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THE TOMATO PSYLLID

AND THE CONTROL OF PSYLLID YELLOWS OF POTATOES

By Leslie B. Daniels

Characteristic terminal leaf symptoms of "psyllid yellows." Note the basal curling of the leaves and light green coloration.

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THE TOMATO PSYLLID
AND THE CONTROL OF PSYLLID YELLOWS OF POTATOES

By Leslie B. Daniels

The potato disease, psyllid yellows, described by Richards (1) in 1927, has been considered one of the most serious maladies affecting potatoes in Colorado. Heavy losses have been incurred periodically over a span of 30 or more years. The disease has been confused with leaf rolls and other conditions having similar symptoms. We have been unable to ascertain the actual losses from the disease up to 1927, altho there is little doubt that "psyllid yellows" was responsible for much of the potato trouble in Colorado up to that date.

In 1927 it was announced by Richards (1) that the tomato psyllid (*Paratrioza cockerelli* Sulc.) was responsible for the disease. Following this the first reports on the disease in Colorado were made by Metzger and Binkley (2) from the Western Slope, where potatoes showed 100 percent infestation in the Fruita district of Mesa County. During this season the disease was found in Delta, Montrose and Garfield Counties. In 1929 to 1933, inclusive, the disease has been observed in practically every potato section of the state. The heaviest losses have occurred in the Greeley and Fort Morgan sections of Northeastern Colorado, and the Fruita area of the Western Slope.

Description.—Adult: The tomato psyllid, known technically as *Paratrioza cockerelli* Sulc., is a small gray insect, about 1/16 of an inch in length, shaped much like a miniature 17 year locust or cicada. The gray body is marked by a distinct white band visible on the upper surface of the front part of the abdomen. A peculiar Y-shaped mark at the end of the abdomen is also characteristic. The wings are colorless and are placed roof-like over the abdomen. They are very active insects, jumping or taking flight when disturbed.

Eggs.—Small, elongate, yellow, placed on a slender white pedicel or stipe. The eggs are laid along the edges of the leaves where they may be observed sticking up like little pegs.

Nymphs.—The immature forms are very small and orange colored when first hatched. As they grow and develop, they pass thru a series of moults, each stage becoming a little larger than the preceding one. The mature nymph is nearly as large as the adult and light green in color. In the late nymphal stage the wings are placed in small sacks clearly visible on the upper surface of the scale-like body. When this late stage is observed the feeding period is nearly complete and in a short time the adults will emerge.

LIFE HISTORY.—The life cycle of the psyllid takes place in from 11 to 23 days, depending upon weather conditions. The egg hatches in from 3 to 5 days and the 5 stages of nymphs are passed in 15 to 20 days. The length of each stage varies, depending upon field conditions. The adult may live several weeks, but the average is about 2 weeks. The average female lays about 300 eggs. Lehman has reported 94 (3) and Knowlton 318 (4) eggs laid by the average adult. In one case Knowlton found that one female laid 1300 eggs.

DISTRIBUTION.—Tomato psyllids are found only in the Rocky Mountain and Western States. They have been recorded from Utah, Arizona, New Mexico, California, Wyoming, Kansas, Nebraska and Colorado. Their distribution is apparently governed, to some extent, by the dry, arid conditions found in Western United States.

In Colorado their distribution is extensive. Psyllids and psyllid injury have been noted in practically all parts of the state. The warm plains area of Northeastern and Western Colorado have been especially favorable for them. The greatest injury has occurred in these two sections. The mountainous sections of Wet Mountain Valley, Estes Park and the Divide (Lake George and Florissant) area have had serious infestations of psyllids. The injury has been particularly noticeable in some fields in these sections, while others appear to escape heavy damage.

The early potato sections near Gilcrest (Weld County) and Fruita (Mesa County) have on several occasions suffered a complete loss of their crops. The estimated loss for the Gilcrest area in 1932 was 85 percent.

