Bulletin No. 271 - The Control of Psyllids and Flea Beetles on Potatoes

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Tractor-mounted duster applying the dust from above the plants without a hood over the boom.

The Control of Psyllids and Flea Beetles on Potatoes

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The Control of Psyllids and Flea Beetles on Potatoes
William A. Riedl and Lael R. Harrison

INTRODUCTION

The potato psyllid (Paratrioza cockerelli Sulc.) and the potato flea beetle (Epitrix tuberis Gentner) are two of the most important insect pests of the potato crop in Wyoming.

The potato psyllid causes the disease, psyllid yellows, or what is frequently called “purple top.” This disease in turn causes large reductions in yield during certain seasons (Figure 1). Farmers should always be prepared to control the psyllids whenever they appear.

Figure 1. Left: tubers from ten hills of a plot treated twice for psyllid control. Right: tubers from ten hills of an untreated plot showing yield reduction.

The potato flea beetle causes a large amount of damage to the potatoes produced under irrigated conditions in the North Platte Valley, particularly in the Torrington area. The adult flea beetle feeds on the leaves of potato plants, making small holes about one-sixteenth of an inch in diameter. However, from a commercial standpoint, the injury caused by the larvae to the tubers is far more serious than that caused by the adult. The larvae tunnel along the surface of the developing tubers, producing a condition known as “worm track.” Often the larvae may penetrate the tuber a quarter of an inch or more at right angles to the surface. This
results in a type of injury commonly called flea beetle "slivers." The flea beetle "worm track" and "slivers" injures the appearance of the potatoes and these injuries are scored as defects in commercial potato grades (Figure 2). Potatoes injured by flea beetles sell considerably below the U. S. Number One grade, causing large losses to the potato producer.

Figure 2. Typical flea beetle damage on potatoes. The tuber on the left shows severe "worm track." The peeled tuber on the right shows the flea beetle "slivers."

With the increased use of sulphur dust for potato psyllid control came a demand for more information on the relative effectiveness of various kinds of sulphur dusts, rates and methods of application, as well as what mixtures of sulphur dust and other insecticides would give the best control of both psyllids and flea beetles.

During 1943 and 1944 experiments were conducted at the Agronomy Farm, Laramie, Wyoming, to determine the relative effectiveness of various kinds of sulphur dust, rates of application and methods of application for potato psyllid control. During the same period, experiments were conducted at the Torrington substation, to determine the relative effectiveness of various mixtures of sulphur dust and other insecticides for the control of both psyllids and flea beetles. The results of these experiments are given in this publication.
REVIEW OF LITERATURE

A number of workers have reported on methods of controlling potato psyllids and flea beetles with sprays; however, it has been only in recent years that literature could be found on the use of dusts for the control of these insects. Little has been written on the control of the flea beetle damage to the potato tubers.

Daniels (1) reported, in 1934, that lime-sulphur sprays have shown up favorably in controlling psyllids on potatoes. Hartman (5) in 1937, demonstrated that lime-sulphur is an effective control for the damage to yields of potatoes caused by the potato psyllid. List (9) stated, in 1939, that sulphur dust (300-mesh) was highly effective in controlling psyllids on tomatoes. Plots treated with sulphur dust gave higher yields than those treated with lime-sulphur spray. In 1943, he reported (10) that research has shown dusting sulphur and wettable sulphur to be as effective as the lime-sulphur in controlling the psyllid, and these are being used effectively by commercial tomato growers. He also reported that in no case, has either dusting sulphur or wettable sulphur spray proved significantly less effective than the lime-sulphur in controlling psyllids on potatoes. Eyer and Enzie (3) obtained effective psyllid control with 300-mesh black sulphur dust, 300-mesh and 325-mesh yellow sulphur dust. The senior author of this bulletin (11) in 1941, reported that potatoes dusted with a power duster at the rate of 35 pounds of sulphur dust per acre for psyllid control gave higher yields than those sprayed with lime-sulphur; however the increase in yield was not statistically significant. In 1943, he reported (12) that sulphur dust had given better control of the psyllid adult, egg and nymph populations, and had given higher total yield and a higher yield of U. S. Number One potatoes than lime-sulphur or wettable sulphur sprays. The increases in yield were not statistically significant, except in a few cases. The 30-pound rate of sulphur dust per acre had given slightly higher yields than the 20-pound per acre rate, but the difference was not statistically significant. Dusting for the control of the potato psyllid is cheaper, faster and easier than spraying. More timely applications can be made and less damage is done to the vines and the fields.

