Toxicity of Cryolite to Mexican Bean Beetle Larvae

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One of the earliest recommended uses of cryolite was for the control of the Mexican bean beetle. Carter & Busbey (1939) list numerous papers on the use of cryolite for Mexican bean beetle control, but these have dealt mainly with field conditions. The present paper presents certain dosage-mortality and time-mortality data obtained under controlled laboratory conditions.

Table 1.—The mortality of Mexican bean beetle larvae instars feeding for 5 days on the same bean leaf sprayed with cryolite. One hundred larvae per test.

Lbs. in 100 Gals. Water	Mg. Deposit per Sq. Cm.	Larval Instar	Per Cent Mortality in Days				
			1	2	3	4	5
2 pounds	0.0106	1	14.1	39.8	66.0	83.9	96.6
		2	13.0	41.0	69.7	88.2	98.8
		3	4.0	12.0	35.4	86.5	97.9
		4	2.0	0.0	6.4	45.1	75.6
6 pounds	0.0313	1	11.1	39.8	74.5	97.8	100.0
		2	30.0	60.0	81.8	96.8	100.0
		3	12.0	32.0	61.6	92.7	100.0
		4	4.0	19.1	26.6	58.2	82.2
10 pounds	0.0560	1	29.3	64.3	84.1	100.0	100.0
		2	22.0	64.0	91.9	96.8	100.0
		3	23.0	58.0	83.8	95.7	98.9
		4	12.0	28.7	36.2	62.6	80.0
15 pounds	0.0796	1	22.0	60.2	87.2	96.8	100.0
		2	23.0	66.0	85.9	97.8	100.0
		3	23.0	62.0	84.8	92.7	97.9
		4	14.0	33.0	45.7	60.4	88.9
20 pounds	0.1002	1	42.4	77.6	94.7	98.9	100.0
		2	34.0	69.0	92.9	98.9	100.0
		3	24.0	66.0	83.8	95.7	100.0
		4	8.0	35.1	46.8	62.6	81.1

Material and Methods.—Natural cryolite (*Kryocide*, furnished by the Pennsylvania Salt Co.) was used in all tests. The material was micronized and was guaranteed to contain at least 90 per cent sodium fluoaluminate.

A belt sprayer adapted from one developed by Siegler & Munger (1935) was used in all tests. A bean leaf, approximately 40 sq. cm. in area was placed upside down in a petri dish on flannel. The dish and leaf was then passed twice through the spray cone on a moving belt, the spray being applied at 15 lbs. pressure per sq. inch. When the spray deposit had dried, the leaf was removed to a moist chamber until larvae were ready for exposure.

Tests were made in glass specimen dishes 112 mm. wide by 50 mm. deep. These dishes could be stacked and fitted together closely enough to prevent the escape of the larvae but not closely enough to make an air-tight seal. Moist filter paper, the size of the bottom of the dish, was used under the leaf. The hooked hairs on the upper surface of the bean leaf serve to keep the leaf closely appressed to the filter paper and prevent the larvae from crawling under the leaf and feeding on the unsprayed upper surface. Ten larvae were used in each dish. Experiments were performed at a constant temperature of 80 degrees F., and approximately 82 per cent relative humidity. Mortality records were made daily for 5 days.

Deposit determinations were made by weighing tared tin pill boxes of 40.7 sq. cm. area and were found to vary less than 6 per cent in the three deposits determined for each spray concentration.

In the first experiment where the susceptibility of the various instars to cryolite was being tested, the larvae fed for the 5-day duration of the experiment on the same sprayed leaves. In the second series of experiments the purpose was to determine how many days the larvae would have to feed in order to obtain a lethal dose. In these tests fresh sprayed leaves were supplied each day replacing those of the previous day. However, after periods of from 1 to 5 days in the various tests, clean unsprayed foliage was supplied in place of the sprayed leaves. As before, mortality data sere taken each day. Each figure in the tables has been corrected by Abbott's formula for the mortality in check tests.

Discussion of Results.—In the first experiment not only instar, but also dosage, was varied. At given dosages, the younger larvae were most susceptible, and at given ages, those larvae feeding on leaves with the highest deposits died quickest. There was a greater difference in susceptibility between larvae of the third and fourth instar than between any two other age groups. This generalization seemed to apply at all deposit levels.

From the data in table 1, the 20 dosage-mortality and 20 time-mortality curves were plotted according to the method of probits (Bliss 1935, 1937). Dosage mortality curves for the first, second and third instar larvae at the various times were generally straight lines with slight, but apparently random variation in angles of slope, commonly converging or crossing, and grouped close together. The dosage-mortality line for the fourth instar larvae was not closely associated with the group of lines representing the earlier instars, but indicated a markedly more resistant stage. The angle of slope for the fourth instar is generally parallel to that for the third instar. Figure 1 shows a typical group of dosage-mortality lines with mortality data after 3 days.