HOST PLANTS.—The preferred host plants of the psyllid belong to the Solonaneacae or potato family. The list of wild native food plants includes several species of wild ground cherries, wild tomatoes, buffalo bur, night shade; in fact, there are very few of the wild members of the tomato and potato family that do not serve as host plants. Among the cultivated plants peppers, egg-plant, tomatoes, potatoes and alfalfa have served as hosts. Several evergreens have been reported (Crawford); however, greenhouse studies with our Colorado evergreens has shown that the psyllids will not feed on pine, spruce or cedar when hosts of the potato family are present, and it has never been taken on alfalfa in Colorado.

The relation of host plants to the abundance of psyllids has been regarded as important. The perennials of the ground cherries serve as breeding grounds early in the spring and late in the fall. 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 1931 psyllid nymphs and eggs were abundant on the perennial prairie ground cherry up until late in November. The question of what constitutes a favorable season for host plants and psyllids seems to be a matter of climate. The hot, dry seasons have been considered most favorable for psyllid troubles.

PSYLLIDS AS THE CAUSATIVE AGENT FOR "PSYLLID YELLOWS"

"Psyllid yellows" is a disease of potatoes in which the leaves begin rolling at the base and as the disease develops the curling becomes more extensive, working up towards the tip. The normal color changes to a light green or yellow. In the Triumph and Peach Blows (McClures) a reddish-purple coloration appears soon after the leaves begin to roll, and the yellowing does not appear until in the advanced stages of the disease.

The leaves are harsh and have a peculiar rustle when brushed with the hand. The plant remains in an inactive state of growth for a period of several weeks. There is no wilting even under excessively dry conditions. In the advanced stages the yellowing becomes more pronounced and the plant turns brown and dies.

Brown Beauty plant in the San Luis Valley showing typical "psyllid yellows" symptoms. Note the curling of the leaves, both terminal and basal.

The underground symptoms are characteristic. In typical cases a mass of small tubers attached close to the stem, or on short stolons, is formed. A malformation that frequently occurs is one in which the tuber forms on a short stolon, then apparently the stolon growth is resumed and after a time another tuber is formed. This produces a chain tuber effect. Five and six tubers are often formed along a single stolon. This has been found common in fields severely affected by the disease. Plants may have as many as 3 or 4 stolons affected in this manner.

The yield is very low in markets and a large number of small potatoes are produced. Growth and proper development are so completely upset that the plants are unable to produce saleable tubers. In surveys carried on in Colorado during 1932, many fields were found to be completely lost. Several thousand acres were never dug.

Various workers in potato pathology have proved the absence of viruses in this disease. The usual devices and methods of studying the virus diseases have been tried in an attempt to determine the nature of the disease. Richards has published on the effects of feeding psyllids on the potato plant and states that 15 psyllid nymphs are necessary to produce the condition. Considerable of our laboratory work has shown that it is difficult to produce typical symptoms of "psyllid yellows" in the greenhouse. Hundreds of psyllids have been propagated on individual tomato and potato plants at different times, without any ill effects. Several experimental fields in 1933 were considered most favorable for spray work because of the abundance of psyllids; literally hundreds were present on each plant and yet no typical symptoms of the disease developed. The checks in the field failed to show any signs of "psyllid yellows." The yield was exceptionally good on the untreated plots. In other fields with fewer psyllids, the upset was more pronounced and the value of the spray was very definite.

FEEDING HABITS OF PSYLLIDS.—The psyllid nymphs normally take a position on the underside of the lower leaves. In plants where the foliage is particularly dense a few nymphs may be found on the upper side. Their flat, scale-like bodies and green color make them 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 do not crawl about as much as some insects do in their immature stages. With their long, stylet-like mouth parts protruded, and forced into and thru the delicate cells of the leaf, they remain inactive as they feed. The mouth parts are fully two-thirds as long as the body. Their construction is very similar to that of true bugs. The four appendages of the mouth

that make up the sucking tube, form two canals, one for sucking or transporting the juices drawn into the alimentary tract thru the action of a large muscular phayngeal pump and a second duct to carry a secretion from the salivary glands, which is forced thru the duct by an intricate salivary pump situated near the base of the stylets.

