
Control of Soil Insect Pests Attacking Sweet Corn

H. H. Crowell
H. E. Morrison



Agricultural Experiment Station
Oregon State College
Corvallis

Circular of Information 540

April 1954

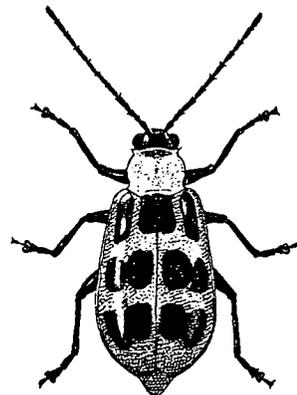
Control of Soil Insect Pests Attacking Sweet Corn

H. H. CROWELL AND H. E. MORRISON

Sweet corn grown for processing and fresh market in Oregon has an annual value of almost 3 million dollars. This important crop is subject to attack from the larvae of the western spotted cucumber beetle, seedcorn maggot, and various species of wireworms. These pests feed on and damage the germinating seed and roots. Poor stands, stunted plants, or lodged stalks may result.

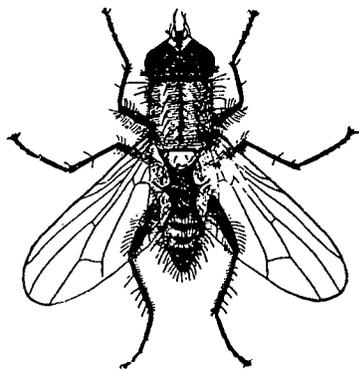
Western Spotted Cucumber Beetle (Diabrotica)

This insect is most serious in the Willamette Valley and does not extend east of the Cascade Mountains. The adult beetle (black-spotted; yellowish-green; 3/8 inch long) overwinters in trash or other sheltered places. The fertilized females appear on sunny days of early spring and lay eggs (rarely seen clusters; bright yellow) under clods or in cracks in the soil. The larvae hatching from these eggs (straw-colored with dark head and dark patch at posterior end) live entirely in the soil, feeding on plant roots, germinating seeds and other organic matter. They often tunnel into the stem portions of young plants. The pupal, or resting, stage is passed in the ground, the new brood of beetles emerging during late June and early July. The females of this brood lay eggs and the larvae hatching from them often attack corn roots. Severe root damage will stunt younger plants and cause older stalks to lodge. The falling-over or lodging of the maturing plants means lower yields in commercial fields where mechanical pickers are used.



Seedcorn Maggot

The seedcorn maggot (bean fly) is a common cause of poor stands in all parts of Oregon during certain seasons. The adults of this pest are greyish-black flies, similar to, but considerably smaller than, house flies. They emerge from puparia (small, brown, seed-like pupae) in the soil during April and lay eggs (elongate, white) on or in freshly disturbed soil. The larvae (white, headless maggots) attack germinating seeds and the roots and stems of a large variety of plants. Several overlapping broods occur during the growing season. They are of importance largely in the spring when seeds are germinating.



Wireworms

Wireworms are the brown, segmented larvae of click beetles. Several species occur in Oregon. The larvae spend all of their lives in the soil and usually require two or three years for development. Adult beetles emerge, mate, and lay eggs in the spring. The larvae (wireworms) attack the germinating seeds and roots of a large variety of crop plants. Injury to corn can be done in the seedling stage or to the roots later in the season.



Wireworm (2X)

New Control Recommendations

Broadcast Soil Treatments

The use of certain residual insecticides as soil treatments has been found to be effective against the pests of corn seedlings and roots. These treatments can be applied before planting and one application will give protection throughout the growing season. The spotted beetle larvae are most easily controlled by this method, with wireworms and seedcorn maggots being a bit more difficult to kill. A heavier dosage may have to be used occasionally where the latter pests are abundant.

Materials and rates of application

Either aldrin or heptachlor, mixed into the soil at the rate of 2 pounds of actual material per acre, is recommended for control of cucumber beetle larvae and wireworms. Rates up to 5 pounds per acre are suggested for seedcorn maggot control and for areas where wireworms are particularly abundant. Other insecticides have been found to be effective also, but only heptachlor and aldrin have so far been tested carefully for their effects on corn growth and quality in Oregon.

