SECOND PROGRESS REPORT
OF
HOP DISEASE INVESTIGATIONS
With Particular Reference to Downy Mildew
by
G. R. Hoerner, Agent, Division of Drug and Related Plants,
United States Department of Agriculture.
December 31, 1932.
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Harvest Scene - Oregon Hop Yard
HOP DISEASE INVESTIGATIONS

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INTRODUCTION

By the end of the growing season of 1931 arrangements were made to concentrate our continued field experimental work in the yards of the E. C. Horst Company near Independence, Oregon.

Two widely separated plots of several acres each were chosen in areas known to be infected with downy mildew.

While the local management of the yards in which our plots were located was sympathetic with the work and desirous of cooperating in its execution, our inability to completely supervise all of the field practices was distinctly detrimental. Most of the various operations were contracted to different individuals, few of whom were informed of our desires or interested in our plans. As a result, we were forced to adjust our experimental program to conditions over which we had no immediate control. This situation necessitated a tremendous amount of work and was in part responsible for inconclusive or negative results.

FIELD SURVEY

No reports reached us of the occurrence of downy mildew in either the California or Yakima county, Washington, hop-growing districts so that these areas were not visited during the season. One brief and incomplete survey was made of the Pierce county, Washington, hop-growing district early in May. Canadian hop-growing districts were also visited early in May in company with Mr. Walter Jones, Assistant Plant Pathologist of the
Dominion Laboratory of Plant Pathology at Saanichton, British Columbia.

Through observation and consultation, information was obtained which was both instructive as well as profitable because of its possible applicability to the downy mildew problem in Oregon and Washington.

Specific information relative to crown treatments and spraying will be referred to under their respective sections in this report.

The East Kent Golding variety, generally considered quite resistant to downy mildew, was found showing both basal spikes and leaf infection in the British Columbia Hop Company yards at Sumas.

The Bramling variety has also been considered quite resistant to downy mildew. In the Hulbert yards at Sardis an old planting of this variety was quite generally infected, although not as seriously as were Late Clusters. Both spikes and leaf infections were in evidence. The previous season this variety was reported as being very resistant to downy mildew, particularly on the cones, while both Early Clusters and Late Clusters were severely attacked. The variety N. 45, considered the outstanding English mildew-resistant development became heavily infected at Agassiz, B. C. during the past season.

In both Oregon and Washington all counties reported as showing infection in 1931 were again infected and in addition Jackson county, Oregon. The date of the first recorded appearance of the disease was advanced from March 28, 1931 to March 15, 1932.

Maps of both Oregon and Washington are presented showing the total number of plantings in each county reported infected. The green figures indicate data for 1930, blue figures indicate data for 1931 and red figures indicate data for 1932.

In addition to occasional information from a variety of sources
besides personal visitations, records of the Portland office of the
Bureau of Agricultural Economics, Division of Crop and Livestock
Estimates, were consulted.

Hop disease survey records covering Oregon and Washington have
been revised and brought up to date. A comparison of the incidence of
downy mildew infection for the years 1930 to 1932, inclusive, are
presented herewith.

<table>
<thead>
<tr>
<th>Oregon Counties</th>
<th>1930</th>
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<tr>
<td>Yamhill</td>
<td>4</td>
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<table>
<thead>
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<tbody>
<tr>
<td>Lewis</td>
</tr>
<tr>
<td>Pierce</td>
</tr>
</tbody>
</table>

It will be noted that in a number of counties there are fewer
reports of infection in 1932 than in 1931. This is not a true picture
of field conditions, and is a result of several causes: (1) no press
cutting service was available; (2) grower questionnaires were not mailed
covering 1932 conditions; (3) personal survey of hop yards was not so ex-
tensive in Washington and in some Oregon counties although a number of new
areas of infection were disclosed in 1932 that had not been previously
reported.

A more detailed summary of the incidence of downy mildew infection
is given by counties in both Oregon and Washington for the years 1930 to
1932.
Benton County:

1930: 1 Early Clusters; 4 Late Clusters; 1 Red Vines.
1931: 2 Early Clusters; 4 Late Clusters; 2 Red Vines.
1932: 2 Early Clusters; 8 Late Clusters; 4 Red Vines; 3 Bavarian.

Clackamas County:

1930: 7 Unknown.
1931: 3 Early Clusters; 6 Late Clusters; 8 Unknown.
1932: 1 Early Clusters; 17 Unknown.

Jackson County:

1930: No reports.
1931: No reports.
1932: 1 Late Clusters.

Josephine County:

1930: No reports.
1931: 5 Early Clusters; 4 Late Clusters; 1 Red Vines.
1932: 2 Early Clusters; 5 Late Clusters.

Lane County:

1930: 2 Late Clusters; 1 Red Vines; 5 Unknown.
1931: 3 Early Clusters; 8 Late Clusters; 5 Unknown.
1932: 2 Early Clusters; 17 Late Clusters; 4 Red Vines.

Linn County:

1930: 1 Unknown.
1931: 2 Early Clusters; 7 Late Clusters; 1 Red Vines; 1 Unknown.
1932: 6 Early Clusters; 13 Late Clusters; 3 Red Vines; 1 Fuggles; 1 Unknown.

Marion County:

1930: 5 Early Clusters; 6 Late Clusters; 57 Unknown.
1931: 19 Early Clusters; 40 Late Clusters; 43 Unknown.
1932: 8 Early Clusters; 13 Late Clusters; 3 Red Vines; 2 Fuggles; 52 Unknown.

Polk County:

1930: 2 Early Clusters; 4 Late Clusters; 12 Unknown.
1931: 12 Early Clusters; 29 Late Clusters; 3 Red Vines; 5 Unknown.
1932: 7 Early Clusters; 15 Late Clusters; 2 Red Vines; 2 Fuggles;
1 Golding; 17 Unknown.

Washington County:

1930: 5 Unknown.
1931: 2 Early Clusters; 7 Late Clusters; 5 Unknown.
1932: 9 Unknown.

Yamhill County:

1930: 1 Early Clusters; 3 Unknown.
1931: 3 Early Clusters; 2 Late Clusters; 6 Unknown.
1932: 1 Late Clusters; 6 Unknown.
Lewis County:
1930: 2 Late Clusters; 1 Unknown.
1931: 2 Late Clusters; 1 Unknown.
1932: No reports.

Pierce County:
1930: 1 Early Clusters; 10 Late Clusters.
1931: 3 Early Clusters; 10 Late Clusters; 1 Fuggles; 1 Unknown.
1932: 2 Early Clusters; 11 Late Clusters; 2 Fuggles.

Although the above data does not in all cases seem to so indicate, mildew damage appears even greater than was the case last season. Severe early season infection of growing vines was responsible in part, at least, for a very definite reduction in yield as compared with 1931. A harvest season very unfavorable to mildew revival or development prevented any general or serious cone infection at picking time.

In an attempt to place a monetary value on the losses caused by downy mildew, grower estimates were secured in 1930 covering in round numbers 6400 acres; in 1931 covering 4700 acres and in 1932 covering 2500 acres in Oregon. Average reductions in yields for the three years were approximately 30%, 31% and 31% respectively, which represented when interpreted in the light of yield estimates for the three years, 6,150,000; 7,040,000 and 6,310,000 pounds respectively. Appraising this loss on the basis of average price per pound of the hops in the respective years covered the totals amount to an amazing sum. Direct and indirect losses occasioned in Oregon and western Washington since mildew first appeared could safely be placed at $1,000,000.00.

WEATHER RECORDS

Weather observation Stations Numbers 1, 2 and 3 as described in our first Annual Report were continued. Despite attempts at adjustment the hygrothermographs continued to record both humidity and temperature at variance with the weekly sling psychrometer readings. Detailed data are on
file but are not included here because no particular significance has been attached to them in relation to the interpretation of the field data recorded.

CROWN TREATMENTS FOR DOWNY MILDEW CONTROL

Despite the fact that this disease has been of economic importance since 1905 and is now a serious menace to nearly every commercial hop-growing area in the world, no attention apparently has been given to this method of control elsewhere than in British Columbia and Pacific Coast states.

The method originated with the Dominion Laboratory of Plant Pathology at Saanichton, British Columbia. In 1930 limited areas were treated experimentally with a number of both dry and liquid materials, of which copper-lime dust (12 pounds of copper sulphate to 100 pounds of hydrated lime) was considered the most promising.

Canadian experimental evidence of the effectiveness of crown treatments was limited but growers were encouraged to try the new method of control. Some growers used a dust mixture of 8 pounds of copper sulphate to 100 pounds of hydrated lime at the rate of 75 pounds per acre or 1 1/2 ounces per hill.

The most extensive trials were made in the spring of 1931 on about 300 acres of Late Clusters in the Canada Hop Company yards at Sumas, British Columbia. The hills were planted seven feet apart each way, giving about 889 hills per acre. The crowns were pruned in the spring and left open. About 50 pounds per acre or 1 ounce per hill of copper-lime dust (16 pounds of monohydrated copper sulphate to 100 pounds of hydrated lime) was dusted with a hand sifter onto the exposed crowns. About one acre per hour was the speed of application, at a cost of 25 cents per acre for labor and $1.25 per acre for both labor and material.
Crown Treatment Plot A

Rows 1-2-3-4-5-6

Independence, Oregon, 1932-32
Actual field counts were made on May 6, 1932. No cultural work had been done at the time the counts were made. New shoot growth was several feet long. The dust was still visible about the treated crowns. Three 50-acre plots were surveyed. In one which had been crown dusted, 600 hills were counted and 28 showed basal spikes. In the second treated plot, 738 hills were counted and but 2 showed basal spikes. The untreated plot showed 124 hills with basal spikes out of a total of 400 hills counted. Approximately 2.5% of the treated hills were spiked and 31% of the untreated.

In another hop-growing section of British Columbia, a one year old planting of Bramlings, a variety considered fairly resistant, on ground that had grown badly infected Late Clusters in 1931 was badly spiked in 1932. An adjoining Late Clusters planting which had been crown treated with copper-lime dust (16 pounds of monohydrated copper sulphate to 100 pounds of hydrated lime) showed fewer basal spikes than the untreated Bramlings.

Commercial crown treatments on the E. C. Horst yard near Independence, Oregon, in 1931 consisted of applications to approximately 475 acres. A mixture of 1 part of monohydrated copper sulphate to 6 parts of hydrated lime was used. Three tons of lime were employed in making this mixture, or an application of about 1/4 ounce per hill. Five men working 10 hours per day at 25 cents per hour treated 58 acres. They carried partly filled burlap bags in each hand and liberated the dust by striking the soil above the crowns, in passing, with the bags. After the crowns had been pruned and covered with soil which had been allowed to partially dry out, this method of application was quite satisfactory. (See photograph on page 44 of our first Progress Report)

Observations on results, however, were not conclusive because no
Crown Treatment Plot A

Rows 7-3-9

Independence, Oregon, 1931-32
untreated plots were left for comparison and spike development varied in different portions of the yard. No accurate counts were made.

Details of our experiments in 1931 are fully reported in our first Progress Report. Results were so inconclusive that we did not feel justified in continuing to recommend the practice to growers until more definite data were in hand.

In an effort to secure conclusive evidence as to the possible merits of the method, two large plots were laid out as indicated by the charts designated as Plots A and B appended to this report.

**Plot A**

Treatments were planned as follows:

- **Rows 1-6 inc.**, fall topped after harvest; trash placed on Rows 7-9 inc.
- **Rows 7-9 inc.**, to be spring topped.
- **Rows 10-12 inc.**, fall topped; trash left in place.
- **Rows 44-46 inc.**, fall topped; trash left in place.
- **Rows 47-49 inc.**, fall topped trash left in place, and covering with trash from Rows 50-55 inc.
- **Rows 50-55 inc.**, fall topped after harvest.
- **Rows 13-43 inc.**, fall topped; trash raked and burned. Green shoots, if any, removed previous to treatment as follows:
  - **Rows 13-15 inc.**, fall treated.
  - **Rows 17-20 inc.**, spring treated.
  - **Rows 21-24 inc.**, untreated.
  - **Rows 25-28 inc.**, fall treated.
  - **Rows 29-32 inc.**, spring treated.
  - **Rows 33-36 inc.**, untreated.
  - **Rows 37-40 inc.**, fall treated.
  - **Rows 41-43 inc.**, spring treated.

On September 9, 1931, the vines were cut on Rows 1-6 inc., and on Rows 50-55 inc. From September 9 to 12, trash from Rows 1-6 inc. was placed on Rows 7-9 inc. A garden rake was used to remove the trash as completely as possible. The same treatment was afforded Rows 50-55 inc., and the trash placed on Rows 47-49 inc. From October 15 to 16 vines were cut on Rows 11-49 inc. On October 19 the vines were cut on Row 10.
Crown Treatment Plot A

Rows 10-11-12

Independence, Oregon, 1931-32
October 30 the trash on Rows 13-43 inc. was raked and on November 2, burned.

On November 4 Rows 37-40 inc., and Rows 25-28 inc. were treated.

On November 5, Rows 13-16 inc. were treated.

In all the crown treatment work on this plot Niagara Copodust was applied with a No. 1 Acme duster. No effort was made to keep account of the actual amount of each material used on individual hills either in Plot A or Plot B. The amount varied slightly from hill to hill due to the wind drift encountered and the moisture of the soil, as well as the relative effectiveness of the covering and adhering qualities of each material. Taking both plots as a whole, the surface soil about the crowns was effectively covered with an application of approximately 1 ounce of each material per crown per application.

The actual time of application was from five to ten seconds per hill. The material was applied to the soil surface around the crown in a radius of about twelve inches. The soil was moist at the time of the first application and there was a considerable growth of weeds and grass around the hills. The material adhered to the soil well, although there was quite a drift of dust despite the fact that no wind was blowing.

A frost occurred on the night of November 4 which killed all of the growth of the vines in both plots.

On February 18, 1932, the vines were cut on Rows 7-9 inc. On February 20 the vines were raked and piled on Rows 7-12 inc., and on Rows 44-49 inc. The vines were burned on February 23, at which time no shoot growth was apparent.

On February 19 a line was run across the plot from south to north on Hill 57 of Row 17. Treatments were made on the hills to the north of
Crown Treatment Plot A

Rows 44-45-16

Independence, Oregon, 1931-32
and including this line as follows: Rows 17-20 inc., Rows 29-32 inc. and Rows 41-45 inc. The spring treatments were divided in order to have material applied both before and after anticipated flooding of the plot.

On March 11 buds from the crowns were beginning to emerge. On March 19 portions of the plot were under water and as late as April 9 there was some water still standing in parts of the plot.

On April 19 the number of basally spiked hills was recorded. The total number of spikes was not counted and they were not removed.