There is little doubt that a secretion is injected into the plant; however, the nature of the agent which causes the upset in the growth of potato and tomato plants is still not definitely known. The possibility of it being an enzyme has been indicated both in field and laboratory work.

The effect of the feeding is systemic. The delicate physiological balance which exists in the potato plant is partially upset by the material secreted by the insect. Histological examination made on a large series of collected stems, has shown that the vascular system or that portion of the stem involved in transportation of food materials from the leaves to the roots, is broken down. The important elements (internal phloem) of the system have been destroyed and a yellowish-brown or black mass remains. The large quantity of starch present in the pith cells of the stem indicates a general disturbance in the translocation of sugars from the leaves to the tubers, where it is normally stored as starch.

CONTROL EXPERIMENTS

Because of the serious nature of the disease a very determined effort has been made to establish a control for the tomato psyllid. The work was started in 1932 and was greatly extended in 1933. Fortunately we have had the work of Dr. G. M. List (5) on the control of the tomato psyllid on tomatoes to refer to, in which he studied the problem as it was involved in tomato growing, and determined the effective strengths of lime-sulphur. He found that lime-sulphur as a spray was very effective in eliminating the psyllid pest. A reaction in the tomato plants from the lime-sulphur was described.

1932 EXPERIMENTS

Preliminary tests were run to determine the value of oil, lime-sulphur and nicotine in controlling the disease. It was considered important to obtain as perfect a spray application as possible because of the peculiar habit of the psyllids concealing themselves on the lower leaves near the base of the plant. The equipment used during the season was far from efficient and we were unable to obtain the perfect application that was considered necessary.

Sprays were applied in the Fort Morgan and Gilcrest sections. The field of Mr. Fred Finney, east of Fort Morgan, was

considered most satisfactory for a test. A traction sprayer equipped with three nozzles to the row, two lower nozzles placed at suitable angles to spray the underside of the lower leaves and one above, shooting the spray directly down on the top of the leaves, was used in the first spray tests. An early field of Cobblers was divided into 3 plots, which included a check, Verdol plot of 1 percent, and lime-sulphur plot with a concentration of 1-40. The field was sprayed June 20, after the primary symptoms were apparent thruout the field. Psyllid nymphs were extremely abundant in all parts of the field. The average was about 70 to the plant and many plants were found with 150 to 200 to the hill.

The field was watched closely, since it was the earliest planting in the section. Symptoms were apparent on a few plants the last week in May. By June 8 the field was showing a purple cast and the plants were very definitely in a state of retarded growth. The leaves became thick and leathery, the stems were rigid, and the seriously affected plants were showing general disturbance of the entire plant. Psyllids were extremely abundant in all parts of the field. A check on diseases was made with Mr. L. A. Schaal, potato pathologist of the Potato Experiment Station, U. S. D. A., Greeley, Colo. Fusarium was negligible, rhizoctonia was running about 10 percent, there was no mosaic, and other diseases such as scab and blight were not apparent this early in the season. The similarity of the characteristic symptoms observed in this field and American leaf roll, as described by Orton and others, as it occurred in Colorado in past years, was most coincident. Is it possible that the psyllid condition and leaf roll, as described from Colorado by pathologists, are the same diseases?

The experimental field on the Finney farm was never dug, since there were no tubers larger than marbles produced on the 6 acres. The portion of the field sprayed with lime-sulphur showed some recovery and remained green for a time after the rest of the field had turned brown and had completely died.

Another field of 35 acres of Minnesota certified Cobblers was sprayed with lime-sulphur. This field was planted a week later than the first field. The condition of the plants at the time of spraying was not serious. About 20 percent of the hills were showing primary symptoms of basal curling and purpling, altho there was little doubt that the condition was developing rapidly. Psyllid nymphs were common thruout the field. It seemed that the spray of lime-sulphur 1-40, applied in June, should check the condition; however, the field was never dug. The plants failed to respond to the treatment, probably because of the imperfect application of material. In all of the experiments on the

Finney farm we had difficulty in maintaining a pressure greater than 250 pounds. About 70 percent coverage was obtained.

