Bulletin No. 217 - Potato Psyllid Control

University of Wyoming Agricultural Experiment Station

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POTATO PSYLLID CONTROL

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POTATO PSYLLID CONTROL

By Glen Hartman

INTRODUCTION

The potato or tomato psyllid was first associated with a trouble of the potato previously known as "blight" and "purple-top," and later called "psyllid yellows" by Richards of Utah in 1927. This disease has been confused with Rhizoctonia, leaf roll, and other conditions or diseases having similar symptoms. It is highly probable that this disease or trouble has been present in Wyoming for several years, but it has not been recognized as a distinct trouble, for the cause remained unknown until 1927.

It was announced by Daniels of Colorado that the tomato psyllid (Paratrizoa cockerilli, Sulc.) was responsible for the disease. The insect and the disease of psyllid yellows in the potato plant were first reported together in the field by Metzger and Binkley at Fruita, Colorado, in 1928. In 1931 the disease was reported and observed in the irrigated section around Torrington. In some fields the losses were very great, but the epidemic was not generally distributed throughout the entire section. In 1932 the disease was reported from many irrigated sections throughout the state. In 1933 the trouble was not reported from any place within the state, although it was reported from Colorado. During the seasons of 1934 and 1935, psyllids were reported in every potato producing section of the state. To the writer's personal knowledge heavy losses were sustained in Albany and Platte Counties, in Goshen County, in the valley of the Big Horn River from Riverton to the Montana line, and in eastern Laramie County. There is no potato disease or trouble known in Wyoming which spreads as rapidly and uniformly or causes the enormous loss that is caused by psyllids.

DESCRIPTION OF THE PSYLLID

Adult. The potato or tomato psyllid, known technically as Paratrizoa cockerilli, Sulc., is a small gray insect, about 1/16 of an inch long, shaped very much like a very small cicada. The body of the insect is a gray color, and upon the front part of the abdomen is a distinct white band. There is a peculiar Y-shaped
The wings are colorless, and, when the insect is at rest, they are folded roof-like above the body. The adult is very active, and although present throughout the season is seldom observed until late in the fall, owing to its habit of flying away when anyone approaches it. When the adult emerges from the last molt of the nymph, it is almost colorless and very inactive for the first 4 or 5 hours. The body soon colors, and then the insect becomes very active. (See Figure 1.)

**Eggs.** The eggs are small, elongated, and of a whitish-yellow color. They are placed on a slender white pedicle or stype about \( \frac{1}{16} \) of an inch long. The eggs are laid by the adult female usu-
ally along the margins of the leaves where they may be observed sticking up like little pegs.

_Nymphs._ The immature forms are very small, about the size of a pin point, and brown or orange colored when first hatched. As they grow and develop, they pass through a series of molts, each stage becoming a little larger than the preceding one. As the molts progress, there is also a change in color, the brown and orange becoming greener in color. The mature nymph has a body which is nearly as large as the body of the adult and is light green in color. In the last nymphal stage the short wings are formed in small sacks and are clearly visible on the upper surface of the scale-like body. At this stage of development there is a peculiar H-like marking upon the rear of the abdomen. The nymph is rather inactive when feeding and lies very flat and close to the surface of the leaf.

_Life History._ The life cycle of the psyllid takes place in from 11 to 23 days, depending upon weather and temperature conditions. The egg hatches in from 3 to 5 days and the five stages of the nymph are passed in 15 to 20 days. The length of each stage varies and depends upon field and temperature conditions. The adult may live for several weeks, but the average life of the adult is about two weeks. The average female lays several or many eggs.

_DISTRIBUTION_

Potato or tomato psyllids to date have been found in the Rocky Mountain and western states. They have been reported from Utah, Arizona, New Mexico, California, Washington, Oregon, Idaho, Montana, Wyoming, South Dakota, Kansas, Nebraska, and western Canada.

In Wyoming their distribution is extensive. Psyllids and psyllid injury have been noted in practically all parts of the state. During the season of 1935, the writer has observed heavy infestations of psyllids on potatoes in both the high mountain valleys and the plains of the state.
HOST PLANTS

The preferred host plants of the psyllid belong to the Solanacea or nightshade family of plants. Potatoes and tomatoes belong to this same family. The list of wild native plants includes several species of wild ground cherries, wild tomatoes, buffalo bur, nightshades; in fact, there are very few of the wild members of this plant family that do not serve as host plants. Among the cultivated plants in Wyoming, the psyllids have been observed upon potatoes, tomatoes, egg-plants, and peppers. Recently psyllids have also been observed upon our native red cedars.