On April 20 a line of stakes was run across the plot from south to north, from Hill 50 of Row 1. On April 21 plowing and hoeing started. All hills to the west of the line of stakes were hoed. In the case of all hills to the east of and including the line of stakes, only the spiked vines were removed and apparently healthy vines left to put on the strings.

On April 25 the hills to the west of the line of stakes were treated as follows: Rows 17-20 inc., Rows 29-32 inc., and Rows 41-43 inc.

On May 18 to 20 the plot was again inspected. Basal, lateral and terminal spikes were recorded. Shoots with both lateral and terminal spikes were counted as one each. Those with more than one lateral spike were counted as one. All infected shoots were removed. General leaf infection was noted.

Infection was quite general at the time of the second inspection. Complete and detailed data are on file. A summary only is presented here-with showing the per cent of basally spiked hills.
Crown Treatment Plot A

Rows 47-48-49

Independence, Oregon, 1931-32
SUMMARY

<table>
<thead>
<tr>
<th>Row Numbers</th>
<th>Per Cent of Basally Spiked Hills</th>
</tr>
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<tbody>
<tr>
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<tr>
<td>50-55 &quot;</td>
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* Data for Row 46 not included.

The average per cent of infection in the spring treated hills was 8.5, when the hills were treated before the plot was flooded, and 2.7 when treated after the plot was flooded. The spring treated hills taken as a whole averaged 5.5 per cent spiked hills; exactly the same as the average for the fall treated hills. The untreated hills averaged 6.8 per cent spiked hills.

The fact that early trash disposal or differing amounts left in place over the winter had no very appreciable effect on subsequent basal spike formation may indicate that the vines were not seriously enough infected to make much difference or that the benefit of trash disposal as a means of preventing soil contamination by oospores is not evident in a single season.

PLOT B

Treatments were planned as follows:

- **Rows 1-3 inc., fall topped and raked.** The trash to be piled on
- **Rows 4-6 inc.**
- **Rows 7-9 inc., to be spring topped.**
- **Rows 10-13 inc., fall topped.** To be left untreated.
- **Rows 14-43 inc., fall topped.**
- **Rows 14-16 inc., Copodust in the fall.**
Crown Treatment Plot A

Rows 50-51-53-54-55

Independence, Oregon, 1931-32
Rows 17-19 inc., Copodust in the spring.
Rows 20-22 inc., Cloro in the fall.
Rows 23-25 inc., Cloro in the spring.
Rows 26-28 inc., Carbo in the fall.
Rows 29-31 inc., Carbo in the spring.
Rows 32-34 inc., Oxo Bordeaux in the fall.
Rows 35-37 inc., Oxo Bordeaux in the spring.
Rows 38-40 inc., Monohydrated copper sulphate in the fall.
Rows 41-43 inc., Monohydrated copper sulphate in the spring.

A detailed description of materials used on both Plot A and Plot B is given:

1. Copodust, manufactured by the Niagara Sprayer & Chemical Co., Inc. Active ingredient: monohydrated copper sulphate not less than 19.50%; inert ingredients not over 80.50%; copper as metallic not less than 6.98%, equivalent in copper sulphate crystals 27.4%.

2. Cloro (a dry Bordeaux), manufactured by Lucas Kil-Tone Co. Active ingredient: total copper, expressed as metallic, not less than 12%; inert ingredients not over 88%.

3. Carbo (copper carbonate), manufactured by Miller Products Company. Active ingredient: Copper, metallic copper, guaranteed minimum 53%; inert ingredients 47%.

4. Oxo Bordeaux, manufactured by the Anabacher Siegle Corporation. Active ingredient: metallic copper not less than 12 1/2%; inert ingredient not over 87 1/2%.

5. Monohydrated copper sulphate, manufactured by the Niagara Sprayer & Chemical Company, Inc.

Copodust was an easily handled dusting material which adhered well to the soil surface. Cloro did not adhere so well as Copodust. Carbo adhered well, even better than Copodust. Oxo Bordeaux was nearly the equal of Carbo for adhering and covering qualities. Monohydrated copper sulphate was not in the best physical condition, being lumpy, and making complete and rapid application most difficult.

From September 24 to 25, 1951, the vines were cut on Rows 1-5 inc.

From September 26 to 28 the trash from Rows 1-3 inc. was placed on Rows 4-6 inc. A garden rake was used to remove the trash as completely as possible.

On October 14 the vines were cut on Rows 7-9 inc. From October 30
Crown Treatment Plot B

Rows 1-2-3

Independence, Oregon, 1931-32
to November 4 the vines were cut on Rows 10-43 inc., raked, piled and
burned.

On November 5 Rows 14-16 inc. were treated with Copodust; Rows
20-22 inc. were treated with Clorox and Rows 28-28 inc. were treated with
Carbo. On November 6 Rows 32-34 inc. were treated with Oxo Bordeaux. On
November 10 Rows 38-40 inc. were treated with Monohydrated copper sulphate.

On February 18, 1932, the vines were cut on Rows 4-9 inc. The trash
was raked and piled on February 20 and burned on February 23, at which time
no shoot growth was apparent.

On February 20 a line was run across the plot from east to west
on Hill 43 of Row 17. Treatments were made on the hills to the north
of an including this line as follows: Copodust was applied to Rows 17-19
inc.; Clorox to Rows 23-25 inc.; Carbo to Rows 29-31 inc.; Oxo Bordeaux to
Rows 35-37 inc., and Monohydrated copper sulphate to Rows 41-43 inc. The
spring treatments were divided in order to have material applied both
before and after anticipated flooding of the plot.

On March 11 buds from the crowns were beginning to emerge. On
March 19 portions of the plot were under water, and as late as April 9
there was some water still standing in portions of the plot. On April 20
a line of stakes was run across the plot from east to west on Hill 43 of
Row 1.

On April 22 the number of basally spiked hills was recorded. The
total number of spikes was not counted and they were not removed. On April
26 the first plowing was done. On April 27 vines in the portions of the
plot south of the line were cut back. In the case of all hills to the
north of and including this line of stakes, only the spiked vines were
removed and apparently healthy vines left to put on the strings; except
that through error vines in Rows 35-43 inc. were also cut back.
Crown Treatment Plot B

Rows 4-6-6

Independence, Oregon, 1951-52
On April 27 treatments were made to the vines south of the line of stakes as follows: Rows 17-19 inc. were treated with Copodust; on April 28 Rows 23-26 inc. were treated with Clorox; Rows 29-31 inc. were treated with Carbo; Rows 35-37 inc. were treated with Oxo Bordeaux. On April 29 Rows 41-45 inc. were treated with Monohydrated copper sulphate.

On May 16 the plot was cross cultivated. From May 16 to 18 the plot was again inspected. Basal, lateral and terminal spikes were recorded. Shoots with both lateral and terminal spikes were counted as one each. Those with more than one lateral spike were counted as one. All infected shoots were removed. General leaf infection was also noted. Basal spikes were difficult to diagnose as many seemed to be formed by terminal infection by zoospores on very young buds.

Complete and detailed data is on file. A summary only is presented herewith showing the per cent of basally spiked hills.

**SUMMARY**

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<thead>
<tr>
<th>Row Number</th>
<th>Per Cent of Basally Spiked Hills</th>
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<tr>
<td>35-37</td>
<td>25.6</td>
</tr>
<tr>
<td>38-40</td>
<td>27.3</td>
</tr>
<tr>
<td>41-45</td>
<td>15.8</td>
</tr>
</tbody>
</table>

The average per cent of infection in the spring treated hills was 24.7 when treated before the plot was flooded and 14.9 when treated after the plot was flooded. Taken as a whole, the spring treated hills averaged 19.8 per cent spiked hills. The fall treated hills averaged
Crown Treatment Plot B

Rows 7-8-9

Independence, Oregon, 1931-32
22.2 per cent spiked hills. An average of all treatments was 21 per cent spiked hills. The untreated hills averaged 44.1 per cent spiked hills.

The relative merits of the five different copper-containing dusting materials used in the crown treatment work was not definitely demonstrated. It seems questionable whether a continuation of this comparison in the field is desirable until such time as a laboratory study can be made in view of the fact that Copodust, or its equivalent, which has been previously recommended, is readily available to growers and reasonable in price is quite satisfactory. It will be of interest perhaps to summarize the data for each of the five materials used. The name of each material is shown. The column headed 'fall' represents the per cent of hills spiked following fall treatment. Under the heading 'spring' two columns are shown. The column headed 'before' shows the per cent of spiked hills where treatments were made before the floods. The column headed 'after' shows the per cent of spiked hills where treatments were made following the floods. An average is shown for these three times of treatment for each of the five materials.

**SUMMARY**

<table>
<thead>
<tr>
<th>Material</th>
<th>Fall</th>
<th>Before</th>
<th>After</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copodust</td>
<td>16.5</td>
<td>26.2</td>
<td>14.4</td>
<td>19.7</td>
</tr>
<tr>
<td>Clorox</td>
<td>24.3</td>
<td>28.8</td>
<td>17.3</td>
<td>23.6</td>
</tr>
<tr>
<td>Carbo</td>
<td>25.6</td>
<td>15.0</td>
<td>16.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Oxo Bordeaux</td>
<td>10.9</td>
<td>33.5</td>
<td>17.9</td>
<td>22.7</td>
</tr>
<tr>
<td>Monohydrated Copper Sulphate</td>
<td>27.3</td>
<td>18.6</td>
<td>9.0</td>
<td>18.3</td>
</tr>
</tbody>
</table>

The same remarks concerning the effect of trash removal as made for Plot A apply in general to Plot B. While there is considerable difference in the percentage of spiked hills in the treated and untreated rows in this plot, the percentage of infected hills in the treated per-
tions of the plot seem unduly high. The only way this can be accounted
for perhaps is by reference to the fact that the materials were applied
to the soil surface in all cases and not directly to the exposed crowns.

The E. C. Horst company this season dusted some 455 acres of Late
Clusters applying a mixture of 1 part of instant bluestone to 4 parts of
hydrated lime to the crowns after they had been covered following pruning.
41 acres of this total was re-dusted with a mixture of 1 part of mono-
hydrated copper sulphate to 6 parts of hydrated lime. The average cost
was about 70 cents per acre for labor and material. They left no un-
treated hills by which to check the effectiveness of the treatment and
made no careful counts. It was impossible therefore to state definitely
the value of their applications.

Opportunity was afforded to secure supplemental crown treatment
data because of very late working of two yards situated near Corvallis.
1. Ireland Yard.

Shoot growth was well advanced on May 12, 1932, at which time 8 rows
of 25 hills each were staked and a count made before the crowns were pruned,
which was done on May 13. After pruning the crowns were left open. Odd-
numbered rows were treated on May 14 with Copodust. The even-numbered rows
were untreated. Counts were made on June 1, at which time the spikes were
removed, and again on June 13. Detailed data is on file. Summaries only
are presented herewith.

May 12:
Rows 1-3-5-7 showed 48 per cent of the hills spiked with a
total of 151 spikes.
Rows 2-4-6-8 showed 29 per cent of the hills spiked with a
total of 129 spikes.

June 1:
Rows 1-3-5-7 showed 24 per cent of the hills spiked with a
total of 74 spikes.
Rows 2-4-6-8 showed 39 per cent of the hills spiked with a
total of 186 spikes.
June 13:
Rows 1-3-5-7 showed 19 per cent of the hills spiked with a total of 46 spikes.  
Rows 2-4-6-8 showed 64 per cent of the hills spiked with a total of 372 spikes.

Averages showing the result of treatment:
Rows 1-3-5-7 showed 23.5 per cent of the hills spiked with a total of 60 spikes.  
Rows 2-4-6-8 showed 51.5 per cent of the hills spiked with a total of 279 spikes.

2. Butler Yard.

On May 10, 1932, the crowns were pruned and the hills left open after pruning.  No counts were made previous to the pruning.  8 rows of 25 hills each were staked out.  Odd-numbered rows were treated on May 11 with Cope-dust.  The even-numbered rows were left untreated.  Counts were made on June 1 and June 11.  All spikes were removed at the time of the first count.  Detailed data is on file.  Summaries only are presented herewith:

June 1:
Rows 1-3-5-7 showed 2 per cent of the hills spiked with a total of 7 spikes.  
Rows 2-4-6-8 showed 6 per cent of the hills spiked with a total of 11 spikes.

June 11:
Rows 1-3-5-7 showed no infection.  
Rows 2-4-6-8 showed 1 per cent of the hills spiked with a total of 1 spike.

Averages showing the result of treatment:
Rows 1-3-5-7 showed 1 per cent of the hills spiked with a total of 3.5 spikes.  
Rows 2-4-6-8 showed 3.5 per cent of the hills spiked with a total of 6 spikes.

A consistent and continued practice of crown treatments coupled with strict sanitation in conjunction with cultural practices throughout the growing season seems to hold more promise of an effective and economical control of downy mildew than does the application of fungicides in either dust or liquid form.
Basal Spikes on Early Clusters
Thacker and Williams Yard near Salem, Oregon.
March 15, 1932.
SPRAYING AND DUSTING FOR DOWNY MILDEW CONTROL

SPRAYING

Spraying with copper-containing fungicides, principally Bordeaux mixtures, has been the standard recommendation for the control of downy mildew from its inception as a disease of economic importance. Varying formulas have been tried but the standard formula at present in most downy mildew territories is 4-4-50 Bordeaux mixture, if stone lime is used or 6 pounds of hydrated lime.

European workers have recommended a very fine, misty spray and have not found the use of spreaders necessary. On large tracts on the Pacific Coast where high powered spraying equipment is used, growers are inclined to speed up the operation by using large discs which give a coarser spray. Under such conditions we have demonstrated the desirability of using a spreader to insure thorough coverage.

Spraying is at best a costly operation. Operations on the Canada Hop Company tract at Sumas, B. C., will illustrate the point. On this tract four applications are usually necessary. The number of hills per acre on some 600 acres average 889. The first application is made as soon as the vines are string using 245 gallons of 4-4-50 Bordeaux mixture per acre. The spray is applied at 400 pounds pressure using a 6-foot bamboo rod with 45° angle attached to a Maidstone nozzle. The second application is made when the vines are halfway to the wire. The same equipment and material is used but 445 gallons per acre are applied. The third application is at the pre-burr stage when 560 gallons per acre are used. The equipment at this and the next application is either a 12-nozzle automatic with Hayes or Friend power take-off or the Niagra Box Liqui Duster. The fourth application is a cone spray at which time 675 gallons per acre are used. Working some 18 hours each day, the cost of materials and labor averaged $14.00 per acre.
Our problem has been one of attempting to minimize the number of applications necessary and to so time them as to offer maximum control. This has been difficult because it is not possible to predicate weather conditions favorable to the spread of downy mildew. Under certain climatic conditions, 4-4-50 Bordeaux mixture causes severe foliage burn and there is still objection to the presence of the copper spray deposit on the cones. To overcome these two objections, a modification of the standard formula seems decidedly desirable.