In the Gilcrest section a series of weekly plantings on the Earl Cogburn farm offered other possibilities in preliminary control work. The symptoms appeared in this field June 8 and a close check on the development of psyllids indicated that a serious condition existed. A power sprayer was obtained from Rocky Ford and sprays of lime-sulphur 1-40, Verdol, 1 percent nicotine 1-800, were applied. A pressure of 350 to 400 pounds was maintained on this field and a coverage of about 90 percent was obtained. Similar to the Finney field, the lime-sulphur gave very definite indications of partial recovery. The plants in this block remained green for some time after the others had died.

SUMMARY OF 1932 SEASON

This was considered the worst outbreak of "psyllid yellows" that the state has ever experienced. Many acres were never dug.

1. Lime-sulphur gave indications of controlling the condition.
2. Verdol, 1 percent, showed no control.
3. Nicotine failed to show control.

Field of Brown Beauties severely injured by psyllids.

4. Lime-sulphur must be applied early enough to prevent appearance of primary symptoms.
5. Late crop was seriously affected.

1933 EXPERIMENTS

The heavy loss from the disease in 1932 increased the demand for some suitable control of psyllids on potatoes. Plans for the season provided for control tests in the more important potato sections of the state, such as the Greeley and Morgan sections, the San Luis Valley, Fruita on the Western Slope, and the Divide section of Teller County, a mountainous area above Colorado Springs where a considerable acreage of seed potatoes is grown.

It was realized from preliminary observations in the spring that the season would not be as serious as the 1932 season. However, the experimental fields were obtained for spray work. A new power sprayer, with a truck for transporting it from one area to another, was obtained. The mobility of the spray equipment made possible the treatment of a number of spray blocks situated in widely separated sections.

EARLY GREELEY SECTION

The season was begun in the Gilcrest area where early potatoes were planted. The first indication of the malady appeared about June 20. The Bett's field at Milliken, Colorado, was considered the most satisfactory for experimental work. This field was treated with lime-sulphur, Verdol, Sunoco and Bordeaux sprays. There was little doubt that the lime-sulphur had a favorable effect, altho the field was not seriously damaged by the psyllids. The yield was normal thruout the field. The check may have been slightly below the sprayed plots. However, there was nothing conclusive about the field.

The Roy Love fields near Gilcrest were next considered favorable for experimental work, as a series of plantings and different varieties were obtainable. A Cobbler field of 6 acres was the earliest planting and at the time of spraying about 25 percent of the plants were showing primary symptoms. The control value of each spray was determined by taking a series of 30 hills in each plot, 10 at the upper, 10 in the middle and 10 at the lower end. Each hill was dug, the number of markets and culls counted, and the weight of the saleable and the total weight for the hill was obtained. The yield for each plot was established on the basis of the weights obtained from hills in each plot. The value of the spray is indicated by the difference in the yields of the treated and untreated plots. The check of the Love field yielded 129

A field of Rurals in the Greeley area, showing psyllid injury. The growth has been checked and the plants were in serious condition of retarded growth.

bushels per acre, while the sprayed plots adjacent to it gave the following figures: Lime-sulphur 1-30, 296 bushels; 1-40, 378 bushels and 1-50, 302 bushels. The lime-sulphur 1-40 showed an increase of 249 bushels or 193 percent over the untreated.

FRUITA SECTION

The R. Long field at Loma, on the Western Slope, was used for another test on early potatoes. Lime-sulphur, pyrethrum and nicotine were tested on the fields of Cobblers. Applications were varied in this field, two were compared with one and early was compared with late. At the time the first application was made, 40 percent of the plants were showing symptoms of the disease.

Table I—Cobblers field belonging to Mr. R. Long, Fruita. Sprayed for Psyllid Yellows.

