Lygus Control in Sugar Beets Grown For Seed

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Studies to determine the presence and effect of insects, other than the leafhopper, on the sugar beet seed crop were first undertaken by the Bureau of Entomology and Plant Quarantine at Phoenix, Ariz., in 1938. The beet leafhopper *(Eutettix tenellus)* (Bak.)) as a vector of the curly top disease was known to be of considerable importance in the growing of this crop, and a method of controlling this insect had already been developed by Romney *(10).*,[2] This insect damages seed beets primarily in the fall of the year while they are still in the vegetative stage. Insect population studies from 1938 to 1945 showed that, of the insects in the seed-beet fields in the spring, *Lygus* sp. and the Say stinkbug *(Chlorochroa sayi* Stal) were causing the most damage, and that lygus was of greater concern because of its general occurrence each year. The Say stinkbug, although capable of doing much damage to the crop, only occasionally becomes numerous that the primary damage caused by these insects was a reduction in enough to be of economic importance. These studies further showed the percentage of viable seed produced, although they also had a tendency to reduce the yield of seed *(1, 3, 4, 5*).

Experiments leading to the development of a method for controlling these insects have been under way since 1940. Since the work was started, beet field populations of the Say stinkbug have been too low for experimental work; therefore, experiments have dealt almost entirely with the lygus bugs—the tarnished plant bug, *L. oblineatus* (Say), the western plant bug, *L. hesperus* Knight, and the pale plant bug, *L. clisus* Van D. Progress reports summarizing the results of these experiments on small-scale field plots have been issued from time to time (*6, 7, 8).*

Laboratory Tests

Approximately 116 materials or combinations of materials were

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[2]italic numbers in parentheses refer to literature cited.

tested in the laboratory to determine their comparative toxicity to lygus bugs and the Say stinkbug. Many of them were new materials, the insecticidal value of which had not been established. The results have been recently published (Hills and McKinney 9). Materials showing promise were later tested in small field plots to determine not only tlieir effectiveness against these insects but also their effect, if any, on the plant and seed crop. Usually materials that showed promise against these insects in laboratory cages showed some value in field tests, but some of them proved to be too caustic to use on the plants.

Small-Plot Tests

Small-plot tests to compare values of various insecticides in controlling lygus on sugar beets grown for seed have been conducted in the Salt River Valley of Arizona from 1940 to the present time.[3] Each year from 42 to 64 plots approximately 1/50 of an acre in size and arranged in either a Latin square or randomized blocks were used, and data regarding insect populations, seed yield, and viability were obtained. A curly top resistant variety was used each year until 1945 in order to prevent complications due to possible curly top infection in the fall. This was one of the earliest bolting and most vigorous varieties. The 1945 plots included also one of the later bolting and less vigorous varieties. These plots were arranged in a split plot, randomized block design in which the varieties were replicated three times in major blocks. Each of the six variety plots was divided into smaller plots in which the insecticidal treatments were tested. The insecticide tests were replicated six times.

Each year the plots were laid out with 9- or 10-foot roadways between plots in one direction and at least 6-foot spaces between plots in the other direction. This arrangement facilitated insecticide applications and insect population sampling. The tall, dense growth of the beet seed plants in the spring presented difficulties in this regard. During 1940, 1941, and 1942 the insecticides were applied by means of hand dusters or an especially designed power sprayer *(2)* operated from two towers mounted on runners with a footbridge, between, of sufficient length to span the plots. These towers were drawn by automobiles along the roadways between the plots. Cloth-covered, wooden framework barriers were set up around the plots to prevent drift of the insecticides. In 1943 and 1944 a more simple technique was employed, which consisted in dusting a plot simultaneously with hand dusters from two platforms built on the tops of cars as illustrated in figure 1. This method was adopted primarily to save time

[3]In this area sugar la-els for seed are planted in August and September and harvested the following June or July. Plots are referred to according to.the calendar year in whieh the prop is harvested.

Figure 1.—Applying insecticides from car-top platforms to small plots of seed beets for experimental control of lygus. Phoenix, Ariz., 1943.

and labor but had the disadvantage of uncontrolled insecticide drift between the plots at the time of application. In 1914 a springboard type of scaffold attached to a pickup truck, developed for taking insect population samples, was adapted for use in the application of the insecticides (figure 2).

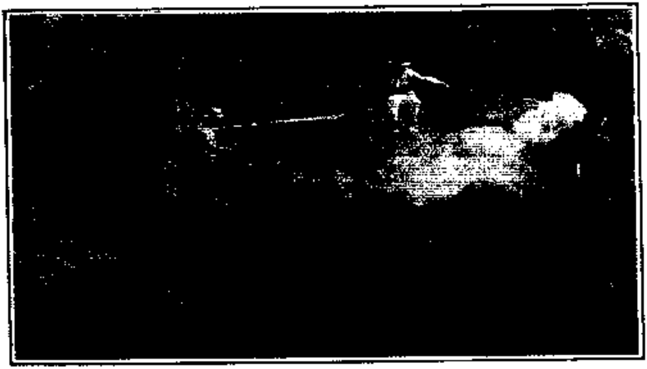

Figure 2.—Applying insecticides from the springboard scaffold to small plots of seed beets for experimental control of lygus. Phoenix, Ariz., 1945.