The relation of host plants to the abundance of psyllids has been regarded as important. The perennial ground cherries serve as breeding grounds in the early spring and late in the fall. The native cedar trees probably serve as a winter host to the psyllid. In years when psyllids have been a most important agency in damaging potato fields, these host plants have been found harboring large numbers of psyllids. In 1935 psyllid nymphs were abundant on the perennial ground cherry until November. After the first killing frost, a large number of plants near potato fields were found to have many psyllid nymphs upon them. Such plants as alfalfa, Canada thistle, bind weed, in fact, any plant which still retained some green leaves was covered with the psyllid nymphs, if it was located near an infested potato field.

PLANT SYMPTOMS

"Psyllid yellows" or "purple top" is a disease or trouble of potatoes in which the leaves begin rolling, and as the disease develops the curling becomes more extensive. The plants first show a slight yellowing along the mid-rib of the leaf. This is soon followed by a purple discoloration at the edge of the leaf. At this same time the young leaves of the plant begin to curl upward. As the disease progresses, this curling of the leaves spreads to all parts of the plant. The leaves become harsh, thick, and leathery, and have a peculiar rustle and feel when brushed with the hand. The plants remain in an inactive state of growth for the period of several weeks. There is no wilting, even under extreme drought conditions. In the advanced stages the yellowing becomes more pro-
nounced; the plant may die or it may remain alive until frost. (See Figure 2.)

The underground symptoms are characteristic. In typical cases a mass of small tubers attached close to the stem, or on short stolons, is found. In the Bliss Triumph variety these small tubers are often of a brighter red than is normal. Frequently the small tubers are found in long chains. Apparently the first small tuber is formed upon a small or short stolon, then stolon growth is resumed and another tuber is formed. This is often repeated until a chain of several tubers is formed. Growth may be resumed by the stolon growing from the bud-end of the small tuber, or the stolon may branch just back of the stem end of the tuber. Several such chains of tubers may be found in one hill. Often more than one hundred small tubers are found under one plant, none of which has attained a marketable size. The exact symptoms which may be found underground seem to depend upon the stage of growth of the plant when psyllid infestation occurs. If the infestation is
early, before tubers are normally set, the symptoms as listed are most commonly found. If the psyllid infestation does not occur upon the plant until the tubers have been set and partially grown, then further development of the tuber seems to be halted. In this case, the tubers seem to increase but little, if any, in size after vine symptoms are produced. The tubers already formed have a marked tendency to become rough in shape and intensified in color. If psyllids are not in some way removed from the plant, no further growth is produced in the tubers of the plant, but if the psyllids are removed from such a plant, often another set of tubers is made by the plant. This second set of tubers never, under Wyoming conditions, reaches maturity or marketable size. Tubers from infested vines do not develop a normal rest period and have a tendency to sprout much earlier in the season than is normal. Occasionally tubers are sprouted at digging time.

The yields of infested fields are usually low in potatoes of marketable size and quality, and a large number of small potatoes are produced. Growth and proper development are so completely upset that the plants are unable to produce normal tubers.

**FEEDING HABITS OF THE PSYLLID**

The psyllid nymphs normally take a position on the underside of the leaves in the lower third of the plant. In large plants, where the foliage is abundant, the nymphs may sometimes be found upon the upper side of the leaves and even upon the stem of the plant. Since the bodies of the nymphs are small, flat, and scale-like, they are difficult to see. When young, they stay close to the site where the eggs were laid and remain quite inactive in the early stages. They become quite mobile in the latter stages of development. The insects feed with sucking mouth parts, and when they are feeding they are very inactive.

There is little doubt that a secretion is injected into the plant. However, the nature of the agent which causes the disturbance in the growth of the potato plant is still not definitely known. The possibility of its being an enzyme has been indicated both in the field and laboratory. The action of the lime-sulphur in the control of the psyllid is not definitely understood. In many instances many
nymphs may be found upon the plant shortly after spraying, yet the plant responds to the treatment.

A large number of tests have indicated that the disease is not carried over from one year into the next by tubers from infested plants. The disease is produced only by the feeding of the nymphs of the psyllid upon the plant. However, results of the present season's work have indicated that the vitality of the seed tuber may be slightly reduced when severe psyllid symptoms appear in the vines. Various workers in potato pathology have demonstrated the absence of virus in this disease.

It has not been known where or in what form the insect spends the winter months. Neither has the source of the first adult insects which appear in the late spring or early summer been determined. During the first days of May, 1936, Leslie B. Daniels of the Agricultural College, Fort Collins, Colorado, announced through the Associated Press that he had found potato psyllids in appreciable numbers upon red cedar trees. These psyllids were found upon red cedars in the sand hills of western Nebraska and in protected canyons in eastern Wyoming. At this time the psyllids were spreading from the cedars to the wild members of the Solanacea family. This means that if weather conditions are favorable to their development, there is likely to be an abundant supply of psyllids by the time potato plants are subject to their attack.