Horner and Gillette (7) reported, in 1928, that 5 days after an application of a spray consisting of 3 pounds of calcium arsenate, ¾ pound of calcium caseinate and 100 gallons of water flea beetle populations were reduced 85 per cent and that after a 11-day period, populations were reduced 95 per cent. Gui (4) in 1938, stated that pyrethrum sprays reduce flea beetle populations but are not sufficiently effective to produce a commercial degree of control. Data obtained in relation to crop yield, flea beetle populations and foliage damage support one another. They indicate that calcium arsenate
at the rate of 2 pounds to 50 gallons of 4-6-50 Bordeaux mixture, applied at approximately weekly intervals during the growing period, is the preferred schedule for flea beetle control on potatoes. When a schedule of dusts is employed, the addition of 1 pound of calcium arsenate to 10 pounds of monohydrated copper-sulphate hydrated-lime is of value in flea beetle control. In 1940, Swenk and Tate (14), stated that although many growers in western Nebraska have not experienced satisfactory flea beetle control with zinc arsenite it appears to be the most practical control measure available at the present time. Skaptason and Blodgett (13) reported, in 1941 that rotenone dust reduced the number of flea beetles and aphids. Daniels (2) reported that studies up to 1941 in Colorado, on the control of flea beetles, indicate that zinc arsenite spray (2 pounds of zinc arsenite to 50 gallons of water) is the most satisfactory. A combination spray of 2 pounds of zinc arsenite, 1 gallon of lime-sulphur and 40 gallons of water will control psyllids, flea beetles and Colorado potato beetles. Calcium arsenite, mixed at the rate of 1 pound to 8 pounds of hydrated lime, applied at the rate of from 25 to 30 pounds per acre, has been found to be the most effective and economical dust for controlling the flea beetle. A most satisfactory dust material for the control of flea beetle on potatoes is available in commercial mixtures of cryolite, applied at 10 to 15 pounds per acre, but the cost is prohibitive in commercial potato growing. Landis (8) in 1943, reported that flea beetle damage to potato tubers can be largely prevented by frequent and properly-timed applications of either a 25 per cent calcium arsenate dust or a 30 to 35 per cent cryolite dust. The rate of applications of these materials should be gradually increased from 15 to 30 pounds per acre, as the plants increase in size. Turner (15) in 1944, reported that dusting at weekly intervals for flea beetle control showed cryolite at higher dosages only provides slightly less control than rotenone at 0.5 or 1.0 per cent. Hill and Tate (6) in 1944, found that among the sprays tested for flea beetle control, zinc arsenite and basic copper arsenate proved best. Cryolite and Dutox sprays were among the less effective materials. Of the dusts, Dutox and cryolite, which were equally effective, ranked first. The addition of 0.5 per cent rotenone to a cryolite-sulphur mixture increased effectiveness to a slight extent. On the basis of a single test in 1943, a 0.5 per cent rotenone sulphur dust was less effective than Dutox-sulphur or cryolite-sulphur dust. Their experiments showed that dusts were as effective as sprays in controlling potato flea beetle infestation. The presence or absence of dew has little or no influence on the effectiveness of the dusts used in western Nebraska. DDT used as a 3 per cent dust or as a spray (4 pounds of 10 per cent DDT to 100 gallons water) gave very good control of flea
beetles in 1944. However, they did not state that DDT controlled the flea beetle damage to the tubers.

A review of the literature shows that experimental work, with emphasis on the control of the flea beetle damage to the potato tuber, has been done only in recent years.

**EXPERIMENTAL METHODS**

All of the dust and spray treatments were applied to Bliss Triumph potatoes grown under irrigated conditions. The dust was applied with power dusters which had two nozzles per row and a canvas hood suspended over the boom, except for some of the treatments on methods of dusting. The spray was applied with a four-row horse-drawn, engine-powered sprayer having three nozzles per row, one nozzle on each side of the row spraying upward at a 45 degree angle and one on top of the row spraying down. Approximately 80 gallons per acre of spray solution was applied at a pressure of 300 to 400 pounds per square inch.

At Laramie the potatoes were planted by hand, spacing the seed pieces one foot apart in the row and three feet between rows. In 1943, the treatments were applied to four-row plots 60 feet long, and in 1941, eight-row plots 60 feet long were used. The dusts were applied with a four-row engine-powered, horse-drawn duster.

At Torrington the potatoes were planted with a potato planter with rows spaced three feet apart. In 1943, the treatments were applied to four-row plots 1000 feet long. The dust was applied with a two-row engine-powered duster. In 1944, the treatments were applied to eight-row plots 60 feet long and a four-row tractor-mounted duster was used.

The sulphur dust and other insecticides were thoroughly mixed by means of a dust mixer especially designed for mixing insecticide and fungicide dusts. The treatments in all the experiments were replicated four times, except in a preliminary trial on new treatments in which two replications were used. The treatments were arranged in a randomized manner within each replication. The readings on the psyllid and flea beetle populations were made by R. L. Wallis, Entomologist of the U. S. Department of Agriculture, stationed at Scottsbluff, Nebraska. The data were analyzed by the analysis of variance method and the difference for significance was calculated at the five per cent point. Other variations of experimental methods are explained under each experiment.

*The difference required for significance, shown in the various tables is two times the standard error of the difference as computed by the variance method of R. A. Fisher. The assumption is that the odds are 19 to 1 that a difference between any two treatments as great as, or greater than, the value shown is due to a real difference between treatments and not to experimental error.*
Figure 3. Making first application on experimental plots with a four-row, horse-drawn, engine-powered duster.