Figure 3. - Taking insect population samples in experimental plots of seed beets by menus of the sweep net from the springboard scaffold. Phoenix, Ariz., 1944.

During 1940, 1941, and 1942 various methods were tried to obtain adequate insect population samples. While these methods gave comparative results between treatments, the data are not directly comparable with data of later years and will therefore not be presented. During 1943, 1944, and 1945 the sweep-net method of sampling was adopted. One disadvantage of this method is the difficulty of getting through the field after the seedstalks have become entangled. With the development of the springboard type scaffold the sweep net operator was carried over the tops of the plants (figure 3).

All the seed from the 1940, 1941, and 1942 plots was harvested, threshed and cleaned in order to obtain yield data. Samples of seed for germination analyses were taken from the harvested seed from each plot. In 3 943, 1944, and 1945 only a sample area four rows wide and 10 feet long from the center of each plot was harvested. Yields were based on the weight of seed from these areas, and samples of seed for germination were taken. This technique has saved much time and labor in harvesting and handling the seed.

In 1940 and 1941 lygus populations in the Salt River Valley were low, and populations were correspondingly low in the experimental plots. Seed viability, as indicated by the germination tests in the untreated check plots, was above 80 percent in both years and, although some increase in the percentage of viable seed was indicated for the more effective insecticides, the results were not outstanding.

From 1942 to 1945 radishes were planted in the roadways between the plots to increase the numbers of lygus and to insure adequate populations on which to make insecticide tests. The radishes were planted in the fall at about the same time the beets were planted, but they bloomed and matured considerably ahead of the beets. Lygus bugs were introduced onto the radishes in the fail and sometimes also in the spring. These insects seem to prefer tender, developing flower buds or immature seed for breeding, and a brood of lygus was developed on these radishes at about the time the beets were beginning to bolt. When the radishes were cut, the insects were forced onto the

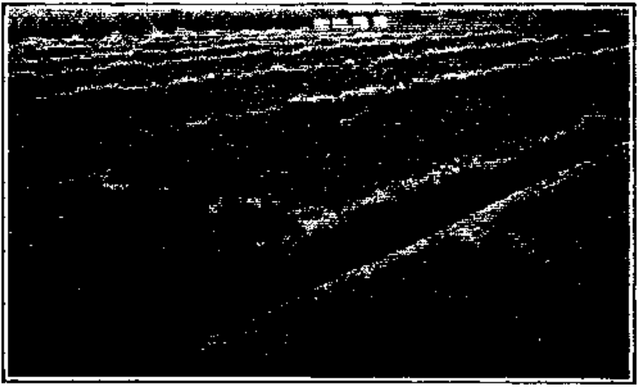

Figure 4.— Experimental seed beet plots on April 6. Radishes in roadways are in seed stage and serve as breeding host for lygus; beets are just beginning to bolt. Phoenix. Ariz., 1942.

beets. Figure 4 shows the radishes blooming and setting seed in the roadways between the plots. Just how much this technique increases the number of lygus bugs in the plots is not definitely known, but from 1942 to 1945 populations in the plots were sufficiently high for satisfactory insecticide tests, although they were very low in 1944 in the commercial seed beet fields.

Tn 1942 seven insecticides were tested in eight replicate plots arranged in a Latin square. Five applications of all materials were made at weekly intervals during May at an average rate of approximtely 90 pound per acre. Seed yield and viability data from these experiments, which are given in table 1, indicate that the best results were obtained with a pyrethrum extract dust, either with or without sulphur. Dusting sulphur also gave good results, but the addition

Table 1.—Yield and viability of seed from small plots of seed beets dusted five times at weekly intervals for lygus control (8 replicate plots in a Latin square). Phoenix, Ariz., 1942.

Treatment (Amounts in percent)	Seed yield, pounds per plot (1/58 acre)	Seed viability, percent
Pyrethrum concentrate* 10 (pyrethrins 0.2), pyrophyllite 40, sulphur 50	70.6	90.1
Pyrethrum concentrate* 10 (pyretnrins 0.2), pyrophyllite 90	74.7	89.3
Sulphur	66.2	84.8
Phthalonitrile 13.3, sulphur 86.7	64.0	84.7
Dinitro-o-cyclohexylphenol 1, sulphur 50#	68.3	84.0
Paris green 7.5, sulphur 92.5	65.7	83.7
Dinitro-o-cyclohexylphenol 1#	64.1	75.1
Untreated check	66.8	61.1
Difference required for significance (P = 0.05)	5.0	4.7

*Proprietary dust mixture prepared from pyrethrum extract,
#Proprietary mixture, inert diluent unknown.

of phthalonitrile, dinitro-o-cyclohexyiphenol, or paris green to the sulphur did not increase its effectiveness.

In 1943 five insecticides were tested in eight replicate plots arranged in randomized blocks. Three applications of all insecticides except the pyrethrum-sulphur dust, at approximately 80 pounds per acre-application, were made at 10-day intervals from April 30 to May 20. Previous experiments had shown two applications of this material to be effective in controlling lygus.