During the season of 1935 it was observed that as soon as one field in a given community was found to be infested with psyllids, they could be found some place within nearly every field in that same locality; especially was this true in the early planted fields. Usually the first nymphs in a field were found around the edges of the field or in low places within the field. It was also observed that after infestation by psyllids occurred in any locality, some fields readily developed psyllid symptoms and produced very low yields. At the same time, other fields in the same community developed very few or no symptoms, and very good yields were secured.

Certified seed potato fields afforded a very good opportunity to study the problem of variation in the damage from psyllids. In 1935, psyllid infestation of the potato fields in the certified sections did not occur until after July 10. Psyllid counts were made in fields
at the time of the first and second field inspections. The number of psyllids present in the fields and the damage done was found to vary greatly from field to field. Fields grown upon the same farm were found to vary in this respect. When the planting dates were compared, it was found that, almost without exception, the early planted fields showed the presence of large numbers of both psyllid nymphs and plant symptoms. In the late planted fields, although psyllids might or might not be easily found, comparatively little damage was found. At digging time, it was found that the early planted fields gave very low yields of poor quality potatoes, while the late planted fields gave larger yields of higher quality potatoes and fewer psyllid symptoms were present in the tubers harvested.

In the experimental fields during 1935 the same relationships were found to be present. In the late planted fields, the unsprayed plats gave higher yields than the same plats in early planted fields. In so far as possible, the planting dates of the fields observed during the season of 1934, were compared. Here also the damage was least in the late plantings.

CONTROL EXPERIMENTS

Because of the serious nature of the disease known as purple top, very determined efforts have been made to establish a control for the potato psyllid. Daniels of the Colorado Experiment Station following his tests in 1932 reported as follows:

1. Lime-sulphur in a 33 1/3% solution gave indications of controlling the condition.
2. Verdol, 1%, showed no control.
3. Nicotine failed to show control.

In 1933 Daniels enlarged his test work and found that the lime-sulphur solution sprayed on the vines under high pressures showed up favorably in controlling psyllids.

In 1934 potato psyllids were found upon the University Agronomy Farm at Laramie as early as June 28. Heavy losses from psyllids were sustained upon the Agronomy Farm and throughout the state that year. Because of inability to secure the necessary special equipment, no control studies were made that year upon the Agronomy Farm.
Early in the season of 1935 a high pressure sprayer of the four row type was purchased by this experiment station. A supply of lime-sulphur was also purchased. A series of experimental plats were laid out upon the Agronomy Farm to test the effectiveness of this treatment in the control of psyllids.

By means of an automobile trailer the spraying equipment was moved to test fields in other parts of the state, thus insuring uniformity of treatment throughout.

Early in June, fields for testing purposes were selected near Lingle, Torrington, Albin, Pine Bluffs, and Egbert. In each case a small field or a portion of a large field was selected for test purposes. No psyllids had been found or reported at this time. Each field selected was divided into plats of equal size. The spray program was so arranged that at the close of the season each field would contain plats which remained unsprayed; plats sprayed only once, but at different dates; plats sprayed twice, but with different combinations of dates; and plats sprayed three times during the season. The owner of each field cooperated with the University in the tests.

Three tours were made to these fields with the spraying equipment. Counts were made of the psyllids and the plant symptoms. The first spraying tour was made during the period, July 10 to July 15; the second July 29 to July 31; and the third and last, August 13 to August 17.

Only a few of the cooperators were equipped to sort the potatoes into grades. From September 29 to October 1, a tour was made to these fields. At that time counts were made of the psyllids and the vine symptoms present in the plats. For the purpose of determining the effect of the spraying upon the quality of the tubers, ten-hill samples were dug by hand from each plat. These ten hills were selected for digging by first selecting a representative row in each plat. Then a hill with an average appearing vine was selected, this hill was dug, and beginning with this every fifteenth hill was dug. The method was used to avoid any personal factors in selecting the hills and to secure a sample which would be representative of the plat.

After careful and accurate sizing over a 1½ inch screen in the dry-land fields and a 1⅞ inch screen in the irrigated fields, the
larger tubers were graded for certified seed in the dry-land fields and for U. S. No. 1 table stock in the irrigated fields. The tubers which remained upon the top of the sizing screen but which would not qualify for these grades were called grade number 2. All tubers which passed through the sizing screen were designated as culls. The total weight as well as the weight of each grade was recorded for each sample. The total number of the tubers and the number in each grade were counted and recorded.