Two steps are required for adequate soil pest control. They involve (1) the application of materials to the soil surface and (2) the proper mixing of these materials into the soil. These steps are discussed below:

1. Methods of application. It is very important to cover the entire surface of the field with the insecticide. Cucumber beetle larvae and seedcorn maggots, especially, may damage the seed or roots in corners or other areas missed when the materials are applied. The insecticides can be applied to the soil by ground equipment or airplane and can be purchased in several different forms. These forms or formulations are adaptable to various types of equipment such as sprayers, dusters, and fertilizer applicators.

DUSTS of various concentrations (1 to 5%) are available. They are composed of very fine particles and are designed for use in dusting equipment. This type of material is not favored for application on large fields because air currents often carry the insecticide away from the desired area of treatment. Dusts will not flow readily from small lawn fertilizer applicators. The efficiency of flow of the dusts through this kind of equipment can be improved by thoroughly mixing the desired amount of dust with dry sand. If dusts are used, the following table will aid in determining the amount of material needed:

Per cent of insecticide in dust	Amount of dust to use			
	Per acre		Per 1,000 square feet	
	2-pound rate	5-pound rate	2-pound rate	5-pound rate
	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>
1	200	500	4 1/2	11 1/2
1 1/2	133	333	3	7 3/4
2	100	250	2 1/3	5 3/4
2 1/2	80	200	1 3/4	4 1/2
5	40	100	1	2 3/4

WETTABLE POWDERS can be purchased in concentrations of 20, 25, 40, and 50%. They contain wetting agents and are intended for use in spray machinery with mechanical agitation (orchard-type sprayers). If the sprayer is equipped with a horizontal boom, these formulations can be readily and evenly applied to the soil. They should not be used in weed sprayers because the suspended materials will clog the nozzles. The wettable powders can be used in small garden sprayers if care is taken to keep the materials agitated. These materials, like dusts, can be used in lawn fertilizer applicators, but dilution with dry sand will improve the efficiency of application. If orchard-type sprayers are used, the rate of delivery should be from 50 to 100 gallons per acre (2 1/2 gallons per 1,000 square feet). If wettable powders are used, the following table will aid in determining the amount needed:

Per cent of insecticide in wettable powder	Amount of wettable powder to use			
	Per acre		Per 1,000 square feet	
	2-pound rate	5-pound rate	2-pound rate	5-pound rate
	<u>Pounds</u>	<u>Pounds</u>	<u>Ounces</u>	<u>Ounces</u>
20	10	25	3 3/4	9
25	8	20	3	7 1/3
40	5	12 1/2	1 3/4	4 1/3
50	4	10	1 1/2	3 3/4

EMULSIFIABLE CONCENTRATES are liquids which may contain 1 1/2 to 8 pounds of actual insecticide per gallon. When mixed with water they form emulsions which require only occasional agitation. These emulsions can be readily used in either weed or orchard sprayers. They can also be used in small garden sprayers. In weed sprayers, a rate of application of 10 to 20 gallons per acre of the emulsion is suggested. (For small garden plots, 2 1/2 gallons per 1,000 square feet.) Emulsions recommended here are for application to the soil. If used for spraying plants and shrubs, serious foliage burning may result. If emulsifiable concentrate formulations are used, the following table should be useful in determining the amount needed:

Amount of active ingredient per gallon	Amount of emulsifiable concentrate needed			
	Per acre		Per 1,000 square feet	
	2-pound rate	5-pound rate	2-pound rate	5-pound rate
<u>Pounds</u>	<u>Gallons</u>	<u>Quarts</u>	<u>Fluid ounces</u>	<u>Fluid ounces</u>
1 1/2	1 1/3	13 1/3	4	10
2	1	10	3	7 1/2
4	1/2	5	1 1/2	3 3/4
8	1/4	2 1/2	3/4	1 7/8

INSECTICIDE-FERTILIZER MIXTURES can be used with fertilizer applicator if the proper materials are used in blending. The insecticide formulations used (dusts and wettable powders) are generally much finer than the fertilizer and tend to separate in the applicator. This results in unequal distribution of the material. The use of finely ground landplaster blended with the insecticide tends to eliminate this undesirable feature. Aldrin and heptachlor are compatible with practically all of the common fertilizers.

If it is desired to combine the insecticide with commercial fertilizers or soil conditioners, it is suggested that they should be blended by a custom mixer. The information needed by the custom mixer will include (1) the acreage to be treated, (2) the amount and kind of fertilizer or conditioner desired per acre, and (3) the recommended rate of application of the insecticide. The use of dilute materials (1 or 2%) will minimize inequalities in application.