Material	Concentration	No. Applications	Yield, bushel per acre
Lime-sulphur	1-33⅓	One (late)	65.32
Lime-sulphur	1-33⅓	Two	209.61
Lime-sulphur	1-33⅓	One (early)	202.95
Check			51.17
Nicotine	1-600 plus soap	One (early)	63.81
Check			70.85
Pyrethrum	1-600 plus soap	One	84.80
Check			88.5

The plot receiving two sprays of lime-sulphur 1-33⅓, had the highest yield, 209.61 bushels per acre, or 148.60 bushels increase over the check. This increase of 242.6 percent may be attributed to the two applications of spray in controlling the

tomato psyllid. The early spray of one application gave an increase 231.9 percent over the check, while a late spray gave no control, indicating that the early spray is more important than the late. There was no value in the applications of nicotine and pyrethrum sprays.

SUMMARY OF EARLY POTATO TESTS

The value of lime-sulphur sprays was apparent from the first. The two applications were more effective than the one. One spray, as an early treatment, gave better control than as a late spray. The concentration of 1 gallon of lime-sulphur to 40 gallons of water is considered the most satisfactory.

TESTS ON LATE POTATOES, 1933

Variation in plantings in Colorado gave us the opportunity of making two complete tests during the season. The late plantings, more extensive, are not usually injured to the same degree as the early plantings. The yield was lowered considerably in 1932 in this class of potatoes, but very few fields were complete failures. The fields of late tests were selected in three sections of the state. The Greeley tests were made at the Potato Experiment Station, and on one of the Farr farms near Lucerne. A series of tests was run on mountain potatoes belonging to the Snare Bros. near Florissant, Colo.

In the San Luis Valley five experimental fields were used in a rather complete study of psyllid control and conditions affecting control. The test included fields in a serious state of disease, where it was apparent from the first application of material that recovery was very uncertain; a field where psyllids were extremely abundant, but few symptoms were visible; a field affected with psyllids and grown without irrigation; a field affected with psyllids and grown with irrigation; and last, a field of commercial size with different dates of planting, where lime-sulphur 1-40 was used thruout with suitable checks left at intervals in the various fields. There were 94 plots of late potatoes where tests of liquid and dry lime-sulphur, in different concentrations, nicotine, pyrethrum, Bordeaux, Verdol and Sunoco oils, were applied with suitable checks, to determine their value as controls.

GREELEY SECTION

The late plantings in this section in 1933 showed very little indication of the "psyllid yellows" condition. Fields at the Experiment Station did not show over 10 percent primary symptoms, altho a few psyllid nymphs were present in the different fields. Lime-sulphur in the concentration of 1-40, in early and late applications, was used. One plot was given two applications to compare with the plots receiving one application. The increase

Favorable results from spraying in the Gilcrest area, where extremely heavy losses have been incurred in past years from psyllids.

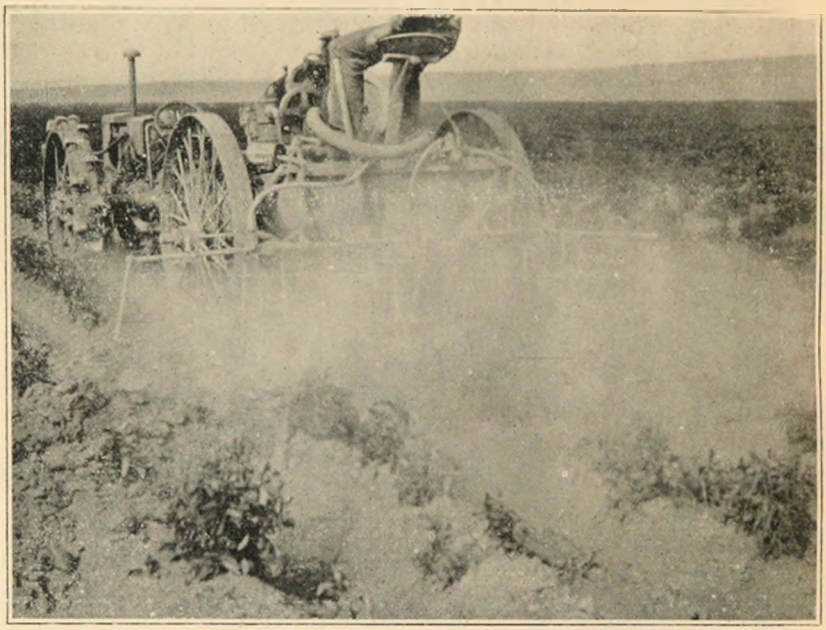
in yield in the late sprays was considerable. A plot of Triumphs receiving one late application, produced 416.91 bushels per acre, or an increase of 159.04 bushels over the untreated plot. In a similar treated plot of Rurals the yield was 318.7 bushels per acre, or an increase of 120.7 bushels over the untreated plot adjacent to it.