The width of the rows, the drop of the row, and the percentage of stand were determined for each field. Thus the number of hills per acre was calculated for each field, and the results of the ten hill samples were converted into acre yields.

This method of obtaining acre yields and grades was checked in several plats upon the Agronomy Farm at Laramie in the fall of 1935 and found to be reasonably accurate and reliable. The yields obtained by this method also corresponded very closely to the yields reported by the cooperators.
THE COST OF SPRAYING

The cost of spraying potatoes for the control of psyllids involves many factors which vary with each individual farm. The test fields studied were too small for the accurate determination of costs. It is hoped to secure an average cost figure arrived at by using data from every available source. Each potato grower will then be able to compare his own case with these average costs and make the changes necessary to fit his own conditions.

Machinery. The type of spraying machinery varies from a cheap machine costing $180 which will cover four rows at a time, up to machines costing $800 to $1000, which are drawn and operated by tractors and which will cover eight rows at a time. It is believed that if spraying is to be done each season, a reasonably good, high-priced machine will be the cheaper over a period of years. A horse-drawn, power-driven sprayer of the four-row type which includes most of the desirable features was used in this experimental work and found to be very satisfactory.

A machine as above described cost $535 in the spring of 1935, delivered at any Wyoming shipping point. A sprayer of this type should last for at least five years, if given reasonable care. The yearly depreciation charge is one-fifth of this amount or $107. The interest rate to growers of this section is 8 per cent. In addition to the depreciation and interest, a charge of 10 per cent of the depreciation is allowed each year for repairs and replacements. The total yearly machinery cost including depreciation, interest, and repairs is $131.10.

To obtain the best results from spraying, a field should be covered in a comparatively short time, say 10 days. With this type of machine 25 acres is about the upper limit of a day’s work. Two hundred to 250 acres should be about the acreage which one sprayer of this type can care for during a given season. This is equivalent to a charge of from 52 to 65½ cents per acre. For this study 58 cents will be used as the machine cost regardless of the number of times a field is sprayed.

Labor. This type of sprayer requires a man and team to operate. It was found that, in most cases, 15 acres was an average day’s
spraying. Allowing wages of $6.00 per day for the man and team, the labor charge for operating the sprayer is 40 cents per acre for each spraying.

**Material.** Lime-sulphur ready mixed could be bought in 1935 at the rate of $15 for a 55-gallon drum laid down at Wyoming points, which is 27 cents per gallon. In most fields nearly 2 gallons of lime-sulphur per acre were used for each spraying making the cost for materials 54 cents.

**Water.** In dry-land sections water for use in spraying must be hauled to the potato fields. The cost of getting this water to the fields varies from farm to farm. About 80 gallons of water is required to spray one acre once. Twelve hundred to 2000 gallons of water are required in the field each day. An 800-gallon galvanized iron tank which will fit upon a light truck can be purchased for about $125. This amount prorated per acre in the same manner as the cost of the sprayer equals 13 cents per acre per season. Computations based on truck hire at 6 cents per mile and driver’s wages at $3.00 per day show that the cost of hauling water will average about 33 cents per acre for each spraying.

**Total cost of spraying.** Machinery and equipment costs are the same throughout the entire season whether the field is sprayed one or more times. Labor and material costs are the same for each application, and the cost of these items depends upon the number of sprays applied. Thus, in irrigated fields the total costs of spraying as determined in this study are: $1.52 per acre for one application; $2.46 for two; and $3.40 for three applications. In the dry-land fields the cost of hauling water to the field must be added to these figures, making a total of $1.98 per acre for one spray, $3.25 for two, and $4.52 per acre for three sprays.

**METHODS USED IN CALCULATING RESULTS**

**Prices.** In trying to determine financial returns from spraying to control potato psyllids, the question arises as to what prices to use in determining the value of the potato crop produced. Since this is a progress report and represents only one year’s work, it has
been decided to use prices and values prevailing in 1935. This was a year of low prices. If, however, spraying yielded favorable financial returns to the grower this season, larger returns should be expected in years of higher prices, if the treatment has the same effect upon production.

During the last week in November the growers were receiving 80 cents per hundred pounds for U. S. No. 1 table stock and $1.00 for certified seed potatoes for January delivery. All test fields under irrigation were graded to U. S. No. 1 table stock and the fields under dry-land conditions were graded to certified seed requirements. Only the U. S. No. 1 or the certified seed was given a value for the purpose of these computations; all other potatoes harvested were considered as culls and valueless.

