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SUGGESTIONS FOR WIREWORM CONTROL IN CALIFORNIA 1/

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Wireworms, the young of click beetles, are found infesting soils and injuring crops in many parts of California. A great many materials and methods have been used in attempts to control wireworms, but as yet no entirely satisfactory remedy has been found.

Granular Calcium Cyanide

One method which has been used in combating wireworms under California conditions involves fumigating the soil with granular calcium cyanide. Fumigating the entire soil area proved too expensive. It was found, however, that the wireworms could be concentrated into rows by planting seeds which acted as baits. By treating only these bait rows with calcium cyanide, the quantity required per acre was reduced materially. Many seeds have been used for these baits, but beans and wheat have been found to attract the most wireworms. Bean growers commonly use the low-grade or refuse beans for bait. The bait is drilled into the soil just the same as if it were a regular crop, and therefore the soil should be in a good friable condition and have the proper moisture content for planting. The bait crop is planted at the same depth that the regular crop would be planted.

In from 5 to 8 days after planting the bait most of the wireworms in any given area will have gathered in the bait rows and be feeding on the baits. Wireworms are most active when the soil is warm, so they reach the baits sooner in sunny, warm weather. An occasional examination of the planted seeds in the rows will disclose when the wireworms have been attracted to the baits. Granular calcium cyanide is then applied with the same planter used for the baits, in exactly the same rows, but about 1/2 inch below the baits. The hydrocyanic acid gas fumes given off from the calcium

1/ For further details regarding wireworms and their control see U. S. Department of Agriculture Farmers' Bulletin 1866, Wireworms and Their Control on Irrigated Lands, by M. C. Lane.

cyanide in the soil will kill the worms in the immediate vicinity. This material will have dissipated in about 5 days, so that planting any crop is safe thereafter.

The most satisfactory quantity of calcium cyanide to use has been determined to be 1 pound per 1,000 feet of row. The closer together the rows are, the more wireworms will be attracted. Considering this fact, and the quantity of cyanide required, rows spaced not more than $2\frac{1}{2}$ feet apart are suggested. When the rows are $2\frac{1}{2}$ feet apart, this spacing requires approximately 100 pounds of calcium cyanide per acre. When extreme care is exercised in the application of calcium cyanide, as little as 50 pounds per acre gives excellent results, but since this is the case only under favorable conditions, the larger quantity is recommended. The cost per acre for material will be approximately \$15 for 100 pounds.

This method of control works best when used in the spring, just before the regular planting season. At that time the wireworms are most active and are readily attracted to the baits.

Sometimes a crop is planted before the grower is aware of the presence of so many wireworms. These are attracted to the crop the same as to the baits, and may ultimately destroy the crop. In this case the planted crop may be considered as a bait crop and treated in the same manner as described above. After treatment the field may then be replanted.

For crops planted in hills, such as melons or tomatoes, which may become infested, the calcium cyanide treatment may also be used. With a pointed stick, a hole is punched in the ground close to the plant or hill, and a teaspoonful of calcium cyanide is poured in. The hole is then filled up with soil and tamped gently. This treatment will also kill any plants remaining, but replanting can be done several days later, or at the same time if made about a foot from the hole where the calcium cyanide was applied.

Caution: Calcium cyanide is a dangerous poison, and when exposed to the air it yields the deadly fumigant known as hydrocyanic acid gas. This fumigant should be used only by those familiar with its poisonous qualities and with the precautions necessary to avoid accident.

Flooding

Another method of wireworm control which has proved successful under certain conditions involves flooding the land. However, to kill wireworms by this method it is necessary that the soil temperatures average at least 70° F. This method of control is therefore limited to the hot summer months. The land should be diked or ridged into basins so that water can be held on it continuously for at least 5 days. Just enough water to cover the soil is sufficient. Under these conditions (that is, with a soil temperature of 70° F. or more and continuous flooding for 5 days) a very large percentage of the wireworms can be killed. However, if the soil temperature is below 70° F., the percentage of wireworms killed by this treatment will be very low.