EXPERIMENTAL RESULTS ON PSYLLID CONTROL

LARAMIE—1943

Kinds of Sulphur Dusts and Rates of Application

Three kinds of sulphur dusts were applied at 10, 20 and 30 pounds per acre. Number 1 dust was 325-mesh, containing 7 per cent non-alkaline conditioning agent. Number 2 dust was a 90 per cent free-flowing, microfine dusting sulphur having a particle size ranging on an average from 3 to 6 microns and was ground substantially finer than the 325-mesh. Number 3 dust was 325-mesh and contained 7 per cent conditioning agent but a different kind than that in the number 1 dust. Applications of the treatments were made on the following dates: July 14, 26 and August 11. Figure 3 shows the size of plants at the time of making the first application.

The psyllid population was relatively low, probably the lowest during the past ten years. However, psyllids were present in damaging numbers and adjacent fields of potatoes not treated for psyllid control showed symptoms of psyllid yellows and a corresponding reduction in yield.
## Table I
Comparison of Three Kinds of Sulphur Dust
Applied at Three Rates for Potato Psyllid Control
Laramie — 1943

<table>
<thead>
<tr>
<th>No.</th>
<th>Kinds of Sulphur Dust</th>
<th>Rate—lbs. Per Acre</th>
<th>Yield—Bushels Per Acre</th>
<th>Total</th>
<th>Rank</th>
<th>U.S. 1’s</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>93% 325-Mesh</td>
<td>10</td>
<td>336</td>
<td>7</td>
<td>303</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>93%</td>
<td>325-Mesh</td>
<td>20</td>
<td>350</td>
<td>2</td>
<td>311</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>93%</td>
<td>325-Mesh</td>
<td>30</td>
<td>341</td>
<td>4</td>
<td>309</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Microfine</td>
<td>10</td>
<td>347</td>
<td>3</td>
<td>310</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microfine</td>
<td>20</td>
<td>353</td>
<td>1</td>
<td>320</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microfine</td>
<td>30</td>
<td>331</td>
<td>8</td>
<td>296</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>93% 325-Mesh</td>
<td>10</td>
<td>333</td>
<td>6</td>
<td>305</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>93%</td>
<td>325-Mesh</td>
<td>20</td>
<td>326</td>
<td>9</td>
<td>290</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>93%</td>
<td>325-Mesh</td>
<td>30</td>
<td>340</td>
<td>5</td>
<td>304</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Check (untreated)</td>
<td></td>
<td></td>
<td>313</td>
<td>10</td>
<td>279</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difference required for significance</td>
<td></td>
<td></td>
<td>27</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The yield of potatoes for the various treatments (Table I) were based on the tubers harvested from the four rows of each plot. The tubers were graded U. S. Number One, except for scab and mechanical injury.

An analysis of the individual treatments shows that most of the plots treated with sulphur dust gave a significant increase of both total and U. S. Number One potatoes over the untreated check. The sulphur dust number 2 applied at 20 pounds per acre gave the highest yield, followed closely by sulphur dust number 1 at 20 pounds per acre and number 2 dust at 10 pounds per acre, respectively. However, there were no significant differences in yield between any two of the treatments.

## Table II
Average Yield of Potatoes Treated With Three Kinds of Sulphur Dust for Psyllid Control
Laramie — 1943

<table>
<thead>
<tr>
<th>No.</th>
<th>Kinds of Sulphur Dust</th>
<th>Yield—Bushels Per Acre</th>
<th>Total</th>
<th>Rank</th>
<th>U.S. 1’s</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>93% 325-Mesh</td>
<td></td>
<td>342</td>
<td>2</td>
<td>307</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Microfine</td>
<td></td>
<td>343</td>
<td>1</td>
<td>309</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>93% 325-Mesh</td>
<td></td>
<td>335</td>
<td>3</td>
<td>299</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Check (untreated)</td>
<td></td>
<td>313</td>
<td>4</td>
<td>279</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Difference required for significance</td>
<td></td>
<td></td>
<td>25</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
As shown in Table II, the highest yields were obtained with the microfine dust, but differences between it and the lowest yield obtained with dust number 3 were not statistically significant.

The average yields for the three rates of application are shown in Table III. An analysis of the rates of applications shows that all three rates (10, 20 and 30 pounds of sulphur dust per acre) gave significant increases in yield over the untreated check. However, there are no significant differences in yield between the three rates of application.

### Table III

**Comparison of Three Rates of Application of Sulphur Dust for Psyllid Control**

**Laramie — 1943**

<table>
<thead>
<tr>
<th>Rate—Pounds Per Acre</th>
<th>Yield—Bushels Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>10</td>
<td>340</td>
</tr>
<tr>
<td>20</td>
<td>343</td>
</tr>
<tr>
<td>30</td>
<td>337</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>313</td>
</tr>
<tr>
<td>Difference required for significance</td>
<td>23</td>
</tr>
</tbody>
</table>

**LARAMIE—1944**

**Rates of Application**

A 93 per cent 325-mesh sulphur dust containing 7 per cent conditioning agent was applied at 10, 20 and 30 pounds per acre. The treatments were applied four times during the growing season, on July 9, 27, August 14 and 24.