Shrinkage. From digging time (the time when figures for yield were secured) until January, there is considerable shrinkage and wastage of potatoes in storage. In view of this fact, and since the most of the potatoes produced in this section of Wyoming are not sold until January, 20 per cent of the total yield was deducted for shrinkage.

Increased cost of handling crop. Increased yields increase the cost of handling the crop. These costs per bushel were: Picking 3½ cents, hauling 2½ cents, sorting 6 cents, and sacks 6 cents, or, a total of 18 cents.

Crop value. For the purpose of comparing the value of the different spray treatments, the value per bushel of the increase in the yield of saleable potatoes from each plat in the ground at digging time was calculated. Since prices were for January, and an allowance of 20 per cent of the yields when dug was allowed for shrinkage and waste, the value of a bushel of saleable potatoes is 80 per cent of the January price, or 48 cents, at digging time. Subtracting from this value the cost of handling a bushel of potatoes, which is 18 cents, leaves 30 cents, which represents the actual value of a bushel of certified potato stock before digging. For table stock the value in the ground would be 80 per cent of 48 cents per bushel less 18 cents handling cost, which equals 20.4 cents per bushel.
Increase in saleable potatoes. The increased yields in saleable potatoes were determined by subtracting the yield of saleable potatoes in the unsprayed plat from that of each of the treated plats in the same field.

Value of increased yields. The value of the increase in yields of saleable potatoes in each plat was determined by multiplying the increase in bushels of each plat by 30 cents for the certified seed and 20.4 cents for the U. S. No. 1 irrigated stock. This figure represents the value of the spray treatment applied in any particular plat.

Net returns. The net returns resulting from the spray treatment are determined by subtracting the cost of applying the spray from the increase in value of saleable potatoes which was produced by that treatment. Table I shows the total yield and grades harvested from each plat, the increase in saleable potatoes due to spraying, the value of this increase, the cost of spraying, and the net return from spraying of each plat in test field No. 1.

**TABLE I**
DetaileD Report of Results in Field Number 1.

<table>
<thead>
<tr>
<th></th>
<th>Unsprayed</th>
<th>Sprayed once early (1)</th>
<th>Sprayed once mid. (2)</th>
<th>Sprayed twice early (3)</th>
<th>Sprayed twice mid.</th>
<th>Sprayed all three times</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total yield</strong></td>
<td>122.88</td>
<td>167.97</td>
<td>171.09</td>
<td>167.98</td>
<td>186.65</td>
<td>164.65</td>
</tr>
<tr>
<td><strong>Culls</strong></td>
<td>29.56</td>
<td>21.77</td>
<td>15.55</td>
<td>11.44</td>
<td>9.33</td>
<td>9.33</td>
</tr>
<tr>
<td><strong>Grade No. 2</strong></td>
<td>12.44</td>
<td>15.55</td>
<td>6.22</td>
<td>4.11</td>
<td>3.11</td>
<td>6.20</td>
</tr>
<tr>
<td><strong>Certified seed</strong></td>
<td>80.88</td>
<td>130.65</td>
<td>149.32</td>
<td>152.43</td>
<td>174.21</td>
<td>149.32</td>
</tr>
<tr>
<td><strong>Increase in saleable potatoes due to spraying</strong></td>
<td>49.77</td>
<td>68.44</td>
<td>71.55</td>
<td>93.33</td>
<td>68.44</td>
<td></td>
</tr>
<tr>
<td><strong>Value of increase in saleable potatoes at 30 cents per bu.</strong></td>
<td>$14.93</td>
<td>$20.53</td>
<td>$21.46</td>
<td>$28.00</td>
<td>$20.53</td>
<td></td>
</tr>
<tr>
<td><strong>Cost of spraying</strong></td>
<td>1.98</td>
<td>1.98</td>
<td>3.25</td>
<td>3.25</td>
<td>4.32</td>
<td></td>
</tr>
<tr>
<td><strong>Net returns for spraying</strong></td>
<td>12.95</td>
<td>18.55</td>
<td>18.21</td>
<td>24.75</td>
<td>16.01</td>
<td></td>
</tr>
</tbody>
</table>

(1) "Early" means sprayed in season about July 13, pre-bloom.
(2) "Mid." means sprayed in mid-season, about July 30, post-bloom.
(3) "Late" means sprayed late in season, about August 15.
RESULTS AND DISCUSSION OF TESTS UNDER DRY-LAND CONDITIONS

Table II presents the total yields, the yields of certified seed potatoes, and the net profits per acre of all spraying tests in the four dry-land fields, together with the averages for each treatment. Yields are expressed in bushels per acre.