Lygus populations for each of these treatments are shown in figure 5. These data indicate that all treatments reduced lygus populations, and that the two applications of pyrethrum-sulphur dust were more effective than three applications of any of the other materials. No differences were indicated for the yellow or black sulphurs; both were shown to be superior to either the phenoxathiin-sulphnr or sulphur-arsenical dust.

The seed from the 1943 plots-were separated according to size at the time of cleaning. All seed retained by an 8/64- by 3/4-inch screen were termed "large seed," while the seed passing through this screen but retained by a 7/64- by 3/4-inch screen were classed as "small seed." Yield data and results of analyses for both large and small seed are given in table 2. There were no appreciable differences in seed yield. *In* general the viability of seed was higher in the plots having the lower lygus populations. Two applications of the pyrethrum-sulphur dust were more effective in increasing the seed viability than three applications of the other materials.

From the data in table 2 it is easily determined that slightly more than 15 percent of the total yield consisted of small seed. It is

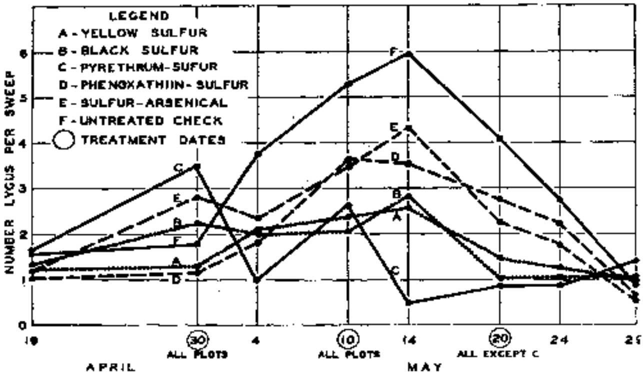

Figure 5.—Lygus populations as indicated by the sweep net in variously treated plots of seed beets. Phoenix, Ariz., 1943.

generally understood that the percentage of germinating seed is lower in case of small seed, and the data in the table substantiate this theory. However, these data also show that where lygus bogs were controlled

Table 2.—Yield and viability of seed from small plots of seed beets dusted three times at 10-day intervals for lygus control (8 replicate plots arranged in randomized block). Phoenix, Ariz., 1943.

Treatment (Amounts in percent)	Seed yield, ounces per plot (8- by 10-foot sample area)		Seed viability, percent		
	Large	Small	Large	Small	Total*
Pyrethrum concentrate# 10 (pyrethrins 0.2), pyrophyllite 40, sulphur 50	68.1	14.3	88.1	03.4	83.7
Sulfur	68.6	12.6	85.8	58.6	81.5
Black (gashouse) sulphur	65,1	12.3	83.9	58.9	19.9
Phenoxathiin 15, sulphur 60, diatomaceous earth 25	60.8	11.7	82.0	53.3	78.6
Calcium arsenate 7.9, calcium arsenite 0.7, sulphur 87.5##	59.6	11.0	81.3	56.1	76.3
Untreated check	61.7	11.4	78,4	45.8	72.3
Difference required for significance (P = 0,05)	**	**	4,0	5.9	

* Figures in (his column represent percentage of germinating seed that would have resulted if all seed had been cleaned over a 7/64- by 3/4-inch screen.

\# Proprietary dust mixture prepared from pyrethrum extract.

\## Proprietary mixture, inert diluent unknown.

** Not significant by the F test.

the viability of the small seed as well as the large seed was improved, and furthermore that the increase in the percentage of viable seed due to lygus control was greater with the small seed.

In 1944 seven insecticides were tested in eight replicate plots arranged in a Latin square. They were applied at an average rate of 100 pounds per acre per application. Two applications were planned for all materials, on May 11 and 19. However, one application of DDT had reduced lygus numbers so greatly that a second application of this insecticide was considered unnecessary, and since one application of dinitro-o-cresol caused severe burning of the foliage, a second application was not made. Lygus populations obtained in 1944 are given in figure 6. Likewise, as shown in table 3, a single application of DDT increased the viability of the seed at least as much as two applications of other materials.

Approximately 13 percent of the total seed obtained from the 1944 plots was small seed, and the data in table 3 indicate, as did the 1943 data, that the viability of the small seed was improved to a greater degree by lygus control than was the viability of the large seed.

In the 1945 experiments the two varieties of beets planted in split plots, arranged in randomized blocks, gave opportunity for testing the effectiveness of lygus control on other than the vigorous early bolting variety used in experiments of previous years. The results of the treatments were compared in three replicate plots on each variety, or a total of six replicates for each insecticide treatment. Except for the three-application treatment of DDT made on April

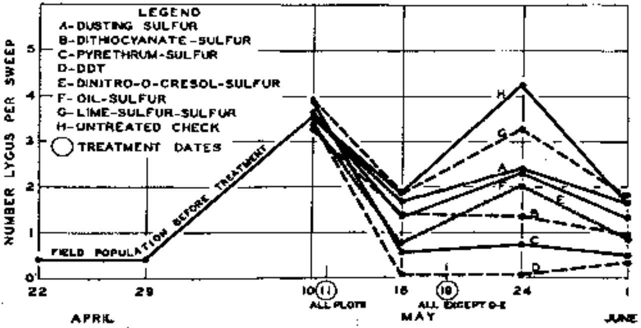

Figure 6.—Lygus populations as indicated by the sweep net in variously treated plots of seed beets. Phoenix, Ariz., 1944.