The same general conclusions can be drawn from a study of the 20 time-mortality curves. Figure 2 shows the time-mortality lines for the four instars at the 20-pound level. The most interesting observation made on these data is that in 19 cases out of 20, the time-mortality lines instead of being straight when rectified according to the method of probits, are curved upward. These consistently curved time-mortality lines are interpreted by the writers to indicate that cryolite kills

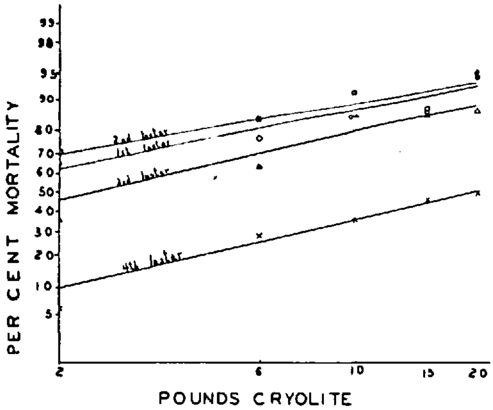

FIG. 1.—Mortality of various instars of Mexican bean beetle larvae after three days feeding on bean foliage sprayed with indicated amounts of cryolite.

bean beetle larvae in such a way that the relation between mortality and dosage is different from the relation between mortality and time. Put in other words, mortality is increased more by extended time of exposure to a given dosage, than by increasing the deposit a proportional amount. In all these discussions, it must be remembered that what is loosely called dosage is actually only deposit on foliage to which the larvae are exposed.

In order to study more closely the relations of time of feeding to mortality at various deposit levels, the experiments reported in tables 2 and 3 were performed.

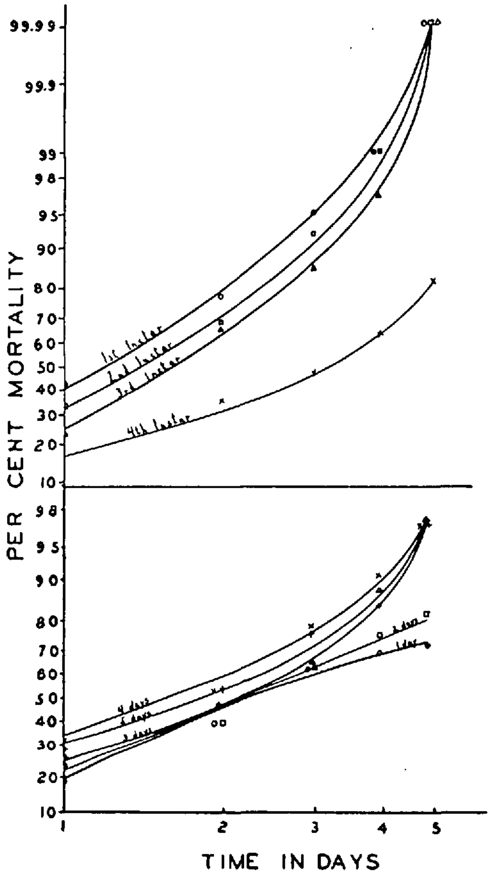

FIG. 2.—Above—Time-mortality curves for various instars of Mexican bean beetle larvae feeding on bean foliage sprayed with 20 lbs. cryolite per 100 gals.

Below—Mortality of third instar larvae of the Mexican bean beetle feeding from one to five days on bean foliage sprayed with 10 lbs. cryolite per 100 gals.

In these tests, poisoned foliage was removed after periods of from 1 to 5 days feeding.

A study of the data in tables 2 and 3 lead to the same conclusion drawn from the first experiment, namely: (1) The fourth instar is considerably more resistant to cryolite than the third, (2) increasing the deposit of cryolite increases the mortality, gradually, but not proportional

Table 2.—The mortality of third instar Mexican bean beetle larvae feeding 1, 2, 3, 4 and 5 days on bean leaves sprayed with various concentrations of cryolite. (One hundred larvae per test).