GRANULAR AND PELLETIZED INSECTICIDES are new developments on the market. They are composed of insecticides on coarse particles of clay, ground tobacco stems, vermiculite or other carriers. They may be applied as purchased with fertilizer applicators, or blended with fertilizers and spread in the same manner. When blended with fertilizers, they do not separate readily from the mixture. In lawn fertilizer spreaders, they may be available in concentrations of 1, 2, 2 1/2 and 5%. The table used for **DUSTS** can be used to determine the amount of material needed. It is generally advisable to use very dilute material in order to compensate for unevenness or irregularities in coverage.

2. **Mixing insecticides with the soil.** Immediately after application (the same day), the insecticide should be mixed into the soil. These materials are volatile and may be lost if several days pass before mixing is accomplished. Thorough mixing of the insecticide into the soil is particularly important for wireworm control. Rotary tillers are satisfactory for this purpose. Double discs or offset discs have been satisfactory in mixing materials for cucumber beetle control. However, discs do not mix materials thoroughly to a depth of 6 inches. The following suggestions are made to growers who contemplate using soil insecticides for control of pests attacking the germinating seeds or roots of corn:

1. Wait until soil is in good friable condition (will crumble readily).

EITHER

For large fields

2. Use rotobeaater or discs to shred cover crop and plant debris.

3. Apply insecticide evenly to soil surface.

Rotary till material into soil to six-inch depth. Two times over may be necessary.

For garden plots

2. Break up cover crop or plant debris with spade or shovel.

3. Apply insecticide evenly to soil surface.

Rotary till material into soil to six-inch depth. Two times over may be necessary.

OR

2. Apply half of the insecticide dosage to the soil surface.

Plow under and disc 2 or 3 times.

Apply remainder of insecticide and disc thoroughly.

2. Apply half of the insecticide dosage to the soil surface.

Spade under and rake to seedbed condition.

Apply remainder of insecticide and rake in deeply.

OR

3. If wireworms are not a problem, apply insecticide evenly to seedbed and work in thoroughly with a disc.

3. If wireworms are not a problem, apply insecticide to seedbed and rake in thoroughly 2 or 3 inches deep.

Timing of applications

Timing is of little importance as long as the insecticide is mixed into the soil before planting. The material is generally applied in the spring, but fall applications can be made if erosion is not a problem. If fall applications are practiced, the soil should be dry at the time of mixing and should not be plowed the following spring. Plowing may bury the material too deeply for it to be effective against some of the pests.

When to re-treat the soil

Aldrin and heptachlor are insecticides which remain active in the soil for a fairly long period of time. Dosages of 10 pounds per 6-inch acre have remained effective against soil pests for periods of 3 to 5 years. There is some evidence that heptachlor and aldrin will remain effective for a second season when applied at the rate of 2 pounds per 6-inch acre. However, if corn is to be planted in the same field for two successive seasons, growers are advised to apply an additional two pounds per acre the second year. If a dosage of 5 pounds is applied for wireworm control, the application should not be repeated until the soil again becomes infested.

Most of the newer insecticides, if present in the soil in excessive amounts, will cause plant injury. The critical concentration will, of course, vary with the insecticide and the crop. The rate of decline in the soil is not yet known for sure. Repeated applications could easily increase the insecticide concentration faster than it declines naturally. Growers are advised to use caution in this respect until more information can be collected.

Other Control Suggestions

Although broadcast soil treatments are presently preferred for control of soil pests of corn, there are other measures which are promising, or which have been used with some success by growers. Three optional methods are mentioned here, on which some information is available. Two of the methods (seed treatments and toxaphene irrigation) are less expensive, but their disadvantages are pointed out. More information will be gathered to determine the advantages (if any) of the row or furrow treatment.

Row or Furrow Treatments

It has been found with corn that treatment of the soil in bands where the seed is to be planted is also effective for control of cucumber beetle larvae and wireworms. This method should also work for seedcorn maggots, but no information is yet available in Oregon to substantiate it.

Emulsifiable concentrates are most easily used and are sprayed onto the ground in the same operation as the seeding. The arrangement tested in Oregon consisted of a fan spray (about 4 inches wide) located directly behind a crows-foot cultivator and in front of the planter shoe. Both the cultivator and the planter shoe effect a certain amount of mixing of the insecticide with the soil.

At present it is suggested that aldrin or heptachlor be used at the rate of 2 pounds actual per acre, in sufficient water to wet the soil slightly. Additional studies may show that lower concentrations of the insecticides may be satisfactory. This type of application would have to be repeated whenever corn is planted.