Table 3.—Yield and viability of seed from small plots of seed beets dusted experimentally for lygus control (8 replicate plots arranged in a Latin square). Phoenix, Ariz., 1944.

Treatment (Amounts in percent)	Number of applications	Seed yield, per plot (8- by 10-foot sample area)		Seed viability, percent		
		Large	Small	Large	Small	Total*
DDT 4.5, pyrophyllite 95.5	1	102.4	15.9	93.0	79.2	91.2
Pyrethrum concentrate# 10 (pvrethrins 0.2). pyrophyllite 40, sulphur 50	2	90.3	13.3	90.6	75.4	88.6
'Beta, beta'-dithiocyanodiethyl ether 3.25, sulphur 75##	2	88.0	13.5	86.4	70.0	84.2
Dinitro-o-cresol 1, sulphur 99	1	68.9	10.7	84.6	59.0	81.1
Sulfur	2	90.0	14.0	82.9	55.4	79.1
Lime-sulfur 20, sulphur SO	2	91.3	13.0	82.7	54.7	79.2
Petroleum oil 5, sulphur 57, talc 38	2	96.5	13.6	82.5	54.8	79.1
Untreated check	0	94.6	11.9	73.1	39.2	64.9
Difference required tor significance (P = 0.05)		13.1	2.0	3.6	7.0	

*See footnote 1, table 2.

#Proprietary dust mixture prepared from pyrethrum extract.

##Proprietary mixture, inert diluent unknown.

18 and 27 and May 9, the first application of each insecticide treatment was made on May 9 and the second on May 21. The improved dusting technique used in 1945 (figure 2) permitted a more even application of insecticides, and the average rate was cut to approximately 48 pounds per acre-application.

The effectiveness of each treatment as indicated by lygus populations is shown in figure 7. These data indicate that all treatments reduced lygus populations; they also show considerable differences in the effectiveness of the various treatments. One application of 5-percent DDT-pyrophyllite was better than two applications of the pyrethrum-sulphur dust. Three applications of 5-percent DDT dust held populations at a very low level during the entire season, but after May 14 populations in these plots were not different from those in plots receiving only one application of DDT. The trends in the plots receiving one and two applications of sabadilla indicated that this material was not so effective as either the DDT or the pyrethrum-sulphur dust, and had very little, if any, residual effect. The dithiocyanate dust was also inferior to both pyrethrum-sulphur and DDT. Lygus populations in the untreated check plots did not show the decline after treatment in 1945 that they did in 1944 (figures 6 and 7). This was undoubtedly due to the prevention of insecticide drift during application.

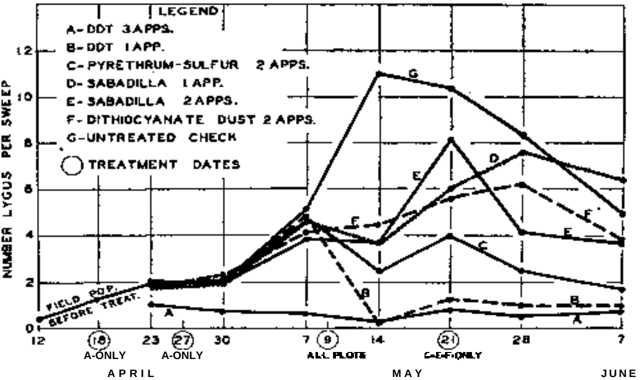

Figure 7.—Lygn populations us indicated by the sweep net. in variously treated plots of seed beets. Phoenix, Ariz., 1945.

The seed-cleaning operation was the same in 1945 as in the two previous years, the large and small seed being separated. Yield data from the 1945 plots, irrespective of varieties, are given in table 4 and show significant increases in yield of large seed for all treatments except the dithiocyanate dust and one application of sabadilla. Significant increases in yield of small seed are indicated for all treatments

Table 4.—Yield and viability of seed from small plots of seed beets dusted experimentally for lygus control (6 replicate plots arranged in randomised block). Phoenix, Ariz., 1945.

Treatment (Amounts in percent)	Number of applications	Seed yields, per plot (8- by 10-foot sample area) Large	Seed yields Small	Seed viability, percent Large	Small	Total*
DDT 5, pyrophyllite 95	3	113.6	15.0	88.0	74.4	86.4
DDT 5, pyrophyllite 95	1	102.6	14.8	81.9	65.2	79.8
Pyrethrum concentrate* 10 (pyrethrins 0.2), pyrophyllite 40, sulfur 50	2	118.0	16.1	81.1	61.0	78.6
Sabadilla 10, pyrophyllite 90†	2	107.8	11.8	71.6	36.4	68.1
Sabadilla 10, pyrophyllite 90†	1	88.6	10.6	62.0	27.8	58.3
'Beta, beta'-dithiocyanodiethyl ether 3.5, sulphur 75†	2	94.0	11.8	60.2	30.1	56.9
Untreated check	0	88.0	10.0	45.8	15.6	42.5
Difference required for significance (P = 0.05)		13.9	1.8	9.6	9.5	----

Proprietary dust mixture prepared from pyrethrum extract.
Proprietary mixture, inert diluent unknown.

except the one application of sabadilla. Results of germination tests, also given in table 4, show that one application of a 5-percent DDT dust gave results as good as two applications of the pyrethrum-sulphur dust; they also show that one application of the 5-percent DDT dust applied on May 9 gave almost as good results as three applications. These data further show that, while some benefit was derived from the sabadilla and the dithiocyanale dusts, these materials were inferior to DDT and pyrethrum-sulphur dusts. Greater increases in seed yield and viability due to lygus control were shown in 1945 than in any of the previous years; this is probably due to higher lygus populations in the 1945 plots as well as better control. Greater increases in viability were again shown for small seed than for large. The mean yield of small seed from all plots in 1945 composed approximately 11 percent of the total yield.