Generally speaking, our springs are rainy and if spraying is to be done the early season applications are of paramount importance. Our recommendation, to be discussed under another section of this report, we have no reason to modify as a result of this season's spraying operation. Since the spread of mildew is dependent very largely upon weather conditions, it is very difficult to prove the value of spraying applications unless infection at harvest time takes place and the benefits of spraying are reflected directly in the yields. Many instances have come to our attention where growers who have not sprayed at all have secured as good a crop as those who have attempted to spray several times during the season at considerable added expense to the cost of production. We feel that the possibilities of crown treatments together with cultural practices offer an opportunity of keeping mildew well in check, and that the spraying operation as a means of downy mildew control can be, in time, relegated to the position of one of secondary importance.

Our spray plots this year were arranged with the idea of determining, if possible, the value of spreader used with Bordeaux mixture as compared with Bordeaux mixture alone. An effort was made to minimize the amount of lime used with the Bordeaux, the object being to start with a neutral formula. 4-2-50 Bordeaux was used as a standard in comparison with 3-1 1/2-50 and 2-1-50. Bordeaux, a copper-containing proprietary material which gave some promise last
year as reported in our first Annual Report, was also used at manufacturer's recommendation. These copper-containing materials were compared with two other types of sprays. One was known as Mildona, an oil emulsion containing copper resinate and nicotine. This was a proprietary material designed for the control of both fungi and sucking insects and was used at manufacturer's recommendation. Another copper resinate material was also used by way of comparison. This material was prepared for us by Mr. R. H. Robinson, station chemist of the Oregon Experiment Station, who cooperated in some of our spraying investigations.

Practically no mildew developed on the cones this season and opportunity was not afforded to attempt further the development of a cone-spray substitute for Bordeaux mixture which leaves an undesirable deposit on the cones. Our first Progress Report presents in detail the results of our previous spraying operations. Spraying trials for 1932 are presented herewith in detail.

The chart of Plot B appended to this report will serve to indicate the layout of the spray plots.

On May 31, as soon as the vines were sprung, the first spray applications were made. The weather was clear and hot but intermittently cloudy and cool with a mild to fairly strong breeze. There was a considerable drifting of the spray material onto the check rows and underleaf surfaces were not very thoroughly covered. The upper leaf surfaces and the nodes on the main stems were well covered.

The following applications were made:

Rows 1 to 4 untreated.

Rows 5 to 6 inclusive sprayed with Bordeaux mixture 2-1-25 without spreader.

Rows 7 to 10 inclusive untreated.

Rows 11 to 12 inclusive sprayed with Bordeaux mixture 2-1-25 plus one-half pint resin-soap spreader.
Rows 13 to 16 inclusive untreated.

Rows 17 to 19 inclusive sprayed with Bordeaux mixture 1 1/2-1/8-26 plus one-half pint resin-soap spreader.

Rows 19 to 22 inclusive untreated.

Rows 23 to 24 inclusive sprayed with Bordeaux mixture 1-1/2-26 plus one-half pint resin-soap spreader.

Rows 25 to 28 inclusive untreated.

Rows 29 to 30 inclusive sprayed with Boroo 1 pound to 25 gallons of water plus one-eighth pound Boroo spread.

Rows 31 to 34 inclusive untreated.

Rows 35 to 36 inclusive Mildona 2 quarts to 25 gallons of water plus one-half pint resin-soap spreader.

Bordeaux without spreader resulted in a very spotted coverage. Boroo did not spread well. The undersides of the leaves were not as well covered as with Bordeaux without spreader. Mildona did not spread well. It left a greasy deposit on the leaves which, however, was not readily visible. The addition of our spreader seemed to curdle the emulsion and it did not emulsify with water satisfactorily.

Rain followed immediately after the spray applications to Rows 35 to 36 inclusive. Rows 37 to 40 inclusive were untreated. On June 1 Rows 41 to 43 inclusive were treated copper-resinate. This material did not emulsify well with water. The copper resinate floated to the surface and adhered to the sprayer. The coverage was like that described for Mildona.

The spreader used consisted of 5 gallons of water, 4 pounds of potash lye, 6 quarts of fish oil, and 10 pounds of resin prepared according to the formula given in Oregon State Agricultural College Extension Bulletin No. 440. The amount of soap used provided good coverage when it was possible to actually contact the under surfaces of the leaves. The plants were uneven, probably averaging two feet in height. The replants were backward and many plants in the northern half of the plot were either not up or had very little shoot
development. The pressure employed was 300 pounds and the equipment that described fully elsewhere. A modified Pilot rod was used with a Bean Vermorel nozzle set at right angles to the rod. Approximately 25 gallons of solution were used to cover each two rows sprayed. There was some variation in the amount of solutions used, however. Those which spread best made it possible to secure thorough coverage with a lesser amount of material than was the case with those solutions which did not spread well.

On June 3 the plot was carefully inspected. On Rows 5 to 6 inclusive, spotted coverage was very evident. There was slight burn on the new growth but no appreciable burn on the older portions of the vines. The coverage was fair on Rows 11 to 12 inclusive. The spread was good. There appeared to be less burn than on Rows 5 to 6 inclusive. The coverage was good on Rows 17 to 18 although there were some missed areas on the under sides of the leaves. The spread was excellent. The burn was very slight. On Rows 23 to 24 inclusive, both coverage and spread were good and there was no evident burn. On Rows 29 to 30 inclusive, the coverage was good; the spread was poor; and there was no burn. On Rows 35 to 36 inclusive it was difficult to determine definitely the extent of either spread or coverage, the spray being almost invisible. Rows 41 to 43 inclusive were similar to Rows 35 to 36 inclusive. There was some evident injury to the young leaves, however, which were wrinkled and otherwise malformed.

From June 8 to 9 inclusive the entire plot was inspected. The number of vines in each hill was recorded as well as the number of terminal and lateral spikes and the presence of leaf infection. Each terminally spiked shoot was counted as was each individual lateral spike. Hills with no vines on the strings were not counted. Hills showing only one vine usually indicated a weak regrowth following late removal of spiked vines.

Detailed data are on file. Only summaries of the data recorded are
Female Inflorescence - "Pin" to "Brush" Stage
1932
presented herewith:

**WHEATED HILLS**

<table>
<thead>
<tr>
<th>Row Numbers</th>
<th>Total Hills Counted</th>
<th>Per Cent Uninfected Hills</th>
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<tbody>
<tr>
<td>5-6 incl.</td>
<td>122</td>
<td>0.0</td>
</tr>
<tr>
<td>11-12</td>
<td>132</td>
<td>0.0</td>
</tr>
<tr>
<td>17-18</td>
<td>135</td>
<td>8.1</td>
</tr>
<tr>
<td>23-24</td>
<td>141</td>
<td>2.9</td>
</tr>
<tr>
<td>29-30</td>
<td>135</td>
<td>2.0</td>
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<tr>
<td>35-36</td>
<td>142</td>
<td>2.5</td>
</tr>
<tr>
<td>41-43</td>
<td>203</td>
<td>11.5</td>
</tr>
</tbody>
</table>

**CHECK HILLS**

<table>
<thead>
<tr>
<th>Row Numbers</th>
<th>Total Hills Counted</th>
<th>Per Cent Uninfected Hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>238</td>
<td>0.0</td>
</tr>
<tr>
<td>7-10</td>
<td>266</td>
<td>16.9</td>
</tr>
<tr>
<td>13-16</td>
<td>268</td>
<td>16.0</td>
</tr>
<tr>
<td>19-22</td>
<td>279</td>
<td>9.3</td>
</tr>
<tr>
<td>25-28</td>
<td>265</td>
<td>15.3</td>
</tr>
<tr>
<td>31-34</td>
<td>263</td>
<td>9.6</td>
</tr>
<tr>
<td>37-40</td>
<td>261</td>
<td>2.6</td>
</tr>
</tbody>
</table>

The average percentage of uninfected hills in the treated plots was 5.7 and in the untreated 9.2. Greater differences might have been apparent if the first application could have been made before the plot was generally infected.

On June 21 the plot was stripped.

On June 27 the plot was sprayed again in the same manner and with the same material in the same proportions as reported for the first application. Approximately 50 gallons of material were used to cover each set of two rows. A Hardie Misto spray rod with four nozzles carrying No. 2 discs was used. The weather was clear and bright and fairly hot with quite a heavy breeze from northwest to southeast. Thorough coverage was impossible, particularly on the arms and on the under sides of the leaves thereon to the leeward, or on the southeastern portion of the vines.

The weather on June 28 was very similar to that of the day before. A careful check of the plot was made. Rows 5 to 6 inclusive again showed a
spotted spread but very good coverage and moderate burn. Rows 11 to 12 inclusive showed good coverage, good spread, and but slight burn. Rows 17 to 18 inclusive showed good coverage, good spread, and practically no burn. Rows 23 to 24 inclusive were similar to Rows 17 to 18 inclusive. Rows 29 to 30 inclusive showed fair coverage, very poor spread, and practically no burn. On Rows 35 to 36 inclusive it was as difficult to determine the extent of coverage and spread as it was at the time of the first application. Bronzing of the leaves and definite brown spotting was typical of oil burn on hop foliage. Rows 41 to 43 inclusive seemed to be fairly well covered; spread was rather poor and there was a slight burning similar to that described for Rows 35 to 36 inclusive.

On July 14 the development of the plot was between the "pin" and "brush" stage. Sucker growth at the base of the vines was heavy. The vines generally were over the wire and beginning to arm out. The males had not yet opened. There were many immature vines as the result of early spiking. The general growth of the field was very uneven. All of the check rows appeared to be in poorer condition than the adjoining treated rows though little noticeable difference between the various treated plots was evident. There was no apparent blossom infection, and little live secondary leaf infection. Many terminal and lateral spikes were still alive and probably capable of re-sporulating under favorable conditions. No counts were made.

On August 6 the cones were from one-half to one inch long and there were not many immature cones left. Most of the males had dried up and were functionless.

On August 9 the third spray application was commenced. The sky was overcast and it was showery and quite windy at times. The vines, however, were generally dry at the time the applications were made. There was a light drizzle between the applications on Rows 5 to 6 inclusive and Rows 11 to 12 inclusive,
but it was sunny between the application on Rows 11 to 12 inclusive and Rows 29 to 30 inclusive. There was considerable drifting of the spray material. Rain prevented completion of the work. There was quite a heavy shower following the Boroo application. All materials apparently were dry before the rain fell in any quantity. The same materials in the same proportions were applied to the same rows as described at the time of the previous application. Approximately 75 gallons of material were used on each set of two rows.

On August 11, Rows 35 to 36 inclusive, Rows 17 to 18 inclusive, and Rows 23 to 24 inclusive, which had not been sprayed on August 9, were sprayed. Foliage was dry, the weather cool and fair to partly cloudy with no wind. The sun was shining at the time the applications were made to Rows 17 to 18 inclusive. Mildoma, which was used, had been mixed and held over in the tank from August 9. Previous applications of the copper-resinate material had been so unsatisfactory that this material was not used at this last application.

On August 12 the plot was inspected. On Rows 5 to 6 inclusive a very slight leaf burn on the younger leaves was evidenced. There was very little evidence of any burning of the cones. Observations on Rows 11 to 12 inclusive was the same as for Rows 5 to 6. Rows 17 to 18 inclusive, Rows 23 to 24 inclusive, and Rows 29 to 30 inclusive all showed no burn, in spite of the fact that in all cases a heavy visible deposit of spray material was evident on the cones. On Rows 35 to 36 inclusive there was general leaf blotching due to fine, reddish-brown spots, doubtless an oil burn. There was a little visible evidence of injury to the cones. There was no visible residue on either leaves or cones except for a glossy film which was apparent upon close examination. Rows 41 to 45 inclusive, since they had not been sprayed on August 11, presented an appearance similar to that described at the time of the previous application.

On August 22 a final check of the plot was made at which all unproductive hills were recorded. Out of a total of 3162 hills only 2685 figured in the
yield of 242 boxes of 43 pounds each or a total of 10,406 pounds which was an average yield of 4.0 pounds per plant. On this basis the loss from each class of unproductive plant has been evaluated in the following tables.

**TREATED HILLS**

<table>
<thead>
<tr>
<th>Row No.</th>
<th>No. Hills</th>
<th>Per Cent of Total</th>
<th>Loss in Pounds</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>O M S H X</td>
</tr>
<tr>
<td>5-6</td>
<td>144</td>
<td>6.2 0.6 0 22.2</td>
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<tr>
<td>11-12</td>
<td>146</td>
<td>2.0 0 0 13.8</td>
<td>12 0 0 0 80</td>
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<tr>
<td>17-18</td>
<td>150</td>
<td>4.6 0 0 17.3</td>
<td>23 0 0 0 104</td>
</tr>
<tr>
<td>23-24</td>
<td>151</td>
<td>3.9 0.6 0 9.2</td>
<td>24 4 0 0 56</td>
</tr>
<tr>
<td>29-30</td>
<td>149</td>
<td>2.6 0 0 13.4</td>
<td>16 0 0 0 80</td>
</tr>
<tr>
<td>35-36</td>
<td>150</td>
<td>2.6 0.6 0 10.6</td>
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</tr>
<tr>
<td>41-43</td>
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<td>2.7 0.9 4 0 9.1</td>
<td>24 8 0 0 80</td>
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<td><strong>TOTALS</strong></td>
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<td><strong>156 20 8 4 592</strong></td>
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</table>

**UNTREATED HILLS**

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<th>O M S H X</th>
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</thead>
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<td>7-10</td>
<td>287</td>
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<tr>
<td>13-16</td>
<td>289</td>
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<td>40 4 0 0 164</td>
</tr>
<tr>
<td>19-22</td>
<td>289</td>
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<tr>
<td>26-28</td>
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<td>44 20 4 0 156</td>
</tr>
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<td>36 4 0 0 156</td>
</tr>
<tr>
<td>37-40</td>
<td>298</td>
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<td><strong>2072</strong></td>
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<td><strong>254 72 28 4 1240</strong></td>
</tr>
</tbody>
</table>

**SYMBOLS:**
- O = Missing hills
- B = Bastards or sexless plants
- H = Hermaphrodites
- X = Plants not on strings; on strings but not in bloom; in bloom or with hops too immature to be harvested.

**DUSTING**

The use of dusting materials and equipment is not a common commercial practice in Pacific Coast hop yards for the control of hop diseases.

