weather during these and all other applications in the Greene orchards was favorable. As the town is only 6 miles from Highmoor, the conditions described for the latter locality will apply fairly well for the cooperative work.

Results. By July 21 considerable sunscald had been produced. This was common to all trees, irrespective of the nature of the spray. Aside from the 24 trees in question, the rest of Mr. Keyser's orchards had been treated with the insoluble lead arsenate alone. Unsprayed orchards in the vicinity showed injury of similar nature and of equal amount.

The foliage here, as in all other plots considered in this bulletin, was most excellent. Scab was practically absent and the same was true of chewing insects.

No ill effect of the spray itself was found either on fruit or leaves. The adhesive power of the mixture was here, and in all the experiments under discussion, excellent.

The table on page 25 indicates the results. The same statement regarding the curculio-injured and the "wormy" fruits in the table of the Highmoor results (pp. 14 and 15) holds true here, except that the wormy apples in the Philbrook plot consisted almost entirely of injury done by the codling moth and other chewing insects. In the case of both Mr. Coburn's and Mr. Keyser's plots the conditions allowed for a full count of all the fruit on the trees.

Discussion. The results of the three plots at Greene may be briefly considered as a whole. As at Highmoor, we have this year learned nothing regarding the efficiency of lime-sulphur as a fungicide, since the development of fungi was practically prevented by weather conditions.

The use of a gas sprayer in making the applications produced no injury that could in any way be ascribed to it.

Where sunscald occurred, the injury was increased by later applications, irrespective of their chemical nature.

No foliage injury occurred from the use of lime-sulphur and lead arsenate combined.

Russetting in all these plots was so utterly insignificant in amount as well as degree that whether the few cases were due to natural agents or to spraying is totally immaterial, so far as the production of high grade fruit is concerned.
### Table 9.

Data of Coöperate Experiments, 1911.

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</table>

* Number of apples counted. For explanation of data from this orchard see page 22.
As in Table 8, the number of fruits indicated in the "Stung" column includes all apples with wart-like deformities, the cause of which is not known.

The apparently numerically large number of "wormy" Baldwins in Mr. Keyser's plot is not so great as it appears,—being but 2 percent. Here also, as at Highmoor, very few "wormy" apples were caused by the codling moth. The same statements made regarding such fruit in the discussion of the Highmoor results (pp. 14 and 15) hold for this case.

The scab on Mr. Coburn's McIntosh apples undoubtedly developed in storage during the damp weather intervening between harvesting and sorting. But few infections of the fungus were observed on the trees and the above is the only reasonable explanation of its increase.

Conclusions.

Regarding the several experiments as a whole, it is evident that the observations group themselves into two general divisions: one associated with a certain unusual, or perhaps we may say abnormal factor, distinctly associated with one seasonal period. To this factor, i. e., excessive heat, may be ascribed certain definite effects.

The other observations are associated with climatic conditions, the effects of which can only be considered to advantage on the normal or average results of many years. One year will vary from another in its total precipitation or in the relative times of the rainy periods, and upon such conditions the great prevalence or comparative absence of parasitic fungi may rest. Another year may be unfavorable to fungous epidemics and at the same time bring an invasion of insect pests. Again, these two groups of orchard enemies may combine forces, or on the other hand, the seasonal conditions may coincide with the presence of inhibitive factors to result in the absence of both fungus and insect injury to any practical degree.

This last named condition seems to have existed during the past season. Hence there is no data of any great value for estimating the fungicidal or insecticidal value of the sprays.

In the case of fruit russetting, none of the percentages from any plots are high and all are so nearly alike that no deductions are warranted. The relation of lime-sulphur injury to strength
of solution is not indicated in any way. Again, if the same percent of injury can be secured from both the lime-sulphur-lead arsenate combination (plot E), and the insoluble arsenate used alone (plot E); and if a double dose of arsenate (i. e., 4 lbs. to 50 gals.) used alone produces injury half as great as the 2 to 50 formula, it is difficult to point out any results that may well be attributed to chemical action.

Furthermore, the gas sprayer cannot well be held accountable for the results on the lime-sulphur plots at Highmoor, since these are contradicted by the results in the Keyser orchard at Greene, where the nature of the application was identical.