A combination spray was used on the Farr farm near Lucerne. The field of Rurals was showing at the time of application about 8 percent primary symptoms of the disease, and considerable flea-beetle injury. The plots consisted of straight lime-sulphur 1-40, a dual spray of zinc arsenite and lime-sulphur 2-1-40, and a check. The yield on the two treated plots was 357.2 and 387.9 bushels per acre, respectively, or an increase over the untreated of 36 bushels for the lime-sulphur and 61 bushels for the combination spray.

There was some reduction in the amount of worm tracks which would indicate that flea-beetles possibly were more of a factor than psyllids in decreasing the yield.

FLORISSANT SECTION

This mountainous area west of Colorado Springs was considered, since extremely heavy infestations of psyllids had occurred in the fields of potatoes grown for certification. The losses were heavy, as many fields were not dug in 1932. The lower areas of the state offer more favorable conditions for experiment-



Large power sprayer at work on psyllid control. High-pressure equipment drawn by tractor made it possible to cover large acreages in a short time.

ing, since the rolling and hilly nature of the fields at Florissant makes it difficult to obtain the most satisfactory coverage. A series of 20 plots was run on the farm of Mr. Max Snare. Three varieties of potatoes were grown without irrigation. Pyrethrum, nicotine, Verdol and Sunoco were included with lime-sulphur in the experiments. Each treated plot was adjacent to a check. This was considered advisable because of the topography of the field. The higher yields occurred in the three lime-sulphur plots. Concentration of 1-50 yielded 274.5 bushels per acre or 57.7 bushels over untreated; 1-40, 199.46 bushels per acre or 60.8 bushels over untreated; and 1-30 produced 179.9 bushels per acre or 85.2 bushels over the check plot. Among the remaining plots the Sunoco sprays in 1 and 2 percent gave an indication of control with increases in yield over their checks of 60.2 and 43.5 bushels, respectively.

ALAMOSA SECTION

The field of Mr. W. E. Lutz, southwest of Alamosa, was treated with pyrethrum, nicotine, Verdol, Sunoco and dry and liquid lime-sulphurs in different concentrations. The number of applications was varied on the lime-sulphur plots. The test included 23 plots of McClures and two plots of Brown Beauties, all grown without irrigation. The Lutz field in 1932 was seriously

injured by psyllids, and offered the most reliable test in the San Luis Valley. There was no question that psyllids were abundant and causing serious damage early in the season of 1933. The plants showing symptoms totalled fully 50 percent by mid-summer and between 75 and 80 percent later in the season on the areas of check and where sprays were not effective. A check was adjacent to each spray plot, which undoubtedly increases the value of this field as a fair test of psyllid sprays. The following table from the Lutz field gives a most interesting picture of the lime-sulphur treatment:

Table II—Field of Peach Blows belonging to W. E. Lutz, Alamosa. Sprayed with lime-sulphur

Treatment	Concentration	Number of applications	Number tubers market size per 30 hills	Number tubers under market size per 30 hills	Yield, bushels per acre
Check	.....	....	80	281	127.61
Lime-sulphur	1-50	2	105	320	195.93
Lime-sulphur	1-50	1	96	397	158.65
Check	.....	....	69	296	119.92
Lime-sulphur	1-40	2	125	297	242.14
Lime-sulphur	1-40	1	115	363	204.03
Check	.....	....	96	329	151.45
Lime-sulphur	1-30	2	138	316	288.08
Lime-sulphur	1-30	1	101	317	175.56

The two applications in the three concentrations show a slight advantage over one application. The value of one application is apparent with the exception of the last check, which for some unaccountable reason shows the advantage. A consideration of the value of the other sprays has been left for a more complete report in a technical bulletin.