**TABLE II**
CONSOLIDATED REPORT OF RESULTS ON 4 DRY LAND FIELDS.

<table>
<thead>
<tr>
<th>Field number</th>
<th>Unsprayed</th>
<th>Sprayed once early</th>
<th>Sprayed once mid.</th>
<th>Sprayed once late</th>
<th>Sprayed twice early late</th>
<th>Sprayed twice early mid.</th>
<th>Sprayed twice mid. late</th>
<th>Sprayed all three times</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total yield</td>
<td>122.88</td>
<td>167.97</td>
<td>171.09</td>
<td>167.98</td>
<td>186.65</td>
<td>164.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Total yield</td>
<td>84.99</td>
<td>91.52</td>
<td>93.70</td>
<td>89.34</td>
<td>98.70</td>
<td>106.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Total yield</td>
<td>91.96</td>
<td>125.60</td>
<td>116.83</td>
<td>123.80</td>
<td>132.33</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>4. Total yield</td>
<td>40.11</td>
<td>72.78</td>
<td>74.27</td>
<td>80.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>84.98</td>
<td>120.75</td>
<td>115.79</td>
<td>128.66</td>
<td>140.17</td>
<td>106.27</td>
<td>135.71</td>
<td></td>
</tr>
</tbody>
</table>

| 1. Cert. seed | 80.88  | 130.65        | 149.32 | 153.43 | 174.21 |
| 2. Cert. seed | 39.22  | 50.12         | 63.20  | 65.19  | 65.37  |
| 3. Cert. seed | 44.86  | 107.83        | 100.93 | 112.15 |
| 4. Cert. seed | 4.46   | 16.34         | 34.11  | 46.05  |
| Average         | 42.35  | 90.36         | 84.27  | 108.31 | 119.79 | 79.10  | 117.14 |

| 1. Net return | $12.95 | $18.56         | $18.22 | $24.75 | $16.02 |
| 2. Net return | 1.29   | 5.21          | 3.94   | 4.59   | 9.20   |
| 4. Net return | 1.58   | 6.93          | 11.02  |
| Average         | $ 7.12 | $10.57        | $14.67 | $13.98 | $12.60 |

In total yields per acre all three sprayings gave the highest average increase in production, with an average increase of 50.73 bushels per acre over the average of the unsprayed plats. In the production of certified seed the combination of two sprays, one applied early and one during mid-season, gave the highest average increase.
Each spraying gave an increase in both yield and quality. The largest increase from any single application of the lime-sulphur spray was secured when the potato plants were in full bloom but before many of the blossoms had fallen. A single application of lime-sulphur applied just before blooming or in the very early stages of blooming was more effective than a single application at any later stage of growth.

Since the fields tested did not receive any rain between the time of applying the early and the mid-season sprays, part of the vines in the early sprayed plats were still covered with lime-sulphur at the beginning of the blooming stage of plant growth. However, the new growth produced by the plants in these plats was not covered with lime-sulphur at this time. This may account for the fact that the early sprayed plats showed some benefits because of the early spray but were not benefitted as much by a single spray as those plats which were not sprayed until mid-season, or at the beginning of the blooming period.

Since no field was observed to be badly infested with psyllids or show symptoms of psyllid troubles until after the plants had begun to bloom, it may be that the potato plant is not susceptible to damage by psyllids until it has reached the blooming stage. Many fields in the blooming stage were observed to be badly infested with psyllids and showed severe symptoms of psyllid troubles, while adjacent fields which were planted later and not yet in bloom contained very few if any psyllids and showed no symptoms of psyllid troubles. As pointed out before, late planted fields were less affected by psyllids than were early planted fields in the same community.

If the plants are not susceptible to the attack of the psyllids until near the blooming stage, then infestation will not occur in the late planted fields until after the warmest and the driest part of the season is past. Thus, the growth and activity of the psyllids is retarded by lower temperatures, and less damage results. This may be the explanation of the apparent influence of the date of planting upon the reaction of the potato plants to the attack of the psyllids.

A lime-sulphur spray applied after the blooming stage was not very effective in increasing the yield and quality, if the vines had
not been sprayed before. In this case an abnormally large number of tubers had been set, and the plant could not grow them to a marketable size.

A second spray applied after the blooming period was effective in increasing yields and quality of the tubers, if the vines had also been sprayed in the early stages of the blooming period. These two applications apparently enable the plant to develop a normal or nearly normal set of tubers.

A combination of two lime-sulphur sprays, one applied in the early stages of bloom and the other following the blooming period, gave the largest returns in yields and quality in most of the dryland fields tested and observed. The one year of tests and observations indicates that, with this as with other treatments or no treatment, the later plantings are less injured by psyllids than the earlier ones. It remains to be seen if this holds true in all seasons.