Baits

For small plots or back-yard gardens the use of baits such as carrots or potatoes has proved successful. These are placed in the soil to a depth ranging from 3 to 5 inches and left for several days. They are then dug up, the wireworms collected, and the baits returned to the soil for another collection. The wireworms collected in these baits may be destroyed by exposing them to the air in an open can. By digging up the baits every few days and collecting the wireworms from them, the plot of ground can be almost freed of these pests. The closer together the baits are placed, the quicker the wireworms will be attracted and collected. On small plots the baits may be placed 3 or 4 feet apart, but on large plots it may be necessary to space the baits farther apart so that there will not be too many of them to handle without excessive labor.

Two methods of wireworm control developed at the Walla Walla, Wash., laboratory of this Bureau, under the direction of M. C. Lane, may be applicable also in California. These methods involve the use of carbon disulfide and naphthalene.

Carbon Disulfide

When carbon disulfide is introduced into the soil it forms a vapor that is heavier than air and that penetrates downward into the soil to a depth of 18 inches or more, killing all wireworms present. For best results the soil should be fairly moist, but not too wet to be plowed, and the temperature at a depth of 6 inches should be above 60° F. Areas to be treated with carbon disulfide should first be prepared by loosening the ground by plowing, and smoothing it lightly afterwards with a float. One fluid ounce of carbon disulfide should be applied in the soil about 2 inches deep and at points not over 24 inches apart in each direction. A simple procedure is to mark off the area lengthwise and crosswise by using a marker with teeth set at 24 inches or less. At the intersections of the marks, holes 2 or 3 inches deep can be punched with a stick, and the carbon disulfide poured into the holes from a 1-ounce measure or with a device having a valve set to admit 1 ounce at a time. After being filled with carbon disulfide, the holes should be covered immediately with damp soil and pressed down firmly with the foot.

After 2 days the chemical will have accomplished its maximum kill of wireworms. In hot weather the vapor will work itself out of the soil, but a second deep plowing after a week will help to aerate the soil and allow the gas to escape faster. It is reasonably safe to plant crops a week after treatment. A 100-pound (10-gallon) drum of carbon disulfide will be sufficient to treat approximately 5,000 square feet at a cost of about \$8.50.

Caution: Liquid carbon disulfide evaporates very rapidly upon exposure to air, and the vapor is extremely inflammable and explosive when mixed with air in certain proportions. It should therefore be kept in a cool place and handled with great care. Do not smoke when handling it. It must be remembered that lighted lanterns, cigars, pipes, cigarettes,



sparks from electric switches, static or frictional electricity, sparks caused by hammering upon metal, or even hot steam pipes may cause an explosion of carbon disulfide vapor.

Crude Naphthalene

Crude naphthalene in soft crystalline form, containing over 90 percent of pure naphthalene, is most satisfactory for use against wireworms. The best time to apply this material is when the largest numbers of wireworms are nearest the surface and most active. Sprinkle the naphthalene by hand or machine along the sides of the fresh furrow from top to bottom as the field is being plowed. Immediately after the material has been plowed in, the entire field should be disked as deeply as possible, to mix the crude naphthalene thoroughly with the soil containing the wireworms. The disking is very important, because the deeper and more thoroughly the naphthalene flakes are mixed with the soil, the better will be the percentage of kill of wireworms.

When applied in this manner, 500 pounds of crude naphthalene must be used per acre to obtain a satisfactory kill of wireworms. To insure an even distribution over the entire field, the crude naphthalene should be weighed out at the rate of 20 ounces to 109 linear feet of 12-inch furrow slice. This material is very effective in killing wireworms in the sandier types of soil. It is less effective in soils rich in organic matter, and it should not be applied after heavy applications of barnyard manure or the plowing under of a green crop. After 5 days the gas from the naphthalene will have accomplished its greatest kill of wireworms, and seed can be planted with little risk of injury. The cost of naphthalene is about 5 cents per pound in California, at which rate it would cost about \$25 for the material to treat an acre.

It is important that the temperature of the soil be at least above 60° F. during the period of treatment and that the soil be in a good tillable condition, if the best diffusion of gas is to be obtained with either carbon disulfide or naphthalene.

Poisoned Baits

Many experiments have been made by numerous investigators in different parts of the country in an attempt to find a poisoned bait that will kill wireworms. But unfortunately none has been found. Although the wireworms can be attracted to various baits, any poison added to these baits either has not affected the wireworms or has been repellent, so that the wireworms would not feed on the bait.

Other Materials

Many other materials have been used to treat the soil infested with wireworms, but they have been ineffective or too expensive. Therefore only the control methods listed here are recommended at this time.