Analyses of the data from the 1945 plots indicate, as is shown in table 5, that the lygus control program was equally effective on the two varieties, but that, irrespective of insecticide treatment the more vigorous, early-bolting variety outyielded the less vigorous, late-bolting variety. There was also some tendency for the early bolting variety to produce a higher percentage of viable seed than the late-bolting variety, but these differences were not great enough to be mathematically significant.

Table 5.—Comparison of yield and viability of seed from two varieties of seed beets grown in experimental plots. Phoenix. Ariz., 1945.

	Seed yield, ounces per plot (8- by 10-foot sample area)		Seed viability, percent	
Variely	Large	Small	Large	Small
Early bolting, vigorous	117.4	13.3	74.3	57.3
Late bolting, less vigorous	83.4	12.5	65.8	41.4
Difference required for significance {F = 0.05)	19.6	*	*	*

•Not significant by the F test.

Large-Scale Control Experiments

Large-scale experiments for the control of lygus in seed beets have been conducted in Arizona, New Mexico, southern California, northern California, Oregon, and Utah. Most of the applications have been by airplane, although ground equipment has been used exclusively in New Mexico and Utah. The results have usually indicated that where lygus bugs were controlled the viability of the seed was improved; however, sometimes the increases in seed viability were not so great as expected. Other factors also may contribute to the nonviability of the seed.

Klamath Falls, Ore., and Northern California.—The first large-scale control experiments against lygus in seed beets were conducted at Klamath Falls, Ore., in 1942. Prior to 1942 high lygus populations and crop failures were reported from the Klamath Falls and northern California beet seed producing areas. Lygus populations in seed beets at Klamath Falls in 1942 were high, and field tests were conducted to determine the effectiveness of the pyrethrum-sulphur dust shown to be effective against lygus in small-plot tests at Phoenix. Two applications were made during July with a tractor-mounted power duster at the rate of 25 pounds of dust per acre-application. The first application was made when the plants were in the early bloom stage and the second application about 2 weeks later. This treatment resulted in good control of lygus and definite increases in the percentage of viable seed produced. Germination analyses by a commercial seed analyst showed 70.8 percent of viable seed from the treated portion of the field as compared with 49.5 percent from the untreated portion.

In 1943 the seed beets at Klamath Falls were frozen out by extremely low winter temperatures. In 1944 high lygus populations again occurred and one application of pyrethrum-sulphur dust was made as a commercial control program. A satisfactory kill was reported, but no further applications were made, and seed viability was so low that the crop was not harvested. Much of the acreage in northern California in 1944 was also left unharvested because of extremely low quality seed.

The beet seed acreage at Klamath Falls in 1945 was confined to one field of approximately 160 acres. Lygus populations in this field the first part of July were extremely high, nearly 20 per sweep of an insect net. The beets at this time were in the late pre-bloom stage, and the entire field, except for a small strip along one side, was dusted by airplane with 5-percent DDT at approximately 30 pounds per acre. Populations were reduced practically to zero and remained so throughout the rest of the season. Lygus numbers in the untreated strip were also greatly reduced, probably by drift of the insecticide during application, so that little or no differences in seed viability occurred bel ween the treated and untreated areas. The viability of the seed produced in 1945 at Klamath Falls was not satisfactory, however, and the seed was marketable only after drastic cleaning. Factors other than lygus also probably contributed to the nonviability of seed produced in this area.

Portions of seed beet fields in northern California and Medford, Ore., were dusted with DDT during the blooming period of the beets in 1945, and lygus populations Mere satisfactorily reduced. In all these fields lygus control was accompanied by increases in seed viability, and usually seed with satisfactory germination was produced.

Salt River Valley, Ariz.—The first large-scale control experiments in the Salt River Valley, Ariz., were conducted in 1943. In that year all such experiments except one were with dusting sulphur. From three to five applications, ranging from 40 to 50 pounds per acre, were made by airplane to a number of fields containing moderate to high lygus populations. In five of these fields untreated, check areas were left, and samples of seed from the treated and untreated portions of the fields were taken for germination analyses at harvest time.[4] The mean percentage oP viable seed from the untreated portions of the fields was 51.6 as compared with 65.9 from the treated portions.

Another airplane-dusting experiment was set up on a 65-acre field of seed beets to compare the effectiveness of five applications of dusting sulphur with two applications of pyrethrum-sulphur followed by three applications of dusting sulphur. The sulphur was applied to 55 acres, the pyrethrum-sulphur to 5 acres, and 5 acres were left as an untreated check. Germination analyses showed that 76.6 percent of the seed from the area treated with pyrethrum-sulphur was viable, 68.5 percent from the sulphur-treated area, and only 44.6 percent from the untreated check.