The following facts must also be kept in mind. The russetting in 1911 was in large measure no more severe than the "natural" russetting found on unsprayed trees. The weather conditions, according to past experiences, were adverse to the production of russetting; nevertheless, in a season almost ideal for the development of fine fruit, the bordeaux mixture was still able to effect a very high percent of injury (Table 8). The cause of the latter is well known to be indirectly due to meteorological factors acting upon the insoluble spray. Why may not such factors, if they are able to effect bordeaux injury in a comparatively favorable season, produce some damage to fruit otherwise treated? It would at least seem probable that if the sprays themselves (not including bordeaux) were primarily responsible, that some indication would have shown itself in the form of leaf injury on the plot treated with lime-sulphur solution 20 percent in excess of the recommended strength.

In general, then, we are led to the same conclusions published in last year's bulletin on this point,*—namely that spray injury may be, and very likely is, due as much to a physical factor, i. e., the application of a mist or spray to growing plant tissues under extreme, or some now undetermined, but unfavorable, meteorological conditions, as to any chemical action of the material used. Certain it is that spraying should be avoided if possible during such extreme heat as was experienced in Maine in July 1911.

Fruit growers must not be discouraged by the above statement into abandoning spraying operations. Granting the great-

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est amount of injury obtained under the conditions of 1911, it is seen that from the commercial standpoint the injury is altogether negligible in comparison with the advantages of annual crops of clean, worm-free fruit. Spray applications must, of course, be made at fairly definite, and in some instances at very definite, periods of the season. At times of unsettled weather or during very hot periods the orchardist must exercise his judgment with a view to applying his spray at an opportune time both in regard to making it effective and at the same time to avoid all possible ill effects that might be induced by unfavorable weather.

It is unlikely that a heat wave of such severity as that of last summer will be known in Maine for many years.—perhaps decades. Hence this question of sunscald in relation to spray injury will prove to be more a matter of scientific interest than a practical obstacle to the fruit grower. It is probable that with the highest of summer temperatures common to this State experiments with the spray pump can be made which will throw some light upon the relation of physical to chemical factors in this problem.

APPENDIX.

A.—Expressing Ingredients in Spray Formulas.

In discussing spraying experiments it is customary for authors to indicate the proportions of the materials used in a definite order. In general, the formulas for bordeaux mixture are given in the following order: Copper sulphate in pounds, lime in pounds, and the volume to which the ingredients are to be diluted with water, in gallons. Sometimes the amount of lead arsenate is inserted between the figure representing lime and that indicating final volume.

For example: 3-3-50 bordeaux mixture means that 3 pounds copper sulphate and 3 pounds of stone lime are used to make a spray solution of 50 gallons. 3-3-2-50 means that 2 pounds of lead arsenate have been added to the bordeaux of the strength indicated, after said mixture has been made and is ready to be applied.

A similar rule applies to the formulas for making the home boiled concentrated stock solution of lime-sulphur. In this
case, however, authors differ in the order of stating the ingredient amounts. Some give sulphur in pounds, lime in pounds, and dilution volume in that order. Others reverse the order of lime and sulphur weights. In practically all cases the order of ingredients in the formula is stated by the author.

Lead arsenate may be inserted in the lime-sulphur formulas as indicated in the example for bordeaux mixture.

In diluting the stock solution of lime-sulphur, either for a dormant spray or for summer use, the number of gallons precedes the total volume of mixtures ready for use. Thus, \( 1\frac{3}{8} - 50 \) indicates \( 1\frac{3}{8} \) gallons of concentrate diluted with water to a volume of 50 gallons.

B. DIRECTIONS FOR MAKING CONCENTRATED LIME-SULPHUR SOLUTIONS.

The directions given in former publications of this Station for the preparation of the stock solution have been superseded by the more recent chemical investigations referred to in this bulletin. The formula recommended is as follows:

Stone lime ......................... 40 lbs.
Sulphur ............................. 80 lbs.
Water sufficient to make .......... 50 gals.

Larger or smaller amounts can be made by multiplying or dividing respectively these quantities.

The lime must be of high grade, not less than 90 percent pure; no lime should be used that contains more than 5 percent of magnesium oxide. The sulphur should also be high-grade, either in the form of flowers of sulphur or sulphur flour. Do not use ground brimstone.