As early as 1923 Canadian hop growers employed copper-lime dust consisting of one part of monohydrated copper sulphate to eight parts of lime for the control of downy mildew. These materials were put on by both power and hand dusters at various times of the day and night. Results were variable and on the whole, all factors considered, apparently less satisfactory than the customary liquid Bordeaux spray.

During the 1930 season the E. C. Horst Company at Independence, Oregon,
used a considerable quantity of copper-lime dust prepared from monohydrated copper sulphate and hydrated lime (1-6), mixed in the field with a self-mixing power duster. This duster had a Y attachment and two outlets. The outfit was under-powered and while the speed of the operation was encouraging, the coverage was not entirely satisfactory and the results obtained could not be accurately determined since both dust and spray were applied to the same plots.

Some interest on the part of other growers was expressed relative to the possibilities of dusting for downy mildew control. The rapid coverage of maximum areas in minimum time at possibly critical periods seemed worthy of further consideration. The low first cost of equipment, its long life and economy of maintenance and the low labor cost in connection with the operation might, it was hoped, offset the increased cost per acre of the materials as compared with liquid Bordeaux mixture.

Preliminary dusting trials in 1931 were recorded in our first Progress Report, pages 76-86 and 145-146.

During the 1932 season the dust plots were removed some distance from the spray plots. The same area as that indicated under the discussion of crown treatments as Plot A was used for the dusting trials. Large, untreated blocks were maintained in order to allow for unavoidable drift from the dusted portions of the field onto the untreated portions. Since it was found in the laboratory that Kolodust, which was used in the 1931 trials, had no fungicidal value against the zoospores of the downy mildew fungus, the only dusting material used was Niagara Copodust, which consisted of 20 per cent monohydrated copper sulphate and 80 per cent hydrated lime.

No effort was made to conserve on materials. An excess was applied intentionally to insure ample coverage, if possible, and early morning applications were made in order to take advantage of quiet air conditions and such moisture as might be present in the form of dew. Three applications were made during the season, at practically the same times during the
Immature male inflorescence
1932
development of the vines that the liquid sprays were applied. Even at daybreak at the time of each application there was some breeze, causing a considerable drift of the dusting material, which was thus largely wasted, since observation disclosed the fact that very little of this material drifted onto adjoining rows resulted in coverage which could be depended upon to prevent infection, most of the material falling on the upper leaf surfaces. At the time of the first application the vines were dry, and the coverage secured was very unsatisfactory, particularly on the under sides of the leaves and at the nodes. At the time of the second application, part of the vines were thoroughly moist with dew, and excellent coverage was secured; the dust particles penetrating even between the bracts of the young cones. It was found, however, that the copper particles burned the stigmas of the flowers, as well as some of the floral parts of the male bloom. A very definite spotted burning of the younger leaves was also evidenced. The third application was made following a rain. The vines were still wet, although the under sides of the leaves were dry. Very good coverage was secured where the dust came in contact with the portions of the vines that were still wet from the rain. There was much more breeze at the time of application than was true at the time of the second application. Coverage was spotted and the under sides of the leaves were not satisfactorily covered.

The following equipment was used:

I. Hand dusters. At the time of the first application an Ace No. 1 bellows type duster was used. This machine is rather unhandy to fill (by means of a scoop at the side of the dust chamber) and very difficult to clean out satisfactorily after use. While the flow of dust is adjustable, a uniform, even coverage is not possible since the bellows which is located at the top of the dust chamber delivers an uneven blast of air controllable only by the length of stroke of the lever in the hands of the operator. An American Beauty bellows
type hand duster was also used. The dust capacity was less than that of the Acme, and it was equally difficult to clean. Filling, however, was facilitated by removal of the entire top of the dust chamber. The flow of dust was adjustable by modifying the thrust of the lever which operated the bellows, which was located on the rear of the dust chamber, toward the bottom. The lever operated by means of a ratchet arrangement and the equipment was more easily handled and a more uniform coverage was effected than was the case with the Acme.

II. Power duster. The experimental power duster consisted of a Niagara self-mixing duster, powered with a 12-horsepower Murray air-cooled motor, mounted on an automobile-tired truck. A V attachment provided a two-way outlet. In contemplation of night dusting, electric lights were provided. Two automobile headlights were installed at the rear of the truck, one on each side near the outlets. Electric current was supplied by means of a generator connected with a battery. The generator was operated by a pulley attached to the crank shaft of the motor. The entire equipment was generally highly satisfactory. The truck permitted reasonably short turns at the ends of the rows. The duster was driven down each center so that each row was dusted from both sides. The self-mixing attachment was not used since prepared dusts were employed. The flow of dusting material can be definitely regulated and by modifying the speed of the motor an air blast is available which makes it possible to use a minimum amount of dust and envelop the highest vines in a uniform cloud of dusting material. This equipment was used at the time of the second and third applications. It was hauled by a tractor. Since the tractors available at the time of the dusting applications were not equipped with headlights, it was not possible to carry on any night work. In consequence the lighting equipment of the duster was not used. Details of the experimental dusting work follow.

The Chart of Plot A appended to this report will serve to indicate the layout of dusting trial plots.
Rows 1 to 16 inclusive and Rows 32 to 48 inclusive were untreated.

Rows 17 to 31 inclusive and Rows 49 to 55 inclusive were dusted.

Stringing of vines was not completed in the plot until May 24, at which time infection was general. On May 25 the first dust was applied from 4 A.M. to 7 A.M. on Rows 56 to 49 inclusive, and on Rows 31 to 23 inclusive. On May 26 dust was applied from 4 A.M. to 6 A.M. on Rows 27 to 17 inclusive. Both mornings were clear and the air was apparently quiet, although there was an appreciable drifting of the dust. Vines were practically dry and thorough coverage, particularly of the under sides of the leaves, was not accomplished.

On June 3 dust was evident along the midrib on the under sides of the leaves and at the nodes on the stems. No browning was apparent.

On June 8 the entire plot was sprayed for aphids with nicotine sulphate, 1/3 pint to 100 gallons of water with 1-1/3 gallons resin soap spreader per 100 gallons of spray.

From June 9 to 14 the entire plot was inspected. The number of vines in each hill was recorded, as well as the number of terminal and lateral spikes and the presence of leaf infection. Each terminally spiked shoot was counted, as was each individual lateral spike. General leaf infection was noted. Hills with no vines on the strings were not counted. Hills showing only one vine usually indicated a weak regrowth following late removal of spiked vines. In the process of making these counts on June 14, all lateral spikes on Rows 27 to 55 inclusive were removed at the request of the company manager.

Detailed data are on file; only summaries of the data recorded are presented herewith.

**TREATED ROWS**

<table>
<thead>
<tr>
<th>Total hills counted</th>
<th>1581</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent uninfected hills</td>
<td>10.2</td>
</tr>
</tbody>
</table>
CHECK ROWS

<table>
<thead>
<tr>
<th>Total hills counted</th>
<th>Per cent uninfected hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>2639</td>
<td>6.2</td>
</tr>
</tbody>
</table>

While the dusted rows show a higher percentage of healthy plants than the untreated, both plots were so generally infested that commercial control can hardly be claimed for the dusting practice. Greater differences might have been apparent if the first application could have been made before the plot was generally infested.

On June 30 the second dusting was made from 4:30 A.M. to 6:30 A.M. on Rows 17 to 51 inclusive. The air was quiet until 5:30 but there was a decided drift over the entire plot from north to south. Vines were practically dry and no coverage, particularly of the under side of the leaves, was not accomplished. Upper leaf surfaces, including the first 16 check rows, were fairly well covered. Approximately 200 pounds of dust were used.

On July 12 the second dusting was made from 4:30 A.M. to 5 A.M. on Rows 49 to 55 inclusive. There was a decided drift from south to north. Vines were moist with dew and an excellent coverage of all parts of the vines was secured with the exception of some of the nodes on the main vines. Less than 100 pounds of dust was used.

On July 19 an inspection of the plot was made. No recent blossom or leaf infection was apparent, and very few spikes were in evidence. Rows 17 to 51 inclusive showed some dust adhering to the upper leaf surfaces, but the coverage was very poor on the under side of the leaves. Male flowers were just opening and there appeared to be some copper burn of the floral parts. "Pin-hole" burning was evident in the younger leaves with a slight amount of brown-spotting on the older leaves due to copper burn. Female flowers were in the "brush." There was little sucker growth. Most of the vines were over the top wire. The stand was more uniform than on the sprayed plots. There were many vines in the eastern portion of the plot that were not on the strings, due to
removal because of early mildew infection. Rows 49 to 55 inclusive showed excellent coverage of dust, but some female blossom burn was evident, particularly on the stigmas. The dust particles had penetrated between the bracts of the young cones. The burning of the young leaves was similar to and nearly as severe as that induced by Bordeaux mixture. The older leaves showed a marked reddish brown spotting on the upper leaf surfaces, which was distinctly evident on the under sides of the leaves when viewed by transmitted light. This injury was very evidently a copper burn, as the rows to the windward showed no similar injury. There was little apparent difference notable between the treated and the checked rows. No counts were made.

On August 6 the plot was again inspected. The growth was very uneven. The males were still shedding pollen, some were still in bud, some development was present in all stages, some quite immature, others were over 1 inch in length.

On August 9 the final dust application was made from 5:30 A.M. to 7:30 A.M. on Rows 17 to 31 inclusive, except between Rows 23 and 24 and the north side of Row 31. About 360 pounds of dust were used. It had rained during the night and in the early morning, with over-hanging clouds and an occasional light drizzle. It was not raining at the actual time of the dust application, but it did rain rather hard shortly after the application was completed. The vines were wet, but the under sides of the leaves were mostly dry. The wind was from the north to the south, and quite gusty, causing the dust to drift clear across the entire plot. We experienced some belt slippage, which made maximum engine speed impossible, and as a result it was difficult to hit the top of the vines against a rather strong down head wind. The coverage was spotted. The nodes on the main stems and the undersides of the leaves were not thoroughly covered. Better coverage was secured on the upper leaf surfaces and on the cones, but the material which adhered to the vines was largely confined to local spots.
where moisture from the rain was still adhering to the vines.

On August 12 from 5:30 to 6:20 A.M. dust was applied to the inside of Rows 23 and 24 and to the north side of Row 31. Rows 49 to 55 inclusive were also dusted. It was quiet and clear. Some dew was present on the vines and an excellent coverage was secured with not over 100 pounds of dust.

The coverage of the dusting done on the ninth of the month was inspected and found to be poor on the under sides of the leaves. A heavy application was still visible on the upper leaf surfaces on the vines that were wet when the dust was applied, and on the cones. There was no evidence of burn and no serious burn developed later on any of the rows treated at this third application.

On August 23 a final check of the plot was made, just previous to harvest. Notes were taken on missing hills, males, bastards, and hermaphrodites, and on all vines that were not on the strings, or if on the strings, still in bloom, or with hops too immature to be harvested.

Summaries only are presented. The data is evaluated on the basis of yield as follows: The grower's records of yield which were for an 18-acre plot, of which our Plot A, the dusting plot, was a part, showed a total of 1276 boxes of 43 pounds each, or 54,954 pounds of green hops, which was equivalent to 3,055 pounds per acre of 888 hills each, or 3.43 pounds per hill. There were approximately 4735 hills to the dusting plot, of which 1,059 were unproductive, or 22.1 per cent. The number of hills on the entire 18 acres was 15,984, approximately. Assuming 22.1 per cent of this total to be unproductive, there remained 12,452 plants, or 692 productive hills per acre, at an average yield of green hops at 4.41 pounds per hill. A summary is presented of the total number of treated hills and the total number of untreated hills, classifying the unproductive hills. The actual number of hills in each classification is given, the percentage of the total number that they represent and the loss in yield that each represents.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>No. Hills</th>
<th>Per Cent of Total</th>
<th>Loss in Pounds</th>
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</thead>
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<tr>
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<td>67</td>
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<td>1.7</td>
<td>132.30</td>
</tr>
<tr>
<td>B</td>
<td>32</td>
<td>1.7</td>
<td>141.12</td>
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<tr>
<td>H</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>12.1</td>
<td>939.33</td>
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<tr>
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</table>

**UNTREATED HILLS - 3058**

<table>
<thead>
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<th>Symbol</th>
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<th>Per Cent of Total</th>
<th>Loss in Pounds</th>
</tr>
</thead>
<tbody>
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<td>7.1</td>
<td>961.38</td>
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<tr>
<td>B</td>
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<tr>
<td>H</td>
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<tr>
<td>X</td>
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<tr>
<td>TOTALS</td>
<td>717</td>
<td></td>
<td>3162.02</td>
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</table>

**SYMBOLS:**
- O = Missing hills
- M = Males
- B = Bastards or sexless plants
- H = Hermaphrodites
- X = Plants not on strings; on strings but not in bloom; in bloom or with hops too immature to be harvested.

Based on this season's experience, we are of the opinion that the dusting method cannot be depended upon by growers generally in their control program for hop downy mildew, because of the fact that at needed times during the growing season, air currents are apt to be unfavorable for a thorough coverage and for conservation of a relatively costly material, and because the moisture necessary to insure thorough coverage is not consistently present. For those growers who wish to use the method as an auxiliary to their regular liquid spraying practices, dusting might be worthy of further consideration for use particularly in late seasons during wet harvest periods when no other method of fungicidal application could insure the coverage of a large area in a short period of time. At such times also airplane dusting might offer additional advantages worthy of further trial.
SPRAYING EQUIPMENT

During the 1932 season experimental spraying was accomplished by means of a Hardie sprayer consisting of a 100 gallon tank equipped with refiller, a 2-cylinder pump capable of delivering 5 gallons per minute, and a 2-horsepower water-cooled motor mounted on a "Berry" truck which permitted maximum cut-under of the front wheels and very short turns at the ends of rows. A constant pressure of 300 pounds per square inch was readily maintained. One horse in shafts handled the loaded sprayer with ease.

The tank drain opening was too small to permit rapid emptying particularly in the case of solutions containing extensive foam producing resin soap spreaders. Aside from this minor difficulty, the outfit was entirely satisfactory.

Opportunity was not afforded for a careful comparison of the various types of spraying equipment used throughout the territory by hop growers.

The tank and pump capacity of outfits to be used commercially can best be determined by prospective users after taking into consideration (1) the size of the yard to be sprayed, (2) the number of operators to be employed on each outfit, (3) the pressure desired, (4) the number and type of rods or guns to be used and the size of the opening in the nozzle tip.

Large operators could advantageously design and use an adequate and appropriate central spray mixing plant in order to reduce labor to a minimum, and rapidly deliver to tank wagons supplying spray rigs in the field accurately and uniformly prepared material. Tank wagons should be provided with agitators.
Opportunity was afforded during the season for testing the relative merits of certain spray rods, guns, and nozzles in connection with the experimental spraying previously described.