In 1944 lygus populations in the Salt River Valley were low and the viability of the seed produced that year was correspondingly high; none of the fields were treated for lygus control.

In 1945, lygus populations in the seed beet fields of the Salt River Valley were high, and control was undertaken in practically every field. DDT was unavailable except for large-scale control experiments, and the pyrethrum-sulphur dust, previously recommended was entirely unavailable because of wartime conditions. A new insecticide, sabadilla, was obtainable, and cage tests indicated that this insecticide was toxic to lygus, but no field tests on seed beets had been made. A few large-scale single applications by airplane early in the season gave fair results. Therefore single commercial applications

[4]Unless otherwise mentioned, all samples of seed were 1aken by hand from the windrow or shocks and were threshed, cleaned, and placed between moist blotters for germination, according to the. rules and recommendations for testing seed established by the U. S. Department of Agriculture (11). For cleaning these seed samples a 7/64- by 3/4-inch screen and only enough air to separate the light trash from the seed were used, so that virtually all seed were saved. Germination analyses were lower than would be obtained from the more drastic commercial cleaning of the seed, but more accurate data were obtained on the viability of the total seed produced regardless of weight or size.

of a 10-percent sabadilla dust were made to many of the fields in the vicinity of Phoenix. It was soon found, however, that, although approximately 75 percent mortality could be expected within 24 hours from the application of 40 pounds per acre of 10-percent sabadilla dust by airplane, this insecticide had little or no residual effect, and lygus populations soon again reached a high level in the dusted fields.

Additional supplies of DDT became available later in the season, and during the first 3 days in June many of the fields previously treated with the sabadilla dust were redusted with DDT. However, the beet seed crop at this time was approaching maturity and, although lygus populations were reduced, much of the damage had already been done and results from these applications were not nearly so good as those obtained by applications of DDT during the early bloom period of the plants. Several untreated portions of fields were left as checks, and lygus population samples and samples of seed for germination analyses were taken in these untreated areas as well as in the variously treated portions of fields. Seed germination data from eight fields, portions of which were variously treated for lygus control, are given in table 6. These data clearly show that a 4- or 5-percent DDT dust, applied at the rate of 30 to 40 pounds per acre May 16 or earlier, gave good results. This date of application corresponded to the early bloom or full bloom period of the plants. A 10-percent sabadilla dust applied at about the same time, and followed by a 5-percent DDT dust the first of June, increased the viability of the seed somewhat, but the value of the 10-percent sabadilla alone was questionable.

Table 6.— Percentage of viable seed from variously treated portions of seed beet fields, Salt River Valley, Ariz., 1945.

Field No.	4- or 5-percent DDT dust applied May 16 or earlier	10-percent sabadilla dust applied May 16 or earlier	10-percent sabadilla dust applied May 21 or earlier and 5-percent DDT dust applied June 2	Untreated check
1	87.4	----	----	47.5
2	69.1	----	----	42.4
3	75.3	40.9	68.5	
4	80.8	37.5	59.2	
5	70.7	----	----	51.5
6	87.1	----	----	73.2
7	88.8	----	78.2	56.9
8	92.5	53.0	70.0	49.8

Albuquerque, N. Mex.—The first large-scale control experiments at Albuquerque, N. Mex., were undertaken in 1943. The 1942 lygus populations were extremely high, and yields and viability of the seed produced that year were very low. A survey of the beet fields the middle of May 1943 indicated that the infestation was going to be moderately heavy, and therefore a control program involving practically all fields in the area was outlined. Two applications of the pyrethrum-suJphur dust were recommended for the fields containing high populations, and either one application of pyrethrum-sulphur followed by two applications of sulphur, or three applications of sulphur alone, were recommended for the other fields. Applications were to be made with ground equipment at the rate of 2.1 to 30 pounds per acre, and several portions of fields were to be left untreated as checks.

Considerable difficulty was encountered in carrying out this program, and results in all cases were not so good as anticipated. Only one duster, a tractor-mounted power duster, was available, and since the fields were scattered over a wide area it was difficult to make the applications at the proper time in all fields. Moreover, there was considerable wind, which further delayed operations. Consequently, in most fields not more than two applications of any insecticide were made, and many fields received only one of pyrethrum-sulphur dust; often this application was not so timely as it should have been. The kill obtained with this equipment and the pyrethrum-sulphur dust was better than 95 percent at 24 hours. However, pyrethrum has very little residual effect, and populations built up somewhat after application. Where one portion of a small field was treated and one was left untreated, lygus populations later in the season tended toward equalization, partially obliterating the results of the control program. However, a. survey made June 8 and 9 showed a mean lygus population of 2.5 per sweep for those fields receiving treatment as compared with a mean population of 7.6 per sweep for the untreated portions of fields.

Perhaps the best measure of the effectiveness of the 1943 control program in this area is a comparison of 1943 lygus populations, seed yields, and viability with similar records of previous years. The data given in table 7 indicate that the viability of the seed produced in 1943 was comparable with that of 1941, which was the only year of low lygus populations since records have been kept for the Albuquerque area. These data also show that lygus populations in 1943 without control were about the same as in 1939 and 1940, when the average percentages of germinating seed produced were 76 and 64 as compared with 81 for 1943.