Lbs. in 100 Gals. of Water	Mg. Deposit 1 Sq. Cm.	Days of Feeding	Per Cent Mortality in Days				
			1	2	3	4	5
2	0.0106	1	4.0	13.0	26.2	31.3	37.2
6	0.0313	1	26.0	44.0	52.5	56.3	63.8
10	0.0560	1	19.0	39.0	63.6	69.8	73.4
15	0.0796	1	33.0	45.0	63.6	67.7	73.4
2	0.0106	2	2.0	13.0	27.3	38.5	50.0
6	0.0313	2	16.0	28.0	55.6	74.0	77.7
10	0.0560	2	23.0	39.0	63.6	77.1	83.0
15	0.0796	2	24.0	45.0	67.7	75.0	80.9
2	0.0106	3	7.0	11.0	43.4	77.1	89.4
6	0.0313	3	10.0	28.0	55.6	79.2	94.7
10	0.0560	3	25.0	44.0	65.7	87.5	96.8
15	0.0796	3	27.0	54.0	70.7	82.3	93.6
2	0.0106	4	4.0	11.0	33.3	78.1	95.7
6	0.0313	4	16.0	35.0	63.6	79.2	94.7
10	0.0560	4	31.0	52.0	77.8	90.6	95.7
15	0.0796	4	30.0	50.0	69.7	84.4	98.9
2	0.0106	5	3.0	9.0	31.3	56.3	93.6
6	0.0313	5	13.0	36.0	58.6	81.3	92.6
10	0.0560	5	29.0	52.0	75.8	84.4	95.7
15	0.0796	5	28.0	48.0	71.7	83.3	98.9

Table 3.—The mortality of fourth instar Mexican bean beetle larvae feeding 1, 2, 3, 4, and 5 days on bean leaves sprayed with various concentrations of cryolite. (Seventy-four to 80 larvae per test.)

Lbs. in 100 Gals. of Water	Mg. Deposit 1 Sq. Cm.	Days of Feeding	Per Cent Mortality in Days				
			1	2	3	4	5
2	0.0106	1	1.3	6.3	7.6	8.9	16.7
6	0.0313	1	5.0	21.3	25.0	22.4	20.8
10	0.0560	1	15.0	26.3	35.0	39.4	45.2
15	0.0796	1	14.9	23.5	43.2	44.6	48.1
2	0.0106	2	0.0	5.0	7.5	13.2	25.2
6	0.0313	2	15.2	24.1	36.8	45.4	48.9
10	0.0560	2	10.0	32.5	43.8	46.1	56.7
15	0.0796	2	20.0	38.7	42.7	48.1	46.1
2	0.0106	3	1.3	5.0	15.0	30.3	45.2
6	0.0313	3	7.6	25.3	34.2	61.4	73.7
10	0.0560	3	10.0	35.0	47.5	63.2	74.4
15	0.0796	3	23.8	53.8	65.0	78.9	88.5
2	0.0106	4	0.0	6.4	16.3	39.4	65.4
6	0.0313	4	5.0	17.5	40.0	59.3	74.1
10	0.0560	4	18.8	32.5	45.0	67.2	77.5
15	0.0796	4	18.8	43.3	50.0	68.4	87.1
2	0.0106	5	1.3	2.8	8.8	38.2	65.2
6	0.0313	5	5.0	21.3	41.3	60.5	74.1
10	0.0560	5	16.5	35.4	48.1	68.0	85.4
15	0.0796	5	21.3	46.3	52.5	80.3	90.0

to the size of the deposit. It is interesting to note that in these latter tests where freshly sprayed foliage was supplied each day, the mortality never reached as high a percentage as in the first experiment where the larvae fed on the same leaves for the duration of the experiment. In the group fed for 5 days on poisoned foliage, the same curved time-mortality lines result as were shown in the first experiment. If the plotting is made of larvae that fed for 4 days, most of the lines are still concavely curved, although less distinctly. However, with those larvae which fed for 3 days or less on sprayed foliage and then were moved to clean foliage, the time-mortality lines over the 5-day period are either straight or convexly curved. Such a group of curves are shown in figure 2 representing the mortality during the 5 days of the experiment of third instar larvae feeding from 1 to 5 days on a deposit of 0.560 mg./cryolite per sq. cm. When these curves are studied, they indicate that the concavely curved time-mortality lines result from the nature of the feeding of the larvae on cryolite deposits, and not the nature of the toxic action of the insecticide after it is ingested.

These experiments further serve to emphasize that cryolite is a slow-acting insecticide. Fourth instar larvae fed for one day were less than half dead after 5 days. Evidently fourth instar larvae must feed for 3 or 4 days even with heavy deposits in order to obtain a high mortality. With third instar larvae 2 days' feeding with the higher doses seem to be necessary. On the evidence of these laboratory tests, it would seem wise to emphasize in field recommendations, that in order to obtain good results with cryolite the applications should be made before the larvae have reached the fourth instar.

The photographs show the amounts of feeding, and give a reasonably good estimate of comparative dosage. Figure 3 shows the feeding on the first, third and fifth day by third and fourth instar larvae.