A pressure of 300 pounds per square inch proved ample when using one lead of 3/16 inch hose to properly break up the spray particles and to reach the top of the vines in the highest yards.

**Bamboo Spray Rod**

The use of rods is generally advised abroad for hop spraying. Their use has not been found essential to good commercial coverage of hop vines in Oregon yards. They are available in lengths of from six to fourteen feet. Eight foot lengths should be a minimum for use in high trellised yards. They may be obtained with iron, brass, or aluminum pipe. Aluminum is preferable because of its light weight and resistance to the corrosive action of spray materials. Rods are relatively clumsy as compared with guns. The use of the shut-off at the bases of rods is slower and more difficult than the use of the shut-off handle of guns. While suitable perhaps for small yards, their use is not advised for large plantings where the speed with which good spraying may be done is an important consideration from the standpoint of timely application as well as cost.

**Pilot Spray Rod**

A Bean model was used on very small vines at the time of the first application. This rod "is six feet long and throws a spray changeable from fog to long distance similar to the Bean gun. It has, however, smaller capacity, being about equal in that respect to the ordinary spray rod. Spray is controlled by pressing down on the lever. Releasing the lever shuts off spray instantly."
A very satisfactory cone shaped spray is possible when the smallest disk opening is used, but the angle should be modified by using a nozzle ell. This greater angle makes it difficult to employ the nozzle with which the rod is normally equipped as pressure tends to bind the plunger making satisfactory operation impossible. The rod alone may be used when equipped with other nozzles as the "side cyclone" or "Vermorel" and a ball cut-off at the handle end. The iron pipe, however, corrodes readily when bordeaux mixture is used. This equipment cannot be recommended for large scale, commercial application. 

Spray Guns

1. The only standard length gun used was a Hardie with an aluminum barrel and a "cold washer" nozzle. A good cone shaped, adjustable spray is produced and directed at the desired angle. If used at all, this particular equipment is considered suitable preferably for young vines.

2. The "Hardie Misto spray rod" is really a modified gun similar to the "Dean Fog-drive gun." The former was used in our experiments at the second and third application. This rod is made of aluminum tubing, adjustable as to length up to a maximum of six feet. It is equipped with a head of three, four, six or eight nozzles with strainers. The extreme length was found most suitable for hop work, and four nozzles enough to throw a sufficiently wide pattern. The nozzles develop a cone shaped spray, and the angle of spray is adjustable.

Since the best features of both gun and rod are employed, this rod was found to be the most satisfactory of any rod or gun used and is to be highly recommended for midseason and late season applications on hops.
Downy Mildew
Cone Infection in Greenhouse
September 8, 1932
Nozzles

All nozzles used were compared at 300 pounds pressure, using the smallest available disk. While this pressure is ample, the volume of spray is relatively small. A highly desirable mist-like spray is developed, however, and a maximum coverage secured with a minimum amount of material.

The coverage is slower than desired in large scale, commercial operations where higher pressure and pump capacity is often used with larger disk opening. This procedure sacrifices fineness of spray particles and economy of material in favor of speed of operation. Fairly good coverage under these conditions is made possible by the use of excessive amounts of spreader.

In any event, regular disks were found preferable to newer type disks of the same size opening which throw a flat spray and are difficult to keep in alignment where multiple nozzles are employed.

Nozzles which throw cone shaped spray patterns are preferable to those that throw a flat spray pattern.

Many types of nozzles are available, all of which deliver suitable spray patterns. The simplest type of nozzle construction is desirable in order to save time necessary for adjustment and cleaning. Screened nozzles are gaining in popularity and have definite advantages. The screens often become plugged so quickly in expensive field operations, however, that in cases where large disk openings are used, they are often removed. Aluminum alloys, now commonly employed in the construction of rod, gun, and nozzle parts, are to be recommended because of their light weight and resistance to corrosive action of spray material.
By the use of various available nozzles and fittings a wide variety of spray patterns are possible which direct the spray at many different angles. For instance, in the case of spray rods when using either a spray Y fitting and two angle nozzles or an angle nozzle Y fitting with two straight nozzles, the angle nozzle Y fitting throws a wide pattern with considerable up curve direction of spray. Two straight nozzles on a straight Y fitting throw a wider pattern than two angle nozzles on a straight Y fitting. Two angle nozzles on an angle nozzle Y fitting may be used to increase the angle of the spray pattern. A single Bean Majestic straight nozzle throws a pattern nearly as wide as those secured from two nozzles on the Y mentioned above. The use of angle nozzles, however, is much the more satisfactory for directing the spray material to the under leaf surfaces and into the "cups" formed at the nodes by the two opposite pairs of leaf stipules clasping the stem.

1. "Bean Clipper (patented)" throws either a fan shaped spray, a long distance spray, or a solid stream; can be shut off altogether and has the same patent adjuster as the "Bean Bordeaux."

Spray particles are coarser than desirable. The spray cannot be easily directed at an angle without the use of a nozzle all intended for rods but since a flat spray pattern is developed is not recommended for use on hops.

2. "Bean Bordeaux." Two sprays in one nozzle. One side gives a broad, fine, fan-shaped spray; the other side a long distance spray. It will throw a solid stream or shut off altogether. The spray can be easily adjusted to suit and held in position by tightening of "set screws."
Practically the same as Bean Clipper as far as use on hops is concerned; not recommended.

5. Hardie Blizzard - same type of spray pattern as Bean Bordeaux and Clipper. All three throw a solid, fan-shaped sheet of liquid. This nozzle throws the spray at right angles, which is preferable for under-surface coverage, and breaks the material into finer particles than the two Bean nozzles mentioned; is somewhat adjustable; not recommended.

4. Maidstone nozzle, manufactured in England and used by some Canadian growers. The nozzle is well made, adjustable, but somewhat complicated. Certain vital parts are subject to wear and since replacements are not locally available its use is not recommended despite the fact that it does develop a very satisfactory spray pattern directed at the proper angle when the nozzle all is employed.

5. Hood nozzle, manufactured by Charles Hood, Puyallup, Washington, originally used on automatic sprayers. The nozzle is well made and throws, when used with a nozzle ell, a satisfactory cone shaped spray at the proper angle. It has five openings, however, in the nozzle cap which causes considerable difficulty in cleaning. Since equally suitable nozzles without these objections are available, its use is not recommended.

6. Bean Best (patented) "throws a fine spray a long distance. To clean, force the end against a tree. Pressure from the pump instantly forces it back."

This nozzle throws a very fine, powerful spray. The proper angle can be secured by using a nozzle ell. The spray pattern is too narrow, however, and is not recommended for use on hops.
7. Side Cyclone "throws a powerful cyclone spray at right angles." This nozzle should prove very satisfactory used on about a four foot rod for the first mildew application just as soon as vines have first been strung.

8. Bean Vermorel "throws a beautiful, misty, circular spray. All trouble caused by clogging in the bend is avoided by having the stem detachable. This also allows the nozzle to be turned to any angle desired. Has a steel needle point for cleaning."

This nozzle is in many ways superior to the Side Cyclone and preferable to either the Bean Majestic angle or straight nozzles except that the stem is apt to prove a nuisance and become entangled in the vines when used later than the first application.

9. Bean Mist, straight, "throws a very fine, uniform, penetrating, misty spray. A very good nozzle but does not have a strainer like Bean Majestic."

A good cone shaped spray pattern produced. Recommended.

10. Bean Mist, angle, "same as the straight except sets at angle." Recommended.

11. Bean Majestic, straight, "an extra deep body and is fitted with strainer." Same as Bean Majestic angle except that it is straight. A good cone shaped spray pattern produced. Recommended.

12. Bean Majestic, angle, "throws a very large, beautiful, penetrating spray at just the right angle. Fitted with removable whirl chamber and strainer. This nozzle can quickly be taken apart and cleaned. Wearing parts can cheaply and quickly be replaced."

A good cone shaped spray pattern produced. Recommended.
13. Hardie Vapo, either angle or straight, produces a very satisfactory, fine, cone shaped spray. Similar to the Bean Majestic nozzle. Made of aluminum alloy and very light weight similar to the nozzle used on the Hardie Misto spray rod. Highly recommended.

During the coming season it is hoped that opportunity will be afforded to test other nozzles and spray guns not included in the present list, since the spraying of hops both for mildew and the control of insects is a practice that in the light of present information cannot be entirely avoided.

MISCELLANEOUS GREENHOUSE LABORATORY AND FIELD INVESTIGATIONS

Dormant Mycelium as a Means of Perpetuating Downy Mildew. In the W. L. Butler yard at Corvallis, Oregon, during the 1932 season it was evident that leaving the crowns exposed in itself was not a practice that could be depended upon to effectively limit the development of basal spikes.

Adjoining our experimental plot, floods had formed gullies which exposed the crowns and portions of the roots, in some cases washing them clean of adhering soil. These exposed crowns were even more affected with basal spikes than the general field; an immense number of spiked shoots with very little normal shoot growth being in evidence.

While these observations do not invalidate the hypothesis that soil contamination by conspores is largely responsible for a continuance of the disease, it does suggest the possibility of hibernating mycelium.

English workers report having traced the mycelium from basal spikes into the tissues of the root stock and into the roots. Other
workers in Germany while admitting the presence of mycelium in underground portions of the plant maintain it to be incapable of persisting alive and causing subsequent spike formation.

It is not uncommon, particularly early in the season, to find crowns from which basal spikes arise discolored and these discolored areas filled with mycelium. We do not have positive evidence, however, that this mycelium is associated with the downy mildew fungus.

1. On March 13 a crown of Early Clusters bearing 2 basal spikes one-half inch long was removed to the laboratory. The crown tissues were brown and contained mycelium. Conidia were present on the under leaf surfaces of both spikes as well as on both surfaces of the leaf stipules and on the petioles. Eight other dormant buds occurred in the same cluster as the spiked shoots. The entire crown was placed in water under a bell jar. On April 4 there was no further shoot development and the buds were dead and rotten due to an overgrowth of molds.

2. On March 13 a second larger crown of Early Clusters bearing two basal spikes was removed to the laboratory and placed in water under a bell jar. There were 15 buds in one cluster and 20 in another cluster adjoining the cushion of tissue from which the spikes arose. The crown was discolored throughout its length of 3 inches and into one side root for one-half inch, mycelium being present in the discolored area.

On March 23, 3 buds had developed into shoots which became spiked, apparently from conidia rather than from mycelium from the crown. One cluster of 4 buds and one of 10 buds, under water at the base of the crown section, did not become infected. On April 4 the specimen was overgrown with molds and was discarded.
Greenhouse Inoculation Chamber
1932
3. Canadian workers report that hop crowns which have borne basal spikes, if surface sterilized and planted in clean soil, do not develop spikes.

On March 1, ten crown sections of Late Cluster plants with the buds still white but beginning to elongate were removed from our experimental field plot, sterilized ten minutes in acidulated mercuric chloride, rinsed in water and planted in clean soil in greenhouse benches. All of the parent plants had developed basal spikes the previous season.

All plants developed normally, except one which died, without producing basal spikes. On September 19 all aerial growth was removed and the plants potted and retained for further observation.

4. On April 25, four spiked replants were removed from our experimental field plot and potted in the greenhouse. On June 18 one plant was dead. The three remaining plants were transferred to a bench. By September 19 no spikes had developed. The plants were repotted and retained for further observation.

5. There remains the possibility that dormant buds on the crown may become infected in the fall or before, and mycelium remain dormant in the buds and be responsible for causing basal spikes when such buds resume growth in the spring.

From February 25 to 28, buds were removed from 725 hills in one of our field plots before shoot growth had started. Of this number 9 hills had shown basal spikes in 1930, 110 in 1931, and 5 in both 1930 and 1931.

Free-hand sections were made and examined microscopically for evidence of infection such as the usual browning of infected tissue. None was found.
6. On November 25, bud clusters were removed from 72 plants in the plot referred to above, all of which had shown basal spikes in both 1931 and 1932. The buds were removed from parts of the crowns in contact with the surface soil and plant debris. The clusters were packed in moist soil, removed to the laboratory and held under cool temperatures until sectioned.

Both cross and longitudinal free-hand sections were made; the sections removed to slides; stained with Ano Blue to which lye had been added and examined microscopically. Neither mycelium or conspores were discovered. There was, however, a profusion of mycelium-like strands throughout the pad of tissue from which the buds arise; in the crown proper, the roots and extending upward into the lower tissues of the young bud stem but not into the leaves of the buds. These strands appear to be laciferous ducts or some similar structure rather than fungal mycelium. Interspersed among these tissues, brown-colored cells were numerous and conspicuous. They might readily be mistaken for conspores but appear to be merely cells containing stored food material.

Soil Contamination with Conspores. During the early part of the growing season just past, field observations disclosed the fact that cuttings from mildew-infected yards when planted in clean soil developed basal spikes.

This situation might be accounted for in one or more ways: (1) mycelium carried in the cuttings, (2) mycelium hibernating in the buds on the cuttings or (3) conspore-bearing soil adhering to the cuttings. This last supposition seems the most probable.

1. On March 25, one Late Clusters plant was potted in the greenhouse and covered with soil from an infected portion of one of
our field plots. By June 18 the plant had made little growth and no spikes had developed. On September 19 external leaf infection producing conidia and conidia was present. Aerial portions of the plant were removed and the plant retained for further observation.

2. On May 10, two pots of Late Clusters seedlings were covered with soil from a badly infected yard. One plant was planted in clean soil as a control. On June 18 there was little growth on any of the plants and no evidence of spikes. On September 17 the check plant showed good growth but no spikes. One of the two other plants had no aerial growth but the roots were still alive; the other made a fair growth but there was no evidence of spikes. Two plants showed external, natural leaf infection from nearby benches. Aerial portions of the plants were removed and the plants retained for further observation.

3. On March 3, five cuttings each of Early Clusters, Late Clusters and Fuggles were sterilized five minutes in acidulated mercuric chloride (1 ounce mercuric chloride, 8 ounces commercial hydrochloric acid, 5 gallons of water) and rinsed in water. Three plants of each variety were potted in soil from a badly infected yard. Two controls of each variety were potted in clean soil. On May 11, all of the Early Clusters plants were alive with normal shoot growth on three but with no spikes on any of the plants. Four Late Clusters plants were alive with normal shoot growth on one and no spikes on any of the plants. All the Fuggles plants were alive with normal shoot growth on three but no spikes were present. All fifteen plants were discarded.
4. The most convincing evidence was obtained when, on March 13, before shoot development was general, 130 Late Clusters seedlings were obtained from refuse on a dryer platform. These seedlings were planted in flats in clean soil, removed to the greenhouse and the flat covered with glass to secure humid conditions. None of the seedlings developed mildew.