Seed Treatments

Seed treatments have come into prominence in recent years as control measures for pests attacking the germinating seed of various crops. Thorough studies have been made in other parts of the country on the effectiveness of this method. Only limited tests have been made in Oregon, so far. In general, the following conclusions can be made:

1. Seed treatments with insecticides must be made in combination with a fungicide to prevent excessive seed decay after planting.
2. The concentration of insecticide needed for satisfactory insect control is very close to that which will cause chemical injury to the germinating seed. This will vary with the variety, the viability of the seed, and the climatic conditions prevailing at germination time. Over-dosing the seeds may do more damage than good. Only the dose or rate recommended by the manufacturer of the insecticide should be used.
3. Seed treatments with lindane, dieldrin, and a few other materials will give protection at germination time, but they have no direct effect on later attacks by soil pests.

Sprinkler Irrigation Treatments

Many sweet corn growers in the Willamette Valley have wondered whether cucumber beetle larvae might not be controlled in mid-season by the application of an insecticide through the irrigation water. This held promise of being a convenient method and the grower would not have to expend money on an insecticide unless soil examinations around the corn stalks showed that larvae were present in his field. An inexpensive insecticide was indicated and exploratory trials with growers showed that toxaphene was more effective than DDT. The use of emulsifiable concentrates, at the rate of 3 pounds of actual toxaphene per acre, was suggested as a "stop-gap" procedure until a more effective one could be worked out.

Aldrin and heptachlor are now known to be more effective at 2 pounds per acre when mixed with the soil. Furthermore, the pre-planting treatment will give control of early season attacks by cucumber beetle larvae, wireworms and seedcorn maggots. The irrigation method of application did not give this early protection and often an infestation was not discovered in time to prevent considerable root damage in the maturing corn. If the toxaphene is applied within 30 days of harvest, ensilage from the corn husks should not be fed to cattle.

Plant response

Trials on plant response to soil insecticides conducted in sandy loam soil during the 1953 season revealed no injurious effects on the growth and yield of Golden Cross Bantam corn from soil mixtures of aldrin and heptachlor at either 3 or 10 pounds actual per acre. Time to maturity in the treated plots was accelerated one or two days over the untreated plots. This change in rate of maturity may be important to growers and field men, particularly if only part of a corn field is treated.

Residue studies

Studies have been made in various parts of the country on corn grown in insecticide-treated soil to determine whether or not toxic residues might be translocated from the ground into the ears. There has been no indication that either aldrin or heptachlor is deposited in the kernels in amounts approaching the current safety level of one-tenth of a part per million (0.1 ppm).

Flavor studies

Sweet corn grown in soil treated with heptachlor and aldrin has been subjected to careful flavor tests by the Food Technology Department. There have been slight changes in flavor detected by taste panels consisting of college students who have tasted under laboratory conditions in which a treated and untreated sample are directly compared. These slight flavor changes, however, may not be noticeable when corn is prepared and eaten in the home.

Effects of earthworms

Most insecticides are poisonous to earthworms if applied to surface litter on which they are feeding. However, soil treatments with aldrin and heptachlor at the high rate of 10 pounds per 6-inch acre have produced no measurable changes in earthworm populations.

Precautions

Heptachlor, toxaphene and aldrin are insecticides and should be considered as poisonous materials. Directions for their use are always printed on the label. Growers are advised to read and follow these detailed instructions.

Summary

Soil insect pests attacking the germinating seeds and roots of sweet corn can be controlled by mixing certain insecticides with the soil. The method is practical for both home gardens and commercial plantings.

Aldrin or heptachlor is recommended at rates of from two to five pounds of the actual material per acre. Spotted cucumber beetle (*Diabrotica*) larvae and most wireworms will be controlled at the 2-pound level, but 5 pounds may be needed where seedcorn maggots and wireworms are particularly serious pests.

Heptachlor and aldrin are available as dilute dusts, concentrated or wettable powders, emulsifiable concentrates and granular formulations, and in fertilizer mixtures.

Methods of spreading the soil insecticides, so as to get even coverage, are discussed. It is important to mix the insecticides thoroughly with the soil. Directions for soil mixing on both commercial and garden scale are given.

ACKNOWLEDGMENTS: This circular has resulted from cooperative studies of the Departments of Entomology, Bacteriology, Agricultural Chemistry, Agricultural Engineering, Food Technology and Horticulture. Special credit should go to the following individuals for cooperation in this project: W. B. Bollen, L. C. Terriere, G. E. Page, Mrs. Lois Sather, L. A. Pettit, and W. A. Frazier.