In 1944 all fields in the Albuquerque area w[T]ere treated commercially with a pyrethrum-sulphur dust for lygus control except a 7-acre strip in the center of a 20-acre field which was dusted experimentally with a 5-percent DDT dust. This dust was applied at the time of the first pyrethrum-sulphur dust application (June 5), when

Table 7.—Relation of lygus populations to average beet seed yield and viability. Albuquerque, N. Mex., 1939-1943.

Year	Sampling date	Number of lygus bugs per sweep	Average yield per acre, pounds	Average percent of germinating seed*
1939	May 25	3.8	620	78
	June 27	8.4	----	--
1940	June 1	3.0	1,430	84
1941	June 5	.5	1,195	83
1942	June 8	20.5	233	47
1943	May 25	2.8	----	--
	June 9	7.6†	1,010	81

*Germination analyses were made by a commercial seed analyst from samples taken from commercially cleaned seed.

†Computed from fields which had not received any Treatment, for lygus control up to June 9.

the beets were in the pre-blossom stage of development. Population counts taken immediately before treatment indicated the presence of between three and four lygus bugs per sweep in this field. Within 24 hours the lygus population in the portions of the field treated with DDT and with pyrethrum-sulphur had been reduced almost to zero, but by June 15 the population had increased to more than one per sweep in the pyrethrum-sulphur portion, owing largely to additional influxes. In order to prevent the population from increasing more, a second application of pyrethrum-sulphur dust was made. Populaitons in the DDT-treated strip, however, remained at a low level throughout the season. Germination tests on samples of seed taken from this field showed that 71.4 percent of the seed from the portion treated with pyrethrum-sulphur was viable compared with 77.6 percent from the DDT-treated portion. These data indicate that one application of 5-percent DDT gave results equal to if not better than two applications of the pyrethrum-sulphur dust.

In 1945, lygus populations in the Albuquerque area were again high, and all seed beet fields were dusted with a 5-percent DDT dust at the rate of 25 pounds per acre with hand dusters, between June 1 and 7. The plants at this time were in the later pre-bloom to early blossom stage, the most advantageous for applying the dust. Ten portions of fields were left untreated in the area, and on June 19 and 20 lygus population counts were taken in these untreated and comparably treated portions. The mean population for the untreated portions at that time was 11.4 per sweep as compared with 0.6 per sweep for the treated portions, a difference which indicated that excellent control had been obtained. However, seed germination analyses from samples of seed taken from 10 treated and 10 untreated areas showed that, despite the excellent control of lygus obtained by the DDT applications, very poor seed was produced, and in some eases there were no differences in viability of seed from treated and untreated portions of the field in spite of great differences in lygus populations. The mean percentage of viable seed from the 10 treated areas was 40.2 as compared with 30.1 from the untreated areas. As previously explained, the technique used in cleaning and preparing these samples for germination gives results lower than can be expected from commercial analyses; nevertheless, the seed produced under controlled conditions in the Albuquerque area in 1945 is far lower in viability than would be expected in view of the lygus populations and strongly indicates that other factors also have influenced the viability of seed produced in that area.

Hemet, Calif.—Lygus control on a commercial scale was undertaken in the seed beet fields in the vicinity of Hemet, Calif., in 1944. Some dusting sulphur and some pyrethrum-sulphur were ajjplied by airplane. Results with the pyrethrum-sulphur were disappointing, apparently owing to the substandard quality of the material as shown by chemical analyses.

Detailed lygus population data for the seed beet fields in the Hemet area were not available for 1945, but such information as was available indicated that populations were not high at any time during the season. However, the spring development of the crop in that area was somewhat slower than in the Salt River Valley, Ariz., and we have some evidence that populations of approximately one lygus bug per sweep existed over a comparatively long period of time, probably from May 1 to July 1. The beet seed in the Hemet area was not mature and ready for harvest until the middle or latter part of July. Under those conditions the value of a control program was considered questionable, but, to determine the effect of controlling lygus under those conditions, portions of several fields were treated by airplane with 5-percent DDT dust at the rate of approximately 30 pounds per acre, and portions of the same field were left untreated. Samples of seed for germination analyses were taken from the treated and untreated portions of six fields. These samples indicated that, without exception, the treated portion of the field produced a larger percentage of viable seed than the untreated portion of the same field. The mean percentage of viable seed from the DDT-treated areas was 82.2 as compared with 64.8 for the untreated areas.

Southeastern and Heber Valley, Utah.—Yields and viability of sugar beet seed produced in southeastern Utah in the vicinity of Hurricane, St. George, and Leeds in 1941 and 1942 were low. Insect-population counts taken in the seed beet fields in those areas in early June 1942 showed that large numbers of lygus were present on the beets at that time; however, the crop was then too far advanced to attempt control. In 1943 surveys of beet fields in these areas were commenced in March and continued until early May, at which time lygus numbers became extremely high (20 to 30 per sweep in some fields). All seed beet fields in southern Utah having 12 or more insects per sweep at the full bloom stage were given one application of a pyrethrum-sulphur dust (similar to the material shown to be effective in small-plot tests at Phoenix, Ariz.). The material was applied with a horse-drawn power duster at the rate of approximately 30 pounds per acre while the plants were in the full bloom to late bloom stage of development. The duster had a 52-inch clearance and was equipped with a canvas trailer. Excellent kills were obtained, ranging from 83 to 97 percent for adults and 94 to 99 percent for nymphs. The seed produced in these southern Utah areas in 1943 averaged 88.9 percent viable, whereas in 1942 when lygus was not controlled the seed averaged 64.2 percent viable. Yields also were somewhat higher for 1943 than for 1942.