The improvement in quality, especially in the matter of true-ness to type, was very noticeable in the sprayed plats when compared to the unsprayed plats in the same fields. There was also a marked improvement in the color of the tubers. This is very important to the producer of seed potatoes.

RESULTS IN IRRIGATED FIELDS

Table No. III shows the total yields, yields of U. S. No. 1 table stock, and the net returns per acre of all spray tests in the three irrigated fields together with the averages for each treatment. Yields and net returns are expressed upon the acre basis.

A total of three tests were made in irrigated fields. Two of the three fields were planted medium late in the season. The other was planted earlier. The yield of potatoes was much higher for the unsprayed plats in the late-planted fields. The yields in the sprayed plats were also much greater in the late-planted fields; however spraying produced the largest percentage of gain in the early-planted field.

The most effective single spray in these fields was the one applied in the blooming stage of growth. The net return from two applications was nearly as large as for three. The average net
TABLE III

<table>
<thead>
<tr>
<th>Field number</th>
<th>Unsprayed</th>
<th>Sprayed once early</th>
<th>Sprayed once mid.</th>
<th>Sprayed twice early mid.</th>
<th>Sprayed three times</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total yield</td>
<td>144.99</td>
<td>221.62</td>
<td>241.50</td>
<td>267.07</td>
<td>278.44</td>
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<tr>
<td>2. Total yield</td>
<td>343.04</td>
<td>351.20</td>
<td>400.21</td>
<td>420.63</td>
<td>420.62</td>
</tr>
<tr>
<td>3. Total yield</td>
<td>61.41</td>
<td>136.79</td>
<td>139.58</td>
<td>201.00</td>
<td>231.71</td>
</tr>
<tr>
<td>Average</td>
<td>183.15</td>
<td>236.53</td>
<td>260.43</td>
<td>296.23</td>
<td>310.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U. S. No. 1</th>
<th>U. S. No. 1</th>
<th>U. S. No. 1</th>
<th>U. S. No. 1</th>
<th>U. S. No. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total yield</td>
<td>53.98</td>
<td>159.11</td>
<td>167.63</td>
<td>227.30</td>
</tr>
<tr>
<td>2. Total yield</td>
<td>208.27</td>
<td>257.27</td>
<td>306.28</td>
<td>326.70</td>
</tr>
<tr>
<td>3. Total yield</td>
<td>5.58</td>
<td>25.12</td>
<td>25.12</td>
<td>100.50</td>
</tr>
<tr>
<td>Average</td>
<td>89.21</td>
<td>147.16</td>
<td>166.34</td>
<td>214.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Net return</th>
<th>Net return</th>
<th>Net return</th>
<th>Net return</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Net return</td>
<td>$19.92</td>
<td>$21.66</td>
<td>$32.89</td>
</tr>
<tr>
<td>3. Net return</td>
<td>2.11</td>
<td>2.11</td>
<td>16.91</td>
</tr>
<tr>
<td>Average</td>
<td>$10.71</td>
<td>$14.41</td>
<td>$23.83</td>
</tr>
</tbody>
</table>

The return for making two applications of lime-sulphur sprays in these fields was $23.83 per acre.

The improvement in the quality of the potatoes harvested from the sprayed plats was very noticeable. The tubers were larger and smoother in the plats which were sprayed.

Based upon the results of this one year’s testing, it appears that, under irrigated conditions it is advisable to spray the potato vines twice, and possibly three times, during the growing season. The first application should be made during the early part of the blooming period of the plant. The second application should be made about two to three weeks later. The third spray, if applied, should be made about 10 days later than the second. It remains to be seen if this is true of all seasons.
GENERAL DISCUSSION

In all field tests every application of lime-sulphur spray showed a net return for its application. The smallest net return from spraying was $1.59 per acre, secured in a dry-land field in a plat upon which only one early application was made. The highest net return secured in a dry-land field was $24.75 per acre and resulted from two applications of spray. The highest net return under irrigation was $34.26 produced in a plat which was sprayed three times during the growing season. (See figure 3.) In this same field the application of two sprays produced a net return per acre of only $1.37 less than that produced by three applications of the spray.

In addition to the gains from spraying resulting from the tests, the application of lime-sulphur spray in fields containing psyllids showed a marked improvement in the quality of the marketable tubers harvested. In all sprayed plats the tubers were larger, more true to type, smoother, and carried a more desirable color than did the tubers harvested from the unsprayed plats in the same field.