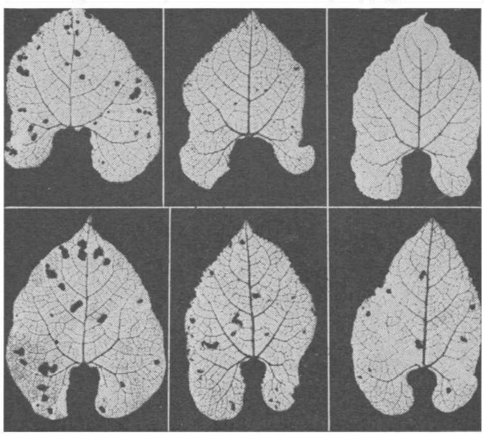

FIG. 3.—Above—Feeding on first, third and fifth day by 10 third instar larvae on bean foliage sprayed with cryolite at 10 lbs. to 100 gals.
Below—Feeding on first, third and fifth day by 10 fourth instar larvae on bean foliage sprayed with cryolite at 10 lbs., to 100 gals.

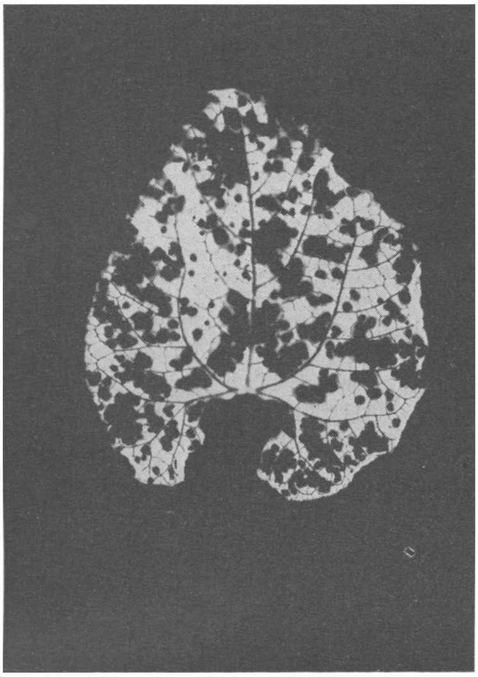

FIG. 4.—After 1 day of feeding by 10 third instar larvae which had previously fed 2 days on leaves sprayed with 10 lbs. cryolite per 100 gals.

Leaves freshly sprayed with cyrolite at the rate of 10 lbs. to 100 gals, were supplied each day. It is evident from these photographs, that while the older larvae will feed each day for at least 5 days, the third instar larvae obtain a lethal dose around the second day, since their feeding has almost entirely ceased by the third day. The fact that cryolite deposits are truly repellent is shown in figure 4 which is a photograph of a leaf after one day's feeding by 10 third instar larvae which had fed on sprayed leaves for 2 days prior to placing them on the clean foliage.

SUMMARY.—In laboratory cage tests against the larvae of the Mexican bean beetle, cryolite sprays were shown to be highly toxic, although slow acting and repellent. First, second and third instar larvae are more susceptible than fourth instar larvae. Three to 4 days of feeding on heavy deposits seem necessary to obtain high kills with fourth instar larvae, whereas, 2 days, feeding give the same results with larvae of the younger stages. Time-mortality lines plotted according to the methods of probits are convex curves instead of straight lines and are considered to be shaped by the nature of the feeding, rather than by the nature of the toxic action of ingested cryolite.—7-5-44.

LITERATURE CITED

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Notices of recent revisions of Arizona State quarantines carry an introductory note briefly stating the nature of the changes made by such revisions. This time-saving practice, which is also employed in the issuance of California notices, is a great convenience in saving the reader the necessity of checking back with former quarantines to determine the purpose and extent of the respective revisions. These changes in the Arizona regulations and quarantines, as adopted in April or May 1944 included: (1) lifting all tolerances as to entry of crown-gall infected plants; (2) under the general citrus quarantine, providing for entry of citrus nursery stock from any part of California into any part of Arizona, under permit; (3) providing for fumigation as a condition of entry of cured sweetpotatoes and so-called yams from sweetpotato weevil regulated areas, and redesignating such areas by removing Conecuh and Crenshaw Counties, Ala., Charlton County, Ga., and 9 Mississippi counties, and by the addition of Chatham County, Ga., De Soto and Sabine Parishes, La., Greene County, Miss., and Shelby County, Tex.

A revision of Washington State quarantine relating to the greater bulb fly and the bulb nematode, which became effective March 15, 1944, broadens the provisions with respect to treatment of narcissus bulbs for these pests, and requires appropriate labeling of containers of certified narcissus bulbs taken from original containers for reshipment in small lots. The Washington quarantine pertaining to vetch weevil, as revised effective April 13, 1944, extends the regulated areas to apply to 13 States and the District of Columbia and provides for acceptance of vetch seed from such areas when treated under one of the various approved schedules, or when originating in noninfested area.