Lygus populations in the seed beet fields of southern Utah were low in 1944 and yields were correspondingly high, the viability of the seed was good, and no insecticidal control was necesary. In 1945 high populations again occurred in these areas, and control was undertaken by using the pyrethrum-sulphur dust. Results were poor, however, and seed yields and viability were comparatively low.

In the Heber Valley, in 1945 the effectiveness of a 5-percent DDT dust against lygus was tested by dusting one-half of a seed beet field with this material and leaving the other half of the field untreated as a check. Ground equipment was used, and only one application was made to the plants in the pre-bloom stage at the rate of 30 pounds per acre. There were 4.5]ygus bugs per sweep in the field at the time the dust was applied. Counts taken at 5, 9, 16, and 23 days after treatment showed that populations in the treated portions had dropped to a *very* low level in 5 clays and remained so for at least 23 days, after which time the crop was approaching maturity and was no longer susceptible to injury by this insect. Lygus numbers in the untreated side of the field reached a peak of nearly 10 per sweep 16 days after treatment, and then declined. Germination analyses on samples of seed from the two sides of the field showed 84 percent of viable seed for the treated side as compared with 78 percent for the untreated side.

,In one field the 5-percent DDT dust was compared with a 20-percent sabadilla dust and with a pyrethrum-sulphur dust mixture (pyrethrins 0.2 percent). Plots were about 0.14 acre in size, and were arranged in four randomized blocks. The dusts were applied at about 35 pounds per acre with rotary hand dusters when the plants were in full bloom. Applications were made in the morning when there was no air movement, and they were followed by frequent thunder showers. The lygus population of 6.0 per sweep before treatment decreased to 2.1 per sweep in the untreated plots in 8 days, while in the plots treated with DDT, sabadilla, and pyrethrum the numbers of lygus bugs per sweep 8days after treatment was 0.2, 0.2, and 1.2, respectively. Seed viability at harvest was not appreciably different, as the germination ranged from 93 percent in the DDT plots to 87 percent in the check plots. These data demonstrate the effectiveness of DDT and sabadilla but are not conclusive with respect to the relative efficiencies of these insecticides.

Summary and Conclusions

Preliminary tests were made in laboratory cages to determine the comparative insecticidal value of. various materials against *Lygus* spp. and the Say stinkbug *(Chlorochroa sayi* Stal). Materials showing value as insecticides against these insects were further tested against lygus in small experimental plots of seed beets. The best insecticides were then tested on a large scale in commercial seed beet fields with commercial equipment. In general those insecticides giving good results in laboratory cage tests have also been of some value in controlling lygus under field conditions. Sometimes insecticides showing promise in the laboratory cages have not shown comparable results in the field, and a few of the insecticides giving good results in laboratory cages have caused foliage-burn or other damage to the crop.

Small-plot and large-scale experiments have shown dusting sulphur, pyrethrum-extract dusts, and DDT to be of value in controlling lygus in seed beets. Dusting sulphur has been shown to be inferior to the other insecticides in that three to five applications were usually required, only the nymphs were affected to any appreciable degree, and the kill was very slow Pyrethrum-extract dusts containing 0.2 percent of pyrethrins gave excellent kills especially when used in ground dusters. Its action was fast and the insects died within a few hours. However, the effectiveness of the pyrethrum was soon lost under field conditions, and at least two applications at 10-day or 2-week intervals were usually required, the first application to kill the insects present, and the second to kill the nymphs hatching from eggs deposited in the plants prior to the first application. More than two applications may be necessary if additional influxes of lygus appear. Five-percent DDT, either in pyrophyllite, talc, or dusting sulphur,, was found to give better results than the other inseticides. The action of DDT as an insecticide was slower than that of pyrethrum-extract dusts, and it was sometimes 2 or 3 days before the affected bugs died. However, DDT has retained its insectieidal properties sufficiently under field conditions that one application made in the late pre-blossom to early bloom stage of the beet plants has held lygus populations at a very low level throughout the remainder of the season.

Field tests have shown that 30 pounds per acre of a 5-percent DDT dust were required for maximum results against lygus in seed beets if applications were made by airplane, but if ground equipment was used from 20 to 25 pounds were sufficient. When pyrethrum-extract dust or sulphur was used, best results were obtained with 40 pounds applied by airplane and from 25 to 30 pounds by ground equipment.

Studies are still continuing on the timing of insecticidal dust applications for lygus control, and to date these studies indicate that best results are obtained if the first application is made during the late pre-bloom or early bloom stage of the seed beets. If pyrethrum-extract dust is used, a second application should follow in 10 days or 2 weeks; if DDT is used, the one application will be sufficient.

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