A flat of seedlings from one of our field plots in the same yard, which had been infected the previous season, was collected on March 15. (26 seedlings were planted in clean soil.) Three of the seedlings showed conidia on the cotyledons. The seedlings were subjected to the same treatment as afforded the seedlings collected on the platform with the result that downy mildew developed on the leaves of 12 plants; on the cotyledons of 93 plants and on both cotyledons and leaves of 1 plant by April 4. By March 25, 12 plants had wilted down and contained oospores.

On March 13, 55 seedlings of Early Clusters were obtained from plant refuse on the soil surface; the plants arising from old cones that had never been covered with soil. When planted in a flat of clean soil and placed in the greenhouse and treated as previously described, no mildew developed on any of the seedlings.

A flat of seedlings from another section of the same yard, which had been infected the previous season, was collected on March 15 and treated similarly with the result that on April 2 downy mildew had developed on the leaves of 11 plants and on the cotyledons of 61 plants and by April 4 on the cotyledons and leaves of 30 plants. By March 25 two plants had wilted down and contained oospores.
The significant feature of this finding is that these mildew-infected seedlings arise in the immediate vicinity of the developing shoots of the crowns before the shoots develop and probably infect shoots coming into contact with them as they push up through the soil, causing basal spikes. They may also serve to reinfect the soil by means of the oospores being incorporated in the soil when the seedlings are destroyed later during the pruning and cultivation operations.

In some seasons these seedlings are very numerous. A large number of oospores have been found in a single cotyledon. Since hop cuttings are usually obtained in the spring at pruning time, it is quite possible for such cuttings to become contaminated with oospore-bearing soil which might account for the appearance of basal spikes when such cuttings are planted in clean soil.

It is of passing interest to note that seedlings in the fields were more numerous where fall cultivation had turned the soil between the rows over and the seed had been exposed to winter conditions or where the trash had been allowed to remain on the soil surface over winter and particularly on the margins of areas where the trash had been burned in the fall.

**Spreaders**

In view of the desire on the part of large hop yard operators for rapid spray applications, high pressure, large capacity spray outfits predominate. Large discs are used which throw relatively coarse spray particles. Under such conditions thorough coverage is not possible without the use of spreaders.

The two formulae suggested in Oregon Experiment Station Circular
of Information No. 53 appeared somewhat complicated to prepare and field observations disclosed the fact that much more than necessary was being used, causing excess foaming and considerable wastage of spray material when field sprayers were filled from tank supply wagons.

Early in 1932 a comparison of various spreaders was undertaken. Eighteen spreaders and 4 wetting agents were used; first with water alone. Materials were tested by making applications with an atomizer to the under surfaces of hop leaves grown in the greenhouse.

A description of the materials used and the dilution limits at which they spread and wet is given:

1. Neomerpin SS: 2 lbs. to 100 gallons water. Wets at this dilution.
2. Neomerpin 80: 2 lbs. to 100 gallons water. Does not wet.
3. Neomerpin FT: 2 lbs. to 100 gallons water. Does not wet.
4. Neomerpin H: 2 lbs. to 100 gallons water. Does not wet.
5. Blood albumin: .4 gm. albumin - .04 gm. sodium bicarbonate - 1000 cc. water. Wets at .2 gm. albumin to 1000 cc. water.
6. Casein-ammonia: .4 gm. casein - 12 drops ammonia - 1000 cc. water. Wets at .05 gm. casein to 1000 cc. water.
7. Casein-lime: .4 gm. casein - .4 gm. calcium hydroxide - 1000 cc. water. Wets at .1 gm. casein to 1000 cc. water.
8. Fluxit No. 1: 4 gm. - 1000 cc. water. Wets at 1 gm. Fluxit to 1000 cc. water.
15. Potash resin soap: 1 gm. - 1000 cc. water. Wets at .5 gm. to 1000 cc. water.
16. Saponin: .5 gm. - 1000 cc. water. Wets at .25 gm. saponin to 1000 cc. water.
17. Skim milk: 200 cc. milk - .5 gm. calcium hydroxide - 1000 cc. water. Wets at 12.5 cc. skim milk to 1000 cc. water.
18. Skim milk powder: 2 gm. - 1000 cc. water. Wets at 1 gm. skim milk powder to 1000 cc. water.
19. Trippe X: 4 cc. - 1000 cc. water. Wets at 2 cc. to 1000 cc. water.
21. Waste Sulfide powder: 20 gm. - 1000 cc. water. Wets at 2.5 gm. powder to 1000 cc. water.
22. Needham's Spreader: 40 cc. - 1000 cc. water. Wets at 1-1/4 gm. to 1000 cc. water.
Fifteen grams of Cloroa, a proprietary Bordeaux mixture in powdered form, was added to 1000 cc. water and spreaders Nos. 5 to 19 inclusive, 21 and 22 were added. The respective spreading ability of each was compared with an equal amount of Cloroa and water without any spreader. It was found that in some cases the minimum amount of spreader had to be increased as follows: No. 5 to .4 gm. per liter; No. 6 to .1 gm.; No. 7 to .2 gm.; No. 13 to 2 gm.; No. 14 did not spread; No. 15 to 1 gm.; No. 16 to .5 gm.; No. 17 to 25 cc.; No. 18 to 2 gm.; No. 19 to 4 cc.; No. 21 to 5 gm.; and No. 22 to 2-1/2 cc. per liter.

The best spreading with the minimum amounts of each material was obtained with potash resin soap, saponin, skim milk powder and waste sulfide powder. None of the spreaders caused injury in 2 - 3 days when used alone.

A number of copper-containing solutions were prepared, using amounts equivalent to a 4-4-50 Bordeaux mixture, unless otherwise noted, and sprayed on greenhouse hop vines in active growth to determine the relative injury, with the following results:

1. Ammoniacal copper carbonate (Borco); 7 gm. - 1000 cc. water. No burn in 2 days.
2. As above with 1/2 gm. Borco spread added. Same results.
4. Cloroa: 2-1/2 gm. - 100 cc. water. Same results.
5. Copper acetate. Slight burn in 2 days.
6. Copper ammonium sulphate. No burn in 2 days.
7. Copper carbonate (Carbo): 5 gm. - 1000 cc. water. No burn in 5 days.
8. Colloidal copper; 5.5 gm. - 1000 cc. water. No burn in 2 days.
9. Copper phosphate. Same results.
10. Copper sulphate. Bad burn in 2 days.
11. Cupric chloride. Same results.
12. Cuprous chloride. Moderate burn in 2 days.
13. Hammonds Copper Solution: Metallic copper 3.05%; 1 part to 8 parts water. No burn in 2 days.
14. Oxo Bordeaux; 8 gm. - 1000 cc. water. Same results.
15. Zinc Bordeaux: 2 gm. copper sulphate 6 gm. zinc sulphate - 8 gm. lime - 1000 cc. water. No burn in 3 days.
16. Bergundy mixture. Slight burn in 2 days.

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17. Palustrex dissolved in pine oil containing 15% copper-resinate: 40 cc. to 1000 cc. water. Severe injury in 1 day.
19. Fungtrogen: metallic copper .47%, metallic nickel .47%; 1 part to 60 parts water. Same results.

A comparison of oil-containing materials was not actively undertaken. The four most satisfactory spreaders were used with a number of copper-containing materials to determine comparative injury.

Potash resin soap, 1 gm. to 1000 cc. of material Nos. 1, 4, 5, 6, gave results similar to the materials used without spreader; with material No. 7, slight burn developed in 5 days; with material Nos. 8, 9, 10, 13, 14, 15, and 16, results were the same as with the materials used without spreaders.

Saponin, .5 gm. to 1000 cc. of material Nos. 1, 4, 5, 6, 7, and 9, gave results similar to the materials used without spreaders; with material No. 10, slight burn developed in 2 days; with materials Nos. 13 and 14, results were the same as with materials used without spreaders.

Skim milk powder, 2 gm. to 1000 cc. of material Nos. 1, 4, and 5, gave results similar to the materials used without spreaders; with material No. 6, slight burn developed in 2 days; with material Nos. 7, 8, 9, 10, 13, 14, 15, and 16, results were the same as with materials used without spreaders.

Waste sulfide powder, 5 gm. to 1000 cc. of material No. 1, showed no burn in 2 days; material No. 3 showed slight burn in 3 days; material Nos. 4 and 5 gave results similar to the materials used without spreaders; materials No. 6 showed a slight burn in 3 days as did material No. 7. Materials Nos. 8 and 9 gave results similar to the materials used without spreaders; material No. 10 gave slight burn in
2 days; with material No. 11 bad burn resulted in one day and with material No. 12 moderate burn developed in 1 day. With materials Nos. 13, 14, 15 and 16, results were the same as the materials used without spreaders.

Further tests with saponin were abandoned because of the relative high cost and the lack of a commercially available supply.

Various Bordeaux formulae were employed with potash resin soap, waste sulfide powder and both skim milk and skim milk powder. 4-1-50 Bordeaux after 2 days showed slight burn when used alone but no burn when used with potash resin soap, waste sulfide powder or skim milk powder. 6-1-50 Bordeaux produced bad burn in 2 days when used alone and slightly less burn in 3 days with potash resin soap, waste sulfide powder and skim milk powder. 1-4-50 Bordeaux alone in 2 days caused no burn nor did any of the three spreaders used with it. 1-6-50 Bordeaux after 2 days alone caused no burn nor did any of the three spreaders used with it.

Balanced formulae of Bordeaux mixture and zinc sulphate were used alone and with the 3 spreaders just mentioned. In the case of 4-4-50 Bordeaux, lime water and the zinc sulphate, liquid skim milk was also used.

Bordeaux mixture 4-4-50, 3-3-50, 2-2-50, 1-1-50, zinc sulphate 4-4-50 and lime water after 2 to 3 days showed no injury when used alone or with any of the spreaders mentioned.

Zinc sulphate 6-6-50 showed slight burn only with the potash resin soap.

All factors considered the potash resin soaps seemed most satisfactory and various formulae were tried resulting in the method of preparation suggested in Extension Bulletin No. 440. This formula
can still be improved since there is an excess of fish oil which can be eliminated.

The use of skim milk powder offered a number of interesting possibilities and its use with Bordeaux mixture was carefully checked in both greenhouse and laboratory. The proper order of adding the materials in Bordeaux mixture when skim milk spreaders were used was definitely established as indicated in the instructions presented in the bulletin referred to above. In the field, however, results were erratic; some growers reporting satisfaction and others were not satisfied with the material. Field trials were run with varying amounts of skim milk, skim milk powder and casein in varying amounts in comparison with the resin soap spreaders. A modified skim milk formula was appended to the bulletin and the suggestion made that the use of the powder be abandoned until further data might be secured.

**Sterilization of Cuttings**

In an effort to prevent downy mildew from becoming established in new yards by the planting of cuttings from infected yards with conspore-bearing soil adhering to the cuttings, a rapid and economical method of sterilization seemed worthy of trial.

1. On June 4, cuttings of Early Clusters from a badly infected yard were sterilized in acidulated mercuric chloride at five minute intervals up to one hour; washed in water and planted in clean soil in a greenhouse bench. Ten cuttings were used in each treatment and ten left as a control.

No basal spikes developed on any of the plants. Cuttings apparently were not in good condition since the percentage that grew was low in all cases and no very conclusive evidence of possible injury by the treatment was obtained.
Treatment | July 13 | September 7
---|---|---
Check | 30% sprouted | 30% alive
5 minutes | 30% | 20%
10 " | 30% " | 30%
15 " | 40% " | 30%
20 " | 10% " | none
25 " | 20% " | 10%
30 " | 20% " | 10%
35 " | 30% " | 10%
40 " | 20% " | 10%
45 " | 30% " | 20%
50 " | 10% " | none
55 " | 20% " | 20%
60 " | none | none

2. A commercial planting from the same lot of cuttings was made from May 26-27. Twelve rows of 1296 hills were left untreated; 12 rows of 1482 hills were treated. The cuttings were soaked in acidulated mercuric chloride for 5 minutes and rinsed in clear water before planting. Six rows of 744 hills were left untreated but the surface of the ground about the cuttings was dusted with copper-lime dust. Six rows of 744 hills were planted with cuttings given the acidulated chloride treatment and the surface of the ground about the cuttings was dusted with copper-lime dust (1-4).

Only 31.4% of the plants in the first 12 rows sprouted; 41.9% of the second 12 rows; 23.5% of the first 6 rows and 43.0% of the second 6 rows, by July 13. No spikes were found in any of the hills in the planting so that the merits of the method from the standpoint of mildew control or injury to the cuttings could not be definitely determined. The plot continues under observation for any further developments the coming season.

Weed Killers

Escaped vines growing in uncultivated margins of commercial yards are a constant source of mildew inoculum from which nearby plantings may readily become reinfected throughout the growing season.
if weather conditions are favorable to infection.

Complete and continued eradication of this menace is extremely
difficult because of the rapid regrowth of underbrush in which es-
caped vines are commonly entangled.

The chlorates seemed the most promising materials for experimen-
tal purposes to determine the feasibility of eradicating escaped
vines by spraying with weed killers.

On March 12, two potted greenhouse cuttings showing vigorous
growth, though not armed out, were sprayed with a solution of "Atla-
cide" (1 pound to 1 gallon of water). On March 14 the tops were all
dead and on March 23 one entire plant was apparently dead.

On April 29 five rows of Late Clusters in a nursery plot approx-
imately 12 x 24 feet dimensions were sprayed with 3 gallons of "Atla-
cide" solution (1 pound to 1 gallon water), using a "Simo" hand sprayer.
The sun was shining; vines were in active growth; the shoots were
several feet long and in full leaf. On May 7 all tops were dead and
brown. On June 1 most of the plants apparently were not dead; some
bore shoots as long as one foot, but on the whole the growth was stocky
and the leaves yellow. On this date the plot was resprayed with 3
gallons of the same material. Final observations will be made the com-
ing spring.

The time required for such applications, the cost of materials,
the nature of the undergrowth in which escaped vines grow and the
character of growth of the hop plant itself all point to the fact that
this means of eradicating escaped hop vines will probably not be either
efficient or economical.

Fertilizers in Relation to Downy Mildew

Reports from some of the southern states indicating efficiency
Hop Downy Mildew on Nettle Leaves
September 6, 1932.
in cotton root rot control by applications of ammonium nitrate and ammonium sulphate suggested the trial of the effects of various fertilizers on hop downy mildew.

An extensive series of fertilizer combinations was worked out, including the two mentioned above and 21 plots of Late Clusters in our experimental field plots reserved for a cooperative project with the Farm Crops Department. One plot contained 59 hills, 19 plots contained 60 hills each and one plot contained 82 hills.

This work was not undertaken. The project, however, might be worthy of completion at some later date.