BLANCA AND FORT GARLAND SECTIONS

Two fields were treated in this area to determine the value of lime-sulphur in bringing about recovery in a field so seriously injured by pysillids and influenced by other unfavorable factors that recovery appeared impossible—and a field that probably had more psyllids per plant than any other field observed during the summer, but due to its location, soil and irrigation, which were almost perfect, and the seed, which was exceptional. the field had failed to show pronounced symptoms of "psyllid yellows."

The first field, belonging to Mr. Jerry Morris, was sprayed early and late, in one and two applications, in an attempt to bring about recovery. An increase of 33.5 bushels per acre was obtained with two applications of 1-40 lime-sulphur spray. The untreated plot yielded 9.35 bushels per acre, which was practically a complete loss.

The second field, belonging to Mr. Robert Skinkle, was treated with lime-sulphur 1-40 in one early application, and a second plot was given two applications of lime-sulphur 1-40, one early and the other 2 weeks later. The plot receiving two applications gave an increase in yield of 140.5 bushels per acre over the untreated. The yield from the plot of one application of lime-sulphur 1-40, was identical with the untreated or check.

SAN ACACIA SECTION

The field of Mr. Fred Hermann was used for a rather complete experimental test of psyllid sprays. Psyllids have been an important factor in potato production in this area for the past 3 years. Early in the season of 1933 psyllids and psyllid symptoms were apparent. Fourteen experimental plots were run, testing pyrethrum, nicotine, Bordeaux mixture and dry and liquid lime-sulphur.

The applications and concentrations were varied in the lime-sulphur. The greatest yield over its adjacent check was 58.3 bushels per acre in the lime-sulphur 1-30, or an increase of 160 percent. The various lime-sulphur plots all showed substantial yields over their checks. However, Bordeaux and other materials showed no control. Because of the nature of this circular considerable of the technical data have been withheld for publication in a more technical bulletin at a later date. Further investigation is necessary before a complete report on control can be made. An emergency has existed and the importance of getting any encouraging information to potato growers has been regarded as more important than waiting until various phases of the problem are completed, as would be the case under ordinary conditions.

SUMMARY FOR 1933

The entomology section of the Colorado Experiment Station has had to meet an emergency in obtaining a control of the tomato psyllid on potatoes. An extensive program of spray testing was carried thru the season, with the object of finding some means of control as soon as possible. The heavy losses incurred by potato growers in various sections in 1931 and '32 have made it necessary to forget for the moment other important phases of the work. The lime-sulphur sprays have shown up very favorably in controlling the psyllids. The tests in both early and late fields of lime-sulphur treated plots have been consistent in their increase in yield over the untreated fields. In some cases over 200 percent increase in yields has been noted. Two applications are more satisfactory than one. The concentration of 1 gallon of liquid lime-sulphur to 40 gallons of water has been considered the most satisfactory.

RECOMMENDATIONS

Spraying must be carried on carefully and thoroly with equipment that will develop the pressure necessary to cover completely the foliage of the lower leaves of the plants. Three nozzles to the row should be used. Two lower nozzles turned upward at an angle sufficient to get the under surface of the lower leaves should be provided. An efficient, well-made nozzle is important in high-pressure spraying.

Spraying must begin very soon after the psyllids appear in the field.

At least two applications should be made, the second about two weeks after the first.

The concentration should be 1 gallon of liquid lime-sulphur, 30 to 33 degrees Baume test, to 40 gallons of water.

In areas such as Morgan or Weld Counties, where flea-beetles and Colorado potato beetles are injurious, 2 pounds of zinc arsenite added to each 40 gallons of 1-40 lime-sulphur solution will aid materially in controlling the two leaf-eating pests.

TOMATOES

Psyllids on tomatoes have been controlled with lime-sulphur spray. The concentrations recommended by Dr. G. M. List (5), 1917, were 1 gallon of lime-sulphur to 45 or 50 gallons of water. Tomatoes are more sensitive to this spray than potatoes and it should be used with caution.

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