Severe hail storms occurred on July 3 and 10, which cut the potato vines to the ground. A heavy frost, on September 1, killed a portion of the vines. The field was harvested September 19 and the tubers were graded September 26. The tubers were graded over a 1-inch screen instead of a 1⅛-inch screen because of the low yield resulting from the damage done by the hail and early killing frost. The yields for the various treatments were based on the potatoes harvested from the four center rows of each plot. These data are shown in Table IV.
Table IV
Comparison of Three Rates of Application of Sulphur Dust for Psyllid Control
Laramie — 1944

<table>
<thead>
<tr>
<th>Rate—Pounds Per Acre</th>
<th>Total Yield Per Acre</th>
<th>Yield Over 1 Inch Psyllids Per Acre</th>
<th>Adult Psyllids Per 100 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels</td>
<td>Rank</td>
<td>Bushels</td>
</tr>
<tr>
<td>10</td>
<td>36</td>
<td>3</td>
<td>29</td>
</tr>
<tr>
<td>20</td>
<td>58</td>
<td>2</td>
<td>51</td>
</tr>
<tr>
<td>30</td>
<td>72</td>
<td>1</td>
<td>64</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Difference required for significance</td>
<td>10</td>
<td>10</td>
<td>8.20</td>
</tr>
</tbody>
</table>

There was an extremely high psyllid population all through the season. While the yield was unusually low, because of the hail and frost damage, there were highly significant differences in the yield between treatments. The higher the rate of application the higher the yield obtained. All of the sulphur dust treatments gave a significant reduction in the adult psyllid population over the untreated check. The 30-pound rate gave the best control of adult psyllid population.

Methods of Application

The following five methods of application were tested: (1) nozzles on each side of the row with hood (Figure 4); (2) nozzles on each side of the row without hood; (3) nozzles above the plants with hood; (4) nozzles above plants without hood and (5) check (untreated).

The hood used in this experiment was made of a light-weight canvas and extended the full width of the boom. It extended one foot ahead and three feet to the rear of the boom. The canvas came to the ground on the sides and the rear (Figure 5). The boom and hood were raised a little at the second and succeeding applications.

A 93 per cent 325-mesh, conditioned sulphur dust was applied at 20 pounds per acre. The dates of applications and cultural operations were the same as in the previous experiment. The results are shown in Table V.
Table V

Comparison of Methods of Applying Dust for Potato Psyllid Control
Laramie — 1944

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Yield Per Acre</th>
<th>Yield Over 1 Inch Per Acre</th>
<th>Adult Psyllids Per 100 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels</td>
<td>Rank</td>
<td>Bushels</td>
</tr>
<tr>
<td>Nozzles on each side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with hood</td>
<td>61</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Nozzles on each side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without hood</td>
<td>46</td>
<td>4</td>
<td>39</td>
</tr>
<tr>
<td>Nozzles above with hood</td>
<td>59</td>
<td>2</td>
<td>54</td>
</tr>
<tr>
<td>Nozzles above without hood</td>
<td>57</td>
<td>3</td>
<td>52</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Difference required for</td>
<td>13</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>significance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Four applications of 20 pounds of sulphur dust per acre did not give adequate control of psyllids under conditions of severe hail, rain and wind storms which closely followed some of the dust applications. However, all of the dust treatments gave highly significant reductions in adult psyllid population and highly significant increases in yields over the untreated check. Nozzles on each side of the plants with hood gave the best control of the adult psyllids and gave the highest total yield of potatoes.
Figure 5. Four-row, horse-drawn, engined-powered duster with suspended canvas hood.

The treatments applied with the hood gave significantly higher yields than nozzles on each side without the hood. The treatment with nozzles above and without hood gave higher yields than nozzles on each side without hood.

EXPERIMENTAL RESULTS ON POTATO PSYLLID AND FLEA BEETLE CONTROL
TORRINGTON SUBSTATION—1943

Kinds of Dust and Spray Treatments

A comparison was made of the following ten treatments: sulphur dust; sulphur plus calcium arsenate 4:1; sulphur plus zinc arsenite 4:1; sulphur plus Dutox (barium fluosilicate) 4:1; sulphur plus cryolite 1:1, 2:1, 4:1 and 6:1; lime-sulphur plus zinc arsenite spray; and check (untreated). The sulphur dust used was 93 per cent 325-mesh and contained 7 per cent conditioning agent. The lime-sulphur solution consisted of 1 gallon lime-sulphur to 40 gallons of water to which was added 4 pounds of zinc arsenite to each 100 gallons of solution.

Two applications of the treatments were made on the following dates: July 16 (when the plants were about one foot high) and August 6 (when the plants almost covered the row). It was planned to make a third application but the vines had covered the rows so heavily at the time that it was decided not to make the third application. The dusts were applied at the rate of approximately 30 pounds per acre.
Readings on the adult psyllid and flea beetle population were made on the center rows of each four-row plot at weekly intervals. The readings were made on the following dates: August 2, 9, 16 and 23. No potato psyllids were found in the field. The average number of adult flea beetles per 100 sweeps for each treatment is shown in Table VI.