Place lime in the cooker. Make a thin paste of the sulphur with hot water and note the amount of water so used. Slake the lime with this paste, taking care neither to drown nor burn the lime in the process. Add water sufficient to make a total of 50 gallons. Bring to the boiling point, and boil vigorously for 1 hour, stirring frequently.

Before boiling begins the volume of liquid should be determined by a measuring stick. As the mixture boils, some of the water will evaporate. It is, therefore, necessary to determine the loss at short intervals by means of the stick and to add
water up to the original volume. If this is attended to frequently the water can be added without stopping the boiling of the liquid to any extent.

At the end of the hour the solution should be allowed to settle and should then be dipped out and strained through a fine sieve into a barrel or other container. Its density should not be determined while hot.

The surface of the liquid should be protected from the air by a layer of heavy mineral oil. By putting a spigot in the lower end of one of the staves the liquid can be drawn off from time to time, its surface will remain protected and no oil will go into the diluted spray. Stock solutions made and protected in this way can be put up in considerable amount in the months preceding the spraying season.

The most convenient vessel in which to make the concentrate is some form of iron stock feed cooker. Such vessels are made in various capacities. The size of cooker to be used should have a volume somewhat greater than the amount of concentrate to be made at one boiling; that is, a 50 gallon vessel will probably not hold 50 gallons of spray mixture, owing to the lime and sulphur present in addition to the volume of water. A cooker of about 35 or 60 gallons capacity should be large enough to make a stock of 25 or 50 gallons respectively.

This process is simple and requires but little experience. After one or two batches have been made, it will be found that if directions have been followed, the density of the several batches will not vary beyond a degree Beaumé, and frequently less. There should be the very slightest amount of sediment in the cooker after the liquid has been removed.

For very extensive spray operations in large orchards the concentrate can be made in larger amounts than 50 gallons at a time. This is not recommended, however, for the average Maine fruit grower.

Directions for making the self-boiled lime-sulphur mixture are not given. This preparation has in practically all cases been found to have much less fungicidal value and to be far less adhesive than the boiled solution. Directions for making it may be found on pp. 385-386 of Bulletin 185 of this Station.
C.—Dilution of Lime-Sulphur Concentrated Solutions.

Although fairly well understood, it is advisable to emphasize the fact that concentrated lime-sulphur sprays, commercial or home made, cannot be used with success by guess-work dilutions. The density of the concentrate must be determined by a hydrometer and the dilutions made according to the reading of the instrument and the dilution table.

Since the publication of the dilution tables in the bulletins of this Station in recent years, additional work has been done elsewhere relating to the chemistry of the lime-sulphur compounds and the most economical and effective dilutions to use.

The table * on p. 32 is recommended. The figures in parentheses are the number of gallons for the respective densities, determined to the hundredth part of a gallon. The numbers in heavier type are the practical amounts to use.

In practice, then, the first step is to determine the density with the hydrometer. Knowing the density, the table shows the amount necessary per 50 gallons of spray. Next, find the weight of a gallon of concentrate; then figure out the weight of the respective fraction shown in the table. The height of this latter amount of liquid can then be marked on a measuring stick. This, of course, need be done only once for each stock of concentrate.

For example, with a stock solution reading 31° Beaumé, having made a measuring stick showing the height in the measure of 2-5 of a gallon, it is only necessary for summer spraying to pour 1 2-5 gallons of the concentrate into a mixing barrel or barrel pump of 50 gallons capacity, fill with water and stir. Greater amounts are of course made in proportion.

Do not add arsenate of lead in any case until ready to apply the spray. It should be thoroughly stirred into the solution. 2 or 3 pounds to 50 gallons is considered sufficient. It should be thoroughly mixed with a few gallons of the water that go to make the total volume of spray so that it may be in a finely divided state and pass readily through the sieve.

* Based on Table XI, Bul. 329, N. Y. (Geneva) Agr. Exp. Sta.
Table io.

Stock Solutions.

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<th>Hydrometer reading. Density of solutions in degrees Beaumé.</th>
<th>Gallons of solution in 50 gallons of spray. (To be used when trees are not in leaf; for aphid eggs and scale insects.)</th>
<th>Gallons of solution in 50 gallons of spray. Summer spray; for scab and other fungi.</th>
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