A very few tests were conducted to determine the effect of pressures used in applying the lime-sulphur spray. They indicated that, while the use of low pressures produced at least some beneficial results, the higher pressures are much more effective. The net returns per acre are also much larger when high pressures are used even though the first cost of the equipment is greater for high pressure than for low. A maintained pressure of 300 pounds per square inch against the spray nozzles gave the most complete and profitable control of the psyllids.

It has been said that the spraying of potatoes has a beneficial effect upon the potato plant, even though psyllids are not present.

This report can throw no light upon this question because psyllids, at least in small numbers, were found at some time during the season in all potato fields studied and observed in the year of these tests.

SUMMARY AND CONCLUSIONS

During the last few years the potato psyllid has caused very heavy losses in potato production in the state of Wyoming. The losses are caused by the small orange or brown nymphs of this in-
sect found upon the under side of the basal leaves of the potato plant. The vines become rigid, and the leaves are harsh, leathery, rolled, and edged with purple. A large number of tubers, only a few of which reach marketable size, are produced. The normal rest period of the tuber is disturbed, and the tubers sprout much earlier than is normal.

Spraying with lime-sulphur solution was tested as a means of controlling the damage from potato psyllids. The tests were made by laying out plats in four dry-land fields and three irrigated fields. The variety in all the fields was Bliss Triumph. In every case the yields were increased by one or more applications of the spray. On the basis of net returns in money after deducting costs of spraying and extra costs of harvesting additional yields, two applications at the right time give larger net returns than one and as large or nearly as large as three. The best time of application appeared to be the early bloom stage for the first, and 15 to 17 days later for the second. On dry land the lowest net return from two applications was $4.95 per acre and the highest $24.75. On irrigated land the lowest was $16.91 and the highest $32.89.

When potato psyllids are present in a potato field, the use of lime-sulphur as a spray is profitable. Two sprays applied at the right time seem to give the most profitable returns. The first spray should be applied at about the time the plants begin to bloom, followed two to three weeks later with the second application.

The actual cost of spraying will vary somewhat in different localities and in different fields. The costs will be higher upon dry-land farms than upon irrigated farms. This is because of the necessity of hauling water to the dry-land field. The cost per acre for two applications, as determined in this study, is $3.25 per acre upon dry-land fields and $2.46 per acre upon irrigated fields.

Potatoes appear to be bothered but little by potato psyllids until the plants have reached the budding or blooming stage of growth. Late planting appears to be a factor in controlling the damage done by the psyllids. During the season of 1935 late planted fields suffered less damage than the early planted ones.

Lime-sulphur sprayed on the vines using a pressure of 300 pounds per square inch gave better control than lower pressures.
To date, there is no indication that the symptoms produced upon potatoes by the action of the psyllids are in any way carried from one season to the next by seed tubers from infested fields. The disease occurs only when psyllid nymphs are found upon the vines.

Since the results reported herein are based upon one year's work, psyllids may or may not be a factor in potato production in Wyoming each year in the future. At present there is no known means of forecasting a serious infestation of psyllids or the extent of the damage which will be done in any season, even if it is known that the winter home of the psyllid is local. The growth of both the potato plant and the insect is affected by conditions of the season. Potato psyllids have been present and caused large losses in both irrigated and dry-land sections for at least the past two seasons. It seems reasonable then to expect them to appear again in the future. If psyllids are present in appreciable numbers, spraying with lime-sulphur solution at the time of the right stage of plant growth is advisable. Experimental work and tests should be continued until much more is learned about the psyllid problem.

By close observation and examination of all fields in a given section, the presence of psyllids can usually be discovered a few days or weeks before it becomes necessary to spray for their control. However, if it is intended that spraying is to be done, when they are present in damaging numbers, previous arrangements should be made so as to have equipment and materials available.

It is now known that psyllids are upon certain wild plants in Wyoming in the early summer of 1936. The extent of damage done to this year's potato crop will depend upon weather conditions during early summer.

It appears now that spraying of potatoes for psyllid control is advisable and may become necessary for profitable potato production. The added cost of spraying will make it all the more necessary to give the utmost attention to all the factors which contribute to successful potato production. Such factors as land selection and preparation, the use of good seed, the proper planting date, better cultural methods, crop rotation, etc., must be carefully studied and practiced.
Stomach poisons such as zinc arsenite and lead arsenate may be mixed with the lime-sulphur solution for the control of chewing insects such as beetles and leaf hoppers. However, none of these are effective in controlling some of the sucking insects such as aphids. Since aphids are a factor in the spread of certain virus diseases of the potato, more study should be given to the proper additions to the spray to insure aphid control also.

It should always be borne in mind when reading this bulletin, that all conclusions and suggestions offered herein are based upon a single year's study.