Table VI
Comparison of Various Dust and Spray Treatments for Potato Psyllid and Flea Beetle Control
Torrington Substation — 1943

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Adult Flea Beetles Per 100 Sweeps</th>
<th>Number of Worm Tracks Per 12 lbs.</th>
<th>Bu. Per Acre</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur dust</td>
<td>41</td>
<td>134</td>
<td>314</td>
<td>6</td>
</tr>
<tr>
<td>Sulphur dust plus calcium arsenate 4:1</td>
<td>26</td>
<td>144</td>
<td>306</td>
<td>9</td>
</tr>
<tr>
<td>Sulphur dust plus zinc arsenite 4:1</td>
<td>41</td>
<td>136</td>
<td>335</td>
<td>2</td>
</tr>
<tr>
<td>Sulphur dust plus Dutox 4:1</td>
<td>32</td>
<td>103</td>
<td>355</td>
<td>1</td>
</tr>
<tr>
<td>Sulphur dust plus cryolite 1:1</td>
<td>33</td>
<td>153</td>
<td>306</td>
<td>9</td>
</tr>
<tr>
<td>Sulphur dust plus cryolite 2:1</td>
<td>30</td>
<td>73</td>
<td>323</td>
<td>5</td>
</tr>
<tr>
<td>Sulphur dust plus cryolite 4:1</td>
<td>31</td>
<td>94</td>
<td>327</td>
<td>3</td>
</tr>
<tr>
<td>Sulphur dust plus cryolite 6:1</td>
<td>24</td>
<td>136</td>
<td>314</td>
<td>6</td>
</tr>
<tr>
<td>Lime-sulphur plus zinc arsenite</td>
<td>40</td>
<td>202</td>
<td>327</td>
<td>3</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>62</td>
<td>363</td>
<td>314</td>
<td>6</td>
</tr>
<tr>
<td>Difference required for significance</td>
<td>17</td>
<td>145</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>

The potatoes were harvested on October 9. The yield data were based on a 50-foot section of one of the center rows of each plot. A 12-pound sample of potatoes was gathered from one of the center rows of each plot for analyses of “worm track” damage. The “worm tracks” were counted on the 12-pound sample from each plot. The averages for number of “worm tracks” and yield for the four replications of each treatment are shown in Table VI.

All of the dust and spray treatments reduced the adult flea beetle population significantly in comparison to the untreated check. Sulphur dust plus cryolite 6:1 gave the best control of the
adult flea beetle and gave significantly better control than sulphur dust alone and sulphur dust plus zinc arsenite.

All of the dust and spray treatments resulted in a significant reduction of "worm track" in comparison to the untreated check. Sulphur dust plus cryolite 2:1 mixture gave the best control, followed by sulphur dust plus cryolite 4:1 and sulphur plus Dutox 4:1. Lime-sulphur plus zinc arsenite spray gave the poorest control; however, there were no significant differences in the amount of "worm track" between the various dust and spray treatments.

There were no significant differences in yield between the various treatments, which was to be expected since no psyllids were found.

Sulphur plus cryolite 4:1 and sulphur plus Dutox 4:1 gave the best average control of the adult flea beetles and "worm track" damage to the tubers; however, none of the treatments gave satisfactory control.

TORRINGTON SUBSTATION—1944

Kinds of Dust and Spray Treatments

A comparison was made of the following nine treatments: sulphur dust; sulphur plus calcium arsenate 4:1; sulphur plus Dutox (barium fluosilicate) 4:1; sulphur plus cryolite 3:1; sulphur plus Kryocide (natural cryolite) 3:1; sulphur plus basic copper
arsenate 4:1; Kenolite (sulphur plus cryolite 4:1); lime-sulphur plus zinc arsenite spray and check (untreated). The sulphur dust used was 93 per cent 325-mesh and contained 7 per cent conditioning agent. The lime-sulphur solution consisted of 1 gallon of lime-sulphur to 40 gallons of water to which was added 5 pounds of zinc arsenite to each 100 gallons of solution. Five applications of the treatments were made on the following dates: July 12, 21, 29, August 4 and 22. The first application was made when the plants averaged approximately 8 inches in height. The dusts were applied at the rate of about 30 pounds per acre.

Readings on the nymph and adult psyllids and adult flea beetle populations were made on the four center rows of each eight-row plot at weekly intervals during the growing season (Figure 6). Six readings were made on the following dates: July 11, 17, 24, 31, August 7 and 14. The averages for number of adult psyllids and adult flea beetles per 100 sweeps, together with the average number of psyllid nymphs per 50 leaflets are shown in Table VII.