Inoculation of Greenhouse Seedlings

In our greenhouse inoculation work the past season, locality collections of seedlings of commercial varieties of hops were not used. Inoculation technique was modified somewhat by using, in a large part of the work, an atomizer to distribute suspensions of conidia and zoospores. While not as positive as the brush technique employed last season, it was faster and on the whole generally satisfactory.

Inoculation results with seedlings are indicated in the same manner as in our First Progress Report.

<table>
<thead>
<tr>
<th>Source of Inoculum</th>
<th>Variety Inoculated</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Clusters</td>
<td>Humulus japonicus</td>
<td>0 4</td>
</tr>
<tr>
<td>&quot;</td>
<td>H. japonicus variegatus</td>
<td>0 3</td>
</tr>
<tr>
<td>&quot;</td>
<td>Cannabis sativa</td>
<td>29 79</td>
</tr>
<tr>
<td>&quot;</td>
<td>Celtis occidentalis</td>
<td>0 1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Ficus sp.</td>
<td>0 311</td>
</tr>
<tr>
<td>&quot;</td>
<td>Humulus japonicus</td>
<td>2 30</td>
</tr>
<tr>
<td>&quot;</td>
<td>H. japonicus variegatus</td>
<td>0 7</td>
</tr>
<tr>
<td>Source of Inoculum</td>
<td>Variety Inoculated</td>
<td>Result</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Early Clusters</td>
<td>Morus alba</td>
<td>0 57</td>
</tr>
<tr>
<td>&quot;</td>
<td>Urtica Lyallii</td>
<td>115;39 187</td>
</tr>
<tr>
<td>Urtica Lyallii</td>
<td>Ficus sp.</td>
<td>0 21</td>
</tr>
</tbody>
</table>

Conidia were also developed abundantly on well developed seedling leaves or on leaves developed from cuttings as follows:

<table>
<thead>
<tr>
<th>Source of Inoculum</th>
<th>Variety Infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Clusters</td>
<td>Urtica Lyallii</td>
</tr>
<tr>
<td>Urtica Lyallii</td>
<td>Fuggles</td>
</tr>
<tr>
<td>&quot;</td>
<td>Late Clusters</td>
</tr>
<tr>
<td>&quot;</td>
<td>Urtica Lyallii</td>
</tr>
</tbody>
</table>

Attempts to infect leaves of young plants of *Morus alba*, *Ulmus americana* and *Ulmus pumila* with conidia from Late Clusters were unsuccessful, as were attempts to infect seedling cotyledons of 19 representatives of the family Cucurbitaceae.

**Spore Germination Studies**

1. Germination of conidia from herbarium specimens of downy mildew on Early and Late Clusters collected in various localities in Oregon and Washington was attempted by means of Van Tiegham cells of distilled water. Results were tabulated after a minimum germination period of 24 hours at room temperature. No germination resulted in material of the following ages in days: 302, 311, 318, 319, 323, 332, 335, 336, 338, 339, 340, 342, 349, 358, 369.

2. Considerable data have been accumulated relative to the phenomena of zoosporangia formation and the various stages in their germination together with the influence of temperature on the process and the activity of the resultant zoospores.

3. Attempts to date to germinate oospores have been unsuccessful.
The details of our experiments with spore germination are withheld for inclusion in a subsequent report when this phase of our laboratory studies is more complete.

**Histological Studies**

Phenomena relative to oospore formation, the mycelial invasion of the host tissues, the character of houstoria, the formation of conidiophores, the procedure of infection by zoospores have been studied by means of prepared microscopic slides and detailed drawings executed. Technique employed and detailed data on this phase of our laboratory studies is also being reserved for a subsequent report.

**Spore Measurements**

As artificial inoculation studies progressed, new hosts were discovered for the downy mildew fungus, particularly in the genera *Cannabis*, and *Urtica*. Cross inoculations between species of the genus *Humulus* and varieties of *Humulus lupulus*, *Humulus americanus*, and *Humulus japonicus* were affected.

In some instances sufficient material was secured and assistance available to begin a series of spore measurements to determine if the host had any influence in modifying the average size of fruiting structures of the fungus.

The dimensions of both conidia and oospores vary widely on the same host so that averages were determined, when possible, after measuring a minimum of 100 spores.

Conidial measurements only are recorded since there is some question in the oospore measurements as to whether, in some cases at least, the oogonium was not also included.

In the following table the column headed "from" indicates the source of inoculum. The column headed "to" indicates the host on which
Hop Dormy Milden on Nettle Leaves
September 6, 1932
conidia developed as a result of artificial inoculation and from which conidia were secured for measurements.

**SPOT MEASUREMENTS**

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>No. Oospores Counted</th>
<th>Ave. Measurement in Microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Clusters</td>
<td>Early Clusters</td>
<td>100</td>
<td>21.609x13.639</td>
</tr>
<tr>
<td>&quot;</td>
<td>Fuggles</td>
<td>100</td>
<td>21.474x13.871</td>
</tr>
<tr>
<td>&quot;</td>
<td>Late Clusters</td>
<td>100</td>
<td>21.755x13.500</td>
</tr>
<tr>
<td>&quot;</td>
<td>Red Vines</td>
<td>100</td>
<td>21.740x13.722</td>
</tr>
<tr>
<td>Fuggles</td>
<td>Early Clusters</td>
<td>100</td>
<td>23.450x14.339</td>
</tr>
<tr>
<td>&quot;</td>
<td>Fuggles</td>
<td>100</td>
<td>20.952x13.746</td>
</tr>
<tr>
<td>&quot;</td>
<td>Late Clusters</td>
<td>100</td>
<td>20.770x13.572</td>
</tr>
<tr>
<td>&quot;</td>
<td>H. lupulus neo-mexicanus</td>
<td>100</td>
<td>21.795x14.096</td>
</tr>
<tr>
<td>H. lupulus neo-</td>
<td>&quot;</td>
<td>Fuggles</td>
<td>100</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>H. lupulus neo-mexicanus</td>
<td>100</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>Late Clusters</td>
<td>100</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>Red Vines</td>
<td>100</td>
</tr>
<tr>
<td>&quot;</td>
<td>Urtica Lyallii</td>
<td>200</td>
<td>20.239x12.397</td>
</tr>
<tr>
<td>Late Clusters</td>
<td>Early Clusters</td>
<td>100</td>
<td>21.946x14.581</td>
</tr>
<tr>
<td>&quot;</td>
<td>East Kent Goldings</td>
<td>100</td>
<td>21.923x14.075</td>
</tr>
<tr>
<td>&quot;</td>
<td>Fuggles</td>
<td>100</td>
<td>22.251x14.112</td>
</tr>
<tr>
<td>&quot;</td>
<td>H. japonicus neo-mexicanus</td>
<td>100</td>
<td>22.311x14.397</td>
</tr>
<tr>
<td>&quot;</td>
<td>Late Clusters</td>
<td>100</td>
<td>21.952x14.133</td>
</tr>
<tr>
<td>&quot;</td>
<td>Red Vines</td>
<td>200</td>
<td>21.293x13.459</td>
</tr>
<tr>
<td>Red Vines</td>
<td>Red Vines</td>
<td>100</td>
<td>20.816x12.339</td>
</tr>
</tbody>
</table>

Variations are not consistent. The conidia from nettle seem slightly smaller in both dimensions. They are distinctly more pear-shaped. It would seem that spore measurements do not have a close correlation with the relative resistance of the host upon which they are developed.

**Fungicidal Tests with Germinating Zoospores**

In order to determine the fungicidal value of a variety of dry and liquid materials for possible use in field control work as sprays or dusts or for crown treatments, conidia were germinated in watch crystals of distilled water at room temperature. One drop of motile zoospore suspension was placed on a glass slide to which was added one drop of the chemical under test and the effect determined by microscopic
Certain solutions, emulsions and suspensions were too opaque for accurate recordings to be made. The miscibility of the materials with the water of the zoospore suspensions varied; in some cases some time elapsed before complete dispersion took place. A tendency for the zoospores to congregate at the edges of the drop and away from the light was noted. In most cases there was a variation in the ability of the zoospores to remain motile. The end point was taken when all motility of all zoospores in the suspension ceased. All materials were observed for a maximum period of 5 minutes. Where dusts were used, glass slides were dusted with each material by means of a small improvised duster. Suspensions of motile zoospores were placed on the dusted slides and observed with the aid of a microscope for a maximum period of 5 minutes.

Seventy-nine separate samples of dusting materials were used. Zoospore motility ceased within 1 minute with 10 materials; between 1 and 2 minutes with 7 materials; between 2 and 3 minutes with 11 materials; between 3 and 4 minutes with 5 materials; between 4 and 5 minutes with 1 material and with 45 materials motility had not ceased in 5 minutes.

Only one material that was apparently lethal to the zoospores within 1 minute was commercially available. It is so much more costly than copper-lime dust that its use in field trials is not considered practicable.

None of the materials that were lethal between 1 and 2 minutes are commercially available.

Sodium carbonate and hydrated lime were the only two materials lethal to zoospores between 2 and 3 minutes.
Copper-lime dust which has given commercial control as a crown treatment under field conditions killed the zoospores between 3 and 4 minutes and was the only commercial material effective within this time range except two mercuric compounds which were much more costly.

All of the other materials were less effective than copper-lime dust. Seventy separate samples of liquid materials were used. A comparison of the relative merits of these materials is much more difficult than was the case with the dusts because the formulae used are not entirely comparable.

Zoospore motility ceased within 1 minute with 22 materials; between 1 and 2 minutes with 7 materials; between 2 and 3 minutes with 5 materials; between 3 and 4 minutes with 1 material; between 4 and 5 minutes with 4 materials and with 31 materials zoospore motility had not ceased in 5 minutes.

All materials were compared with copper sulphate which was effective within one minute. Five materials in the same class were organic mercury compounds either not commercially available or not comparable with copper sulphate on a cost basis. Seven other materials in this class were proprietary compounds or laboratory materials unsuited for field use.

Borco, a proprietary material in this class, was too variable in its effects to prove of much interest.

Commercial lye used at the rate of one pound to 100 gallons water killed the zoospores within one minute. It is already in use as one ingredient of our resin-soap spreader and is not suitable for use alone either as a crown treatment material or as a summer spray.

Two samples of zinc sulphate were effective within 1 minute at a dilution of 2-1/2 pounds to 100 gallons water as compared with half
that amount of copper sulphate. It offers possibilities as a summer spray from the standpoint of leaving no visible residue on the cones.

Lime sulphur 1-8 compared favorably with copper sulphate, but would probably be more expensive. As a combination spray for red spider control, however, it may have possibilities.

Two samples of copper acetate and one of copper ammonium sulphate compared favorably with copper sulphate but offer no particular advantages.

Calcium cyanamide at the rate of 5 pounds to 100 gallons of water compared favorably with copper sulphate. Since this material has fertilizing value, further work with it is contemplated as a crown treatment material.

Results with 2 samples of copper sulphate varied slightly but at 2 pounds to 100 gallons of water it seems still, from the standpoint of availability, cost, and average results, the most satisfactory material for use in dusting, spraying or crown treatments.

It should be borne in mind that these tests are of a preliminary nature. The age of the conidia used and the temperatures under which zoospores were active when the fungicidal effects of the various materials used were observed should if possible be uniform. Both of these important factors varied in the course of the work here reported.

Field Trial of Reeves' "Pestfoe"

This material was being manufactured by Growers' Products Corporation of Tacoma, Washington, and sold to hop growers as a downy mildew remedy. The analysis on labels, follows:

| Nitrogen (in ammonia) min. | 0.10% |
| Potash (water soluble) min. | 10.00% |
| Chlorine, max. | 15.00% |
| Derived from the following materials: ammonia, ammonium sulphate, sodium chloride, and muriate of potash. |
Growers were advised to use 1 pound per hill, applied in a circle two feet from the center of the hill.

Between April 25 and 27, 100 hills were so treated adjoining one of our own field plots for comparison. The one hundred hills were carefully examined on May 20, June 20, and August 23. Detailed data are on file. Results summarized indicate that approximately 2% of the hills remained uninfected by downy mildew throughout the season as compared with 6.8% of the untreated hills of the adjoining plot.

MISCELLANEOUS HOP DISEASES

1. **CROWN GALL**, caused by *Bacterium tumefaciens*. Revised disease survey data on this disease follow:

**OREGON**

1929: Polk county - 1 report on Late Clusters.
1930: Benton county - 1 report on Early Clusters; Linn county - 1 report on Early Clusters; Polk county - 1 report on Late Clusters.
1931: Benton county - 1 report on Early Clusters; Linn County - 1 report on Early Clusters; 1 unknown; Polk County - 3 reports on Lake Clusters.
1932: Benton county - 1 report on Early Clusters; Polk county - 1 report on Early Clusters.

Early in March, 1932, sexless plants were being rogued from a hop yard in Polk county, Oregon, involving several hundred acres. Four hundred roots of these rogued plants were examined and 6.25% found to be infected with crown gall. Most of the galls were similar to that pictured on page 161 of our first Progress Report, although 3 with galls similar to that pictured on page 164 of our first Progress Report were disclosed.

a. Isolations were made on October 19, 1931, from galls on Late Clusters collected in the field. On November 6, inoculations were made in 3 crowns each of Early Clusters, Late Clusters and Fuggles with one control of each variety. The inoculations were made by
placing bacteria by means of a sterile loop into incisions made with a sterile scalpel. The point of inoculation was kept moistened with cotton fixed in place over the incision. On December, none of the controls showed galls. One plant each of Late Clusters and Fuggles showed typical galls at the points of inoculation. On January 6, 1932, reisolations were attempted but proved unsuccessful because of contaminating organisms.

It is of interest to note that Dr. A. J. Riker, to whom specimens of the "normal" and "hairy-root" types of galls were sent, reported inability to isolate the causative organism and suggested the galls might be overgrowths and not of bacterial origin.

b. On October 28, 1931, 10 Early Cluster cuttings with "hairy-root" type galls were planted in greenhouse benches. On May 2, but 4 had sprouted. Three were perfectly normal; 1 had a very weak vine arising from an extensive top gall. The six cuttings showing no growth were dug up. All were still alive though some root rot was developing. The galls had all largely disintegrated but in all cases had involved buds at the crowns since in each case the galls were located at the tops of the cuttings.

On June 10, 4 plants were removed from the bench for planting in the field for further observations as to the effect of the galls in subsequent vine growth. Two of the cuttings had top galls with normal vine growth but no new gall growth. One had middle and bottom gall with normal vine growth and new gall growth on the middle gall only. One had top, middle, and bottom gall with one very weak shoot but no new gall growth.

Charts of the portion of the experimental field in which these cuttings were planted have been made and observations on the plants
during the season cannot be included in this report.