The potatoes were harvested on October 6, and the tubers from each of the four center rows of the eight-row plots were weighed (Figure 7). Twenty pound samples from each of the four center rows of each plot were saved for analyses of grade and flea beetle tuber injury. The tubers were graded over a 1 7/8 inch screen
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Yield Per Acre</th>
<th>Yield Over 1/2&quot; Per-Acre</th>
<th>Adult Psyllids Per 100 Sweeps</th>
<th>Psyllid Nymphs Per 50 Leaflets</th>
<th>Yield Over 1/2&quot; Free of Flea Beetle Injury</th>
<th>Adult Flea Beetles Per 100 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels   Rank</td>
<td>Bushels   Rank</td>
<td>Number   Rank</td>
<td>Number  Rank</td>
<td>Bushels  Rank</td>
<td>Number  Rank</td>
</tr>
<tr>
<td>Sulphur dust</td>
<td>431       1</td>
<td>396       1</td>
<td>2.08     1</td>
<td>.80     2</td>
<td>7       8</td>
<td>9.75    4</td>
</tr>
<tr>
<td>Sulphur dust plus calcium arsenate 4:1</td>
<td>386       7</td>
<td>325       7</td>
<td>2.42     5</td>
<td>1.00    4</td>
<td>26      6</td>
<td>13.10   7</td>
</tr>
<tr>
<td>Sulphur dust plus Dutox 4:1</td>
<td>430       2</td>
<td>393       2</td>
<td>3.00     8</td>
<td>1.20    7</td>
<td>53      4</td>
<td>10.90   5</td>
</tr>
<tr>
<td>Sulphur dust plus cryolite 3:1</td>
<td>421       4</td>
<td>368       4</td>
<td>2.08     1</td>
<td>.75     1</td>
<td>175     1</td>
<td>8.65    3</td>
</tr>
<tr>
<td>Sulphur dust plus Kryocide 3:1</td>
<td>415       5</td>
<td>361       6</td>
<td>2.08     1</td>
<td>.85     3</td>
<td>131     3</td>
<td>5.25    1</td>
</tr>
<tr>
<td>Sulphur dust plus basic copper arsenate 4:1</td>
<td>430       2</td>
<td>391       3</td>
<td>2.75     7</td>
<td>1.25    8</td>
<td>40      5</td>
<td>13.70   8</td>
</tr>
<tr>
<td>Kenolite</td>
<td>411       6</td>
<td>367       5</td>
<td>2.29     4</td>
<td>1.10    5</td>
<td>144     2</td>
<td>6.60    2</td>
</tr>
<tr>
<td>Lime-sulphur plus zinc arsenite</td>
<td>375       8</td>
<td>304       8</td>
<td>2.62     6</td>
<td>1.15    6</td>
<td>19      7</td>
<td>11.00   6</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>325       9</td>
<td>233       9</td>
<td>3.96     9</td>
<td>2.65    9</td>
<td>1       9</td>
<td>25.20   9</td>
</tr>
<tr>
<td>Difference required for signifi-</td>
<td>71        84</td>
<td>.91        .60</td>
<td>57      57</td>
<td>5.93    57</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
and weighed. These tubers were then sorted into two lots, those free from flea beetle injury and those having some flea beetle injury. Injury, as used here, means any tuber having one or more flea beetle “worm tracks” or flea beetle “slivers.” These data are also given in Table VII.

There was a low psyllid population but the flea beetle population was high. All of the dust-treated plots gave a significant increase in yield over the untreated checks, except sulphur dust plus calcium arsenate in total yield. Lime-sulphur plus zinc arsenite spray did not produce a significant increase in yield over the untreated checks.

Sulphur dust, sulphur dust plus Dutox 4:1 and sulphur dust plus basic copper arsenate 4:1 gave significantly higher yields of tubers over 1½ inch screen than lime-sulphur plus zinc arsenite spray. There were no significant differences in yield between the other spray and dust treatments.

Sulphur dust plus Kryocide 3:1, sulphur dust plus cryolite 3:1 and sulphur dust alone, gave the best control of the nymph and adult psyllid populations.

Sulphur dust plus cryolite 3:1, Kenolite and sulphur dust plus Kryocide 3:1 gave significantly higher yields of tubers free from flea beetle injury than any of the other treatments. These treatments also gave the best control of the adult flea beetle population.

Preliminary Trial on New Dust and Spray Materials

The five following treatments were tested: (1) Lethane, 14 per cent (applied as a dust); (2) DDT, 3 per cent (applied as a dust); (3) lime-sulphur plus zinc arsenite plus Dithane spray; (4) rotenone 0.5 per cent (applied as a dust) and (5) check (untreated).

The Lethane was mixed with a finely-ground talc. The DDT was mixed with a 93 per cent 325-mesh, conditioned sulphur dust. The lime-sulphur was a 40:1 solution to which was added 5 pounds of zinc arsenite and 3 pounds of Dithane per 100 gallons of solution. The rotenone was mixed with a 93 per cent 325-mesh, conditioned sulphur dust.

The treatments were replicated two times. The insect population readings, the dates, rates and methods of application, as well as the cultural care, were the same as in the previous experiment. The results of this experiment are shown in Table VIII.
### Table VIII
Comparison of New Materials for Potato Psyllid and Flea Beetle Control
Torrington Substation — 1944

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Yield Per Acre</th>
<th>Yield Over 1(\frac{3}{8}) Inch Per Acre</th>
<th>Adult Psyllids Per 100 Sweeps</th>
<th>Psyllid Nymphs Per 50 Leaflets</th>
<th>Yield Over 1(\frac{3}{8}) Inch Free of Flea Beetle Injury</th>
<th>Adult Flea Beetles Per 100 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels Rank</td>
<td>Bushels Rank Number</td>
<td>Rank</td>
<td>Number</td>
<td>Rank</td>
<td>Bushels Rank Number</td>
</tr>
<tr>
<td>Lethane 14% (applied as a dust)</td>
<td>360 4</td>
<td>317 4</td>
<td>1.92 2</td>
<td>1.20 3</td>
<td>0 3</td>
<td>8.10 3</td>
</tr>
<tr>
<td>DDT 3% (applied as a dust)</td>
<td>381 2</td>
<td>352 3</td>
<td>2.83 4</td>
<td>1.40 4</td>
<td>0 3</td>
<td>2.40 1</td>
</tr>
<tr>
<td>Lime-sulphur, zinc arsenite and Dithane spray</td>
<td>381 2</td>
<td>353 2</td>
<td>1.92 2</td>
<td>1.10 2</td>
<td>10 1</td>
<td>10.10 4</td>
</tr>
<tr>
<td>Rotenone 0.5 (applied as a dust)</td>
<td>391 1</td>
<td>354 1</td>
<td>1.50 1</td>
<td>.80 1</td>
<td>5 2</td>
<td>3.10 2</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>293 5</td>
<td>236 5</td>
<td>4.83 5</td>
<td>3.20 5</td>
<td>0 3</td>
<td>29.30 5</td>
</tr>
<tr>
<td>Difference required for significance</td>
<td>91 81</td>
<td></td>
<td>2.40 .28</td>
<td></td>
<td>13 4.13</td>
<td></td>
</tr>
</tbody>
</table>


Rotenone was the only treatment that gave a significantly higher total yield than the check. However, all of the dust and spray treatments gave significantly higher yields of tubers over 1\(\frac{7}{8}\) inch screen than the untreated check. There were no significant differences in yield between the various dust and spray treatments.

Rotenone dust and lime-sulphur plus zinc arsenite plus Dithane spray gave the best control of the psyllid nymphs and adults.

None of the treatments were very effective in the control of the flea beetle damage to the tubers. DDT gave the best control of the adult flea beetle and was followed closely by rotenone.

Methods of Application

The following treatments were tested: (1) nozzles on each side of the row with hood; (2) nozzles on each side of the row without hood (Figure 8); (3) nozzles above the plants with hood; (4) nozzles above the plants without hood (Figure on Cover Page) and (5) check (untreated). A 93 per cent 325-mesh, conditioned sulphur dust plus cryolite 4:1 was applied at approximately 30 pounds per acre.
Table IX
Comparisons of Methods of Applying Dust for Potato Psyllid and Flea Beetle Control
Torrington Substation — 1944

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Yield Per Acre</th>
<th>Yield Over 1½ Inch Per Acre</th>
<th>Adult Psyllids Per 100 Sweeps</th>
<th>Psyllid Nymphs Per 50 Leaflets</th>
<th>Yield Over 1½ Inch Free of Flea Beetle Injury</th>
<th>Adult Flea Beetles Per 100 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bushels</td>
<td>Rank</td>
<td>Bushels</td>
<td>Rank</td>
<td>Number</td>
<td>Rank</td>
</tr>
<tr>
<td>Nozzles each side with hood</td>
<td>403</td>
<td>2</td>
<td>369</td>
<td>2</td>
<td>1.46</td>
<td>1</td>
</tr>
<tr>
<td>Nozzles each side without hood</td>
<td>428</td>
<td>1</td>
<td>339</td>
<td>1</td>
<td>2.00</td>
<td>2</td>
</tr>
<tr>
<td>Nozzles above with hood</td>
<td>384</td>
<td>3</td>
<td>345</td>
<td>3</td>
<td>2.17</td>
<td>2</td>
</tr>
<tr>
<td>Nozzles above without hood</td>
<td>346</td>
<td>5</td>
<td>314</td>
<td>4</td>
<td>2.67</td>
<td>4</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>382</td>
<td>4</td>
<td>308</td>
<td>5</td>
<td>4.25</td>
<td>5</td>
</tr>
<tr>
<td>Difference required for significance</td>
<td>86</td>
<td></td>
<td>89</td>
<td></td>
<td>1.54</td>
<td></td>
</tr>
</tbody>
</table>


The dates of the insect population readings, dates of application and cultural care were the same as for the previous experiments at Torrington, 1944. The results of this experiment are shown in Table IX.

All of the treated plots produced higher total yields than the check, except nozzles above without hood. The differences, however, were not statistically significant.

All of the dust-treated plots gave a significant reduction in adult psyllid population. Nozzles on each side of the row with hood gave the best control of the adult psyllids but there were no significant differences between methods of application.

In psyllid nymph population all of the dust-treated plots gave significant control. Nozzles on each side of the row with hood gave significantly better control than nozzles above the plants without hood.

Nozzles above the plants with hood and nozzles on each side of the row without hood gave the highest yield of tubers free from flea beetle damage. However, these yields were not significantly better than the check.

All of the methods of application gave a highly significant reduction of adult flea beetles over the untreated check. Nozzles on each side of the row with hood gave the best control but there were no significant differences between the methods of application.
SUMMARY

Approximately equal control of potato psyllids was obtained with a 90 per cent microfine sulphur dust and two 325-mesh sulphur dusts containing 7 per cent conditioning agent but of a different kind of conditioning agent.

Nearly equal control of psyllids was obtained with applications of 10, 20 and 30 pounds of sulphur dust per acre when the psyllid population was low; however, the higher rates of application gave significantly better control when the psyllid population was high.

Higher yields were obtained by applying the dust from each side of the row with a canvas hood over the boom than applying the dust from each side of the row without a hood, when the psyllid population was high and 20 pounds of dust were applied per acre. Under similar conditions higher yields were obtained by applying the dust from above the row without a hood than applying the dust from each side of the row without a hood.