2. On November 28, 1931, 9 cuttings of Early Clusters were planted in pots in the greenhouse; 3 with galls at the bottoms of the cuttings; 3 with galls at the middles of the cuttings, and 3 with galls at the tops of the cuttings. On June 10 all plants were removed to the field for planting and further observation. There was normal vine growth on all cuttings with bottom galls. Two of these had middle galls also and one had top gall also on a shoot near the ground level showing new gall growth. There was no new gall growth on the middle galls and new gall growth on but one bottom gall. There was normal vine growth on all plants with middle galls and all showed new gall growth. Two of the plants with top galls had normal shoot growth; one showed no new gall growth and no shoot development and only a few small leaves arising from buds near the ground level.

For reasons indicated above, observations on the plants during the season cannot be included in this report.

2. ROOT ROT. Revised plant disease survey data on reports of root rot, from all causes, follow:

OREGON

1916: Marion county - 1 report cause attributed to Armillaria mellea.
1928: Marion county - 1 report.
1930: Marion county - 2 reports; Yamhill county - 1 report.
1931: Marion county - 2 reports; Polk county - 3 reports; Washington county - 1 report.
1932: Lane county - 2 reports; Polk county - 1 report attributed to Armillaria mellea.

WASHINGTON

1930: Lewis county - 1 report; Pierce county - 3 reports.

Missing hills, probably due in part at least to root rots were reported as follows:

OREGON

1930: Clackamas county - 1 report; Lane county - 3 reports; Linn county - 1 report; Marion county - 11 reports; Polk county - 1 report; Washington county - 1 report.
Sooty Mold on Hop Leaves
Independence, Oregon, October 22, 1932
1931: Benton county - 1 report; Clackamas county - 1 report; Linn county - 1 report; Marion county - 4 reports; Polk county - 1 report.  
1932: Clackamas county - 1 report; Lane county - 2 reports; Marion county - 1 report; Washington county - 1 report.

In our 1932 experimental plots, out of a total of 8467 hills on which data were recorded, there were 5.2 per cent missing hills. Specific data on replantings necessitated by this trouble are not readily available. Two instances in Polk county, Oregon, the past season, were brought to our attention; using two plants per hill, one 120 acre yard used 80,000 replants; another 500 acre yard used 25,000 replants. The losses have been reported as high as 90% in individual plantings.

In one of our experimental plots the past season there were 105 missing hills out of a total of 3181 hills. In the second plot there were 282 missing hills, out of a total of 4788 hills. All of these hills were inspected. The plant remains, where present, were all too far rotted for culturing except in 23 instances. Cultures of organisms from 18 of the 23 originally made are on hand. Nine other cultures are on hand; two from material secured in the field and 7 from material secured in the greenhouse. Most of these cultures are not of single organisms and opportunity has not been afforded thus far making an attempt to identify this material to determine what organisms are predominant nor to prove their pathogenicity.

Whatever the principal cause of root rot may be, the problem as a whole is of economic importance and would seem to justify more detailed consideration in the future.

But one greenhouse experiment has so far been attempted. On November 13, 1931, plantings were made of greenhouse seedlings affected with root rot as pictured on pages 175 and 178 of our first
Progress Report. On March 26, 1932, six Fuggles seedlings were cut back and planted in pots, 2 of which were left as checks. All roots were examined to see that there was no evidence of root rot. The contents of one slant of potato dextrose agar containing the organism isolated on November 13, 1931, was applied to the center of the root system of each of four plants. The plants were covered with soil and kept watered. On May 11, all pots were examined. There was no apparent growth of the fungus in culture and no evidence of rot in the vicinity. Small brown lesions were noted on the rootlets of both check and the four inoculated plants. On June 25 the lesions were enlarged and assuming the characteristics of the root rot on the original seedlings from which cultures were obtained. Reisolations were not attempted and the plants discarded.

3. **SEED-BORNE FUNGI.** Lupulin, the preservative principle of hops, is commonly present in glands on the perianth enclosing the seed. In attempting to grow seedlings in the greenhouse, difficulty was experienced in securing seed germination.

When seeds were placed on moist blotting paper and potassium nitrate in Petri dishes exposed to light, dormant seeds were overgrown with a number of fungi which were quite evidently in no wise inhibited in their growth by the large number of lupulin granules present.

Some 35 cultures were secured of these various fungi. What role, if any, they may play in seed germination has not been determined. The various forms were not in all cases definitely identified and since the problem is not one of economic importance, the cultures of the organisms were not maintained.

4. **SOUR HOLD** caused by *Fumago vagans*. Cultures have been secured of this organism but no investigational effort has been devoted
Chlorosis on Fuggles in Greenhouse
1952
to it. It appears that "honey-dew" may exude from hop plants under
certain climatic and other indefinitely understood conditions (accord-
ing to growers and some writers) in the absence of aphis. Since the
fungus grows in this exudation regardless of its origin, the control
of aphis may not be sufficient to control sooty mold. This observa-
tion checks with field observations in that considerable mold may
develop even where spraying has reduced aphis infestation to a minimum.
Prune trees are often found in and near hop plantings. This situation
is worthy of serious consideration since the hop aphis overwinters
largely on the prune.

Revised disease survey data on reports of sooty mold follow:

OREGON
1916: Marion county - 1 report; Polk county - 1 report; Yamhill
county - 1 report.
1930: Benton county - 1 report; Clackamas county - 1 report; Lane
county - 1 report; Linn county - 3 reports; Marion county - 5
reports; Polk county - 3 reports; Washington county - 1 report;
Yamhill county - 1 report.
1932: Benton county - 1 report; Polk county - 1 report; Yamhill
county - 1 report.

WASHINGTON
1924: Pierce county - 1 report.

5. VIRUS DISEASES. Little attention has been given this rather
complicated group the past season. Several manifestations of what is
presumably virus infection became apparent from time to time. Revised
disease survey data will be of interest:

a. "Bastards" or Sexless Plants

OREGON
1931: Polk county - 1 report.
1932: In our own experimental plots of Late Clusters in Polk and
Benton counties, out of a total of 8469 hills, a total of only
93 plants were sexless.

b. Blight.

OREGON
1927: Clackamas county - 1 report.
1928: Clackamas county - 1 report.
1929: Clackamas county - 1 report.
1930: Clackamas county - 2 reports.
1931: Benton county - 1 report; Clackamas county - 8 reports; Lane county - 5 reports; Linn county - 2 reports; Marion county - 20 reports; Polk county - 2 reports; Washington county - 2 reports; Yamhill county - 2 reports.
1932: Clackamas county - 8 reports; Josephine county - 1 report; Lane county - 1 report; Marion county - 20 reports; Polk county - 5 reports; Washington county - 2 reports; Yamhill county - 3 reports.

Definite estimates of losses are not available. Growers' estimates vary from 5 to 40 per cent, but their use of the term "blight" includes most conditions unfavorable to normal development of the vines that cannot be specifically charged to some other cause.

c. Dormant Hills or "Sleepers."

OREGON
1930: Benton county - 1 report; Clackamas county - 7 reports; Lane county - 6 reports; Linn county - 4 reports; Marion county - 34 reports; Polk county - 12 reports; Washington county - 7 reports; Yamhill county - 6 reports.
1931: Clackamas county - 17 reports; Josephine county - 2 reports; Lane county - 6 reports; Linn county - 2 reports; Marion county - 45 reports; Polk county - 13 reports; Washington county - 5 reports; Yamhill county - 9 reports.
1932: Benton county - 1 report; Clackamas county - 5 reports; Lane county - 2 reports; Marion county - 20 reports; Polk county - 8 reports; Washington county - 7 reports; Yamhill county - 2 reports.

The exact cause of this condition is not known. It is perhaps more probably associated with virus infection than with root rots since dormancy is apparently not consistent year after year; the plants are not killed and may recover normality the following season. The chief damage is from delayed shoot growth in the spring and the resultant uneven development of the crop. Vine growth may be so long delayed as to result in a reduced yield. Individual yards have reported as high as 90 per cent dormant hills.

d. A variety of terms have been applied by growers in describing conditions probably brought about in part at least by virus infection, e.g.:
Mosaic. In 1931 there was one report each from Marion county, Oregon, and Yakima county, Washington.

Nettle-head. In 1930 there was one report from Marion county, Oregon, and in 1931 one report each from Linn and Marion counties, Oregon.

Snake-head. In 1931 there was one report each from Linn and Marion counties, Oregon.

Virus. In 1931 there was one report from Polk county, Oregon.

White-head. In 1931 there was one report from Marion county, Oregon.

Our discussion of these troubles in our first Progress Report need not be greatly modified by subsequent observations. Serious commercial damage reported in Clackamas county, Oregon, occurs in stock obtained elsewhere in the state and in parent plantings no such symptoms occur. Peculiar local climatic conditions are probably responsible for an expression of the symptoms.

On September 17, 1931, ten cuttings from seriously "blighted" plants from the W. G. Glover yard at Eagle Creek, Clackamas county, were obtained and placed in pots in our greenhouse. Subsequently six of these cuttings did not develop plants. By June 18, 1932, 1 plant was dead but no symptoms of "blight" had appeared. Three plants showed perfectly normal growth and were discarded on August 29.

On July 20, 1931, two crowns of virus infected plants from Union Gap, Yakima county, Washington, were planted in our experimental yard at Corvallis, but the plants died during the 1931 growing season without showing any disease symptoms.

On July 18, 1932, in our Experimental Plot A, several plants showed apparent mosaic mottling of leaves which were also brittle and down-curved. A close inspection revealed the presence of thrips which were causing injury to the under surface of diseased leaves, particularly to the midribs of the younger leaves which was followed by
Chlorosis on Fungus in Greenhouse
February, 1933.
necrosis of the leaf tissues, causing a marked deformity as the leaves enlarged. It is quite possible that thrips may prove to be a vector in the spread of virus diseases of hops.

On March 27, 1931, Dr. E. N. Bressman, in his first annual report, reported one greenhouse seedling infected with mosaic. Attempts at transfer of the disease gave negative results.

On pages 71-72 of our first Progress Report, Mr. Walter Jones describes several virus diseases from England, i.e., infectious chlorosis, nettlehead, split-leaf and mosaic.

e. Chlorosis. One hundred and eighteen rooted Fuggles cuttings from the E. C. Horst Company nursery were planted in greenhouse benches in the fall of 1931. All sprouted and developed apparently normal shoots but were pale and eventually died back and were cut off at the ground level. They remained dormant until about January, 1932. As soon as growth had progressed several feet, a peculiar pale-green chlorotic appearance became evident on some plants. This coloration was distinct from that due to lack of nitrogen as sometimes seen on sandy upland soils. Leaves of affected plants were flacid, with marked puckering due to depressed areas in the intravenous regions. The whole of seriously affected leaves were cupped downward. Mottling was not marked. There was some malformation and rigidity. The abnormal appearance was evident from the first appearance of leaves on small shoots in which cases the terminal growth was slow and the shoots spindly. The symptoms occurred later on some plants; the young leaves on terminals and side arms particularly being affected. A split-leaf condition was also apparent on some of the younger leaves.

Typical mosaic symptoms were thought checked perhaps by high temperatures in the greenhouse. Plant No. 101 was removed to a cool
room on February 6, 1932 and on February 23 showed more pronounced mosaic and severe puckering with less general chlorosis.

By February 8 a total of 11 plants showed more or less distinct symptoms as described above. A red spider infestation followed very shortly. While spider injury was quite distinct, it tended to confuse the symptoms. A spray of Koloform with skim milk powder spreader was applied with indifferent results. The leaves were coated so as to mash the less marked symptoms and some injury occurred as was evident in the 1931 spray plots and therefore the application was not repeated.

Vines were interlaced and in order to follow developments of the condition more closely on March 23, all plants were numbered, diagnosed, and the vines cut back to the crown.

Data secured on March 23, 1932:


4. Symptoms similar to above but still more pronounced, with some young leaf malformation on Plants Nos.: 87-94.

5. Chlorosis only apparent on leaves on lower portion of Plant No. 24.


7. As above with leaves more cupped and brittle and with some leaf malformation on Plants Nos.: 43-68-69.

8. Slight puckering but no chlorosis on Plant No. 95.

On March 12, Plants Nos. 5 to 18 were similar to description in paragraph 2 above. They were cut back. No symptoms were evident.
on March 23 and shoots were again cut back. Plant No. 52 showed severe chlorosis and puckering, mosaiced and cupped brittle leaves on March 12. Shoots were cut back. There was no new growth on March 23.

On March 24, 1932, Plants Nos.: 102-103-105-106-108-111-112-114-115-117-118 were inoculated as follows: Leaf tissue of plants showing chlorotic symptoms was macerated in sterile water. Cheese cloth was saturated with the liquid and rubbed on the upper surface of 1 pair of leaves on each plant inoculated. Inoculated pairs of leaves were tagged. Plants Nos.: 104-107-110-113-116-119 were left as checks.

On March 26 intravenous necrosis similar to symptoms of split-leaf were evident on inoculated leaves on Plants Nos.: 102-195-105-107-109-111-112-114-115-117-118. Similar symptoms, however were apparent on check plants at pairs of leaves tagged on Plants Nos.: 107-114.

On March 29, all plants were stripped of leaves below the tags. On June 16, Plants Nos.: 102 to 119 inclusive were cut back. The experiment had to be abandoned due to injury of plants from spider and cyanide fumes which masked any possible induced symptoms. This was also true as regards further observations on Plants Nos.: 1 to 102 inclusive.

CORRESPONDENCE-PUBLICITY-PUBLICATIONS

Correspondence. Activities along this line were similar to those outlined in our first Progress Report.

Publicity. One executive meeting of the Oregon Hop Growers was attended and a brief account of progress of the investigations was
made, together with a general plan for future work. In October, a paper entitled "Hop Diseases and Their Control" was presented before the first annual meeting of the Oregon Hop Growers. Opportunity was afforded to meet and outline the work to Senator Steiwer and Representatives Martin and Pierce as well as State Senator McFadden and Representative Herron.

Publications. In March, 1932, Extension Bulletin 440, "Downy Mildew of Hops" was published. A short paper on "Downy Mildew Infection of Hop Seedlings" appeared during October in the Journal of the Institute of Brewing. Early in December, Circular of Information 80, entitled "Crown Treatments for Hop Downy Mildew Control" was issued. During October a paper on "Dusting for Hop Downy Mildew Control" was submitted for publication to The Brewers' Journal, and manuscript in collaboration with Mr. Walter Jones of the Dominion Laboratory of Plant Pathology at Saanichon, B. C., was forwarded to Dr. E. C. Stakman, American Editor of Phytopathologische Zeitschrift, for publication in that Journal.