No significant differences in control were obtained among the four methods of application when the psyllid population was low and the flea beetle population was high, and when the rate of application was kept constant at 30 pounds per acre.

Sulphur plus cryolite 2:1 and 3:1, Kenolite (sulphur plus cryolite 4:1), sulphur plus Kryocide 3:1 and sulphur plus Dutox (barium fluosilicate) 4:1 applied as a dust were the most efficient of the treatments tested for the control of both psyllids and flea beetles.

In a preliminary trial Lethane, DDT, rotenone dusts and lime-sulphur plus zinc arsenite plus Dithane spray were not effective in the control of flea beetle damage to the tubers; however, DDT and rotenone were outstanding in the control of the adult flea beetle. It is planned to test these materials further.
RECOMMENDATIONS FOR THE CONTROL OF PSYLLIDS AND FLEA BEETLES ON POTATOES

For Psyllid Control

1. A conditioned sulphur dust of a fineness of at least 325-mesh and containing not more than 10 per cent conditioning agent should be used.

2. Early applications are important, as treatments are for prevention rather than for cure. The psyllid population is the best criterion to follow in determining when to dust. It is advisable to dust when an average of two to three adult psyllids are found per 100 sweeps with an insect net having an opening 14 inches in diameter. In general, the first application of dust should be made when the plants are 4 to 6 inches in height. **Apply dust in the early morning or at night when there is little or no wind.**

3. When a power duster is used, apply approximately 20 pounds of dusting sulphur per acre per application when the plants are small and increase the rate up to about 30 pounds per acre as appears necessary to give adequate coverage for later applications.

4. At least two applications should be made when potatoes are grown under dry land conditions and three to four when potatoes are grown under irrigated conditions. The applications should be made at two- to three-week intervals, or even more frequently, depending upon the psyllid population. Light, frequent applications give better control than heavy applications applied less frequently.

5. It is advisable to use a suspended canvas hood over the boom (Figure 5) and arrange the nozzles to apply the dust from each side of the row (Figure 4). If a hood is not used, better control can be obtained by applying the dust from above the plants (Figure on cover page) rather than applying the dust from each side of the row (Figure 8). This is especially true when the vines are small.

6. If a spray is to be used, apply a solution of 1 gallon of lime-sulphur to 40 gallons of water with at least three nozzles per row and a pressure of 300 to 500 pounds per square inch.

For Combined Psyllid and Flea Beetle Control

1. Apply one of the following dust mixtures: sulphur plus cryolite or Kryocide 2:1, 3:1 or 4:1, or sulphur plus Dutox 4:1.
2. The dusts should be thoroughly mixed by means of a mixer especially designed for mixing insecticide and fungicide dusts.

3. Make the first application when the plants are 4 to 6 inches high.

4. Apply 30 to 40 pounds of the dust mixtures per acre.

5. Make five to six applications at seven- to ten-day intervals.

6. For a spray use a solution of 1 gallon of lime-sulphur, 40 gallons of water and 2 pounds of zinc arsenite.

LITERATURE CITED


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The following publications of the Wyoming Experiment Station may be had upon request: (Revised list, January, 1945).

ANNUAL REPORTS—
44th to 52nd inclusive, 1933-34 to 1941-42, inclusive.

INDEX BULLETINS—
G, H, and I.

STATE FARMS BULLETINS—
No.

CIRCULARS—
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BULLETINS—
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229. Vegetative Composition, Density, Carrying Capacity, and Grazing Land Values in the Red Desert Area.
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232. Breastbones of Turkeys.
234. Cellar Wintering of Bees.
237. Roughage Feeding of Dairy Cattle.
238. Wintering Bees in Wyoming.
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243. Practical Results from the State Experiment Farms.
245. Sulphur Dusting for the Control of Psyllid Yellows of Potatoes.
246. Hybrid Corn Adaptation Trials in Wyoming, 1940.
248. Influence of Cereal Grains Upon Quality of Meat in Turkeys.
249. Coccidia Infesting the Rocky Mountain Big Horn Sheep in Wyoming.
250. Vegetable Culture and Varieties in Wyoming.
252. The Control of Chlorosis in Cottonwood Trees and Other Plants.
253. Range Forage Production in Relation to Time and Frequency of Harvesting.
254. Crossbreeding for Lamb and Wool Production.
255. Lungworms of Domestic Sheep.
256. The Use of Wheat in Livestock Feeding.
257. Utilizing Self-Feeding Methods for Fattening Lambs on Sugar Beet By-Products and Other Home-Grown Feeds.
258. The Wyoming System for Scoring Corriedale Sheep.
259. Life History of Sarcosporidia, with Particular Reference to \textit{Sarcocystis tenella}.
260. Dusting for Potato Psyllid Control.
262. Economic Importance of Sarcosporidia with Especial Reference to \textit{Sarcocystis tenella}.
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264. The Influence of Protein Concentrates Upon the Quality of Meat in Turkeys.
265. War Time Feeding and Management of Hogs.
266. Avia Leukosis and Lymphomatosis.
269. Phosphorus Supplements for Beef Cows and Heifers.
270. Potato Ring Rot and Its Control.

U.S.D.A. Soil Survey of the Fort Laramie Area, Wyoming-Nebraska.